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ENGINEERING AND DESIGN HISTORY

VOLUME VI
POWER AND ELECTRICAL FACILITIES
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ENGINEERING DEPARTMENT

E. I. DU PONT DE NEMOURS & CO. (INC.)

Wilmington, Delaware

Prime Contractor

For

UNITED STATES ATOMIC ENERGY COMMISSION

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DU PONT PROJECT 8980

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SAVANNAH RIVER PLANT

PROJECT 8980

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VOLUMES AND TITLES

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- VOLUME III - #200 AREAS
- VOLUME IV - #300/700 AREAS AND GENERAL SERVICE
FACILITIES
- VOLUME V - #400 AREA
- VOLUME VI - POWER AND ELECTRICAL FACILITIES
(ALL AREAS)

SAVANNAH RIVER PLANT - PROJECT 8980
ENGINEERING AND DESIGN HISTORY
OF
POWER AND ELECTRICAL FACILITIES

VOLUME VI

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ENGINEERING AND DESIGN HISTORY
VOLUME VI - POWER AND ELECTRICAL FACILITIES
PART I - POWER FACILITIES

I - INTRODUCTION

GENERAL

This section of the Engineering and Design History presents a comprehensive account of the planning and extensive evaluation of the problems involved in reaching basic decisions for the design and installation of power facilities at the Savannah River Plant.

The problems were complicated by the urgency of providing early start-up of facilities at a time when critical material shortages were acute, combined with basic requirements for reliable operation and unusual degrees of flexibility to meet a variety of production demands.

Part I describes in detail the steam and water facilities, alternative schemes, and other considerations which were evaluated as a prelude to the final design of equipment and facilities. Included are discussions relating to steam boiler installations, electric power generation, diesel engine plants, water supply for cooling, process and domestic use, and the numerous water treatment procedures employed for specific application.

A comprehensive description of the development and design of electric power facilities is presented in Part II of this volume.

The development of design for the steam and water facilities is presented in the order of priority established early in the program for start-up of production facilities. In spite of the urgency assigned to the completion of the heavy water plant and initial reactor plants, it was necessary at all times to maintain a balanced perspective of the power supply problem from the standpoint of over-all site demands. It should be noted that the facilities installed in the heavy water (#400) area power plant were selected to obtain early delivery commensurate with a flexible and economic installation capable of being readily expanded to meet future requirements.

As explained in the reactor (#100) area chapter, power generation was provided in four of the five #100 Areas in order to effect dispersal of facilities yet retain continuity

of power supply for reactor operation. The fifth area power demand was supplied from purchased power for added flexibility to the over-all system and provided an extra degree of stand-by protection for emergencies. In all areas the steam and power generation facilities were designed to meet specific area requirements as economically as possible, commensurate with availability of materials, time schedules, and thorough reliability.

An intensive survey of diesel engine installations and equipment as prime movers and for stand-by power generation was made during the period of development for emergency "on-line" power. As a result, the final diesel installations met the rigid requirements regarding reliability, and also resulted in attractive investment and operating costs.

Water supply, as described under appropriate area headings, involved a wider variety of problems and long range planning than is usually encountered, and required intensive engineering effort, especially in providing cooling water for the five reactor areas. Many features of this system are unique since they involve protection against blast, flexibility to meet emergency conditions, and unusual problems in hydraulics engineering.

The resulting design of the power facilities for the site, as a whole, combined the principle of maximum flexibility for critical loads with independent dispersal of facilities wherever possible for maximum protection in case of a catastrophe.

In addition to detailed evaluations and the preparation of specifications, Design engineers, supported by groups from the Engineering Service Division, Construction Division, and plant operating groups, conducted functional and performance tests on all major power equipment prior to or immediately after initial start-up. These tests assured compliance with specifications, correction of deficiencies in vendors' equipment, and safe and reliable operation for plant production.

PRELIMINARY WORK FOR SITE SELECTION

The first significant power study work began with the site survey when preliminary power load data were established for use in site evaluations. At that time estimates were made of the power facilities required for each of the more favorable sites, the major requirements being those for water pumping and treatment, steam generation, electric power generation, refrigeration, and miscellaneous auxiliaries.

Water pumping and treatment facilities required for the different sites varied widely due to differences in pumping head, water quality and water temperature. Where cooling

towers were involved, atmospheric wet bulb temperatures also became an important consideration.

Estimates of steam loads varied with site locations because of climate and water temperatures. The availability and cost of fuels at the different sites also greatly influenced the contemplated steam plant designs and affected economic comparisons both in first cost of equipment and in operating costs.

Because it was desired to keep plant investment costs low, a reliable source of purchased electric power was considered preferable to site generated power. The public utility systems in the vicinity of the proposed sites were contacted to determine the availability and reliability of such electric power. However, no block of power in the amount contemplated was found available at any of the locations, and site evaluations, therefore, were made on the basis of site generated power. At all times, however, the possibility was recognized that future negotiations with the public utilities might result in expansion of one or more utility systems to supply part of the power requirements.

Many factors other than power facilities also influenced selection of the Savannah River site as explained in Volume I, Section 3. As a result of the site survey effort considerable preliminary power engineering work had been done at the time Site 5 was selected in South Carolina. At that time production of heavy water at the Savannah River Plant had been projected and the following loads had been tentatively forecasted: (1) electricity, 125,000 kilowatts; (2) water, 450,000 g.p.m.; and (3) steam, 600,000 lbs./hr. (exclusive of steam for electric power generation). This preliminary forecast was adequate for evaluation of the proposed sites from the standpoint of power facilities, recognizing that many refinements would be made later as more reliable design data were developed.

SCOPE OF WORK

As soon as the decision was made to locate the plant at the South Carolina site, work was started on the preparation of a more detailed scope of work. Studies were initiated to obtain information on river water quality, flows and temperatures. The techniques and results of water treatment plants in that area were reviewed to obtain the benefit of local experience. Ground formations were analyzed and studies initiated to determine the possibility of using wells to supply part of the water requirements. A search was initiated to obtain all available weather data, including records of wet and dry bulb temperatures, prevailing winds, rainfall and storms.

Contacts with local utility companies were intensified in an effort to develop sources of electricity for plant construction and also ultimately for plant operation. The South Carolina Electric and Gas Company had an existing transmission line across the plant site and was able to furnish approximately 10,000 kw. for construction purposes. The existence of this line and the ability of the company to furnish this quantity of electricity assisted considerably in getting construction activities underway at an early date.

After the site had been selected, the planning of production facilities also proceeded at an accelerated rate. This resulted in better estimates of power requirements which, in turn, facilitated the establishment of the scope of work for power facilities.

In general, the magnitude of the original scope of work for power design was based on the following considerations.

1. Five or more #100 Areas were proposed, each area having a demand of approximately 20,000 kw. of electric power (exclusive of that needed for river pumping) and a supply of 100,000 g.p.m. of cooling water. The reliability of both the electric power and water supplies would be critical, and it was imperative that design be planned carefully to provide this high degree of reliability. Project security, involving the possibility of sabotage and enemy attack, was a very important consideration. Blast resistant construction was a definite requirement for many critical services, and special considerations were indicated for some of the less critical facilities to provide a measure of protection against damage by external explosion or flying missiles. The urgency of the program was also a factor of primary importance, and design schedules necessarily had to comply with construction requirements since an early start-up of plant facilities was mandatory.

2. Two separations (#200) areas, one metal preparation (#300) area, and one administration (#700) area were also proposed. Each of these would require electric power, steam, cooling water, and other miscellaneous power services, in lesser quantities than the five #100 Areas. Reliability of service was essential for certain processes. Security and safety provisions were also vital considerations in these areas, and area completion dates had to be scheduled to meet the over-all project requirements.

3. Many miscellaneous power facilities were required on the plant site in addition to those strictly within the production and administrative areas. These included such services as inter-area pipe lines, transmission lines and river pump houses.

4. During December, 1950, the scope of work was increased through the decision to locate a heavy water production plant (#400 Area) on the site. Completion of design at an early date was of vital importance to the over-all program and, therefore, it was assigned the highest priority of all of the areas. Estimates of the power requirements for this area were: steam, 680,000 lbs./hr., electricity, 40,000 kw., and water 50,000 g.p.m.

POWER DESIGN SUBCONTRACTS

When the total power requirements for the site were established, it was determined that the du Pont Power Design Group should be supplemented by a design subcontractor to permit completion of design work in the time available. The decision was made to organize a special group of du Pont Power Design engineers to supervise and coordinate the preparation of designs for the power facilities, but to subcontract the work to outside engineering firms. The negotiations involved in arranging design subcontracts are discussed in Volume I of this history.

The services of Gibbs & Hill, Inc. were obtained to design the major boiler plants, power houses, water supply installations, water treating equipment, and certain other facilities for the project. These included the following:

1. River pump houses, river water lines, water treating facilities, steam and electric generating facilities and power services in the #400 Area, terminating at the battery limits of the process buildings.
2. River pump houses, water distribution systems, water treating facilities, steam and electric generating facilities and power services in the five #100 Areas, terminating within five feet of the process building walls. Special electric generating facilities within #100 Area process buildings.
3. Steam generation and water facilities within battery limits in the #200 Areas designated as the "power-blocks". Wells and water treating facilities in the #200 Areas outside of the "power-blocks".
4. Steam generation and other power facilities in the #300/700 Area outside of the process building battery limits, fixed at five feet from the building walls.

No other subcontractor was retained specifically for power design work, but two others did have an active part in the design of power facilities for some of the areas. Voorhees, Walker, Foley & Smith prepared the designs for underground

sewer and drainage lines in the #400 Area, #100 Areas, #300/700 Area, and within the "power-blocks" in the #200 Areas. In addition, they designed several emergency power installations within certain process buildings where diesel engine-driven generators were installed to supplement normal production power. Blaw-Knox, another subcontractor, was primarily responsible for #200 Area process design, but also designed the underground and overhead lines in the #200 Areas outside the battery limits of the "power-blocks", and several emergency power installations in #200 Area process buildings where diesel engine-driven generators were used to supplement the normal production power.

The du Pont power engineers assigned to this project worked in continuous contact with the subcontracting firms, and coordinated the development and design of all the power facilities during the progress of the job. It was the responsibility of this group of engineers to approve all procurement and designs, sign all drawings and, in general, guide all phases of the design activity.

SECTION II —

BASIC REQUIREMENTS

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II - BASIC REQUIREMENTS

LOAD DEVELOPMENT

In the foregoing introduction, the general power design problem has been defined briefly as it existed at the time of site selection. Once the plant site was established, the way was cleared for design development to proceed at an accelerated rate.

One of the most important phases of the early design development work was the establishment of firm power load data. This was dependent primarily on the development of process information with the result that the initial estimates of requirements were revised many times before firm figures were obtained. The successive estimates of steam, electrical and water loads from the original to the firm data are tabulated chronologically on pages 21, 22 & 23. The time required to develop the information may be determined from the dates shown for the estimates.

In many cases it was not possible to delay decisions until final load data were available, and Design and Construction proceeded with the best information at hand to meet the scheduled completion dates. This procedure resulted in minor additional design work, but made possible the early start-up of plant facilities. In most cases, subsequent revisions of estimated loads had little effect on the design work in progress. A few major design changes were required, however, where load revisions were substantial or where the basic concept of design was changed.

The over-all electric power distribution system for the plant was designed for maximum flexibility and reliability, with all major sources of supply interconnected. Power supply problems therefore, were analyzed from the standpoint of over-all availability of power in order to develop over-all peak and average plant conditions. Original area electric load estimates shown on page 22 are combined on page 24 to show the over-all plant peak load. A 93 per cent diversity factor was applied when all of the area peak figures were totaled, and load factors were applied to individual peaks to show average power consumptions.

TIME SCHEDULE

Timing, an important factor on all design projects, especially influenced the design of the Savannah River Plant power facilities. Due to urgency of starting production operations in certain areas of the plant (and the entire

plant in general), the Atomic Energy Commission designated plant start-up dates that allowed a minimum of time for the design and construction of those facilities required for initial operation of the #400, #300, #100 and #200 Areas.

As the Power Design Group obtained the plant steam, electric and water load data (see pages 21, 22, & 23), the basic designs were developed and a schedule prepared to meet plant start-up requirements. Page 25 presents a tabulation of the initial start-up goals and the revision dates due to unavoidable delays. The plant electric load growth curve (page 27) graphically illustrates the range of start-up dates combined with the over-all electric demands.

In general, the Power Design Group goals included a 30 to 60-day equipment trial period prior to area start-up. This period was needed for "shake-down" operation and training of operators so that plant trials and production could proceed with much less likelihood of power interruptions.

It is worthy of note that the power facilities were available for initial start-up of each area and that no delays were experienced from lack of power supply.

SPECIAL CONSIDERATIONS

Certain factors required special consideration in designing the power facilities and special coordination between the du Pont Design and Construction Divisions in order that their respective activities might proceed concurrently. This was necessary to accomplish plant start-up at the earliest possible date. Foundation drawings were sent to the field well in advance of equipment layouts to provide early work for the construction forces, and the Construction Division was kept informed of design status at all times, thereby permitting this group to schedule its work load for maximum utilization of time and man-power.

Du Pont power engineers made frequent visits to the site and later a representative of the Power Design Group was stationed in the field. Each of the subcontractors also set up a field organization to maintain on-the-job contact.

The extremely high degree of reliability required for certain critical power services was another major consideration. Due to the nature of the processes to be served, serious and costly operating difficulties could result from complete failure of a power supply. The #100 Area production reactors, in particular, required a very dependable type of power service since a complete failure of this power could have disastrous effects. In the #400 Area, power failure could cause substantial loss following even short shutdowns.

PROJECT 8980 - SAVANNAH RIVER PLANT
CHRONOLOGICAL DEVELOPMENT OF AREA STEAM LOADS

Steam Demand - Pounds per Hour (Winter Peak Requirements)

Area	Load Data Date	Nominal Pressure, PSIG							
		330	300	175	150	100	50	40	20
400	Original 12/50		420,000		1,000	55,000	125,000		
	Revised 3/51	560,000						150,000	
	Revised 4/51	532,000						114,000	
100 * R,P,L,K	Original 8/51				4,100			57,200	
	Revised 10/51(RP)			7,300					53,300
	Revised 10/52(LK)			11,300					51,850
100-C	Original 1/52			11,300					72,050
	Revised 12/52			11,300					52,050
	Revised 3/53			18,900					44,250
200-F **	Original 4/51		135,000						
	Revised 12/51		152,000						
	Revised 4/53		166,000						
	Revised 7/53		156,000						
	Revised 12/53		155,000						
200-H **	Original 4/51		100,000						
	Revised 12/51		117,000						
	Revised 4/53		106,000						
	Revised 7/53		97,350						
	Revised 12/53		92,500						
300/700 **	Original 2/51		110,000						
	Revised 9/51		92,800						

* Area steam demands for each #100 Area.

** Area steam delivered at 300 p.s.i.g.; varying lower pressures used by consumers.

PROJECT 8980 - SAVANNAH RIVER PLANT
CHRONOLOGICAL DEVELOPMENT
OF
AREA ELECTRIC LOADS

<u>Area and Load Data Date</u>	<u>Electrical Requirements Kilowatts (15-Minute Peaks)</u>
<u>400, including 681-5G River Pump House</u>	
Original 12/50	40,000
Revised 10/51	49,100
Revised 10/52	48,000
<u>100-RPLKC</u>	
Original 12/50	89,000
Revised 10/51	96,600
Revised 10/52	100,500
<u>681-1G, 3G</u>	
Original 12/50	27,600
Revised 10/51	27,900
Revised 10/52	27,000
<u>200-F</u>	
Original 12/50	6,000
Revised 10/51	7,800
Revised 10/52	6,700
<u>200-H</u>	
Original 12/50	2,000
Revised 10/51	3,800
Revised 10/52	4,100
<u>300/700</u>	
Original 12/50	5,000
Revised 10/51	7,800
Revised 10/52	8,300
<u>Miscellaneous Project Loads</u>	
CMX	600
Construction	10,000

PROJECT 8980 - SAVANNAH RIVER PLANT
CHRONOLOGICAL DEVELOPMENT OF AREA WATER LOADS

Area	Load Data Date	Water Demand - Gallons per Minute (excluding water recirculated through cooling towers for Power House and Refrig. System Condensers)					
		Untreated River Water	Clarified Water	Filtered Water	Softened Water	Well	Recirculated
400	1/51	40,000	8,200	8,000			
	2/51	66,800	9,200	9,000	1,300	1,000	
	5/51	69,800	9,500	9,300	1,300	1,000	
100-RPIKC	5/18/51 (i)	80,000*	60,000*	60,000*	100*		
	6/6/51 (i)	80,000	76,200	3,000	100		
	(f)	94,000	89,600	3,000	100		
	3/28/52 (i)	80,000	3,100	3,000	100		
	(f)	96,000	3,100	3,000	100		
	12/31/52	96,000	4,000	3,000	100		
	3/13/53	96,000	4,000	3,000	120		
200-F	1/51	15,000					
	6/51	15,000					
	8/51	12,000	12,000	1,855			
	8/51	3,500	3,500	1,855			8,350
	10/51				430	2,600	15,000
200-H	1/51	10,000					
	6/51	15,000					
	8/51	12,000	12,000	1,855			
	8/51	3,500	3,500	1,855			8,350
	10/51				265	2,430	15,000
300/700	1/51					2,000	
	4/51					2,000	

*100 Area water demands for each 100 Area

(i) - Initial level of operation

(f) - Final level of operation

PROJECT 8980 - SAVANNAH RIVER PLANTELECTRICAL LOADS

Data as of December 1950

<u>Areas</u>		<u>15-Minute Demand Kw.</u>	<u>Annual Av. Load - Kw.</u>
100	(5)	89,000	78,000
200	(2)	8,000	4,800
300-700	(1)	5,000	2,500
400	(1)	38,400	30,700
600	(1) (1G & 3G (5G	27,600 1,400	24,200 1,200
C.M.X.		600	600
Sub-Total		170,000	142,000
Diversity Factor		0.93	-
Total		158,000	142,000

PROJECT 8980 - SAVANNAH RIVER PLANT
SCHEDULED START-UP OF AREA POWER FACILITIES

Area & Date of Schedule	Scheduled Start-up Date	Actual	
		On Line	Final Accept.
<u>400</u> Original 12/26/51	June 15, 1952	7/11/52	4/27/53
Revised 5/1/52	October 1, 1952		
Revised 8/15/52	March 1, 1953		
<u>100-R</u> Original 12/26/51	October 1, 1952	3/26/53	9/18/53
Revised 8/15/52	February 1, 1953		
Revised 1/ /53*	March 1, 1953		
<u>100-P</u> Original 12/26/51	November 1, 1952	7/17/53	10/5/53
Revised 5/1/52	January 15, 1953		
Revised 8/15/52	March 1, 1953		
Revised 1/ /53*	May 1, 1953		
Revised 4/9/53	July 1, 1953		
<u>100-L</u> Original 12/26/51	April 1, 1953	10/8/53	3/11/54
Revised 8/15/52	June 1, 1953		
Revised 1/ /53*	June 15, 1953		
Revised 4/9/53	October 1, 1953		
<u>100-K</u> Original 8/15/52	January 1, 1954	5/27/54	8/31/54
Revised 4/9/53	July 1, 1954		
<u>100-C</u> Original 11/24/52	September 1, 1954	9/2/54	3/23/55
Revised 2/1/54*	October 1, 1954		
Revised 4/9/53 & 9/1/53	December 1, 1954		
<u>200-F</u> Original 12/26/51	March 1, 1953	10/28/53	Not Ac-
Revised 8/15/52	April 1, 1953		cepted
Revised 4/9/53	July 15, 1953		as of
Revised 7/20/53	November 15, 1953		12/31/55
<u>200-H</u> Original 12/26/51	April 25, 1953	11/24/54	Not Ac-
Revised 8/15/52	June 1, 1953		cepted
Revised 7/20/53**	October 1, 1954		as of
			12/31/55
<u>300/700</u> Original 12/26/51	May 1, 1952	9/23/52	2/4/53
Revised 5/1/52	September 15, 1952		
Revised 8/15/52	October 15, 1952		
<u>600-G</u> Original 12/26/51	September 1, 1952	-	3/2/54
<u>681-1G</u> Revised 5/1/52	October 1, 1952		
Revised 8/15/52	November 1, 1952		
<u>681-3G</u> Original 12/26/51	January 1, 1953	-	8/13/54
Revised 5/1/52	February 1, 1953		
Revised 8/15/52	March 15, 1953		

* Construction Schedule

** Boiler laid up 11/19/53 until required.

Directly related to high power reliability was the necessity for protecting power supply facilities against possible enemy attack, sabotage or disaster. Dispersion of facilities and blast-resistant construction, designed to withstand 1000 pounds per sq. ft. pressure were required for the more critical buildings. For other buildings, of non-blast resistant construction, potential damage to side-walls was limited and personnel hazards were reduced by using friable materials which would not create flying missile hazards in the event of a blast.

In so far as was consistent with the dependability required, low investment in power facilities and minimum operating costs were desired. To this end, economy was sought by utilizing out-of-door construction, previous designs, and standard commercial equipment where possible.

Normally, preference is given to the purchase of electric power to reduce the investment in power supply facilities. It was necessary, however, to weigh this desire against the reliability, availability, and general quality of the available purchased utility service, as well as its vulnerability to enemy action.

Security controls were required on this job, as on all AEC projects, in order to safeguard information vital to the national defense. Security of design data was required of du Pont and all its subcontractors, and by its very nature, this security control imposed an extra burden on engineering forces, especially in disseminating information to vendors, thereby affecting work schedules.

During certain periods, shortages of construction materials required deviation from conventional design to avoid delay in procurement. Many elements of this problem, not apparent at the beginning of the project, became critical during the design development stage. This phase of the history is covered in the section titled "Design Development".

SAVANNAH RIVER PLANT

PLANT ELECTRIC LOAD GROWTH CURVE

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III - DESIGN

GENERAL

This section of the history covers the design development of steam and water facilities for the various areas and also includes a brief account of electric power generation equipment. Additional information on the development of the electric power systems is given in Part II of this volume.

In view of the urgency of the over-all program and the required early completion dates for certain initial facilities, design priorities were assigned in accordance with these objective dates. To make this report as nearly chronological as possible, the areas are discussed in the order in which priority was assigned, starting with the #400 Area.

Before proceeding with the design development of the individual facilities, however, it is advisable to note some of the factors which had a significant effect on the design of all facilities. One such factor was the steel shortage during the latter part of 1951. At that time, designers were instructed to use, if possible, reinforced concrete and other available alternative materials to replace steel. As an example of the effect of this order, power house designs for the #100-RPL&K Areas and for the #200-F&H Areas specified concrete coal storage silos, whereas steel coal bunkers had been specified in the #400 Area and the #300-700 Area. By the time the #100-C power house design became active, steel was again available and steel coal bunkers were used.

Availability of equipment was a second significant factor. Designs were limited to equipment which could be obtained in time to meet scheduled dates. This had a definite limiting effect on the size of the turbo-generators, since the larger machines had excessively long delivery schedules.

Economy of design was a third controlling factor. Certain policies were set up for guidance toward low-cost designs. Building enclosures were to be eliminated, where possible, in favor of outdoor equipment installations, and building space, where required, was to be reduced to a minimum. No "frills" or unnecessary features were to be incorporated, and design engineers were instructed to start with the simplest arrangements and to add only those refinements which could be definitely justified.

The effects of these factors and the influence of the special considerations will be noted in the design development of the following area facilities.

WATER SUPPLY

GENERAL

INTRODUCTION

The importance of water to the over-all project has been indicated in the earlier portions of this history. The intent of this section is to describe the uses of water and the methods of obtaining and treating it. The major demands for water were for process cooling, direct process use, steam and electric power generation, and general use including sanitary purposes. Each of these specific demands had certain quality requirements which had to be satisfied. The details of the various conditioning treatments which were developed to meet the individual requirements will be discussed under the respective areas.

Among the major factors considered in selecting the plant site was the availability of water in adequate quantities. From published information it was readily established that the Savannah River could furnish the desired quantities of water, and it was generally but not specifically established in the literature that the geologic structure under the site contained water bearing formations from which water in quantities suitable for industrial purposes could be obtained.

As soon as the site had been selected a detailed study was begun on the over-all problem of water supply and conditioning facilities. A search of the published literature was made to collect all available historical and current information, and field trips were made to water plants in the general area of the site and also in the southeastern part of the United States for the purpose of developing pertinent experience information. The data thus obtained were limited principally to the use of Savannah River water, and very little specific information was available concerning the occurrence and usage of ground water in the immediate area.

To obtain current data, a general and cooperative program was arranged with the United States Geological Survey, Water Resources Division, Surface Water and Ground Water Branches. This program included a study of the geology of the general area with the specific purpose of defining the extent of the principal water bearing formations or aquifers.

SAVANNAH RIVER WATER CHARACTERISTICS

It was established from literature and from persons in the area familiar with its use that the water from the Savannah River had the following general characteristics: (1) it was always turbid, the degree of turbidity varying generally with the rainfall; (2) the dissolved mineral content was low, placing it in the soft water category; and (3) although it had a neutral pH, the water was considered to be definitely corrosive toward mild steel.

The turbidity was a combination of color derived from decaying vegetable matter and very fine particles of silt existing as a colloidal suspension. The comparatively high temperature of the water, combined with its exposure to sunlight and the presence of microscopic vegetable and animal organisms, provided favorable conditions for the growth of algae during a large part of the year. The river was typical of large streams which flowed with a reasonably good velocity, in that its temperature followed closely the variations in air temperature. Contamination of the water with trade wastes and domestic sewage was found not to be significant.

The following tabulation presents a representative analysis of Savannah River water, as developed in the early stages of the project. It is based on the average of a large number of samples taken over more than a one-year period:

Turbidity (silica scale)	50 to 550 parts per million
Total hardness as CaCO_3	21 parts per million
Methyl Orange Alkalinity as CaCO_3	26 parts per million
Phenolphthalein Alkalinity as CaCO_3	0 parts per million
Bicarbonate as CaCO_3	26 parts per million
Chlorides as Cl	5 parts per million
Sulphate as SO_4	8 parts per million
Silica as SiO_4	11 parts per million
Iron as Fe	0.5 parts per million
Carbon Dioxide as CO_2	4 parts per million
pH Value	7.1

An evaluation of the corrosive or aggressive character of the river water was begun early in the design phase of the project. Corrosion test racks were prepared and exposed in the clear wells of three different conditioning plants, namely, CMX, the city of Augusta and the city of Savannah.

All of the historical data concerning the Savannah River water available at the beginning of the project had

been obtained under conditions which would be influenced by operation of the Clark Hill Dam, then under construction on this river some 40 miles upstream from the plant site, and scheduled to be in use at about the time the plant would begin using river water. Accordingly, such influences from this dam as could be predicted were taken into consideration in the design of the water conditioning facilities. Of particular importance was the effect this dam might have upon the temperature of the river water reaching the plant site.

GROUND WATER CHARACTERISTICS

Only a meager amount of historical information was found concerning water bearing formations under the plant site which could be developed for industrial use. The only wells existing in the area were those used for domestic supplies, and information was limited concerning their physical dimensions and construction. Therefore, in order to evaluate promptly the potentialities of the underlying water bearing formations, it was obvious that exploratory drilling should be made. No time was available, however, for a separate investigation so it was decided to utilize the information obtained from the wells which were to be drilled to furnish temporary construction water. The drilling of these wells was predicated on an estimated supply of at least 200 to 300 gallons per minute at any location on the site. This prediction was about the extent to which the limited available information could be used.

At the outset of the construction well-drilling program, it was generally known that two water bearing formations existed under the site, the terrain of which averaged 100 to 150 ft. above sea level except for a line of hills that rose to 400 ft. above sea level, away from the river. A combined Barnwell and McBean formation about 275 ft. thick with its upper surface at approximately 300 ft. elevation above sea level was located in the hills away from the river. The other formation, the Tuscaloosa, had its upper surface at about 0 elevation (sea level). It was of undetermined thickness and was believed to extend considerably beyond the boundaries of the plant site. The Tuscaloosa formation appeared to have the greatest potential as a large source of ground water for plant usage.

The water obtained from the temporary construction wells located principally in the Tuscaloosa formation had the following general characteristics: (1) a very low dissolved mineral content; (2) a relatively high concentration of dissolved carbon dioxide with correspondingly low pH values considered aggressive to steel, especially after aeration; and (3) in some instances a relatively high concentration of dissolved iron, a source of difficulty if the iron was allowed to precipitate from solution. The water obtained from the McBean

formation, on the other hand, contained a much higher concentration of dissolved mineral matter and generally was not considered aggressive toward mild steel. Unfortunately, this latter formation did not have a very great potential as a source of water in the quantities required.

Representative chemical analyses of the deep (Tuscaloosa formation) and the shallow (McBean formation) well waters developed on the plant site are as follows:

	Tuscaloosa Formation			McBean Formation
	Deep Wells			Shallow
	400	300/700	200	Wells
	Area	Area	Areas	900 Area
In parts per million except pH				
Phenolphthalein				
Alkalinity as CaCO_3	0	0	0	0
Methyl Orange				
Alkalinity as CaCO_3	17.5	9.3	2.0	86
Total Hardness as CaCO_3	21.0	9.3	5.0	87
Total Solids	48.0	21.0	33.0	112
Silica as SiO_2	10.5	6.8	15.0	45
Chlorides as Cl	0.9	0.8	1.0	1.2
Sulfates as SO_4	5.5	1.0	15.5	8.3
Iron as Fe	0.7	0.06	0.5	0.3
Carbon Dioxide as CO_2	9.0	-	20.5	1.0
pH Value	6.9	5.8	4.6	7.5

CMX

The quality and conditioning requirements of the water for process use were developed concurrently with the characteristics of the available water. Initially, all water used was to be low in turbidity, particularly river water required for cooling the reactors in the #100 Areas. As this was a critical application, an experimental facility was organized by the AED Technical Group to study the related problems. This facility, known as CMX, was placed in operation soon after design of the plant's facilities was begun. Savannah River water was tested by CMX and complete water conditioning equipment was provided for evaluating the conditioning procedures required for treating the raw river water for the specific cooling purpose under study. The results of these CMX studies will be discussed in some detail in the design development of the #100 Area water treatment facilities. These studies evolved a change in the turbidity requirement, permitting the use of raw river water for process cooling in the #100 Areas.

RIVER WATER CONDITIONING

Even though it was determined that the river water could be used without reducing its suspended solids, the biological growths in the river necessitated the use of some form of bactericide to control the formation of microscopic organisms and slime growths in the main supply lines and to minimize such growths at the points of use.

For those areas where it was established that the Savannah River would be the principle source of cooling water, additional conditioning steps were required for its use as boiler feed, process, special cooling water, or as domestic and fire protection water.

The conditioning steps ultimately established for raw river water consist of a coarse screening and periodic chlorination at the river pumping stations, followed by another chlorination before delivery to the respective conditioning facilities.

If used for cooling purposes only, the river water is treated further by periodic chlorination and passed through a mechanical strainer after retention in a reservoir. If the raw river water is to be used for domestic, process or fire protection use, it is delivered to a clarification facility where it is chlorinated and treated with a coagulant, permitted to settle and then filtered. The filtered water is further conditioned to provide boiler feedwater and special quality process water by being passed through ion exchange facilities designed to demineralize it and remove soluble silica.

The coarse screens provided at the river pump houses serve to remove most of the floating trash and are of the self-cleaning type with 1/2-in. clear openings. They generally protect the large pumps and lines to the storage reservoirs in the respective areas. Further trash protection is provided at the reservoir by self cleaning strainers with 1/16-in. clear opening installed immediately ahead of the distribution pumps.

Chlorination was selected to control the formation of microbiological growths. The hypochlorous acid formed when chlorine gas is dissolved in water is the best known microbiocidal agent for use in water treatment, and commercial equipment for its preparation and application is available in a wide range of capacities.

Where complete removal of suspended solids is required to provide a clean quality of water, a two-step conditioning process was selected. The first step is clarification, which

involves application of a coagulant to the water and adjustment of the pH value (hydrogen ion concentration) to an optimum reaction range by the addition of an alkali. Based on general water treatment practice and local experience, the chemicals selected were aluminum sulfate for the coagulant and high calcium lime for the alkali. The specific types of equipment used for the clarification process will be described in detail later in the appropriate sections.

The second step is filtration, which involves passing the clarified water through filtering media in which the traces of very fine suspended solids and light flocculent materials from the clarification process are removed, together with a high percentage of the bacteria present. Gravity filters of the rapid sand type were selected.

The selection of a process for preparation of boiler feedwater from filtered water was based on the fact that the filtered water had a very low concentration of dissolved mineral solids, of which a large proportion was dissolved silica. Silica reduction is required to minimize blowdown from the boilers, and silica deposits on turbine blading where steam is used to generate electricity. Low silica in the feedwater also permits the use of a reasonable quantity of chemicals for internal boiler water treatment.

The demineralization process selected involves passing the filtered water first through a bed of acid regenerated cation exchange material to remove sodium, calcium and magnesium ions from the water, as well as soluble iron. The resultant water contains small concentrations of carbonic, hydrochloric and sulfuric acids, and the soluble silica becomes acidic in character.

The next step is the removal of most of the carbonic acid by passing the water through a degasifier, a unit in which dissolved gases such as carbon dioxide are stripped from the water by intimately contacting a thin film of water with air flowing in a counter current pattern. Degasifiers were eliminated in those areas where the discharge of the carbon units would not contain excessive amounts of carbonic acid. The cation effluent, either degassed or not, is then passed through a bed of alkaline regenerated anion exchange material to remove the acids and silica.

The water leaving the anion units contains less than two parts per million of dissolved mineral salts. This demineralized water is used without further treatment in several areas for special processes. Further treatment is required for boiler feedwater, involving the continuous addition of a caustic solution to maintain the alkalinity required. This treatment, applied at the exit from the demineralization process, also reduces the aggressiveness of the aerated demineralized water toward mild steel and copper equipment.

The caustic-treated demineralized water is introduced into the boiler system as make-up and the entire flow of feedwater is deaerated in a deaerating feedwater heater. At the exit of this heater the feedwater is treated with a small amount of sodium sulphite to remove any trace of dissolved oxygen not removed in the deaerator. The final treatment involves the injection of a small amount of sodium phosphate directly into the boilers to form a soft sludge with any calcium present in the boiler water.

In those areas where river water is the principle source of supply, it is used as make-up to the evaporative type recirculated cooling water systems without any reduction in turbidity. The water conditioning requirements for such systems include chlorination to control microbiological growths and the addition of lime to counteract the acidity introduced by the chlorination process and to reduce the natural aggressiveness of this raw river water toward mild steel.

The only other major water conditioning requirement involves the treatment of filtered water to remove all carbonates and dissolved gases. This is accomplished by a three-step process involving controlled acidification, deaeration, and pH adjustment with an alkaline chemical. The latter step removes any free acid remaining in the treated water, especially if the acidification step is not precisely under control.

WELL WATER CONDITIONING

In contrast to the general conditioning requirements for the raw river water, the well water conditioning requirements are not extensive since this water is clear and relatively soft. The chemical quality, however, varies from area to area and has a distinct bearing on the selection of the conditioning processes for specific needs. Treating facilities were provided for chlorination, for stabilization of dissolved iron, for corrosion protection, and for demineralization to prepare the water for special uses.

Chlorination is applied to all well water for domestic purposes. Also, periodic chlorination is provided for well water used as a coolant where it is subjected to continued exposure to the air. A free chlorine residual is maintained in the domestic water system to insure the control of biological growth, and periodic residuals are developed in the circulated cooling water to control slime growths on heat exchanger surfaces.

For well water containing dissolved iron, a polyphosphate treatment was specified to form a complex soluble iron phosphate rather than install equipment for removing the iron, since the latter facilities would be too costly in the use of chemicals, equipment, backwash water, and operator attention. The polyphosphate also would act as a corrosion inhibitor or as a calcium carbonate scale preventative depending on the particular quality of the water to which it was added. If the water was of a corrosive character, the polyphosphate would temper this factor, whereas, if the water was of scale-forming character the polyphosphate would extend the range over which the water could be heated before calcium carbonate scale would begin to form.

For those well water supplies having a pH value below 6.5, lime treatment was provided to convert some of the free carbon dioxide to calcium bicarbonate in order to reduce the aggressiveness of the water toward mild steel and copper. Lime treatment also was specified in conjunction with the polyphosphate treatment in those instances where the pH value of the water is below 6.5 and the water contains dissolved iron.

All supplies of deep well water require some degree of the above conditioning and, except for the feedwater for boilers which are required to operate continuously at full load, is the only treatment necessary. In two instances, boiler feedwater is prepared from treated well water by the two-step demineralization process. This process is the same as that described for preparing boiler feedwater from filtered river water except that the cation effluent is not degasified before it is sent to the anion units. The effluent from the anion units is treated with caustic soda for alkalinity adjustment, passed through a deaerating feedwater heater, and treated with sodium sulphite and sodium phosphate in the same manner as described for similar treatment of the river water.

Where well water is used as make-up to recirculated cooling water systems of the evaporative type, the only additional treatment required is chlorination. Where the treated water is used for cooling purposes in a heat exchanger and the water is not exposed repeatedly to the atmosphere, chlorination is not required.

Besides the general conditioning requirements described above, all domestic water is conditioned and handled to meet all standards recommended by the United States Public Health Service and the requirements of the South Carolina State Health Department. The domestic water treatment facilities were designed to produce water of unobjectionable turbidity, color or odor, and without excessive soluble mineral content. The

water treatment facilities and piping systems were designed so that domestic water systems would be isolated with no possibility of contamination due to cross connection with other water systems. Duplicate chlorination equipment was specified for the domestic water system to insure continuity of treatment to prevent microscopic organisms from contaminating the supplies.

It was specified that each water conditioning facility should include a space for storing bulk chemicals used in the respective treatments. The space provided is large enough to permit the storage of at least a 30-day normal operating supply plus one delivery unit of chemicals. In addition, a central storage site was provided for one-ton chlorine cylinders, for caustic soda, and for sulfuric acid. The chlorine cylinders are handled on specially designed trailers and the caustic soda and sulfuric acid are transported in special tank trailers to the individual facility storage media from the respective central storage site. Such an arrangement is necessary because of the numerous small users of these three major treating chemicals. Otherwise, all major water treatment chemicals are transported to the project by rail and delivered to those facilities requiring carload lots. The cars are unloaded in the areas where the chemicals are used and where adequate storage has been provided.

WATER SUPPLY - #400 AREA

GENERAL

It was originally estimated that the #400 Area process would require about 40,000 g.p.m. of water and that additional quantities would be required for electrical generation. Due to the early start-up scheduled for this area, a quick decision regarding the source of water supply was necessary.

During the early planning, it was known that a water-bearing sand formation existed beneath the plant site and consideration was given to the possibility of utilizing this as a source of water supply for the #400 Area. However, no specific information concerning the extent of this water source was available and a decision regarding the use of wells for water supply to process could not be made at an early date. Even if wells had been feasible, an extensive and costly well water collecting and distribution system would have had to be developed. Because of these uncertainties and difficulties and since the location of the #400 Area was relatively close to the Savannah River, the decision was made to supply the major portion of the #400 Area requirements from the river.

N.O. Denotes normally open valve
N.C. Denotes normally closed valve

Design of the river water supply system for the #400 Area provided for a river pump house, Bldg. #681-5G, located on the east bank of the Savannah River, a 60 in. reinforced concrete pipe line to convey the water to the area, and a distribution system within the area to supply the various qualities of water. In the final analysis of water requirements, approximately 62,500 g.p.m. were to be pumped from the river to the reservoir at Bldg. #483-D. Here two distinct courses are followed, one in which additional conditioning is required to make the water suitable for process use, the other where the water is used for cooling and can be used as taken from the river. Water used for cooling purposes is repumped from the reservoir to the power house turbine condensers or to the process area. Water requiring conditioning is run through a clarification plant and then a filter plant from which point it again is separated into two different and separate paths.

Water to be used as feed for the "GS" unit is conditioned by injection of acid, after which it is passed through cold water deaerators. Caustic soda is injected for pH correction as the water leaves the deaerators. The effluent from the deaerators is stored in a tank with a floating roof and is delivered to the "GS" units by means of high head pumps.

Water for boiler make-up to replace steam exported for process use is pumped from the filter clearwell through a softening plant containing hydrogen ion units, degasifiers and silica cation units and thence to the power house. At the power house the water enters the boiler feedwater system in the condenser clearwells from which point it passes through stage heaters and deaerators and on to the boilers. The schematic diagram on page 45 shows the water distribution system in the #400-D Area.

In addition to the river water supply, a well water system, incorporating two wells, was installed to supply domestic water needs, and a third well was installed to supply water for process cooling at Bldg. #421-D. The well water is advantageous for process use because of its lower temperature during summertime and its more stable temperature throughout the year, as compared with river water.

When a later decision was made to install a fourth low-pressure turbine generator, a cooling tower (Building #485-D) was included to supply the additional condenser water since this was found to be more economical than obtaining additional water from the river pump house.

RIVER WATER SUPPLY SYSTEM

River Pump House - Bldg. #681-5G

The #681-5G river pump house was built to supply water exclusively to the #400 Area, and, because of the scheduled early start-up date, very little time was available for design development. It was found that a pump house design previously developed by du Pont for its Victoria Plant could be adapted to the #400 Area requirements with a minimum of engineering time. Accordingly, the Victoria design was used with modifications which provided for double the original capacity. At the #681-5G pump house site the over-all investment was minimized by locating the house close to the river, since it was much less expensive to add discharge pipe line than to lengthen the inlet canal.

A decision was made to locate the pump deck at Elevation 125, based on studies of the flood history of Savannah River and information from the U.S. Army Corps of Engineers on the proposed method of operating the spillway gate of Clark Hill Dam. At this elevation the pump deck is above the maximum expected flood level.

In the initial planning stages for this pump house, five 10,000 g.p.m. pumps were considered adequate to meet the predicted demand for water. Six pumps were purchased, one of which was to be a spare. As the process loads were firmed and decision made to generate electricity on the site, a more definite demand for 62,500 g.p.m. was established. On reviewing the pump design, it was found that the impeller size could be increased to deliver 12,500 g.p.m. per pump. This change in capacity necessitated an increase in size of motor drives from 350 hp. to 400 hp., which in turn necessitated an increase in the size of transformers and switchgear.

While these water requirements were being established, a decision was made to anticipate a 100 per cent expansion of the #400 Area. To meet this possibility, provisions were made in the piping at Bldg. #681-5G to allow for doubling the size of the river pump house at a later date, if required.

It was the intent in designing this river pump house that all facilities would be arranged to require only periodic visits by an operator. Later a watch tower was added to the design for a guard who was to be stationed there to observe activities up and down the river and to control personnel entering and leaving the pump house.

The pump house is a sheet piling structure of rectangular shape with two separate intake chambers, each of which is preceded by a traveling screen. Since three 12,500 g.p.m. pumps

are provided for each intake chamber, cleaning can be accomplished with no more than three pumps out of service. The screen size was selected for removing trash which otherwise would foul the condenser tubes in the power house.

There was no particular need for providing a building structure for housing the electrical and pumping equipment. Accordingly, all equipment purchased for this area was designed for outdoor installation. A concrete deck over the suction chambers provided a mounting for the six vertical type pumps, together with the electrical substation equipment, switchgear, chlorinating equipment, and storage space for one-ton chlorine cylinders.

Chlorine treating facilities were provided at the pump house to control algae growth in the line to the reservoir at Bldg. #483-D, the chlorine to be delivered in one-ton cylinders by trailer trucks from central storage in the #400 Area. Two electric cranes were provided for hoisting these cylinders from the trailers to the operating deck and also for handling major items of equipment during maintenance operations.

Since the pump house was to be unattended, a reliable supply of electricity was essential. To meet this requirement, two independent and separate 13.8 kv. lines were run to the substation equipment on the operating deck, both lines originating in the substation adjacent to the #400 Area power house. Normally each line supplies half of the electrical requirements of the pump house, but in the event of failure of either line, an automatic bus tie breaker energizes both banks of switchgear from the other transmission line.

Water Lines - Bldg. #901-G

Because of the early start-up date for the #400 Area and the unavailability of large size steel or cast iron pipe in the required quantities, a decision was made to use pre-stressed, reinforced concrete pipe between the #681-5G river pump house and the #400 Area. A subcontract was let to a vendor who could guarantee almost immediate delivery, and the 60 in. pipe for this service was among the first important material to arrive at the site.

To guard against damaging water hammer effects, slow closing, tilting disc valves were installed at the pump discharges. The water hammer tests performed on this line are described in the section of this history dealing with field testing.

Water Treatment Plant - Bldg. #483-D

The 60 in. river water line described above terminates at #483-D where it discharges to a reservoir incorporated in the design of the Water Treatment Plant, see page 51. All water for the #400 Area, except that taken from wells, is drawn from this reservoir. Five different qualities of water are required throughout the area and all but one of these receives additional conditioning. The following discussion covers the different types of water and their end use.

Power House Condenser Water

Estimated condenser water requirements for the initial three condensing turbo-generators in the #484-D power house were 28,000 g.p.m. Provisions were made for supplying this additional quantity of water from the river, above process and other requirements, to the reservoir, and then, by circulating water pumps, through the turbine condensers and to the sewer. This condenser water receives no screening or conditioning, other than at the #681-5G river pump house.

Installation of the fourth condensing turbo-generator at the #484-D power house increased cooling water requirements significantly, but since this expansion had not been anticipated when the line between the #681-5G river pump house and the #400 Area was sized, other means of supplying the additional water were required. Various possible sources were investigated and several schemes were evaluated, including: (1) a new line from the #681-5G river pump house, (2) a branch line from the Ellenton header which connects the #681-1G and #681-3G river pump houses, and (3) a cooling tower.

The cooling tower arrangement was found to be the most economical and therefore was used with provision for adding more tower cells if more capacity were needed later.

Water from the cooling tower is delivered into the circulating water supply header in the power house at the end opposite the river water supply. A block valve in this header is used to separate the two systems when both are in use, but all condensers can be operated with one source of cooling water when temperature and load conditions are suitable. Both sets of circulating water pumps, at the reservoir and at the cooling tower, can be started or stopped from the power house control room.

Process Cooling Water

Pumps are provided at the reservoir to supply process cooling water requirements. Water for use in the main #400 Area process must be essentially free of all debris. Since the traveling screens at the river pump house will not remove

Building No. 483-D - WATER TREATMENT PLANT

Lewis & Hill Inc. - Engineers - Constructors, New York, Los Angeles.

debris of sizes less than 1/2-in., additional screening necessary to meet the process requirements, is provided by continuous back-wash strainers installed on the discharge side of the pumps.

Precipitators and Filters

All other water from the reservoir is diverted to the section of this area known as the Water Treatment Plant, consisting essentially of clarification facilities and filters. When the requirements regarding water quality and quantity for this area were being investigated, it was recognized that they were comparable to those of a commercial plant designed by du Pont which had been installed and in satisfactory operation for a number of years at Baton Rouge, Louisiana. In the interest of expediency, the design of the Baton Rouge clarification plant was adopted in its entirety and issue dates of drawings were advanced, with substantial savings in time, manpower and cost. To this adopted design was attached the filter plant, filter clear well, reservoir and chemical building.

Since complete removal of suspended solids is required for boiler feed make-up and process feed, a two-step conditioning process is used. The first is clarification, which involves application of a coagulant to the water and settling in a retention basin. The second step takes place in the filters, where traces of fine suspended matter carried over from the clarification plant are removed. Water flows by gravity from the filters to a clear well storage basin and then is pumped in two separate paths through treating facilities which produce water suitable for: (1) boiler feed, and (2) process use.

Boiler Feed Make-Up

Selection of the process for conditioning filtered water for use as boiler feed make-up was based on the knowledge that the filtered water would be low in dissolved mineral solids most of which would be silica. A low silica content for boiler feedwater is necessary to prevent the formation of hard boiler scale and silica deposits on the blades of the steam turbines. To produce water of this quality, a softening plant was selected which consists of a hydrogen cation or "H" unit for removing the hardness and soluble iron, and "S" anion units for removing the weak acids and silica. Between the "H" and "S" units, degasifiers are installed to remove the carbon dioxide produced in the "H" units. Degasified water is pumped from the clear well below the degasifiers through the "S" units and, in turn, delivered to the boiler feed system through the condensers, where it mixes with turbine exhaust condensate. A 100,000-gallon overhead storage tank is connected to the underground line between the "S" units

and the power house condensers. Water is stored here to be used under emergency conditions. In the event of failure of the softening equipment, water flows automatically by gravity to the condensers. It was found necessary to add caustic to the water after the silica units to correct the pH and to remove the aggressiveness of this water toward mild steel and copper.

Process Feed

Water for use in the main process of this area must be supplied to the "GS" units at high pressure and with zero alkalinity. Extensive investigations were required to determine the most economical method of conditioning the water to produce this zero alkalinity. The results of these studies and investigations indicated that the carbonates and dissolved gases remaining in the filtered water could be removed by controlled acid injection followed by vacuum deaeration. In order to avoid the use of expensive piping materials for transporting the water to the "GS" units, provision was made for adjusting the pH by injection of caustic. Following the deaerators and caustic injection, the water is discharged to a storage tank and, due to the use of vacuum in the deaeration process, these units are supported on a high structure to compensate for the barometric leg. To prevent oxygen pick-up in the stored water, a floating roof is provided for the storage tank. It was found that an installed pumping capacity of four 2200 g.p.m. pumps would be satisfactory to meet the process demands but due to the high head requirements of the process at this capacity, and the fact that pumps of this capacity and head were not readily available, it was determined more economical to purchase eight pumps, each of half capacity. Each pair of these pumps is mounted on a common base plate with a common motor drive mounted between them.

Several manufacturers were contacted to determine the availability of the required vacuum deaeration equipment, but due to the scarcity of steel and the necessity for rubber-lining the inside parts coming in contact with the water, delivery of these units could not be made in time to meet the scheduled start-up date. Further investigation revealed that the cold water deaerators at Hanford were being dismantled and that three of these units were suitable for the #400 Area water treatment needs. These were purchased from the contractor who was dismantling the units and were shipped to Savannah in the spring of 1951 where certain modifications were made to adapt them for use. A similar arrangement was made with the same contractor for the steel supporting structure, except that the required alterations were made in his shops.

Consideration was given to the possibility of conserving turbine condenser water by re-using it for process feed and

boiler feed make-up. This scheme was rejected however, when it became apparent that the thermal currents set up by the warm water would have upset the floc in the clarification basin. The only other place where this water could be re-used was in process cooling, so facilities were provided for returning the power house effluent for that purpose. The water returned from the turbine condensers is tempered with the incoming river water and re-used for process cooling when river water temperatures are not too high. With the controls for the condenser effluent placed in the chemical building, the chemical plant operator may, at his discretion, return or reject any part of the effluent.

Distribution Lines

It was intended originally to transport the process water underground in cast iron pipe. Upon investigating the pressure requirements, however, it was found that cast iron pipe with the proper pressure rating was not readily available in the sizes desired. Accordingly, this service was carried overhead in steel pipe lines, supported by structures already required for carrying steam and air to the process from the power house. Furthermore, the overhead pipe did not require coating and wrapping as would have been the case if steel pipe had been buried in the ground. All other distribution lines were carried in the conventional manner, either overhead or underground, depending upon the type of service.

WELL WATER SUPPLY SYSTEM

Rather than install additional treating facilities for river water to provide potable water for domestic use, it was decided to utilize the two wells that were drilled and used by Construction. This water was potable and the only conditioning required was chlorination for health reasons and calgon addition to maintain the iron in solution so as to avoid discoloration. A separate underground distribution system was required to distribute this well water to the various users throughout the area. A 100,000-gallon overhead storage tank was required for domestic water peak loads and reliability. Since, for similar reasons, an elevated storage tank was required for boiler feed make-up, it was decided to place one tank above the other and to install one tower for supporting both.

The water from a third well is used entirely for supplying the process demand of Bldg. #421-D which requires water with a temperature relatively constant throughout the year. Water from the other well system was not suitable for this purpose, because of temperature variations in the storage tank and the possible mixing of stored water with virgin well water.

WATER SUPPLY - #300/700 AREA

GENERAL

The peak water requirement for this area was originally estimated to be approximately 1500 g.p.m. Because of the relatively small quantity of water involved, and due to the remote location of the #300/700 Area with regard to the river pump houses, it was decided that the water supply should be taken from wells located within the area. The following diagram indicates the general flow of water.

WATER FLOW DIAGRAM 300/700 AREA

Chlorination was provided for sterilization of domestic water, and lime treatment for pH adjustment of service water within the limits of 6.8 to 7.8.

Original estimates of water demand for the #300 and #700 Areas were prepared by du Pont Design working with AED groups concerned with area requirements. Subsequently, when design was further advanced, VWF&S maintained a "power utilities requirement" data sheet, adjusting quantities as the design became firm. The over-all area requirements remained substantially as originally estimated and are tabulated below:

<u>BLDG. NO.</u>	<u>BLDG. NAME</u>	<u>CONSUMPTION G.P.D.</u>	<u>DEMAND PEAK G.P.M.</u>
#305-M	Test Pile	30,000	65
	Air Cond. (100 Tons)	10,000	7
#306-M	Tube Assembly	6,000	40
	Air Cond. (100 Tons)	10,000	7
#313-M	Slug Canning	175,000	130
#320-M	Alloy Bldg.	250,000	313
	Air Cond. (100 Tons)	10,000	7
#704-M	Supv. Office & Change Ho.	9,000	100
#702-A	Telephone Bldg.	750	20
	Air Cond. (25 Tons)	2,500	2
#703-A	Main Office	24,000	200
	Air Cond. (500 Tons)	50,000	35
#708-A	Cafeteria	8,800	40
	Air Cond. (300 Tons)	30,000	21
#709-A	Safety & Fire Prot.	1,600	20
#713-A	Central Stores	1,800	20
#716-A	Automotive Repair	10,500	30
#717-A	Central Shops	11,000	50
#719-A	Medical & Employment	1,500	20
#720-A	Patrol Headquarters	8,000	50
#721-A	Record Storage	150	5
#722-A	Instrument Shop	2,500	20
	Air Cond. (100 Tons)	10,000	7
#724-A	Labor Pool & Trans. Office	6,000	40
#725-A	Paint Shop	400	5
#735-A	Health Inst. Headquarters	3,500	25
	Air Cond. (125 Tons)	13,000	9
#736-A	Health Inst. Calibration	1,000	10
	Air Cond. (100 Tons)	10,000	7
#737-A	Bio-Assay Bldg.	2,300	20
#772 & 3A	Control & Research Labs.	40,000	650
	Air Cond. (1500 Tons)	150,000	105
#784-A	Power House	171,500	250

1,060,800 G.P.D.

WELL WATER SUPPLY SYSTEM

Wells - Bldg. #905-A (15, 20 & 31)

Three deep wells were provided to supply all water used in the #300/700 Area. Well depths were 455 ft., 680 ft. and 685 ft., respectively. Each was built with an 18 in. outside casing and an 8 inch screen line and screen which was gravel packed. Water was obtained from the lower aquifer under the area known as the Tuscaloosa formation where the water was characterized by being low in total solids, relatively soft, low in pH, and with a temperature range varying from 66° to 70°F. depending on the depth of the well. A typical analysis

obtained from well #15 is as follows:

Methyl Orange Alaklinity as CaCO_3	9.3 p.p.m.
Total Hardness as CaCO_3	5.3 p.p.m.
Chlorides as Cl	0.8 p.p.m.
Sulfates as SO_4	1.0 p.p.m.
Silica as SiO_2	6.8 p.p.m.
Total Dissolved Solids	21.2 p.p.m.

The ground storage tank, 50 ft. in diameter by 34 ft. high, was provided with a storage capacity of 150,000 gallons for domestic use and 350,000 gallons for service and fire use. Located near Bldg. #784-A, Boiler House, it has underground suction lines feeding the domestic, service, and fire pumps in Bldg. #784-A.

Well Water Treatment

Based on a typical analysis of the well water developed in this area (refer to section "Water Supply - General" for chemical analysis), it was determined that the only treatment required, other than chlorination, would be lime addition for pH adjustment. The very low soluble iron concentration precluded the need for polyphosphate treatment. Chlorination was provided for all well water since the entire supply was to be delivered through the center or domestic water portion of the ground storage tank. It is necessary under health regulations to maintain the domestic water bacteriologically safe. Therefore, the treatment facilities were located immediately preceding the ground storage tank.

UNDERGROUND LINES

The underground lines, Bldgs. #901 and #902 A&M were provided to distribute service, domestic and fire water to all users within the area, to circulate cooling tower water between the tower and the refrigeration condensers, and to circulate chilled water to all administration area buildings requiring air conditioning cooling.

Separate domestic and service water systems were provided to avoid the possibility of contamination where service water is used in process and laboratories. This decision was made in July, 1951, to comply with Section 13 of the South Carolina State Board of Health's "Rules and Regulations Governing Water Supply and Water Purification Plants".

Fire protection for the entire area is supplied by a separate distribution system from one turbine-driven and one motor-driven pump located in the Power House, Building #784-A. No building sprinkler systems are installed, fire protection being supplied by hydrants located off diagonal corners of each

facility. Requirements of the system are that provision be made to deliver a total flow of 1000 g.p.m. from the two farthest hydrants on the system with a minimum pressure of 90 p.s.i.g.

In general, cast iron mechanical joint pipe was used for all underground services in the #300/700 Area. A frost line of 12 inches below grade was assumed and a 30 in. minimum cover was provided on all lines. Wherever possible underground lines were located between the overhead lines and the roads to provide clear access for maintenance.

OVERHEAD LINES

In general, above-ground steam lines are carried between the fences and the underground lines. Wherever possible, lines paralleling fence lines were kept approximately 15 ft. inside the fence for security, and in all cases a minimum distance of 10 ft. was maintained. Overhead lines are supported on wood poles and, where possible, were kept low with just sufficient clearance under them to install drip pockets. Where these lines cross fence lines they run through the fences. At these points extensions were placed on the fence to maintain full fence height above the top of the line.

BOILER FEEDWATER TREATMENT

Due to the low load factor anticipated for the #300/700 Area boilers and the low concentration of dissolved mineral solids in the well water, internal treatment was considered adequate without dimineralization and silica removal. The boilers are low pressure units which permit a high concentration of silica in the boiler water. The internal treatment consists of phosphate and caustic feed into the boiler drums and sulphite feed into the suction of the boiler feed pumps. The phosphate serves as a scale preventative, the caustic for alkalinity correction, and the sulphite for scavenging out any oxygen remaining after the feedwater has passed through the deaerator. An organic dispersing agent, "Maracel E.", is fed with the sulphite to keep the phosphate sludge in suspension.

COOLING WATER RECIRCULATION SYSTEMS

Cooling Tower - Bldg. #785-A

In June of 1951, consideration was given to a central refrigeration plant to supply the chilled water requirements for air conditioning the #700 Area buildings. On June 29, 1951, AED advised that there were some large centrifugal compressors in excess at Hanford, and it was suggested that

Design investigate the possible use of this equipment for SRP. A large saving was realized by this procurement after their condition had been found satisfactory. However, one big disadvantage existed in re-using this equipment for the proposed service. Instead of a normal condenser water rate of 3 g.p.m. per ton (normally associated with chilled water refrigeration), these units required 7 g.p.m. per ton. On the other hand, since this equipment operated only on a seasonal basis the increased operating cost was not prohibitive. To supply cooling water at this rate for a total of 3000 tons of refrigeration was, however, a major problem in the #300/700 Area, and it was found necessary to install a 22,000 g.p.m. capacity cooling tower, designated as Bldg. #785-A, and to provide the make-up water from the service water system.

The water circulated in the cooling tower system required both chlorination to control micro-biological growth and the addition of lime to counteract the acidity introduced by the chlorination process.

Four 7700 g.p.m. circulating pumps, three of which are turbine-driven, were located outdoors adjacent to the cooling tower. Turbine drives were selected to provide additional summer steam load and permit the operation of a single boiler in Bldg. #784-A at a more uniform and economical rate during the summer months. Water is pumped from the cooling tower basin through the refrigeration condensers and back to the cooling tower. Since operation of the tower is seasonal, provisions were not made for the isolation of individual cells for cleaning and maintenance, it being planned to do such work during the nonoperating season.

Chilled Water Systems

Two separate chilled water systems are necessary because of the temperature requirements for humidity control in some of the #700 Area buildings. The main system was designed to supply water at 45°F. while the second system was to supply water at 39.5°F. All water is returned to the refrigeration plant in a single return system. Supply and return chilled water pipe lines were run underground with a minimum bury of 30 inches. Insulation was considered but found to be not economically justifiable. The chilled water supply and return was designed as a closed, pressure type system with circulating pumps located outside the Refrigeration Building (Bldg. #789-A). These pumps were re-used from Hanford and had insufficient head to supply the necessary pressure at all buildings plus returning the water to the refrigeration building. Consequently, additional pumps were added at each building, as required, to develop the necessary return head. The refrigeration plant is capable of supplying 7200 g.p.m. of chilled water at the required temperatures. For the design development

of Refrigeration Building, reference is made to the section of this history dealing with refrigeration facilities.

WATER SUPPLY - #100 AREAS

GENERAL

One of the many problems to be solved in the design of the five #100 Areas was that of dissipating the large quantity of heat generated in the production reactors. This heat would be removed from the reactor moderator in water-cooled heat exchangers, the quantity of cooling water being approximately 80,000 g.p.m. per area for the initial plant installation, with supply facilities so designed that they could be expanded readily to 96,000 g.p.m. per area. Heat exchanger design required a good quality, clarified, or filtered water with less than 5 p.p.m. turbidity. In addition, water temperatures had to be fairly uniform and not subject to rapid fluctuations.

The first broad analysis of the water supply problem indicated that, economically, this large quantity of water could be obtained from either of two sources: (1) a "recirculating" system using either river water or well water for make-up water to the system, or (2) a "once through" system using river water. The use of a recirculating system with cooling towers, which was the only economical recirculating system, was objectionable because of the design limitation requiring cooling water which was not subject to rapid fluctuations in temperature. It was certain that the desired conditions could not be maintained in cooling tower effluent water, due to variations in the daily wet bulb temperature which influenced the exit water temperature from the towers. These investigations into the use of cooling towers further revealed that the make-up water to the towers would have to be supplied from sources outside the production areas or from the Savannah River and not from wells within the area. The use of wells within the #100 Areas was prohibited for structural reasons to prevent settlement of the reactor building foundations. Because of the high unit foundation loads in Bldg. #105, the du Pont Structural Design Group, supported by advice from the U. S. Corps of Engineers, emphasized the potential risk in operating permanent wells, lowering the underground water table, affecting soil bearing conditions, and eventually causing uneven settlement of Bldg. #105.

For the above reasons, the cooling tower schemes were less attractive than a "once through" system with the Savannah River as a source.

Because of early start-up requirements of the first #100 Area (R Area) a decision was made to supply this area from a

"once through" system using Savannah River water, see page 63 . At the same time a "once through" river water system versus a "recirculation" system, using cooling towers with river water make-up, was evaluated in greater detail for the other four (PLKC) #100 Areas. The "recirculation" system study included a cooling tower water storage basin of sufficient hold-up capacity to reduce rapid fluctuations in water temperature to meet process cooling water requirements. The results of this evaluation indicated that the "recirculation" system would have a slightly lower investment cost but this was offset by the reduced maintenance cost, longer life and other operating considerations of the "once through" river water system. The decision was then made to extend the "once-through" river water system to supply each of the five #100 Areas, see page 65.

To supply water of the high quality considered necessary to prevent fouling of the heat transfer surfaces in the process heat exchangers, it was decided that clarification plants should be installed in each of the areas and that space be provided in each area for the installation of a future filter plant if it was found that water of such quality was required. At the same time a testing program was inaugurated in the Savannah River CMX Laboratory to determine, on a test model, the minimum quality of water permissible. In 1952, about one year after the design of the R Area facilities was started, results of the CMX tests showed that the Savannah River raw water was satisfactory for process cooling without additional treatment, and the design requirements of each area were altered accordingly.

The river water supply system developed for the #100 Areas was designed with a capacity of 96,000 g.p.m. per area, but facilities were installed for an initial firm capacity of only 80,000 g.p.m. per area. The system consists of the following facilities.

1. Two river water pump houses, Bldgs. #681-1G & #681-3G.
2. A header and piping system, Bldg. #901-G, distributing river water from the pump houses to each of the five #100 Areas.
3. The Bldg. #183-1R gravity clarification plant, with a capacity for the entire #100-R Area water requirements, but modified to handle raw river water after this type was adopted for reactor cooling purposes. The river water distribution system (Bldg. #901-G) discharges into this building.
4. A 4000 g.p.m. clarification plant, Bldg. #183-4, in the PLK&C Areas to supply clarified water to the area filter plant, Bldg. #183-2, and to special service water consumers.

N.I. Denotes normally inoperative pump
 N.O. Denotes normally open valve
 N.C. Denotes normally closed valve

WATER FLOW DIAGRAM — 100 PLKC AREA

5. A 3000 g.p.m. filtration and softener plant in each area, Bldg. #183-2, for process, domestic and boiler water needs.

6. A reservoir, Bldg. #186, and a pump house, Bldg. #190, in each area to supply process cooling water to Bldg. #105. The river water distribution system, Bldg. #901-G, discharges into Bldg. #186 in the PLK&C Areas.

7. A process effluent sump, Bldg. #107, in each area handling cooling water effluent from Bldg. #105 for discharge to the effluent system or for partial recirculation to the reservoir.

8. Bldg. #901-RPLKC, water distribution lines in each area.

9. In RPL&K Areas a recirculating water system with a cooling tower, Bldg. #185, to supply condenser cooling water for the steam turbine-electric generator system in the power house and to store ash sluicing water. A total of 27,500 g.p.m. is recirculated; losses and ash sluicing demands are replaced with river water make-up.

10. An effluent system of sewers and canals in each area, Bldg. #904, returning all process waste water to the Savannah River.

RIVER WATER SUPPLY SYSTEM

River Water Pump Houses - Bldgs. #681-1G & #681-3G (See page 69)

River water pumping requirements were based on an initial quantity of 80,000 g.p.m. and a future demand of 96,000 g.p.m. in each #100 Area which totaled an over-all requirement of 400,000 g.p.m. for the initial load and 480,000 g.p.m. for the future demand of river water. The building design called for blast resistant structures about one mile apart for optimum security.

For reliable continuous service the basic design, as of January, 1951, required 100 per cent firm capacity with one pump house out of service. On this premise three pump houses of identical capacity were proposed to handle the 480,000 g.p.m. future load. In June of 1951, the continuity factor was decreased to 50 per cent firm capacity with one pump house out of service based on the improbability of direct blast damage and on good security against sabotage. The design of the required pumping capacity in two pump houses was then developed as the more economical installation.

The two pump houses were located along the bank of the Savannah River about two miles apart. For each pump house a separate intake canal was provided, 1300 ft. long for #681-1G and 1900 ft. long for #681-3G, the length being governed by an economic evaluation of canal excavating cost versus discharge piping cost, the need for securing satisfactory access at flood stage, and certain security aspects. Alternative schemes rejected in making this selection were:

1. Dredging Upper Three Runs Creek, a Savannah River tributary near the #100 Areas, to form a suitable intake channel;
2. Locating the pump houses on high ground a reasonable distance east of the river and digging an intake channel parallel to the river; and
3. Dredging a diversion channel for the main stream west of the existing channel and locating the pump houses adjacent to the present channel.

Economics and practicability led to the choice of the scheme, as installed, although the decision was influenced to a degree by the fact that more experience had been obtained with the chosen design and a significant amount of additional design development work would have been involved in either of the alternative schemes.

To establish the most economical size for a pump house, layouts were studied which involved three different types of pumps: (1) vertical turbine, (2) vertical centrifugal, and (3) horizontal centrifugal. For the required head of 350 ft., turbine pumps of proven performance were obtainable in capacities of 15,000 to 18,000 g.p.m. as compared with 28,000 to 30,000 g.p.m., or possibly higher, for single stage centrifugal pumps. Horizontal centrifugal pumps were selected for the design because they offered reduced building size through a smaller number of units as compared with turbine pumps, and gained definite advantages over the vertical centrifugal pumps in layout and maintenance cost. The pumps and motors could be located on the same operating level, and access to pumps without removal of motors would result in decreased inspection and maintenance cost.

The pumping system adopted from these developments centers about a pump house design using the unit type intake with each pump having a separate suction passage equipped with a trash rack, sluice gate, and travelling screen. Eight pumps, each rated 28,000 g.p.m. at 350 ft. head, for a total capacity of 224,000 g.p.m., are installed in each pump house to meet the initial #100 Area requirements of 400,000 g.p.m. Provision was made for installing two future pumps to obtain 280,000 g.p.m. capacity per pump house and to meet the expected #100 Area requirements of 480,000 g.p.m. In each pump house

Building No. 681-IG - WATER PUMP HOUSE

Grubbs & Hill Inc. - Engineers - Constructors - New York, Los Angeles.

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the pumps discharge into a 66 in. header both ends of which are connected through two 72 in. underground reinforced concrete pressure pipe lines to opposite ends of the Ellenton Header which supplies the #100 Areas. To insure continuity of service the pump motors and various electric services in the buildings are supplied by two sources of electric power. An intermittent chlorination system injects chlorine solution at the pump suction intake chamber to control microbiological growths in the pump house facilities and lines. Each of the structures housing the facilities is 185 ft. long by 127 ft. wide. In Bldg. #681-1G the pumps, operating floor, and entrance are located at the 76 ft., 90 ft., and 126 ft. elevations respectively and in Bldg. #681-3G the pumps, operating floor and entrance are located at the 72.5 ft., 76.5 ft., and 126 ft. elevations. Each building is designed to withstand external water pressure under flood level submergence, and the entrance is located above flood stage.

River Water Lines to the #100 Areas - Bldg. #901-G

Screened and chlorinated river water is pumped from each pump house through two 72 in. underground reinforced concrete pressure pipe lines to the 84 in. Ellenton header from which distribution to the #100-RPLKC Areas is made through underground reinforced concrete pressure pipe lines varying in size from 48 in. to 84 inches. The system contains approximately 48 miles of piping protected by air removal and water hammer surge protection devices.

The basic requirements for the design of the distribution system were:

1. Design based upon an ultimate flow rate of 96,000 g.p.m. per #100 Area;
2. Underground lines;
3. Minimum provision for future #100 Areas; and
4. Dependability of supply.

Several distribution schemes were studied before determining that the Ellenton header and piping network was the scheme that suitably met design requirements and had the lowest investment cost. The adopted system was designed with a separate line from the Ellenton header to each of the #100 Areas. The #100 Area sites, approximately 2-1/2 miles apart, are arranged in a ring approximately 6 miles in diameter and about 10 miles from the river. Flexibility of operation was obtained by means of emergency connections from L line to K Area, P line to L Area, and R line to C Area, and by an interconnection of the R line and the P line. Other schemes studied were variations of the adopted system and included:

(1) a loop system designed to follow the actual layout of the #100 Areas; (2) a header between the two pump houses; (3) a two-header system with one header at the river and the other on the far side of the process areas; and (4) two headers a half mile apart, both located at the river.

The choice of piping for the Bldg. #901-G lines was made after full engineering consideration was given to the use of steel, cast iron, and reinforced concrete pressure pipe, the three materials most practical and suitable for the service. Cast iron pipe, about 50 per cent more expensive than the other two types, was the first to be discarded. In the final decision, reinforced concrete pressure pipe was selected over corrosion-protected steel pipe on the basis of a slight differential in material and installation costs, and because the steel sheet and rods for manufacturing the reinforced concrete pressure pipe were more readily available than the steel plate required for the steel pipe. The type of joint used in the reinforced concrete pressure pipe lines was the Lock Joint Co.'s patented rubber and steel "Lock-Joint", considered the most dependable type for the design pressure.

Control of water hammer was recognized as a major problem in designing the water distribution lines. Consultation with outside specialists in this field, as well as studies of high pressure conditions causing water hammer, led to the recommendation to provide special equipment and measures to effect proper control methods. Pipe lines were designed with:

1. Special quick opening, slow closing valves located at high points of the line to break vacuum on separation, and discharge air and water on rejoinder of the water column in order to relieve pressure;
2. Cone check valves in the pump discharge piping set at emergency slow closing time to prevent pressure build-up when closing these valves;
3. Area pipe line valves specified with slow closing rates for the same reason as in Item 2;
4. Slow rate of line filling stipulated to avoid over pressure; and
5. Air inlet valves at specific points to break vacuum.

Tests with these protective measures in use indicated that the lines were protected sufficiently within the design hydraulic gradient limits for the system, which considered 410 ft. for pump shut-off head, 122 ft. for estimated high water level, and 20 ft. water hammer allowance.

SAVANNAH RIVER

RIVER PUMP
HOUSE
BLDG. 681-1G

RIVER PUMP
HOUSE
BLDG. 681-3G

RIVER PUMP
HOUSE
BLDG. 681-5G

400
D

NORMAL SUPPLY
100
C

NORMAL SUPPLY

EMERGENCY SUPPLY

100
R

EMERGENCY
SUPPLY

100
P

NORMAL SUPPLY

EMERGENCY
SUPPLY

NORMAL
SUPPLY
100
L

EMERGENCY
SUPPLY

NORMAL SUPPLY

100
K

RIVER WATER FLOW DIAGRAMS — 600/900G AREAS

All valves normally open.
Area valves shown on area diagrams.

Clarification Plants - Bldg. #183-1R & #183-4PLKC

In the R Area the river water delivered by the Bldg. #901-G lines was distributed from the area's normal header or the emergency header to Bldg. #183-1R, a large 5-basin clarification plant capable of clarifying the initial full area demand of 80,000 g.p.m. Exterior views of the two buildings are shown on pages 77 & 79.

As mentioned in the general comments on water supply, when the #100-R Area design was first considered a low turbidity water was desired for circulation through the shell and tube heat exchangers in Bldg. #105 because fouling and subsequent cleaning of the heat transfer surfaces was known to be a critical factor in their operation and maintenance. It was uncertain whether filtered, clarified, or untreated river water should be used but, based on engineering experience in treating large quantities of water from other southern rivers, and because the early required plant start-up made it necessary to start construction as soon as possible, the decision was made to use clarified river water.

A conventional gravity clarification plant capable of handling 80,000 g.p.m., 100 per cent of the area's initial requirements, was designed, and construction was begun to meet R Area needs. The plant was designed as a 5-basin unit to clarify the 80,000 g.p.m. to a turbidity of less than 5 p.p.m. in a total detention time of four hours. The clarification plant consisted of: (1) an underground stilling chamber; (2) a water inlet structure with a flash-mixer chamber to agitate the water, chlorine and coagulant chemicals; (3) five flocculating chambers wherein slow moving paddle wheels promoted floc growth; and (4) five 265 ft. long gravity settling basins that allowed 3-1/2 hours detention time on an 80,000 g.p.m. flow basis.

At the same time that design was progressing on the clarification plant, arrangements were made to establish space requirements for standard filtration facilities to be located downstream from the clarifiers in case further design development indicated they were necessary.

To check the decision on the treatment of the cooling water, studies and experiments on fouling effects and chemical cleaning methods for the process heat exchangers were conducted at the Savannah River CMX Laboratories. In 1952, about one year after the design of the R Area facilities was started, the CMX tests developed that the use of raw river water as the cooling medium was satisfactory and that it was not necessary to have clarified cooling water for the process heat exchangers.

At the time of this development construction of the clarification plant in the R Area was well advanced. Since the CMX tests were on a small scale basis, it was concluded

that it would be desirable to have facilities available for full scale evaluation of raw water and clarified water as a cooling medium. The decision was made to complete the Bldg. #183-1R facilities as a clarification plant, and to modify this facility to permit operation on raw river water.

The flash mixer and inlet chamber at the clarification plant were divided by a partition. Two low lift pumps were provided to take 4000 g.p.m. of untreated water from the inlet chamber for clarification purposes. This water could be pumped to two of the basins, either one capable of clarifying the water to be supplied to the Bldg. #183-2R filter plant and Bldg. #105. In order to pass raw river water through the other basins, inlet gates were provided in each basin to decrease hydraulic loss through each basin. These changes made it possible to operate Bldg. #183-1R to supply the process heat exchangers under either of the following conditions: (1) full raw river water flow; (2) split flows with clarified water going to one half and raw water to the other half; or (3) all clarified water. Under any of these conditions it was possible to clarify the 4000 g.p.m. of river water required for the Bldg. #183-2R filter plant and Bldg. #105.

The design requirement for supplying water with a turbidity of 5 p.p.m. or less was not in the original design of Bldg. #183-1R by providing for feed of chlorine, alum, lime and activated silica into the incoming water at the flash mixer. In the modified design, the low lift pumps furnish the basins supplying water to the filter plant with water diverted from the main supply upstream from the flash mixer. It was possible to relax the turbidity requirements of water supplied to the filter plant to 10-12 p.p.m., since the filters themselves would remove remaining turbidity to 1-2 p.p.m. or less. For this reason, the supply of activated silica was not required, so that chlorine, lime and alum are fed into the suction of the low lift pumps, with mixing obtained from turbulence of the water passing through the pumps.

For the PLK&C Areas the design requirement for 4000 g.p.m. of clarified water was met by providing sludge contact clarification equipment. This was a change brought about by the cancellation of the Bldg. #183-1PLKC design, since the large clarification plants were no longer required when the decision was made to use strained river water in the process heat exchangers. The new clarification plants, Bldg. #183-4PLKC, include as major equipment two high flow-rate sludge blanket clarifiers with a capacity of 2000 g.p.m. each of clarified water at 10 p.p.m. turbidity. The facilities are arranged so that additional units could be installed in the future if required. For these clarifiers the water flows from the cooling water reservoir via low lift pumps which discharge into a flash-mixer where the coagulant chemicals, alum and lime, are

Hubbs & Hill Inc. - Engineers - Constructors. New York - Los Angeles.

Building No. 183-IR - CLARIFICATION PLANT

Building No. 183-4PLKC - CLARIFICATION PLANT

Culbert & Hill Inc. - Engineers - Constructors - New York, Los Angeles.

added along with chlorine solution. The clarifier, or precipitator tank, consists of two concentric truncated cones; the inner cone with its apex pointing upward and the outer cone forming the open bowl of the tank. Influent enters at the top of the center cone and flocculation is aided by the gentle motion of paddles attached to a moving vertical shaft in the center of the precipitator. The water containing the floc flows under the bottom edge of the inside cone and upward toward the surface of the water in the outer cone. Upward velocity of the water and floc is maintained in equilibrium with the sedimentation rate so that the floc is suspended in a blanket of sludge instead of being carried to the surface, where the clarified water is collected in radial channels for distribution to the filter plant, Bldg. #183-2PLKC.

Filtration and Softener Plant - Bldg. #183-2 (See page 83.)

The 4000 g.p.m. of water clarified in the individual #100 Areas flows by gravity from Bldgs. #183-1R and #183-4PLKC to Bldg. #183-2 at which point 900 g.p.m. is taken to the clarified water sump serving Bldg. #105 and 3100 g.p.m. is delivered to the filtration and softener plants. The filter plant produces 2,500 g.p.m. of filtered water for process use, 500 g.p.m. for domestic purposes, and 120 g.p.m. which is softened in a two-step demineralizer plant adjacent to the filter plant for boiler feed water and for special use in Bldg. #105.

The filter plant, an outdoor installation of reinforced concrete construction, was designed as a gravity rapid-sand system with four filters rated at 775 g.p.m. each, arranged in parallel. An underdrain system discharges to a two-compartment clear well below ground level. The discharge lines are controlled to insure filtration rates not exceeding 2.4 g.p.m. per sq. ft. of filter surface and production of filtered water with a turbidity of less than 1 p.p.m. The clear well is partitioned by an overflow weir to maintain distinct process and domestic water sections in order to have an isolated domestic water supply system that cannot be contaminated by cross connection with any other system. Pumps mounted on a concrete slab at grade over the clear wells pump the filtered water to the softener plant and to the various consumers on the filtered and domestic water distribution systems.

The filtered water in the clear well is treated with chlorine and polyphosphate (sodium hexametaphosphate) as part of the water treatment method. The chlorine maintains the water free of biological formations to make the domestic water safe, and the polyphosphate keeps any iron present in the water in solution. To provide boiler feed water the filtered water is softened by passing it through a two-bed

demineralizer. In this operation the filtered water is passed first through two cation exchangers also operated in parallel, providing for silica absorption. After leaving the anion exchangers the boiler water make-up is treated further by feeding a 1 per cent caustic solution in order to adjust the pH of the softened water before it is piped to the power house, Bldg. #184.

Cooling Water Reservoir and Pump House - Bldgs. #186 & #190

The strained and chlorinated water pumped from the Savannah River to each #100 Area is received and stored in the reservoir, Bldg. #186, from which it is pumped to the Building #105 process heat exchangers by pumps located in Bldg. #190. In the R Area the river water flows by gravity into the reservoir basins after passing through the Bldg. #183-1R Clarification basins; in the PLK&C Areas the river water flows directly into the reservoir from the river water distribution lines, Bldg. #901-G. Pumps in Building #190, adjacent to the reservoir take suction from the reservoir, and deliver cooling water to the #105 Building and service water to the various users throughout the area. In addition, water from Bldg. #186 is supplied by gravity to the emergency pumps located in Bldg. #108-2.

Building #186 (see page 85) is a reinforced concrete, 3-basin, 25-million gallon reservoir. The three basins are so arranged that each section may be used separately or in combination with the other two, and so designed that the area can continue in full operation with one basin out of service for cleaning. In the R Area the water flows into the reservoir through submerged inlet chambers which also incorporate an overflow and drainage chamber. For PLK&C Areas, although the inlet-drainage chamber design was retained, the river water is pumped directly to the reservoir through a pipe line discharging to atmosphere on top of the basin dividing walls. This free discharge to the reservoir was adopted to reduce the possibility of cavitation in the butterfly control valves. The reservoir design includes a covered two-section pump suction chamber located at one end of the middle basin.

Building #190 (see page 85) with its facilities for pumping process heat exchanger cooling water and area service water, abuts this pump suction chamber. Water flows into the pump suction chamber from each of the three basins through traveling screens backed up by stationary screens. The traveling screens were provided in the reservoir design when the cooling water specification was changed from clarified to raw river water. The purpose of the traveling screens is to stop the major portion of trash and large suspended matter while the stationary screens retain any material which might not be removed by the traveling screens.

Building No. 183-2RPLKC-FILTER AND SOFTENER PLANT

Gibbs & Hill Inc. Engineers-Constructors. New York. Los Angeles.

Building No. 186-RPLKC-COOLING WATER RESERVOIR
& Building No. 190-RPLKC-COOLING WATER PUMP HOUSE

Hubbs & Hill Inc. Engineers-Constructors. New York-Los Angeles.

The reservoir and pump house system supplies 68,000 g.p.m. of cooling water, 8000 g.p.m. of service water, and 4000 g.p.m. for clarification treatment in meeting the initial flow requirements of 80,000 g.p.m. to the area. On the basis of the 96,000 g.p.m. future flow the cooling water flow was to be increased to 84,000 g.p.m. To meet the design requirements for a system capable of operating under both the initial and future loads, eight pumps, six on line and two spares, were installed for cooling water use. The head required on these pumps under future conditions was 136 ft. and the pumps and motors were sized for this condition. But since they were to operate for some period under the initial load condition, the pumps were purchased with an undersized impeller to deliver 14,000 g.p.m. at only 90 ft. head in order to reduce power consumption during this initial operating period. For service water requirements four pumps rated at 3000 g.p.m. were installed in each pump house.

In keeping with the process requirements for continuous cooling water supply, the pumping facilities, electric supply, and control of cooling water supply were designed for utmost reliability. However, to supply water to Bldg. #105 in case the normal cooling water flow was interrupted, emergency water supply connections were incorporated in the reservoir and pump house design.

The initial emergency system was designed to be put into operation when the Bldg. #190 pumps failed with the reactor operating at normal power level. A flywheel was installed on each pump to keep the impeller rotating for about one minute to provide a gradually decreasing flow until the process low level adjustment could be completed. As the pumping action due to the flywheel inertia decreased, gravity flow from the reservoir through four 24 in. by-pass lines supplemented the flow through the pumps to maintain a continuous flow at about one-eighth the normal cooling water flow to the #105 Building.

This gravity flow emergency system was conceived while a study was being conducted on a hydraulic turbine scheme which has been more fully described in the design development section of the #100 Area electrical supply elsewhere in this volume. This scheme involved the use of hydraulic turbine drives on the process pumps in Bldg. #105, the hydraulic turbines to be driven by cooling water pumped by Bldg. #190 pumps through the turbines, the process heat exchangers, and then to waste, in that order. For operation of the turbines under emergency conditions of low flow, a static differential head between the reservoir supply and the #105 Building outlet to waste was added to the design concept to provide gravity flow through the system. Although the hydraulic drive method was abandoned, the gravity flow design was adopted for the present emergency system.

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For a secondary emergency system a 36 in. by-pass gravity flow line from the pump suction chamber in the Bldg. #186 reservoir was connected with the emergency pumps in Bldg. #108-2 also arranged to discharge cooling water to the process heat exchangers.

Area Distribution Lines - Bldg. #901

Within each #100 Area underground piping systems, designated as Bldg. #901, are the distribution lines for the various types of water consumed throughout the area by the buildings inside the area fence.

Water demands are practically the same in each area, but since the #100-R Area was designed to provide for the clarification of process cooling water, the distribution system for the R Area differed from that used for the subsequent PLKC Areas. In the #100-R Area water is delivered from the river water lines, Bldg. #901-G, to the Bldg. #183-1R clarification plant, from which the primary flow is piped by gravity to the reservoir, Bldg. #186-R. In the #100-PLKC Areas the river water is delivered directly to the Bldg. #186 reservoir from which, in all areas, it enters the pump suction well of the Bldg. #190 pump house. From Bldg. #190 river water is pumped into the main cooling water lines to Bldg. #105 to supply the major requirement of the system, and into the service water systems to supply river water to Bldg. #183-4, #185 and #105. Cooling water effluent lines between Bldg. #105 and Bldg. #107, the process effluent sump, handle the reactor cooling water discharged to waste.

Treated water of clarified, filtered, demineralized, and softened quality is produced in each area and distributed by pumping facilities and piping systems similar in each area. Bldg. #105 receives clarified, filtered and demineralized water. Bldg. #184 receives softened water for boiler feed make-up. Filtered water is pumped into the domestic water system which was sized to handle flows to several hydrants for the area fire protection service, since the fire protection requirements in the #100 Areas did not justify a separate fire protection system.

The cooling water distribution lines, the major requirement in each area, were designed in accordance with the following flow patterns.

Cooling Water System

Normally, cooling water is delivered to Bldg. #105 from the Bldg. #190 pump house through two lines, each sized for a flow of 42,000 g.p.m. These lines are of welded steel construction, adequately protected from external corrosion, and have a continuous slope toward Bldg. #105 in order to

take maximum advantage of Bldg. #186 reservoir storage capacity during emergency periods when the flow through these lines is by gravity.

Cooling Water By-Pass System

A secondary source of cooling water for Bldg. #105 is provided by furnishing gravity flow lines, one from the Bldg. #186 reservoir inlet connecting with one from the Bldg. #190 pump suction well to the emergency pump room in Bldg. #108-2, where diesel-engine powered pumps discharge the water into the process heat exchanger lines. The lines were sized for 12,000 g.p.m. flow and sloped toward Bldg. #108-2.

Raw River Water By-Pass System

A third source of cooling water for Bldg. #105 is furnished by direct connection to the incoming river water lines, both normal and emergency, ahead of the area valves. This line was sized for 12,000 g.p.m. flow and was run to the emergency pump room in Bldg. #108-2 where it was connected directly into the main system supplying the process heat exchangers.

Cooling Water Recirculating System

For emergency cooling water when the above sources were inoperative, a system for recirculating a portion of the cooling water effluent from Bldg. #105 back to the reservoir was provided. The line was sized for a flow of 11,800 g.p.m.

General

The conditions of design applicable to all underground lines were given in Specification 3018, "Process, Utility, and Building Service Piping". Primary and secondary cooling system piping, effluent piping and recirculation piping were required to have flexibility and strength which only steel pipe could provide. Reinforced concrete pressure pipe was used for the raw river water supply and by-pass lines. For the other water distribution systems, such as service and domestic water of raw, clarified, and filtered quality, mechanical joint cast iron pipe was used. Demineralized water required stainless steel pipe because of its low pH, and cast iron pipe with an internal bitumastic lining was used for the distribution of boiler feed make-up water after the treated water pH was adjusted by feeding caustic.

Some of the more detailed considerations entering into the design of the underground cooling water lines were as follows. The cooling water piping between Bldgs. #190 and

#105 was designed to be 42 in. in diameter, but in order to utilize material available in the field the size of these lines was changed to 54 in. for the #100-K and #100-C Areas. The depth of bury on these to meet slope requirements was 17 to 20 feet. For this reason, and because of the large pipe size, it was concluded that standard type flanged orifice installations in these lines were not practical. The method devised was to install each segmental orifice plate inside the pipe by bolting it to a ring fitted around the inside circumference of the pipe. In another phase of the piping design an interconnection was provided between cooling water by-pass system in the #100-R Area and the clarified water supply line to the filter plant. A portion of the storage capacity of the clarification plant was thereby made available for gravity flow to the emergency pump room at Bldg. #108-2R.

Process Effluent Sump - Bldg. #107

The effluent cooling water from the process heat exchangers in Bldg. #105 was discharged to the drainage system flowing out of the building to an underground sump and then to waste at an outfall structure located outside the area fence. The sump in this system was fitted with a deep well pump which was designed as part of an emergency recirculating system for returning a portion of the waste cooling water back to the reservoir as an emergency conservation measure.

Originally, in 1951, the cooling water effluent from Bldg. #105 had been expected to be sufficiently radioactive to require the design of a retention basin with a capacity of 40,000,000 gallons equivalent to a retention time of 7 to 8 hrs. This basin was to be used to store the effluent water and allow the activity to decay prior to being returned to the main stream of the Savannah River. Through later developments based on effluent flows of 84,000 g.p.m. and 60 minutes detention the capacity of the retention reservoir was established at 5,100,000 gallons. The system was to include a discharge distribution flume and an outfall structure; in the R Area at that time a pumping station of seven 15,000 g.p.m. vertical pumps was included also to move the water over high ground and discharge it into a stream on the plant property.

Late in 1951, the retention basin design was abandoned when radiation dissipation was no longer considered necessary for the cooling water effluent. This decision was based on the improved construction of the process heat exchangers and the improbability of a leak in the heat exchangers coinciding with a fuel slug rupture, the greatest source of radiation contamination.

With the abandonment of the retention basin, a minimum structure was designed which would house a pump and at the same time not interfere with the flow of effluent water to the drainage system. Building #107, basically a sump with an

overflow chamber integral with the Bldg. #105 process effluent lines, was provided for this purpose.

The sump consists of a two-chamber reinforced concrete box-type structure 27 ft. deep, with the chambers separated by a 13 ft. weir wall. A one-foot thick slab covers the sump chambers and supports an 11,000 g.p.m. vertical two-stage centrifugal pump which was installed in the chamber on the influent side of the weir. Under normal flow conditions the water travels over the weir into the overflow drainage chamber and is discharged through underground pipe to the head wall of the drainage canal system briefly described in the Process Effluent Lines, Bldg. #904. The sump was designed to handle a maximum flow of 100,000 g.p.m. at a water level of 2 ft. above the weir. The vertical pump installed in the sump provides a means for conserving water by recirculating a portion of the cooling water discharged from Bldg. #105 back to Bldg. #186, for use in the event of a river pump house or distribution line failure. The Bldg. #105 diesel powered emergency generation equipment supplies the emergency electrical power for the pump.

For health physics reasons the original retention basin and the Bldg. #107-R & P replacements were located quite a distance from Bldg. #105, necessitating long pipe runs. In Areas LK&C the sumps were located nearer Bldg. #105 as an economy measure.

Process Effluent Lines - Bldgs. #904-RPLK&C and #904-G

The process effluent lines included four waste systems in each area: (1) the Bldg. #105 process cooling water effluent lines; (2) the Bldg. #105 process drainage system; (3) the Bldg. #186 reservoir overflow drain; and (4) the Bldg. #183-2 filter plant clear well overflow drain. Also, in the R Area two sludge drains were run independently to another head wall to carry away sludge washed from the Bldg. #183-1R clarification basins. The reservoir drainage system was also a collection system for the river mud washed from the reservoir basins.

Basically, these disposal facilities carried their effluent by gravity to a head wall outside the area where it was discharged into an open canal leading to a tributary stream of the Savannah River. In the R Area, pumping the water over high ground to a distant stream on the property was eliminated through the purchase of additional land so that the waste canal could provide gravity discharge to Lower Three Runs Creek, the nearest tributary of the Savannah River.

RECIRCULATING WATER SYSTEM

Cooling Tower - Bldg. #185

The RPL&K Area power houses were equipped with two steam turbo-generators, each, to generate electric power required for reactor operation. This system required cooling water for the turbine condensers, for the lubricating oil, and generator air cooling systems. Detailed cost studies indicated that a cooling tower recirculation system was more economical for this purpose than a "once-through" system using river water supplied from the river pump houses. Accordingly, a cooling tower recirculation system was designed to supply 27,500 g.p.m. of cooling water for each area. Since ash sluicing water also was required in the power house, it was decided to make the cooling tower basin large enough to accommodate the additional water periodically required for that service.

The cooling tower designed for this purpose is a four-cell double flow, induced draft tower with its basin divided into two sections so that one section can be used for each turbo-generator. The design rating of each tower is 27,500 g.p.m. of water recirculation cooled from 103° to 88°F. based on a 76°F. outside air wet bulb temperature.

Since river water is used as the source of cooling tower make-up, chlorination of the water is required for algae control. In order to protect the steel distribution piping against corrosion, a lime feeding system was provided to counteract the acidity produced by the chlorine treatment.

WATER SUPPLY - #200 AREAS

GENERAL

The water requirements for the #200-F&H Areas were moderate when compared with those for the #100 and #400 Areas. It was estimated that the #200-F Area would require only approximately 15,000 g.p.m. and the #200-H Area only approximately 10,000 g.p.m. The major water use in the #200-F&H Areas was for the removal of heat from process equipment, a very small quantity being consumed as make-up.

In July, 1951, a comprehensive economic comparison was made of fourteen methods of water supply from the river and other sources. The following schemes were investigated: (1) river water with clarification in the #200 Areas; (2) river water without clarification at the #200 Areas; (3) clarified river water from the nearest #100 Areas; (4) storage dam and pump house on Upper Three Runs Creek with clarification in the #200 Areas; and (8 through 14) cooling towers versus once-

through process cooling for each of the above seven schemes. The results of these studies indicated that cooling towers were justified regardless of the source of water selected or whether or not clarification facilities were included.

The major water users in the #200-F&H Areas are the Bldgs. #211, #221, and the #221 "A" Line with peaks of 3600, 8300 and 1200 g.p.m. respectively. The loads are largely those of cooling process liquids. Process equipment includes jets, evaporators, condensers, dissolvers and mixer-settlers. Part of the process cooling load, amounting to some 4000 g.p.m. peak, is of a critical nature and supply must be maintained in event of an electrical power failure. The reasons for its being critical are: (1) material in dissolvers might produce a "run-away" exothermic reaction without cooling; (2) condenser cooling must be maintained so as to avoid contamination of the ventilating system with radioactive vapors; and (3) cooling water pressure should be maintained on all "hot" equipment in order to prevent leakage of radio active materials into the cooling water system.

Active waste material is stored in the underground tanks of Bldg. #241 where, subject to radioactive decay, it produces large quantities of heat. This heat is dissipated by means of cooling water circulated through coils placed in the tanks. If this cooling were not provided, boiling would take place and radioactive vapors could contaminate the surroundings.

In October, 1951, a study was made to determine how the underground tank cooling of Bldgs. #241-F&H was to be accomplished. Two systems were considered - closed and open. The closed system involved the refrigeration of 1000 g.p.m. of cooling tower water from 85°F. to 75°F. which in turn was to be used in a heat exchanger to cool the circulating water in the closed system to the required temperature of 85°F. before pumping it through the tank coils. The open system involved a 1000 g.p.m. supply of 85°F. water from the cooling tower passed through a vacuum deaerator then pumped directly through the tank coils and returned to the cooling tower. Suitable pH was to be maintained in both systems for the protection of the mild steel coils.

The open system appeared to be the most economical, but would have increased the risk of radioactive contamination of the cooling tower water system. It was decided, therefore,

to use the closed system. By late October, 1951, it had been determined that a 1000 g.p.m. capacity water supply in each of the #200 Areas could be obtained from wells and the decision was made to use well water, instead of refrigerated water, for the heat exchangers in Building #241. Provision was made for once-through use of the well water in the heat exchangers, after which the water was to be re-used as a continuous make-up supply to the process cooling tower system in each area. The arrangement of pumps and drives is described under the following subject of "Well Water Supply Systems".

WELL WATER SUPPLY SYSTEMS

Wells - Bldgs. #905-F&H

By November, 1951, pumping tests conducted on construction wells and other test holes indicated that a sufficient well water supply could be developed to furnish all water requirements for the #200-F&H Areas. Accordingly, five deep wells were provided, drilled to depths ranging from 790 ft. to 880 ft. in each area, all nominally rated at 1000 g.p.m.

Three of these five wells supply water to ground storage tanks from which domestic, service and fire protection water is distributed to all points of use within the respective areas. The other two wells supply once-through cooling water to the Bldg. #241 heat exchangers from which it passes on to the cooling tower for make-up. One well is held as a spare on each of the two systems at all times, and no physical tie was made between the two systems because of the possibility of radioactive contamination entering the domestic, service and fire protection water from the process cooling water system.

All of the wells were designed to have an 18 in. outer casing and an 8 in. inner casing extending below the outer casing into the water stratum. Gravel packing was used to surround the strainers at the end of the 8 in. casing and up into the 18 in. casing for an overlap of from 20 ft. to 30 ft. Each well was provided with a multi-stage turbine type deep well pump.

Water was available from two water bearing formations, a lower aquifer known as the Tuscaloosa formation, and a higher one known as the McBean formation. In these areas all water was taken from the lower or Tuscaloosa formation, the prime consideration being to avoid, as far as possible, radioactive contamination which might enter the ground from

Notes: Changes indicated in pencil were made in Proj. 52-1136
1.6.7

continuous, on-line

TO ALL NON ESSENTIAL USERS WHOSE SUPPLY IS CUTOFF IN EVENT OF LOW HDR PRESS. FOR ANY REASON

TO ALL CRITICAL USERS WITH SUPPLY GUARANTEED BY TURBINE DRIVEN PUMP AT COOLING TOWER.

critical sized
for 1000 gpm

N.O. Denotes valve normally open
N.C. Denotes valve normally closed

TYPICAL WATER FLOW DIAGRAM

200F & H AREAS

The following tabulation of loads can be applied to the preceding diagram and will serve to indicate maximum loads on each component of the system.

200-F&H AREAS - MAXIMUM WATER LOADS, G.P.M.

Batches/Day	<u>F Area</u>		<u>H Area</u>	
	<u>3</u>	<u>4</u>	<u>3</u>	<u>4</u>
Cooling tower demand for all process, air conditioning, and misc. uses.	16,900	17,700	10,350	11,150
Process cooling water returned thru monitored system.	9100	9900	6700	7500
Air conditioning and other uncontaminated returns not monitored.	7200	7200	3330	3330
Water lost to segregated system and other misc. once-thru users.	815	855	575	615
Cooling tower losses evaporation and drift.	375	385	210	220
Average loss for ash sluicing in power house (otherwise lost as cooling tower blowdown for solids control).	70	70	70	70
Max. rate of make-up required from the two 241 cooling system wells.	1260	1310	855	905
Service water loads, boiler feedwater and misc. cooling.	640	680	485	525
Service water pump cap. available for cooling tower make-up.	260	220	415	375
Domestic water demand.	900	900	900	900
Max. demand on three wells supplying the Bldg. 282 ground storage tanks for fire, service and domestic uses.	2000	2000	2000	2000

the Bldg. #241 tanks. This well water was characterized by being low in total solids, relatively soft, and low in pH. The temperature range was from 66 to 70°F., depending on the depth.

A typical analysis obtained from Well #37F is as follows:

Total Hardness as CaCO_3 (p.p.m.)	4.9
Calcium as CaCO_3 (p.p.m.)	4.3
Phenolphthalein Alkalinity as CaCO_3 (p.p.m.)	None
Methyl Orange Alkalinity as CaCO_3 (p.p.m.)	0.5
Chlorides as Cl (p.p.m.)	0.8
Sulfates as SO_4 (p.p.m.)	17.0
Silica as SiO_2 (p.p.m.)	15.5
Ionic Iron as Fe (p.p.m.)	0.03
Total Iron as Fe (p.p.m.)	0.74
Carbon Dioxide as CO_2 (p.p.m.)	22.7
Total Sulfide as S (p.p.m.)	1.4
Total Solids (p.p.m.)	30.2
pH at 25°C.	4.22

Wells No. 24-F, 21-F and 39-F supply domestic, service and fire protection water to all users in the #200-F Area, and Wells No. 43-H, 35-H, and 48-H supply similar services in the #200-H Area. Wells No. 24-F and 43-H are located near their respective area power houses and have pumps which are dual-driven by either steam turbine or electric motor through combination right angle drives. One of the power house requirements was that limited steam service be provided for an 8-hour period during any electric power outage. The purpose of the turbine drives on the well pumps was to insure adequate water supply for boiler feed and equipment cooling during any such emergencies. Wells No. 21-F, 39-F, 35-H, and 48-H have pumps which are driven by electric motors only. All wells were test pumped at a rate of 1500 g.p.m. prior to establishing their nominal rating at 1000 g.p.m. Specific capacities of these wells ranged from 30 to 60 g.p.m. per foot of drawdown.

Buildings #241-F&H each required 1000 g.p.m. of cooling water in an uninterrupted once-through supply. This water passes through the Bldg. #241-F&H heat exchangers, then flows to the Bldg. #285-F&H cooling towers for use as make-up. Due to the critical nature of the cooling load in this system, auxiliary diesel drives and blast-proof housing were provided for one well in each area, Well No. 37 in the F Area and Well No. 44 in the H Area. Right angle drives were also provided for Wells No. 49-F and 45-H to make it possible to physically move the diesel drives from Wells No. 37-F and 44-H to these locations, should the need arise. The construction details of the Building #241 system wells below ground were made identical to those supplying service, domestic and fire protection water needs, and the water was similar in character, being obtained from the same aquifer.

WATER TREATMENT

Domestic, Fire and Service Systems

Based on the typical analysis of the well water developed in this area (refer to "Water Supply - General" for chemical analysis), it was considered necessary to provide lime treatment for pH adjustment, polyphosphate to keep the soluble iron in solution, and chlorination to maintain the domestic water bacteriologically safe. All of these treatment facilities are located immediately up stream from the Bldg. #282-F&H ground storage system.

Cooling Tower and Bldg. #241 Tank Cooling System

The well water used for Bldg. #241 tank cooling and eventual make-up to the cooling tower system had the same characteristics as the well water referred to in the preceding paragraph, and therefore required the same treatment. Chlorination was applied to the cooling tower system to control algae growth. Lime and polyphosphate treatment facilities were located immediately following the point where the flow from the two wells enters the common header. The treatment thereby affords protection for the lines and the Bldg. #241 heat exchangers. Since this water is used for cooling tower make-up after it passes through the heat exchangers, sufficient lime is added to maintain proper pH in the cooling tower system. Measurement of pH for controlling lime feed is located in the cooling tower return line.

As previously discussed, Bldg. #241 tank cooling is accomplished by a closed circulating system requiring very little make-up. Chromate treatment was provided for corrosion protection to the mild steel coils in the Building #241 tanks.

Boiler Feedwater

Due to the high load factor anticipated for the #200-F&H Area boilers and the need for a process steam supply of maximum reliability, boiler feedwater softening and silica removal equipment was installed. Even though the total solids content of the feedwater was low, the silica content was nearly half of the total and, without silica removal, close control of solids in the boiler with excessive blowdown (about 25%) would have been required to prevent silica scale deposits. The probability of silica scale deposits would have been much greater in the presence of calcium if softening had not been provided.

In addition to softening and silica removal, provision was made for internal treatment by the addition of sulfite, caustic, phosphate and an organic dispersing agent. The sulphite was added to scavenge out residual dissolved oxygen remaining after deaeration. The caustic was added to provide alkalinity for preventing corrosion and to hold residual silica in solution. The phosphate was added to form a soft sludge with the residual calcium and prevent hard scale deposits. The organic dispersing agent was added to maintain the soft sludge in suspension so that it would be removed in the blowdown water rather than be left to accumulate inside of the boilers. Provisions were made for adding the sulfite and dispersing agent ahead of the boiler feed pumps and the caustic and phosphate into the boiler drums.

COLLECTION AND DISTRIBUTION SYSTEMS

Two individually metered well water collecting systems were required for each area; one to deliver domestic, service and fire water to Bldgs. #282-F&H (ground storage tanks), and another to supply cooling water to the Bldgs. #241-F&H heat exchangers. Cast iron mechanical joint pipe was specified for underground lines with a minimum bury of 2 ft.-6 in. and a bury of 3 ft.-6 in. under roads and railroads.

The Bldg. #282-F&H ground storage tanks were sized to provide sufficient water for normal and emergency uses. In the #200 Areas the domestic water storage tank was separated from the service and fire water storage tank, with capacities of 100,000 gallons for domestic water, 100,000 gallons for service water, and 500,000 gallons for fire protection use. At the time the ground storage tanks were designed, steel was a very critical item, and conservation was accomplished by using reinforced concrete tanks covered with dome roofs. Water levels in the tanks are maintained by pneumatically operated pilot controlled valves in the incoming well water lines.

The fire, service and domestic water pumps are located on an outdoor platform adjacent to the #284-F&H power houses to minimize building requirements. Pumping capacities were set at 10,000 g.p.m. for fire use, 900 g.p.m. for domestic use, and 900 g.p.m. for service water use. Three of the five fire pumps and one each of four service and four domestic water pumps in each area are steam turbine driven.

The fire protection requirements were established in accordance with the needs of the spray system in the #221 Canyon Building where solvents are used with flash points as low as 145°F. The spray supply headers entered the #221 Building at the north end and the 10,000 g.p.m. demand was

at a minimum pressure of 90 p.s.i.g. and for a minimum period of 30 minutes.

For convenience in assigning design responsibility to the various subcontractors, boundary limits were established arbitrarily around the area containing the power house, cooling tower and water storage tanks. This area was designated as the "power block". Distribution of all water services within this power block was the responsibility of Gibbs & Hill, while distribution of all water services outside the power block was the responsibility of Blaw-Knox. Domestic and fire protection services were distributed throughout the areas, although service water was not distributed outside the power block. Metering was provided for all services.

Recirculating Water System

Cooling Towers - Bldgs. #285-F&H

Cooling towers (Bldgs. #285-F&H) were chosen to provide a continuous source of 85°F. process cooling water with hot water being returned to the towers at a maximum temperature of 125°F, based on a wet bulb temperature of 78°F. It was necessary to specify a high return temperature to insure the design of adequate facilities before actual return temperatures from much of the process equipment had been determined. The cooling towers were sized for 15,000 g.p.m. in the F Area, and 10,000 g.p.m. in the H Area, but were laid out in each area for ultimate expansion to 25,000 g.p.m. capacity.

Make-up water to the cooling towers was supplied from the Bldgs. #241-F&H cooling systems as previously described. The storage basins under the cooling towers were sized to hold up sufficient water to permit locating and isolating process leaks and flushing the cooling system in the event failure of any process equipment made it necessary to by-pass the return cooling water to the area retention basin.

In addition to the process water reserve storage, provision was made for ash sluicing water for the power houses to be stored in the tower basins, the arrangement of the ash sluicing supply pump suction being such that the water level could not be pulled down below the minimum required for process reserve. The use of this ash sluicing water provided a well balanced system since the quantity of water so used closely approximated that necessary as blow-down for solids control in the cooling tower systems.

To provide flexibility and satisfactory year-round operation, a minimum of three cells was specified for each tower, the number of circulating pumps to be one per cell with one additional as a spare. Each cell and each cooling

tower circulating pump could be isolated for maintenance or cleaning without affecting the operation of the balance of the installation.

Certain critical process cooling water users required an emergency supply in the event of an electrical failure or mechanical loss of the circulating water pumps. Accordingly, a turbine drive was placed on one circulating pump at each of the #200-F&H Area cooling towers and was arranged to start automatically upon loss of pressure in the process cooling water header. Arrangements were made in the distribution system outside the power block to cut off nonessential users so that the capacity of the single turbine driven pump would not be exceeded during an emergency.

Fully automatic operation of the cooling tower pumps was required due to the fact that there would not be an operator in constant attendance to make immediate changes in response to process flow requirements. Accordingly, automatic stop-start control of the circulating pumps was installed, the pumps being started and stopped as determined by flow measurement in the discharge header. A manual selector switch also was included so that any desired changes in the pump starting sequence could be obtained. Chlorination facilities for algae control were provided in Bldgs. #280-1 F&H and piped to the pump suction wells. The proximity of these buildings made this a logical choice rather than providing additional local housing. The pH of the water was controlled at the Bldg. #280-2 F&H Chemical Feed Buildings through treatment of the well water used as make-up. The pH was measured in return lines at the cooling tower.

In early 1955, process cooling water loads in the #200-H Area were increased as a result of process changes for 6 Batches/Day operation. These are tabulated as follows:

200-H Area Maximum Water Loads, g.p.m. 6B Operation

Cooling tower demand for all process, air conditioning and misc. uses.	11,700
Process cooling water returned thru monitored system.	8800
Air conditioning and other uncontaminated returns not monitored.	2100
Water lost to segregated system and other misc. once-thru users.	800
Cooling tower losses evaporation and drift.	260

Average loss for ash sluicing in power house (otherwise lost as cooling tower blowdown for solids control).	100
Max. rate of make-up required from the two Bldg. #241 cooling system wells.	1160
Service water loads, boiler feedwater and misc. cooling.	630
Service water pump cap. available for cooling tower make-up.	720
Domestic water demand.	900
Max. demand on three wells supplying the Bldg. #282 ground storage tanks for fire, service and domestic uses.	2000

This increase in loads necessitated the addition of one cell and a circulating water pump to the Bldg. #285-H Cooling Tower.

Distribution Lines - Bldgs. #901-F&H

The recirculating water system is a part of the underground lines, Bldg. #901-F&H. Supply and return lines within the power block battery limits were designed by Gibbs & Hill, while those outside these limits were the responsibility of Blaw-Knox. The main headers, both supply and return, are constructed of 36-in. reinforced concrete pipe. Smaller size branch lines are cast iron mechanical joint pipe. These distribution lines were installed essentially as previously described under the well water system.

Cooling Water Return System

After the decision was made to use cooling towers for supplying process cooling water in the #200-F&H Areas, certain problems became manifest relative to keeping this cooling system free of radioactive contamination. That portion of the water used in air conditioning and refrigeration condensers was returnable with very little risk, but many difficulties were encountered in the return of process cooling water used in equipment where the possibility of radioactive contamination existed. It was finally determined that this process cooling water would be segregated in a separate return system and monitored for radioactivity before it was returned.

The first concept of this separate return system entailed three basins with approximately two hours' capacity for the full flow of process cooling water in each one. In operation, one of these basins would be filled while the second was being monitored and the third was being emptied. The size and cost of these basins was excessive and their operation on a continuous basis was not desirable.

The advantages of a continuous monitoring system were evident, but this type of monitoring had not been proven successful at Hanford. In October of 1951, AED advised Design that it would be necessary to have a continuous record of alpha, beta and gamma contamination in waste and cooling water return streams which should normally contain no radioactivity. It was pointed out that the measurements obtained at Hanford had apparently reflected accumulated or background radioactivity over a long period of time rather than the direct activity of the water at the time of sampling. AED also advised that the allowable activity in such streams would require a more sensitive measuring device than that employed at Hanford. It was suggested that work be undertaken to develop an automatic sampling device meeting these requirements.

This work was begun jointly by the Design Division Instrument Group, the Development Engineering Division Machine Development Group and the American Machine & Foundry Company. Design responsibility for the development of a prototype of an automatic water activity sampler, with the exception of the monitoring equipment and the sample circulating line and pump, was assigned to the American Machine & Foundry Company. The monitoring equipment and circulating water system sample line and pumps were selected and designed by the Design Instrument Group in conjunction with the AED Technical Division.

The primary design feature of the instrument, as developed, is an aluminum tape moving on reels. During the travel of the tape from the feed to the take-up reel, it is dimpled by a die. The size of the dimple impressed allows each dimple to contain a 1 cc. water sample deposited by a metering pump of adjustable output. The water is evaporated by a radiant heater and the sample residue is monitored by two scintillation screens, one of which, an alpha screen, was a special development of the AED Technical Field Group.

A manhole was installed as a sampling point in the monitored return system ahead of a delaying chamber. The delaying chamber was arranged with over and under baffles and was designed to provide sufficient hold-up time for the monitor to evaluate samples and for valve operation to divert the water from the normal return system to an earth retention basin if the water was found to be contaminated. This time was originally specified to be 10 minutes for a flow of 8600 g.p.m. A small

structure adjacent to the monitoring manhole was provided to house the automatic water activity sampler and its auxiliary equipment. This building required filtered, dehumidified air, as well as electric heat.

In May of 1952, an evaluation of the automatic water activity sampler system resulted in a du Pont recommendation that a back-up device be provided for the sampler. Current design incorporated the parallel installation of ionization chambers, but since these ionization chambers would not be sensitive to alpha contamination, it was thought that a dual installation of automatic activity samplers would greatly improve the reliability of the system. Design was altered accordingly to provide for the installation of two automatic activity samplers on the cooling water return system.

Following much study and development work, four activity samplers were ordered in December, 1952, with these general specifications.

1. Aluminum tape 0.004 in. thick unwinding from a feed spool onto a rewind spool - indexing rather than continuous tape movement. A 72 hour tape supply specified for each spool.
2. Tape to be dimpled by a die during travel from feed to rewind spool.
3. A metering pump with adjustable output, multiple nozzles $1/64$ in. in diameter on the discharge side for depositing samples in the dimples.
4. Drive rollers to flatten the tape after sample residue exposure and prior to rewinding.
5. A radiant heater to evaporate water in the tape dimples.
6. A ventilating system to remove excess heat and moisture from the machine with air flow across the tape held to less than 6 c.f.m.
7. Three scintillation counters; one beta-gamma counter with photo multiplier feeding to the input of a standard scaler, and two alpha counters with photo multiplier, connected in parallel, feeding to the input of a second scaler, each scaler to be separately recorded.
8. Entire machine to be enclosed with convenient access doors for maintenance and repairs.

The monitoring equipment specifications were subsequently changed to incorporate the following; two scintillation screens with photo multipliers, two scalars, two curve drawing attachments, and one recorder. The first of these machines was accepted after field tests early in March of 1953.

The process cooling tower return system was built to perform a definite function, its success hinging largely on successful continuous monitoring. The delaying basins, Bldgs. #281-1 F&H, were designed for a hold-up time of 10 minutes. If the water is monitored clean, it is allowed to flow by gravity to the pump basins, Bldgs. #281-2 F&H. The physical location and depth of the pump basins are determined on the basis of providing gravity flow. Initially, a dividing wall was incorporated in the design of the pump basin to separate monitored from non-monitored water. This was eliminated later as being unnecessary, and all monitored and unmonitored water is returned to the cooling tower by a common set of pumps through a common header. Automatic controls were provided for stopping and starting the pumps, depending on flow since no operator is in attendance at all times. Pumps of 5000 g.p.m. capacity were selected to match system flows from the cooling tower.

If the monitors show radioactive contamination, a motor-operated valve in the line between the delaying basins and the pump basin closes before any of the contaminated water can get into the cooling tower return system. At the same time, a second valve opens to direct the contaminated water through the delaying basin and into the earth retention basins, Bldgs. #281-3 F&H, where the water is impounded. The retention basins were designed to retain approximately 600,000 gallons of contaminated water and were located by the necessity of placing them away from congested areas and providing gravity flow from the delaying basins. It was anticipated that water impounded would be dissipated through ground seepage.

In April of 1953, the AED Process Design Group decided that process equipment using both steam and water in alternate parts of the operating cycle constituted too great a risk of contamination to be coupled with the balance of the process cooling water return system. This decision was brought about by experience gained at Hanford. Consequently, a separate system designated the "segregated" system was installed to collect water from this equipment. This segregated system was provided with its own monitoring stations, Bldgs. #281-6 F&H, and delaying basins, Bldgs. #281-5 F&H, the latter being designed to provide a hold-up time of four hours for a flow of 750 g.p.m. Continuous monitoring was installed as in Bldgs. #281-1 F&H, but with the additional provision that equipment for collecting a continuous sample, proportional to flow, for laboratory analysis could be added at a later date if found desirable. As long as this water

was monitored and found to be uncontaminated, it was permitted to flow to the river. If contamination was detected, a motor-operated valve closed to stop this flow and a second valve opened to permit the contaminated water to flow to the earth retention basins, Bldgs. #281-3 F&H, where it was impounded.

The order for activity samplers was increased to eight units in May, 1953, to take care of this additional system.

ELECTRIC POWER SUPPLY

GENERAL DISCUSSION

PRODUCTION POWER

In the "Basic Requirements" section of this volume, the estimated area electric loads were correlated with the required power availability dates and presented as a load growth curve (page 27). This curve incorporates adjustments for load diversity factors as regards both combined area loads and loads within the individual areas. The curve, therefore, was used directly by the design group to plan and schedule the electric power generating facilities and/or purchased power to be provided.

With the addition of the #400 Area to the scope of work late in 1950 immediate attention had to be given to the problem of supplying electrical power to operate this area. The established early start-up date allowed only minimum time for providing the required power facilities, the first estimate of loads indicating that approximately 40,000 kw. of electrical power would be needed. The indicated steam requirement for process use was approximately 600,000 lbs. per hr., two-thirds of which would be required at 300 p.s.i.g. and the remainder at somewhat lower pressures. Most of this steam would be required as a steady load, offering the attractive possibility of generating electricity with back-pressure units at low fuel cost. The potential amount of by-product generation, however, would be sufficient to serve only about one-half of the area demands. The rest of the required electric power would have to be generated with condensing units on the site or purchased from outside sources.

These alternatives were investigated together with the possibility of purchasing the entire electric power requirement for the #400 Area. It was found that little or no purchased power could be obtained in time for the proposed area start-up and that it would be necessary to install firm

generating capacity to meet the full requirement. Furthermore, promised delivery dates for large turbo-generators could not meet required schedules. The only available alternative was to use a number of smaller turbo-generators. On the basis of heat balance and availability, it was decided to install the following generating equipment:

1. Three high pressure non-condensing turbo-generators of 7500 kw. capacity each, taking throttle steam at 900 p.s.i.g. and 900°F. and exhausting at approximately 385 p.s.i.g.;
2. Three extraction condensing turbo-generators of 10,000 kw. capacity each, taking throttle steam at 370 p.s.i.g. and having pressure controlled extraction points for supplying the area steam requirements at the lower pressures; and
3. Three 325,000 #/hr. 900 p.s.i.g. 900°F. boilers to supply steam for the electrical generation and for process.

The power house was arranged to take full advantage of by-product electric power generation from process steam flows.

With the decisions made to meet the early power requirements of the #400 Area, studies were resumed on a project-wide basis to develop means of supplying electric power to the other areas. Even this portion of the program had to be firmly established at an early date to enable design to conform to established schedules. Referring again to the load growth curve (page 27), it will be noted that approximately 5000 kw. of power would be needed by the #300/700 Area shortly after start-up of the first #400 Area process unit. Within four or five months power would be required for the #100-R area, with subsequent #100 Areas scheduled for start-up at intervals of approximately six months. The #200-F Area was scheduled to require power about five months after the start-up of #100-R Area.

A great deal of work was required to arrive at firm decisions regarding the supply of electric power for the plant. This phase of the over-all scope of work is covered in detail in the Electrical Section, Part II, of this history. As a result of the many investigations and studies carried out by the du Pont Engineering Department, recommendations were made on May 23, 1951, to proceed as follows.

1. Order one additional 325,000 lbs./hr. boiler and one additional 10,000 kw. extraction turbo-generator for the #400 Area. The fourth boiler was needed in any case to firm up the #400 Area steam supply during boiler outages. Normally, however, with all boilers in service there would be excess steam

available for electrical generation. Installing a fourth 10,000 kw. unit to take advantage of this situation could be done quickly and appeared to be one of the most expedient ways of building up sufficient power to meet the early operating schedules.

2. Install two 11,500 kw. turbo-generators with allied equipment in each of the first three #100 Areas (#100-RPL). The installation of this generating equipment was mandatory, as purchased electricity in adequate amounts could not be obtained prior to the middle of 1953. This arrangement had the advantage, also, of placing the bulk of the electric generating facilities on the site in a number of small, dispersed stations close to the important points of consumption. Units of this size could be obtained also in time to meet construction schedules. The inability to get larger units ruled out considerations of central station construction on the site.

These decisions were incorporated in the plant design while additional power studies were made to determine the best course of action for Areas #100-K and #100-C. Investigations were continued during June, July and early August of 1951, and a decision was finally reached to provide facilities for the generation of 25,000 kw. of electricity in the #100-K Area. Again, the factors of economics, reliability, protection and timing were considered in arriving at this decision. Units for the #100-K Area were to be similar to those for the #100-RPL Areas, except that the generators specified for #100-K were of 12,500 kw. capacity each rather than 11,500 kw. The boilers and the turbine drives for these generators were to remain the same. The decision to enlarge the generators was based on economic evaluations of incremental capacity costs compared with other means of meeting the requirements. Load reviews had indicated that the larger generators could be driven by the same turbines and boiler facilities.

Concurrently with the decision to provide generating facilities for the #100-K Area, it was decided that no electricity would be generated in the #100-C Area. Instead, 30,000 kw. of firm service would be obtained from the South Carolina Electric & Gas Company. Two major factors were involved in the decision to purchase this electricity instead of generating it as in the other #100 Areas: (1) analyses of construction schedules indicated that the South Carolina Electric & Gas Company would be able to provide the 30,000 kw. by the time it would be required; and (2) it was considered advantageous for the plant to have an interconnection with the utility companies for a second source of supply. This interconnection would allow flexibility for purchasing additional power at a later date in case the plant power demands should increase.

The choice of purchased power for the #100-C Area would not materially affect the factor of protection to be gained by the dispersal of generating facilities. The same number of generating stations would be involved whether electricity for the #100-C Area was purchased or generated, the only additional vulnerability of these facilities being due to the longer transmission lines and the location of the South Carolina Electric & Gas Company station outside of the plant perimeter where it would not be under the care of plant protective forces. As the block of firm power on the site location would be large in comparison with the amount of power brought in, it was believed that the effect of outside utility system disturbances on plant operation would be minimized.

Superimposed over the load growth curve on page 111 is a second curve showing the growth of the electrical power supply system. By comparing these two curves it can be seen how the work was planned to make firm power available for each of the areas as it was needed. The over-all capacity was sufficiently greater than the predicted plant peak to allow for spinning reserve and a spare generating unit. Such design was necessary to provide a firm supply of power during unexpected generator outages and during maintenance periods. The difference in plant loads on this chart and that on page 27 reflects power requirements for generation.

It will be noted that 168,900 kw. of capacity was expected from the generating equipment installed at the Savannah River Plant. This is in excess of the name plate ratings of the various units, which total 156,500 kw. After considerations of power factor, turbine capability, steam supply and generator construction, the generation capacities were up-rated as follows:

- (1) Bldg. #484-D generator ratings corrected to 85% power factor (80% power factor name plate rating);
- (2) Bldg. #184-RPL generators up-rated by 10%; and
- (3) Bldg. #184-K generator rating corrected to 85% power factor (80% power factor name plate rating).

It was planned that all production power sources would be operated in parallel. However, the transmission line system was constructed in such a manner that it could be segregated in sections if desired.

"ON-LINE" AND "EMERGENCY" POWER

In the previous paragraphs the over-all electric power requirements for the plant have been discussed. This power was provided essentially for production purposes and, within the limits of reasonable expenditure, was made as reliable as possible because interruptions were a serious threat to the safe and

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economical operation of many of the processes. However, it was not economically feasible to build into this system complete freedom from unscheduled interruptions, and special attention had to be directed to the problem of uninterrupted electric power supply in many instances. Power consumers were classified according to the type of service required and a decision was reached that three classes of electrical service would be provided. These were designated as "production" power, "emergency" power, and "on-line" power. The previous discussion dealt with production power for the plant, with more than 90 per cent of the plant power requirements being supplied from this over-all production power network.

In order that critical loads could be served during outages of the production power, secondary electrical supply systems were provided. These consisted for the most part of diesel engine-driven generating facilities. For one type of application, however, diesel engines were installed to drive well pumps directly through angle drives during emergencies. Small gasoline driven generators also found some application.

With one exception, electric power from these secondary sources was designated as "emergency power", and it was planned that the units supplying such power would be kept in a standby condition ready to be started or to start automatically when required. It will be noted that a short time interval was permissible between the failure of production power and the starting of "emergency" power equipment. Approximately 30 diesel engine-driven generators were specified for "emergency" service.

For one application in the #100 Areas, the type of secondary power just described as "emergency" power was not considered adequate. A source of secondary power was needed to keep the reactor cooling pumps in operation during production power outages. Due to the nature of the process little or no time lag could be tolerated in applying the secondary power when needed. For this application it was necessary that diesel-driven generators operate continuously to be ready to supply reserve power when required. This type of back-up power was designated "on-line" power to distinguish it from the normal concept of "emergency" power as described above.

To obtain the highest reliability for "on-line" power, it was decided to provide an individual diesel generator for each of the six process cooling pumps in each #100 Area. Two spare diesel generator sets were also to be made available in each #100 Area for this application. The development of this system is explained in a subsequent section devoted to the #100 Area electric generating facilities. Forty diesel generator units were required for the "on-line" service.

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The total diesel generating capacity, both emergency and "on-line", is approximately 20,000 kw.

ELECTRIC POWER SUPPLY - #400 AREA

GENERAL

Original data for the #400 Area electric power requirements indicated that approximately 40,000 kw. of electric power would be required. Having decided early in the planning phase that the power house should be designed along the unit system, the optimum electric power per unit was found to be 17,500 kw. The unit system was decided upon for higher reliability and a greater degree of flexibility. The previous section, "Electric Power Supply - General" describes briefly the over-all electric power studies which resulted in the decision to install high pressure non-condensing turbo-generators of 7500 kw. capacity each and low pressure extraction condensing turbo-generators of 10,000 kw. each in the #400 Area.

Some doubt had been expressed regarding justification for generating electricity in the #400 Area. It was pointed out, however, that most of the #400 Area power requirements could be generated as by-product electricity from the steam required for process. Furthermore, a survey of public utility systems serving the region disclosed that insufficient purchased power could be made available in time for the scheduled start-up of #400 Area process. Economic evaluations indicated that operating savings of \$1,600,000 per year could be made by generating the electric power requirements of the #400 Area plus certain other areas that were scheduled for early start-up. The estimated incremental increase in investment cost for these electric generating facilities and added boiler features that would be required for electric generation was \$9,000,000, and could be recovered in approximately 5-1/2 years by the operating savings. A recommendation to proceed with plans for installing the electric generating facilities was submitted to the AEC in February, 1951, and approval was given during the same month.

Following the decision to generate electricity in the #400 Areas, outline specifications were prepared for 7500 kw. and 10,000 kw. units, and requests forwarded in February, 1951, to the leading turbine manufacturers for quotations. A field visit by Engineering Department personnel was made to the shops of the only two vendors who quoted on the specifications to determine the type equipment that could be furnished in the shortest possible time. From this field survey it was determined that one manufacturer could produce a high pressure unit while the other could furnish a low pressure unit in the

shortest time. To expedite delivery, approval of drawings was waived to permit simultaneous design and manufacture to begin. It should be noted that while these turbo-generator units were not identical with previously constructed units, they were made up of various parts, each of which, in itself, was a copy of existing design. By the end of February, 1951, orders were placed for the two types of turbo-generator units with a release to order materials and prepare the necessary drawings. The fact that the design details were settled so promptly, and no changes were permitted after the date of the order, made it possible for the manufacturers to make delivery of one high pressure unit and one low pressure unit in slightly less than a year from the date of the order. Normal delivery on this type of equipment was in not less than 15 to 16 months. Very few modifications were required during the production of this equipment from design to assembly. Problems encountered were of a minor nature and were quickly resolved.

As a result of over-all studies for supplying plant electric power requirements, it was decided during May, 1951, to install a fourth low pressure condensing turbo-generator unit, this new unit to be included in the manufacturer's contract.

The high pressure units were selected for 900 p.s.i.g. 900°F. TT throttle steam and 385 p.s.i.g. exhaust. This exhaust pressure was chosen to meet the large process requirement of 330 p.s.i.g. steam at the process battery limits. The low pressure condensing units were selected to expand steam from 370 p.s.i.g. throttle pressure to 130 p.s.i.g. at the first controlled extraction point and then to 55 p.s.i.g. at the second controlled extraction point. A third non-controlled extraction point in the low pressure end was used for preliminary feedwater heating. Condensers were provided for condensing all steam not extracted. These were sized to handle the full generating capacity of the low pressure unit, assuming no extraction except for the feedwater heating cycle. This provision was made to allow full generation for the project electrical system even with #400 Area production reduced or completely shut-down.

The design had specified that condensing water for the first three low pressure units should be obtained from the river pump house through the reservoir in Building #483-D. When the fourth condensing turbo-generator was added it was necessary to supplement the water supply and it was found most economical to do this by the addition of a cooling tower (see "Water Supply - #400 Area").

Early studies indicated that outdoor installation of the turbo-generator units would be desirable from the standpoint of economy. However, it was not possible to obtain the

outdoor type equipment in time to meet start-up schedules, so an indoor type turbine room was specified in the design.

In establishing the heat cycle for the plant it was determined that the addition of plant make-up water through the condensers would be desirable, and this design was adopted. With this type of operation the required capacity of the condensate pumps was approximately double the capacity that would be necessary to pump the condensate produced by maximum exhaust steam flow from the turbines. To provide standby capacity, three pumps were installed for each condenser, each pump capable of handling one-half of the expected load. To keep the floor space requirements to a minimum and to provide the pumps with the most desirable suction conditions, it was decided to utilize vertical type pumps.

ELECTRIC POWER SUPPLY - #300/700 AREA

GENERAL

Original estimates indicated that approximately 5000 kw. of electric power would be required by the equipment in the #300/700 Area. As firm data were developed, this requirement was increased to approximately 8300 kw.

Steam requirements for the area were not of such magnitude nor sufficiently stable to make the generation of by-product electricity attractive. Condensing generation was not considered desirable either, because of the relatively small electric load. Also, it was preferred to locate the electric generating facilities in the #100 Areas where the more critical requirements existed. For these reasons it was decided to provide electric power for the #300/700 Area from the plant distribution system.

EMERGENCY POWER

A number of emergency diesel generators were installed throughout the area for standby power during outages of the normal supply. These included a 30 kw. unit in Bldg. #776-A, a 10 kw. unit in Bldg. #720-A, a 400 kw. unit in Bldg. #773-A, a 30 kw. unit in Bldg. #751-A, a 100 kw. unit in Bldg. #501-A and a 100 kw. unit in Bldg. #777-M. Of these units, only the one for Bldg. #777-M was housed in a blast resistant structure.

ELECTRIC POWER SUPPLY - #100 AREAS

GENERAL

Plans for the Savannah River Plant electric power supply system were essentially controlled by #100 Area requirements, since approximately 70 per cent of the total plant electric power supply was to be utilized by these Areas and their associated river pump houses. Also, the most critical requirements, as regards reliability and voltage and frequency stability, were associated with loads in the #100 Areas.

In each #100 Area it was planned to circulate heavy water in a closed circuit between the reactor and a group of heat exchangers. By this means heat is transferred from the reactor to the exchangers, where it is removed by cooling water. Once the reactors were placed in operation, it was essential to maintain adequate circulation of heavy water and cooling water at all times to prevent overheating and serious damage. Process control equipment was capable of quickly curtailing the heat liberation of the reactor but only to a certain minimum residual level.

It was possible to guard against damage during the short curtailment period following an interruption of the normal pumping supply by installing flywheels on the pump shafts. However, an ultra-reliable secondary source of power was required for the period following this curtailment in order to maintain cooling at the minimum level of heat release for an indefinite period.

The basic #100 Area power problems were concerned with the following process requisites:

1. Supplying adequate pumping power for circulating the heavy water (primary and secondary power);
2. Supplying adequate pumping power for the once-through river water (primary and secondary power); and
3. Supplying miscellaneous power for auxiliaries, fans, water treatment and lights (primary and emergency power where required).

To meet the #100 Area requirements, three type of electric power were provided: (1) "production" power; (2) "on-line" power; and (3) "emergency" power.

These three classes were defined earlier in the discussion of the over-all plant electric supply problem.

Reference is made also to the section of this history dealing with the #100 Area water supply and to Part II, for additional details.

PRODUCTION POWER

The first problem to be resolved in planning for #100 Area production power was to determine the type of driving power desired for the heavy water and cooling water pumps. Two plans were evolved for final consideration from a study of many different arrangements. These became known as the "hydraulic scheme" and the "electrical scheme" each of which assumed that river water would be pumped to each #100 Area where it would be properly treated (if treatment was necessary) and stored in a 25,000,000-gallon reservoir. Cooling water pumps would take suction from the reservoirs and pump the water through the heat exchangers in the reactor buildings, from where it would be discharged to the sewers for return to the river.

The "hydraulic scheme" embodied cooling water pumps driven by efficient multi-stage condensing turbines. Pump delivery pressures were to be sufficiently high to pass the cooling water through hydraulic turbines prior to its passage through the heat exchangers. Sufficient power would be extracted by the hydraulic turbines to operate the heavy water circulating pumps. Tunnels were to be constructed from the lower levels of the reactor buildings to ravines outside the areas to produce a gravity head differential between the reservoirs and the water discharge points. This gravity head would be adequate to drive the heavy water pumps under the reduced emergency flow conditions and to provide the reduced emergency cooling requirements. It will be seen that the "hydraulic scheme" incorporated a most reliable and simple method of providing secondary "on-line" power as well as meeting the requirements of production pumping.

The "electrical scheme" involved conventional electric motor drives for operation of the heavy water and cooling water pumps. With this scheme, it was necessary to plan for a smaller, highly reliable independent secondary source of electricity to carry on minimum pumping operations during outages of the production power. Investigations disclosed that the most desirable source of this secondary power would be diesel engine driven generators, and that the power would best be applied to the pumps through a second set of motors on the pump shafts.

After a careful comparison of the two schemes, it was decided to adopt the "electrical" scheme. This arrangement offered more flexibility as regards the possibility of purchasing power or importing it from other areas during

emergencies. It also avoided the problem of constructing the long drainage tunnels with their high associated cost. However, as an outgrowth of the hydraulic scheme, a gravity flow arrangement was developed for supplying emergency water from the reservoir to the process heat exchangers for cooling following an interruption of the production power. The principal feature of this plan involved a slight increase in the level of water in the reservoir to provide the static head required. This plan eliminated the need for electric "on-line" power at the cooling water pumps, leaving "on-line" power only required for the heavy-water pumps.

With the adoption of the "electrical scheme", production electric power requirements for the #100 Areas could be firmly established. It was determined that the peak load for each #100 Area would be approximately 20,000 kw. with an additional 5400 kw. being needed at the river pump houses to supply water to each area. These requirements were incorporated in the plant loads for the over-all power study described earlier. As noted, this study ultimately resulted in the decision to install in each of the #100-RP&L Areas two 11,500 kw. preferred standard generating units taking throttle steam at 600 p.s.i.g. 825°F. and operating condensing with four non-controlled extraction points for feedwater heating. Area steam requirements were adjusted to incorporate generation of this block of power and boiler designs were established accordingly. Later, when the over-all study indicated that generation should be extended to the #100-K Area, duplicate facilities were provided except that 12,500 kw. generators were substituted for the 11,500 kw. units provided in the earlier areas. No changes were made to the turbine or boiler requirements, as it was determined that the earlier area installations could be duplicated.

As previously explained, it was decided to import electric power for the #100-C Area and no generating facilities were provided there.

Building #184-RPL&K - Power Houses

The turbo-generator designs were integrated with boiler plant requirements in each of the #100-RPL&K Areas to produce a common facility for exporting steam and electricity to process. Intensive efforts were made to get high reliability while keeping the cost of the installation as low as possible.

Turbo-generator units were located out-of-doors to eliminate building costs. To afford weather protection, a 1/4 in. thick steel housing was placed over each unit. This was fabricated in three sections - one for the exciter, one for the turbine, and one for the generator. Observation

ports and hinged doors were incorporated in each of the three sections to simplify operation and maintenance.

It is normal practice in the industry to install gantry cranes for servicing turbo-generator units of this type, but due to the high cost of these cranes and their long delivery schedules, (approximately two years) a search was initiated to find alternate handling equipment. A hand-operated A-frame on rails was developed which, when used in conjunction with the area mobile crane, would satisfy the requirement of erectors and operators for maintaining the turbo-generators. This resulted in a considerable saving in investment, as well as meeting scheduled erection dates for the turbo-generators.

While the power houses were to be of Class III construction, it was considered advisable to take reasonable precautions to protect the outdoor turbo-generators against blast damage where expense was not a significant factor. For this reason, bottom-mounted air coolers were used in preference to the more vulnerable side mounted coolers.

Also, to minimize the effect of local difficulties within the generating plants, the design employed "unit" systems as far as practical with minimum cross connection between the units. Each unit consists of one turbo-generator and one boiler with associated auxiliaries.

Studies were made to determine the most economical source of cooling water for the turbo-generator condensers, with three alternatives being considered: (1) use of river water; (2) use of effluent process cooling water; and (3) use of cooling towers.

The use of river water was found uneconomical when compared with the use of cooling tower water or because of the long pipe lines and high pumping head involved. The process effluent cooling water was found to be too warm for economical use, as turbine steam rates would be excessive and turbine capacity significantly decreased. As a result of these studies, cooling towers were adopted as the source of supply of condenser water.

Additional details regarding the design of the #184-RPL&K power houses will be found in that section of this history dealing with steam facilities for the #100 Areas. Also, reference is again made to the Electrical Section, Part II, of this history.

"ON-LINE" POWER

As originally conceived, "on-line" power would be required at two locations to provide the required reactor cooling following

an interruption of the normal production power supply. In this event, it would be necessary to continue pumping cooling water from Bldg. #190 to the Bldg. #105 heat exchangers, and the heavy water pumps in Bldg. #105 would be required to operate continuously at reduced flow to transfer reactor heat to the heat exchangers. A failure of either set of pumps would result in reactor overheating. Flywheels could be installed on the pump shafts to furnish energy immediately following a loss of production power and to delay the loss in flow sufficiently to allow safe curtailment of reactor heat output. However, it would be necessary to maintain the pumps at approximately one-third speed to handle the subsequent heat load. This transition from production to emergency operating conditions would occur in such a short period of time that it was considered necessary for the "on-line" power to be immediately available at all times. Several methods of meeting this requirement were considered.

1. Storage batteries would meet the requirement of being immediately available when required. Large batteries for such service had been used for submarine propulsion, so a similar application was suggested here. However, preliminary data indicated that the batteries would be required to drive motors developing between 600 and 900 horsepower for each reactor building and that the operation might continue for an extended period of time. A battery installation of this magnitude with its charging equipment, ventilation requirements, and Class I housing did not compare favorably, from a cost standpoint, with diesel engine generator sets, and this proposal was abandoned.

2. Thought was given to a small steam-driven generator installation for supplying "on-line" power. However, the problem of housing such an installation in a Class I structure, even with package-type oil-fired or gas-fired boilers, led to unfavorable comparisons with the proposed diesel engine houses.

3. The plan of driving the reactor process cooling pumps with hydraulic turbines (discussed earlier in this volume) incorporated a method of supplying the "on-line" power which would meet all requirements. It was recognized that a hydraulic turbine, backed up with a sufficient volume of water in a reservoir at an elevation which would supply adequate gravity head, would provide a reliable source of power only until the supply of water was exhausted. Since the design for the water cooling system already included a 25,000,000 gallon reservoir, and the hydraulic scheme called for a water turbine to drive the process cooling pumps, the possibility of obtaining the desired gravity head from the reservoir to the turbine discharge for emergency operation was investigated.

It was found that tunnels could be extended from the lower levels of the #105 Buildings to ravines outside the areas to produce a net effective head across the turbine of 30 to 40 feet of water, which would be adequate to deliver the reduced power requirements of "on-line" power following a normal power interruption. Furthermore, the amount of water required to drive the turbine would be essentially the same quantity required to cool the reactor heat exchangers, the water in this case serving a double function of providing "on-line" power from gravity flow and the heat exchanger cooling medium. As discussed earlier, however, the disadvantages of this scheme, one of which was the necessity for the long underground drainage tunnels with their added cost, led to its abandonment in favor of more conventional electric drives for the process cooling pumps.

4. A decision was made to use diesel engine-driven generators for furnishing "on-line" power after considering the various schemes proposed. Diesel engines, being fairly compact, could be housed easily in Class I blast-resistant structures. Units could be virtually self-contained so that their reliability would not be affected by associated major auxiliaries. The "on-line" power supply could be broken down into a number of small independent units for greater reliability. The first cost of diesel engine installations favored this type of equipment, and such engines could be procured in sufficient time to meet the job schedule and would present no unusual problems of operation.

When the choice of diesel engine drives was made, it was recognized that they would have to be operated continuously to meet "on-line" requirements. To make certain that the engines would not fail to pick up their load when called on to do so, it was considered advisable to have them operate under load at all times, thereby eliminating the necessity for excessive governor action or control operation during the transition period following a sudden production power interruption.

As an outgrowth of the hydraulic scheme, a gravity flow arrangement was developed for supplying cooling water from the reservoirs (Bldg. #186) to the process heat exchangers following an interruption of production power. This plan, described in the section of this history dealing with the #100 Area water supply, eliminated the need for "on-line" power at the Bldg. #190 pumps, leaving "on-line" power required only for the process heavy water pumps.

Following the selection of the diesel engine drives for "on-line" power, consideration was given to the most satisfactory arrangement for such facilities. It was known that there would be six process cooling pumps to be driven by

"on-line" power during outages; therefore consideration was given to driving them in groups of three, in pairs, and individually with diesel engines. Electrically, an individual generator was planned for each process pump "on-line" drive. To drive three process pumps with one diesel engine would require coupling the engine to three small generators. If the process pumps were to be driven in pairs, each diesel engine would be required to drive two generators.

The main advantage of limiting the number of diesel engines was one of economy. The chief advantage in having a number of smaller engines was that of diversity with greater reliability. In view of the critical nature of "on-line" power, it was finally decided to employ an individual diesel generator unit for each process cooling pump. These were to be arranged in unit systems in such a way that failure of one would have no effect on the other five units for each Bldg. #105. Two spare diesel generator units were to be available for each #100 Area (one for each Bldg. #108). It was anticipated that each diesel engine in continuous operation would have a load of approximately 130 hp. During emergency periods this load would increase to 160 hp. Momentary starting loads of 180 hp. were expected.

EMERGENCY POWER

While the continued operation of the heavy water circulating pumps in Bldg. #105 was of the greatest importance during production power outages, other equipment, such as fans, valve controls and lights also would require a supply of emergency power. The previous discussion has dealt with "on-line" power for the heavy water pumps only. Power for the other equipment was designated as "emergency" power to distinguish it from "on-line" power. Early load estimates of this power indicated that 1800 to 1900 kw. would be required for each Bldg. #105, and it was originally decided to install three 1000 kw. diesel generating units for each #100 Area, one unit to serve as a spare. More detailed studies of the loads substantiated the original figures, but disclosed that process building safety could be maintained with less than 1000 kw. of emergency power. On this basis it was decided to install only two 1000 kw. units for each #100 Area with the understanding that "emergency" loads not essential to safety would be curtailed when one unit was out of service.

It was determined that a short time lag could be tolerated after a production power failure before emergency power would become a definite requirement. Diesel engine manufacturers felt that there would be no difficulties in using quick-starting

units which would come into operation automatically within ten to fifteen seconds after a failure of production power. On this basis it was decided to procure the quick-starting automatic units and to leave them normally shut down but ready for automatic quick-start.

Building #108-1&2 RPLK&C - Diesel Engine Houses (See page 125)

Because of the great importance of "emergency" and "on-line" diesel generating equipment in maintaining #100 Area process safety, it was decided to house these facilities in Class I blast resistant buildings as close to the main process buildings as possible.

After a study of numerous arrangements, it was decided to provide two diesel engine houses (Bldgs. #108-1 and #108-2) for each #100 Area, the facilities to be separated into two groups to provide a measure of protection by dispersion from enemy attack, sabotage or other disaster. Design specified that these buildings should be located underground with roofs at grade level and with passageways to provide access to the minus 20 ft. level of the process building. Two outside access doors were provided, one small steel door for personnel and maintenance use and one large blast resistant door for moving equipment into or out of the building. Use of the area mobile crane would be required for removing the large door, but it was not anticipated that this operation would be required often. Annexes were added to Bldg. #108-2 to house process emergency cooling water pumps.

The following equipment was specified for each diesel engine house.

- 4 - "On-line" 169 hp. diesel generating units
- 1 - "Emergency" 1000 kw. diesel generating unit
- 1 - 580 c.f.m. instrument air compressor
- 1 - Instrument air dryer
- 2 - Air receivers
- 1 - 580 c.f.m. service air compressor - (Bldg. #108-1 only)

Miscellaneous auxiliaries, switchgear, battery room, control room, lavatory, lighting, ventilating and heating equipment.

It was desired to locate the process instrument and service air compressors and the associated instrument air dryers and air receivers in Bldgs. #108-1&2 so this equipment would be under the constant surveillance of the engine house operators. Also, this equipment required Class I housing to protect it from possible blast, instrument air being a critical requirement for process controls. This location was also convenient because of the proximity of the compressors to the "emergency" power source and to the cooling water supply serving the diesel generators.

Building No. 108-1RPLKC - ENGINE HOUSE

Gibbs & Hill Inc. - Engineers, Constructors - New York - Los Angeles

Electrical Gear

As the Bldg. #108 requirements took shape, it was found desirable also to house certain electrical equipment in these structures.

A storage battery room was provided with batteries for starting the engines and for electrical substation operation. Space also was allocated for battery charging equipment, as well as switchgear associated with the diesel generating unit and auxiliary apparatus. (See the Electrical Section, Part II, of this history for details of this phase.)

Engine Procurement

Throughout the design of Bldg. #108, emphasis continued to be placed on reliability of equipment under all conditions of operation. This, of course, depended largely on the reliability of the diesel engine prime movers themselves. Previous investigations of engine reliability had indicated that engines could be obtained of sufficiently high quality to fulfill the needs for "on-line" power generation. A great deal of study and investigation was made, however, in the course of selecting the vendor for the "on-line" engines. Only those engines were considered which were believed to be designed for strictly heavy-duty service.

The products of many vendors were given consideration with the list eventually being reduced to those of four different manufacturers. When bids from these vendors were compared, it was found that one engine, a production line item, had a great economic advantage over the three competing engines which were not being built in quantity. Delivery dates also greatly favored the production line engine. On the other hand, this engine had not been released for commercial use until 1948, and at the time of this investigation no installation could be found where it had been in continuous service for extended periods to establish the service record desired. Inability to find such a service record created a problem in evaluating the engine. Competing engines were heavy duty units by reputation, and satisfactory operating records for two of these types were checked at installations visited.

It was finally decided to accept tentatively the production line engine bid because of the great economic advantages and better delivery, but to set up two of the engines on endurance tests to establish whether or not they would be adequate for "on-line" power generation. All wearing parts were micrometered prior to the tests. After 7-1/2 months of continuous operation, except for oil changes and inspections, each engine had approximately 5400 hours of

operation and was dismantled for complete inspection. Both engines were found to be in excellent condition and fully adequate for the proposed requirements.

While the 1000 kw. units selected were not expected to operate continuously, their reliability also was of great concern. Before placing orders on the low bidder for these units, field trips were made to investigate actual operating experience and to determine if the units were adequate for the intended use.

Cooling Water Supply

Cooling water was required in each of the diesel engine buildings to cool the jacket water and lubricating oil of the "emergency" and "on-line" diesel engines, as well as to cool the air compressors and air driers. The possibilities of using radiators for cooling this equipment were investigated, but the need for providing blast-proof housings around the radiators was found to add considerably to the cost of such a system. It was decided finally to use the Bldg. #105 cooling water supply headers as a source of cooling water for Bldg. #108. The same degree of reliability had been provided in this water supply as was required for Bldg. #108 operations, making it an ideal source.

Disposal of Engine Exhaust Gases

In each of the #100 Areas, the diesel engine buildings were located adjacent to Bldg. #105. In the arrangement developed for the #100-R and #100-P Areas, the roofs of Bldgs. #108-1&2, which were at ground level, were adjacent to the process building main air intakes. The originally contemplated scheme of running individual stacks from the diesel engines through the Bldg. #108 roofs and discharging to the atmosphere could possibly contaminate the air entering the intakes. Therefore, considerable study was given to evaluating alternative arrangements of handling the engine exhaust gases. Three schemes were considered.

1. Provide a header on each building roof to collect the exhaust gases and a duct to carry these gases to a remotely located exhaust stack.
2. Collect all exhaust in a header, as in Scheme 1, and pass the gases through a scrubber to remove the undesirable elements. (Scrubbers are used on diesel engines for mining operations, indicating this system could be used.)
3. Collect the exhaust gases in a header, as in Schemes 1 and 2, and convey these gases to a stack located on

the Bldg. #108 roof, this stack to be of such a height and so located as to prevent contamination of the air inlet locations.

An economic comparison of the three schemes indicated that Scheme 3 would be the least costly. Further study indicated that, in all likelihood, this scheme would also be satisfactory from the standpoint of preventing contamination at the air intakes and would not interfere with the adoption of one of the other schemes at a later date if it was found to be inadequate. On this basis, Scheme 3 was chosen, with the design laid out in such a manner that should the results be inadequate, the header could be extended to a scrubber or to a remote stack.

Lubricating Oil Handling Facilities

Due to the need for extreme reliability of the "on-line" diesel engines and the associated high availability factor required, it was necessary to install auxiliary equipment which would make the addition and changing of lubricating oil a simple function for the operator. A central oil storage tank with a supply pump was provided in each engine house and piped to each engine. Engine crankcase drains were piped to a central "used-lubricating oil" receiver. Piping systems were provided for filling and emptying these tanks from trucks adjacent to the Bldg. #108 roofs.

A simple Bowser dispenser was provided for storing the new lubricating oil for each 1000 kw. "emergency" diesel generator. However, the used lubricating oil system for the "on-line" equipment was designed to include the used lubricating oil from the "emergency" equipment as well.

Since the lubricating oil used in the "on-line" diesel engines would be an expensive type and considerable quantities would be consumed, consideration was given to reclaiming facilities for this oil. However, such an arrangement was found to be uneconomical because of the difficulty of refining the oil and maintaining the proper amount of each additive.

Fuel Oil

Based on AED requirements (approximately 30 days' supply of fuel oil storage for the "on-line" diesels), it was decided to locate two 10,000-gallon fuel oil storage tanks at each Bldg. #108. These were separated and buried underground for maximum protection and a double header system was designed to carry the oil from the tanks to Bldg. #108 distribution pumps which would be used to fill the engine day-tanks. Each engine was provided with a day-tank of sufficient

capacity to maintain operation for approximately two eight-hour shifts. In the case of the 1000 kw. "emergency" units, which are subject to intermittent duty only, this requirement later was reduced to approximately eight hours' operation. Provisions were made for pumping fuel oil from one Bldg. #108 to the other in the same area in case of emergency.

Compressed Air

As noted, it was decided to locate three process air compressors in Bldg. #108 for each area. Two compressors were installed in Bldg. #108-1 and one in Bldg. #108-2. Also an air drier and two air receivers were installed in each building. All compressors are duplicate 480 c.f.m., 125 p.s.i.g. units equipped with carbon rings to supply oil-free air.

The compressed air loads were divided between instrument and service air uses. Although all air was obtained from the common compressor discharge header, only the instrument air was dried. Priority was given to the instrument air service, and automatic shut-off valves were placed in the service air lines leaving the buildings to close if the system air pressure should fall to 100 p.s.i.g. Isolating the service air users left all available capacity for use in the more critical instrument air service.

Sound-proofing

The problem of noise in Bldg. #108 was given consideration early in the design. However, at that time it could not be determined whether sound-proofing would be required. Experience gained from observation of other diesel plants in operation indicated that with 4 cycle non-supercharged engines (the type to be used for "on-line" continuous operation) the need for sound-proofing would be marginal. On this basis, it was decided that no action should be taken until one of the diesel engine houses was placed in operation and actual noise measurements made. However, consideration was given to the types of sound-proofing that might be adopted, if required, and considerable information was accumulated. Early in 1953, it was possible to obtain readings in one of the diesel engine rooms upon which to base further action. It was found that the noise level in the room with the engines operating was above that which could be safely tolerated by an operator in constant attendance, and three schemes were investigated to overcome this difficulty:

1. Install sound-proofing material on the ceiling and walls to absorb noise from the room;
2. Provide cabinet type enclosures over each diesel engine; or

3. Provide a sound-proof enclosure around the operator's control center to furnish a space suitable for operator occupancy.

Scheme 1 was rejected because it was found that insulation of the walls and ceiling would not reduce the noise to within tolerable limits in the room. Scheme 2 was rejected because of its high cost and lengthy development time and because of the interference such a cabinet around each diesel engine would have on normal operation and maintenance work. Scheme 3 was accepted because of its low cost, its simplicity, and because it was thought that it would give the operator adequate protection from noise. Operators and maintenance men can wear individual ear protection at times when they have to be in the noisy areas surrounding the engines. The noise level in the operating enclosure was reduced to approximately 80 decibels, with noise levels in the engine room ranging from 102 to 107 decibels.

Heating and Ventilating

Supply and exhaust fans were installed with the necessary distribution ducts to adequately ventilate the engine rooms (and the emergency pump room built integrally with the #108-2R building). Unit heaters were provided for heating during the winter season.

Redesign for #100-LK&C Areas

A change in design of Bldg. #105 in the #100-LKC Areas resulted in the relocation of Bldgs. #108-1 and #108-2 for these areas. The change in location made it necessary to review Bldg. #108 designs, and the following changes were made.

1. Individual exhaust stacks extending through the Bldg. #108 roofs were provided for each of the engines. This arrangement could be substituted for the header and single large stack used in the earlier areas because the major process building air intakes were no longer adjacent to the Bldg. #108 roofs.

2. It was possible to save concrete and steel by making the building walls lighter than for the #100-R and #100-P Areas. Ground water level in the #100-LKC Areas was relatively lower, giving less buoyancy effect for the buildings and making the reduction in weight possible.

3. Standby cooling pumps for the 1000 kw. diesel generators were eliminated. This change came as a result of reconsideration of the desirability for such units as compared with the cost of their installation.

4. Fuel oil truck and tank car unloading facilities were consolidated at one location instead of being separated as in the #100-R and #100-P Areas. This was made possible by the new railroad track locations in the #100-LKC Areas.

Building #108-3 RPLK&C - Diesel Fuel Oil Unloading Facilities

In addition to the two 10,000-gallon diesel fuel oil storage tanks provided for each diesel engine house, the Explosives Dept. - Atomic Energy Division requested that a 100,000-gallon central storage facility be provided for diesel fuel oil to back up the individual storage supplies. This facility was designed to receive oil from either tank cars or tank trucks, and to transfer oil to tank trucks for distribution to the #100 Areas. Also, it was designed with safety provisions regarding oil contamination and bombing attacks, but was not designated as a Class I facility, since oil could still be delivered directly to the #100 Area storages by tank truck in the event of loss of the central storage facilities.

As design progressed, this scheme was changed to provide a more desirable arrangement. The proposed central oil storage of 100,000 gallons was replaced by two 10,000-gallon oil storage tanks in each #100 Area (separated from the diesel engine house storages). These reserve storage facilities were combined with fuel unloading facilities and designated Bldg. #108-3 RPLK&C. Provisions were made for unloading fuel oil from both trucks and railroad cars. Provisions were made also at these points for filling tank truck, and for sampling the oil as it was received to test and maintain the quality. Pump facilities and connecting pipe lines were provided for transferring the oil from the Bldg. #108-3 storage tanks to the Bldgs. #108-1&2 diesel engine house storage tanks after sampling.

Original design specified that the storage tanks and pumping facilities for Bldg. #108-3 RP should be located underground to provide a measure of protection against blast. However, re-evaluation of the cost of this type of construction as compared with above-ground storage tanks resulted in the tanks and pumps being placed above ground in the #100-LKC Areas. In the #100-RP Areas it was necessary to locate the truck unloading and tank car unloading spots separately because of the layout of the roads and railroads in these areas, but in the #100-LKC Areas a revised system of rail facilities allowed a common unloading spot to serve both tank trucks and tank cars. This eliminated the need for one unloading pump and several hundred feet of unloading line.

Buildings #501-RPLK&C - Miscellaneous Diesel Engine-Driven Generators

In each of the #100 Areas a 100 kw. diesel engine driven electrical generating set was installed to supply emergency fence lighting and emergency power for the communication systems. These units were purchased for outdoor installation and no housing was necessary. A small engine-mounted fuel tank was provided, since the units would be used only intermittently and the tanks could be filled periodically during emergencies by trucks from the #100 Area diesel fuel storage facilities.

Additional details regarding the functioning and purpose of these units will be found in the Electrical Section of this history.

ELECTRIC POWER SUPPLY - #200 AREAS

GENERAL

Since the #200 Areas require a fairly large amount of process steam at 110 p.s.i.g., it appeared likely that the generation of electrical energy as a by-product might be justified, and two schemes were investigated. Scheme 1 assumed the installation of three 60,000 lbs. per hour boilers producing 300 p.s.i.g. saturated steam. Scheme 2 also assumed the installation of three 60,000 lbs. per hour boilers but with each designed for the generation of steam at 600 p.s.i.g. and 750°F. In addition, Scheme 2 involved the installation of a 3000 kw. back pressure turbo-generator unit with the necessary auxiliaries, this unit being designed to exhaust at 125 p.s.i.g. so that steam could be supplied to the process at 110 p.s.i.g. This permitted an average generation of 2280 kw.

The installation of the 3000 kw. non-condensing turbo-generator required by Scheme 2 would have resulted in an additional investment of approximately \$560,000, and the operating savings involved were found to be insufficient to justify this additional expenditure. Therefore, no further consideration was given to the generation of by-product electric power in either #200-F or #200-H Area.

EMERGENCY ELECTRICAL GENERATION

Emergency diesel generators were installed as required in individual buildings throughout the #200-F&H Areas. These included a 600 kw. capacity unit in each of the Bldgs. #221-F, #221-H, #292-F, and #292-H; one 100 kw. capacity unit in Bldg.

235-F, and two such units in Bldg. #772-F; and a 20 kw. capacity unit in Bldg. #701-F. A 100 kw. capacity unit was provided for Bldg. #232-F and a 260 kw. capacity unit obtained for Bldg. #232-H. A change in process planning eliminated the immediate need for this latter unit and it was placed in storage for possible future use. One 96-1/2 hp. diesel engine was obtained for use in each area (in Bldgs. #905-F&H) for emergency operation of well pumps through angle drives. All of these diesel units, with the exception of the 20 kw. unit for Bldg. #701-F, were considered of sufficient importance to be housed in Class I buildings.

Emergency diesel generator busses in Bldgs. #221-H, #292-H and #701-1H were also interconnected. This was done to provide means for operating emergency equipment with a minimum number of generators during possible long periods of normal power outage and after emergency power requirements had been reduced. No provision was made for synchronizing the power output of any of the generators. Interlocking was provided so that parallel operation of any two of the units would not be possible.

Emergency diesel generators provided to serve Class I buildings were equipped with radiator cooling, the radiators being located in Class I housing adjacent to the buildings served.

Fuel oil storage for all diesel generators in the #200-F Area was provided in Bldg. #619-F. Supply to the units in Bldg. #221-F and #292-F was provided by means of two electric driven pumps and a pipe line, both of which were designated as Bldg. #910-F. The pumps were located in Bldg. #619-F. Oil supply to the other diesel generators in the #200-F Area was by means of truck delivery. A similar, but separate arrangement was provided for the diesel generators in the #200-H Area.

STEAM SUPPLY

GENERAL

Although the total capacity of the steam generating facilities required for the plant was determined ultimately to be approximately 3,000,000 lbs./hr., the development of an over-all plan for providing these facilities was much simpler than the development of the over-all electric power supply arrangement. It was apparent from the beginning that individual boiler plants would be required for each process area. Central steam generation was not practical because of the long distances between the various loads and the number of locations involved. Also, it was desired to

have the steam supply as close as possible to the users for greater reliability.

Before final steam requirements could be established for each area, it was necessary to know what electric power generation facilities would be installed in the area, as well as what the process and heating steam requirements would be. Steam requirements for auxiliary drives and feed water heating also had to be established. It will be noted that in many cases steam requirements were among the last items to be firmly established because of the dependence of steam quantities on other power services to be furnished.

Page 21 in the "Basic Requirements" section of this volume presents in tabular form the steam requirements as developed for each area. Page 25 of the same section, is a tabulation of the start-up dates required for the area facilities which became the basis for design schedules.

Several major decisions had to be reached during the design development of each of the area steam installations. In general, the primary considerations were as follows:

1. Number and size of boilers;
2. Boiler steam pressure and temperature;
3. Type of fuel;
4. Type of firing equipment;
5. Type of coal handling equipment;
6. Type of dust and ash handling system;
7. Design of boiler auxiliary equipment for handling combustion air, furnace gases, and feedwater; and
8. Arrangement and type of housing for the facilities.

BOILERS

In determining the size and number of boilers for each area, three general policies were observed. First, the capacity provided was to be the minimum amount necessary to carry the winter peak loads, with no spare capacity provided for this condition. Secondly, the number of units was to be selected so that one unit at a time could be taken out of service for maintenance during the summer months. Third, and most important, the arrangement provided was to be the most economical one for the job.

STEAM PRESSURES AND TEMPERATURES

Boiler steam pressures and temperatures were selected primarily on the basis of greatest economy consistent with meeting process needs. Where electric power generation had

been involved (in the #400 Area and #100-RPLK Areas), the pressure and temperature requirements for economical generation became a controlling factor. In the #400 Area, particularly, where the opportunity was present for generating a substantial amount of by-product electricity by passing the large quantities of process steam through non-condensing turbines enroute to the points of use, higher pressures and temperatures were found desirable. In areas such as the #100-C Area, where no electricity was to be generated, the steam pressures and temperatures selected were those which afforded the most economical compromise between the cost of boiler house facilities and the cost of steam distribution systems. In this instance, a boiler design pressure of 300 p.s.i. saturated was found to be most economical although a lower pressure would have been adequate to meet process requirements. Here the cost of the outside steam distribution system had a pronounced effect on the final decision.

FUEL

Numerous studies were made throughout the entire design period to determine the availability and desirability of different fuels or combination of fuels for use in the various boiler houses. In conjunction with these studies, the possibility of natural gas as an alternate fuel for "on-line" diesel generating equipment was also considered.

Initial fuel studies indicated that natural gas could not be given immediate consideration as the plant fuel because of the uncertainty of obtaining an adequate supply in time for plant operations. The possibility that the Southern Natural Gas Company might be able to furnish the gas required was based on the following contingencies.

1. That the Southern Natural Gas Company could procure the additional gas reserves from existing holders (largely petroleum companies) located on the southern coastal areas of Louisiana.
2. That du Pont and/or AEC could prevail upon the Federal Power Commission to waive any right that the Federal Power Commission might have over the sale of gas by such petroleum companies willing to furnish gas to the Southern Natural Gas Company for delivery to AEC at the Savannah River Plant.
3. That du Pont and/or the AEC would assist the Southern Natural Gas Company in securing steel pipe, compressor stations and other equipment necessary for the Southern Natural Gas Company to take the additional load.
4. That the Federal Power Commission's approval could be obtained (a) to construct the 200-mile line

required to pick up new gas reserves in South Louisiana and (b) to change the size of the (then) currently authorized line from Augusta to Aiken from 10 in. to 14 in. diameter pipe. (It was estimated that peak consumption of gas would be approximately 60,000,000 cu. ft. per day).

Should the gas become obtainable it was thought quite improbable that the Federal Power Commission would approve the furnishing of a firm gas supply where it was indicated that another fuel could be substituted in an emergency, as distinct from a situation where natural gas was to be used as a raw material for process. On this basis it would be necessary to install secondary facilities for burning coal or fuel oil. Because of the uncertainties and the long delay anticipated before answers could be obtained and because of the uncertainty of gas costs, further studies were restricted to oil and coal for initial operation. However, as will be discussed later, the use of natural gas as a fuel was reconsidered from time to time for certain power facilities.

Cost comparisons indicated that coal was preferable to oil as a plant fuel, particularly if all of the electric power required was to be generated on the plant site. Other factors favored coal over oil as a fuel.

1. To obtain residual fuel oil in sufficient quantities would present difficult problems even at the time of plant start-up. A survey of the oil industry indicated that residual oil demands were in balance with the residual oil quantities available. The trend in modern refineries appeared to be such that in the future even less residual fuel oil would be produced as a by-product. In the event of a national emergency, the oil consumption by essential users would increase, placing a great strain on the supplies. From this standpoint it appeared that the plant should have coal burning facilities.
2. From the standpoint of bomb resistant storage, coal was preferred to oil. Bomb resistant storage of gas in sufficient quantities appeared impractical.
3. In the event of a national emergency both the distance to the source of supply and the availability of transportation equipment would favor coal over oil unless long oil pipe lines were constructed, which would make this scheme very expensive.

Therefore, it was decided to adopt coal firing for at least the first steam generating facilities designed for the Savannah River Plant. Studies were made for the later areas

as their designs became active, and in each case coal was chosen for these areas also, primarily because of economic reasons. Natural gas was again seriously considered for the #100-C Area boiler house, but was ruled out also because of economic considerations.

A further study was initiated in 1953 to determine the suitability of natural gas as a secondary fuel for the various plant steam generating facilities. This study indicated that some operating savings would be obtained by the use of natural gas, but that the cost of the additional facilities necessary to burn gas could not be economically justified. Furthermore, the unpredictable variations in price differential between coal and gas, together with uncertainty regarding the frequency and duration of interruptions to gas supply, introduced elements of speculation that were undesirable (an interruptible supply being the only type then obtainable).

FIRING EQUIPMENT

After the choice was made regarding use of coal as the fuel, it was necessary to determine the type of firing equipment to be employed. The alternatives considered were: (1) pulverized coal firing; (2) spreader stoker firing; and (3) other stoker arrangements. The choice of a firing method was made after consideration of the type of coal to be burned, characteristics of the loads to be served, and the economics involved.

For the large boiler units in the #400 Area power house, where capacities of 325,000 lbs./hr. were incorporated in a single boiler, pulverized coal firing was selected as the best method. In each of the other areas, where much smaller units were used for steam generation, spreader stoker installations were found to be most economical. Traveling grates were used in each of the boiler installations employing spreader stokers with the exception of the #100-C boiler house, where a reciprocating grate of new design was installed. Considerable information on this new grate was collected before the equipment was selected, and assurances were obtained from the grate manufacturer that full credit on a conventional type grate would be allowed if the new grate did not prove entirely satisfactory. Use of this type grate resulted in some investment savings and would have resulted in greater savings from smaller space requirements had it not been thought necessary to allow full space for possible replacement with a conventional grate if necessary at a later date.

COAL HANDLING EQUIPMENT

The type of coal handling equipment chosen was based primarily on economy within the limits consistent with storage requirements and the reliability desired. Operating and maintenance costs were taken into account, as well as initial investment costs. Where permanent facilities were involved, as in the #100, #200, and #300/700 Areas, additional investment was favorably considered if it would be paid off by operating savings within 10 years. In the #400 Area, where the eventual disposition of the full plant capacity was doubtful, it was desired that incremental investment be paid off in less than five years by operating savings. The outcome of the studies for each area resulted in the installation of somewhat conventional coal handling equipment. Excessive operating costs ruled out the use of the very elementary and simple type coal handling facilities, even for the small boiler plants.

DUST AND ASH HANDLING SYSTEMS

Dust and ash handling systems were selected on a similar economic basis. Where water was readily available, as in the #200 Areas, and/or the quantities of coal burned were large, as in the #400 Area and #100 Areas, wet type sluicing systems with ash storage ponds were found to be most desirable. In the #100-C Area and the #700 Area, where smaller amounts of coal were burned, it was found more economical to install dry-type ash and dust handling systems with an ash storage silo for temporary storage until final removal could be made by trucks.

AUXILIARY EQUIPMENT

In general, all of the power house auxiliary equipment was chosen on the basis of economics consistent with the requirements. Steam driven auxiliaries were provided where indicated by heat balance considerations or for reliability during electrical outages.

Low stacks were preferred to reduce visibility of the installations and to lessen blast hazards, sufficient height being provided only to obtain proper disposal of the combustion products. Induced draft fans were installed to exhaust the combustion gases from the boilers and discharge them to the stacks.

In all cases deaerating feed water heaters were provided to remove oxygen from the feed water and thereby limit boiler corrosion. Chemical treatment facilities were provided to properly condition the boiler water.

ARRANGEMENT

Where possible, equipment was installed out-of-doors to reduce building costs. All boilers were of the outdoor or semi-outdoor type, with only the firing aisles enclosed to facilitate operation.

The more significant of these phases of design development will be covered individually in the following discussions of the area facilities.

STEAM SUPPLY - #400 AREA

GENERAL

The first estimates of process steam requirements for the #400 Area indicated steam loads of 420,000 lbs. per hr. at 300 p.s.i.g., 1000 lbs. per hr. at 150 p.s.i.g., 55,000 lbs. per hr. at 100 p.s.i.g. and 125,000 lbs. per hr. at 50 p.s.i.g. Due to the nature of the process being served the steam was to be saturated and no condensate was to be returned.

Most of the loads were to be continuous and steady in character which suggested the use of non-condensing turbo-generators to provide part of the area electric power requirements. However, boiler studies could not be delayed until firm data were available on generating facilities, so prices were obtained from leading boiler manufacturers for alternative schemes. The first arrangement specified 400 p.s.i.g. boilers to furnish process steam only; two additional schemes specified higher pressure boilers which could be used in conjunction with the generation of electricity.

In February, 1951, it was determined that the generation of by-product electricity in this area could be justified on the basis of savings in operating costs, these savings being sufficient to justify the additional investment required for turbo-generator installations and added boiler features. The amount of electricity to be obtained in this manner, however, was not adequate to operate the area, and it was necessary to arrange for a supplementary source of electric power. A survey of the public utility systems serving the region disclosed that little or no firm purchased power could be made available in time for the start-up of #400 Area operations. As a result it was necessary to proceed on the basis of generating all of the #400 Area electrical requirements. Concurrence in this course of action was received from the Atomic Energy Commission in late February, 1951.

View from SEWER SIDE

Building 484-D - POWER HOUSE

Gibbs & Hill Inc - Engineers - Constructors, New York - Los Angeles

View from Switchyard.

Building 484-D - POWER HOUSE

Lillib & Hill Inc - Engineers - Constructors, New York, Los Angeles.

With the question of electric power generation settled, it was possible to make firm decisions regarding boiler procurement. Heat balances indicated that three 325,000 lbs. per hr. boilers, designed to operate at 900 p.s.i.g., 750°F. total temperature with a feedwater temperature of 250°F., would be adequate for the installation and, in fact, would produce sufficient steam (at overload ratings) to supply full process requirements with one boiler out of service. The boiler survey in progress had already indicated that boilers of this type could be obtained from one vendor at the lowest price per pound of steam. Furthermore, this vendor had recently built several boilers of identical design, and boiler drawings were immediately available. It was anticipated that the boilers could be duplicated, delivered and erected in time to produce steam in March, 1952, the date required. Accordingly an order for these boilers was placed in February, 1951.

As design progressed, it was found desirable and possible to make several alterations to the boilers to adapt them better to the specific facility being designed. These modifications included changing to tubular air heaters from a regenerative type and providing an additional pulverizer per boiler. The changes were made primarily to obtain greater reliability and flexibility.

The boilers, as purchased, were designed for indoor installation and, while many of the parts and accessories were suitable for outdoor service, the boiler itself was not. Since it was desired to install the boilers out-of-doors primarily for reasons of economy, a review was made of alterations necessary for adapting the boilers to outdoor use. It was found that major difficulties would be encountered where the tubes entered the top of the boiler from the drum. Waterproofing at this point would prove very difficult so a simple protective roof was provided over the top of each boiler to meet this need. All other sections of the boiler were placed out-of-doors with the exception of the fronts which became part of the enclosure for the firing aisle.

It was planned originally to provide steam driven auxiliaries for the power plant. However, heat balance calculations and estimates indicated that electric motor drivers would be more economical in the over-all picture and a decision was made to incorporate these in the design.

In March, 1951, a revision in the process loads resulted in new maximum steam requirements as follows; 560,000 lbs. per hr. of steam at 330 p.s.i.g., and 150,000 lbs. per hr. of steam at 40 p.s.i.g. These new figures reflected an over-all increase in steam requirements of 110,000 lbs. per hr. and

an increase in total heat requirements of 133-1/2 million B.t.u. per hour. Investigations were made to determine the best means of altering the equipment on order to meet the new heat requirements. It was found that superheaters capable of producing a final steam temperature of 900°F. could be used in the selected boilers without changing the design of the other pressure parts. However, to keep furnace heat liberation within the manufacturer's allowable limits, it would be necessary to increase the feedwater temperature or raise the allowable furnace operating temperatures and use coal with higher ash fusion temperature than that specified. Increasing the feedwater temperature would improve the heat cycle efficiency, and by using steam from the high pressure turbine exhaust in a high pressure heater the feedwater temperature could be increased to 430°F. Based on raising the feedwater temperature to 430°F. and increasing the size of the superheater to produce 900°F. total temperature steam, the manufacturer would guarantee the boiler for a continuous capacity of 330,000 lbs. per hr. when burning coal having the specified 2000°F. ash fusion temperature. These changes were incorporated in the design since it was found that the high pressure turbines contemplated for electric power generation could be obtained for operation at the new steam conditions.

The heat balances, using the new steam flow quantities, showed that the process requirements could be satisfied with the authorized equipment, but it was evident that the loss of a single boiler would necessitate the curtailment of the process to a proportionate degree. This was in direct contrast to the original scheme, which allowed full production with one boiler out of service. This deficiency in design was reviewed with AED to determine if the basic concept of the design should be revised or whether additional boiler capacity should be provided. The review ultimately resulted in a decision, in early May 1951, to provide a fourth boiler as a standby unit duplicating the units already on order.

Development of the over-all project electric load growth studies indicated that additional electric power would be required for initial operation of the #100 Areas on the planned and scheduled dates. A decision was made, late in May 1951, to install additional condensing generation facilities in the #400 Area and to utilize the fourth boiler to obtain maximum electric power output during periods available.

BUILDING AND LAYOUT

Although an outdoor design was desirable for this power house to reduce investment costs, it was found that the only turbo-generator equipment with acceptable delivery dates was designed for indoor installation. As a result, the power

house was designed primarily as an indoor plant with only the boilers and boiler fans installed out-of-doors. The turbine room and auxiliaries were installed in the enclosed space, as were four 500 c.f.m. carbon ring-type air compressors for plant instrument air and two 500 c.f.m. oil lubricated type compressors for plant service air. The building was constructed with transite siding over steel framing.

An individual reinforced concrete stack was provided for each boiler, and dust collectors were installed at the air heater outlets to limit dust emission from the stacks. A hydraulic jet pump system was provided to convey both furnace ash and fly ash directly to a storage area approximately 1000 feet southwest of the power plant. Because this system omitted the normal intermediate transfer sump and pumps, it was inspected carefully in operation at other plants before being adopted.

Conventional belt conveyor type coal handling equipment was provided capable of handling 350 tons per hour. In addition, the structures were designed to provide space for the future installation of a parallel belt conveyor system of the same capacity. This second system would be required in the event of future expansion to six boiler units.

Individual boiler coal bunkers were sized for 24-hour storage. Larger bunkers were considered but could not be justified economically. A coal storage area of sufficient size for a 6-month storage of coal, if desired, and automatic coal sampling were provided. This sampling equipment was considered necessary to check the quality of coal which was to be purchased on a heat content (B.t.u. per lb.) basis.

A central control room was provided for the entire power house to reduce the number of operating personnel required.

Expansion

From the outset, the possibility was recognized that the power facilities might eventually be expanded. Early planning information also indicated that a duplicate process area might be required. Accordingly, the power house and its facilities were designed for possible expansion to twice the initial size.

Electrical

Steam and electric power generating equipment were integrated in a common operating facility designated as Building #484-D, Power House. Development of design for the turbo-generators has been covered earlier in this section of

the history. Reference is made to Part II of this volume for further information on the development of the electrical design.

STEAM SUPPLY - #300/700 AREAS

GENERAL

Preliminary load data for the #300/700 Areas, based on many assumptions before building designs were firm, indicated that peak process and heating steam requirements would be approximately 100,000 lbs./hr. in the winter and 30,000 lbs./hr. in the summer. Revisions were made as firm data were developed, and the final plant design was based on an estimated winter peak steam requirement of 110,000 lbs./hr. and an estimated summer peak steam requirement of 45,000 lbs./hr. These loads were broken down as follows:

<u>BLDG.</u>	<u>WINTER PEAK LBS./HR.</u>	<u>SUMMER PEAK LBS./HR.</u>	<u>SUMMER MIN. LBS./HR.</u>
#313M	11,930	7450	0
#320M	10,450	5664	0
#701-1A	375	75	0
#702-A	345	100	0
#703-A	12,700	1400	0
#708-A	4900	2900	0
#709-A	205	90	0
#713-A	1300	75	0
#714-A	850	0	0
#716-A	4250	0	0
#717-A	2860	1190	0
#719-A	1620	445	0
#720-A	1215	300	0
#722-A	1500	375	0
#724-A	1750	1075	0
#725-A	560	0	0
#733-A	120	0	0
#735-A	5100	1500	0
#736-A	405	70	0
#773-A	28,000	8500	3800
#776-A	5000	4900	0
#704-M	1230	620	0
#777-M	7000	3500	0
#785-A	0	17,500	4900
#784-A	15,500	8600	3000
Max. Boiler Output Req'd with Diversity Applied	110,000	45,000	11,700

Because most of the steam was to be used for heating, periods were anticipated during the summer months when the load would be so low that stable boiler operation would be difficult. To overcome this condition, steam-driven pumping facilities (with a motor-driven standby pump) were specified for Building #785-A Cooling Tower to enable the boilers to be operated at all times with a reasonable minimum load.

BOILER HOUSE, BLDG. #784-A

It was desirable to locate Bldg. #784-A centrally with regard to the steam loads to be served. At the same time it was desirable to keep the building as inconspicuous as possible from the Administration Area. The location was finally selected after consideration of both of these factors.

Since the steam loads to be served were not especially critical in nature, it was established that Class III building construction would be adequate for this boiler house.

For reasons of economy it was desirable to use outdoor construction where possible. Since the boiler house was scheduled to begin operation by March 1, 1952, however, the design was necessarily influenced by this early start-up date. The resultant design was semi-outdoor in nature. The steam generators were located out of doors but were covered with a small shed-type roof. The boiler fans, air heaters, dust collectors, ash handling system, deaerators and coal storage bunkers also were located outside. The front walls of the boilers formed part of a wall for the building housing the firing aisle, electrical equipment, miscellaneous auxiliaries, pump room and office space. In the interest of economy the design was made as compact as possible, but it was necessary to anticipate in design an eventual expansion to double the original size.

A number of studies were made to determine the most economical arrangements and characteristics for the equipment.

1. A cost comparison was made between alternate designs for 300 p.s.i.g. and 200 p.s.i.g. steam distribution pressure. A distribution pressure of 300 p.s.i.g. was found to be more economical when the cost of the distribution system was taken into account as well as the cost of the steam generating facilities.
2. A study was made comparing the cost of; (a) a plant designed with a firing floor at ground level having pits for the ash hoppers and stoker wind boxes, with (b) a plant having a raised firing floor with ash

hoppers and wind boxes above ground. It was decided to locate the firing floor above the grade floor since this arrangement resulted in the lowest plant cost.

3. A cost study was made comparing; (a) coal scales for each boiler, with (b) a single weightometer on the belt conveyor of the coal handling system and simple coal meters in the coal pipes to each stoker hopper from the bunkers. This study indicated that the weightometer, combined with the coal meters, would result in a saving and would provide acceptable coal metering.
4. The matter of condensate return for this plant was investigated. Because of the wide-spread distribution of the plant loads it was found that savings to be gained by returning the condensate would not justify the investment costs for such a system. It was decided, therefore, to return no condensate but to furnish 100 per cent feedwater make-up for the boilers. Well water make-up was supplied to the deaerator by service water pumps taking suction from the ground storage tank, Bldg. #782-A. Due to the relatively low softness of the well water and the low load factor on the boilers, it was not considered necessary to provide boiler feedwater treating and softening equipment. Space was provided, however, for the possible future addition of such equipment, if necessary. Internal sulphite and phosphate treatments were incorporated in the design to control scale formation and/or corrosion within the boilers.

Boilers of 60,000 lbs./hr. capacity were selected. Two boilers of this size were adequate to carry the anticipated winter peak steam load, while the summer peak steam load could be carried by one boiler with the other unit out of service for maintenance. Spreader stoker firing (with coal as a fuel) was selected as the most economical. A 100-ton capacity steel coal bunker was provided for each boiler based on the necessity of carrying approximately 75 per cent of the peak boiler load for a period of 24 hours. A conventional type coal handling system was included in the design with a feeder capacity of 66 tons per hour and a crusher capacity of 80 tons per hour. The primary coal storage area was made sufficiently large to accommodate a 60-day supply of fuel.

Mechanical dust collectors were incorporated in the design and provision was made for returning the heavier particles collected to the furnace for reburning. It was decided also to reinject the returns from the last boiler pass to the furnace. A pneumatic ash and dust handling system was provided to remove both furnace and fly ash from the boilers,

Building No. 784-A - BOILER HOUSE

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this system incorporating an ash storage silo to 45 tons capacity located along the railroad spur west of the power plant. A rotary dustless unloader of the mixing drum type was included, complete with a discharge chute arranged for loading either railroad cars or trucks. The capacity of this system was approximately 10 tons per hour.

Three boiler feed pumps were provided, two being steam turbine-driven and the third being electric motor-driven. Each of the pumps was large enough to serve one boiler at full load.

The auxiliary bay was completely enclosed and covered by a flat roof with walls constructed of transite siding. Some of the equipment for the #300/700 Area water supply and water treatment facilities were housed in this auxiliary bay, including three domestic water pumps, four service water pumps, two firewater pumps, and two instrument air compressors for the power plant. Each of the compressors was of the carbon ring type and capable of delivering 100 c.f.m. at 115 p.s.i.g. A steam driven 100 c.f.m. air compressor was furnished as an emergency back-up.

A small amount of office space, together with space for the internal boiler chemical treatment, was located adjacent to the pump room.

In general, there were no unusual problems in the design of this plant, the equipment being standard and of the type used throughout the power industry.

STEAM SUPPLY - #100 AREAS

BUILDING #184-RPL&K - POWER HOUSES

Original process and heating steam demands for each #100 Area were estimated as follows:

	<u>Winter-Peak Load</u>	<u>Summer-Peak Load</u>
190 p.s.i.g. steam	5000 lbs./hr.	5000 lbs./hr.
40 p.s.i.g. steam	55,000 lbs./hr.	20,000 lbs./hr.

These requirements were subsequently revised as process data became established, and design proceeded on the basis of supplying the #100 RPL&K Areas with the following firm process and heating steam demands per area:

	<u>Winter-Peak Load</u>	<u>Summer-Peak Load</u>
190 p.s.i.g. steam	10,600 lbs./hr.	10,600 lbs./hr.
40 p.s.i.g. steam	54,050 lbs./hr.	18,900 lbs./hr.

Before boilers could be selected for supplying area steam requirements, it was necessary to know the quantities of steam needed for turbine drives in the area. In the section of this volume on "Electric Power Supply - #100 Areas", the two major schemes of providing the reactor cooling pumping power are discussed. If the "hydraulic" scheme had been adopted it would have been necessary to supply a substantial amount of high pressure steam for the steam turbine driven water pumps. With the decision to use electric drives, however, this requirement was eliminated and, in its place, steam for electric power generation had to be considered. As explained in "Electric Power Supply - General", it was decided to install two 11,500 kw. turbine generators in each of the #100-RP&L Areas and two 12,500 kw. turbine generators in the #100-K Area. The steam turbine drives for this generating equipment were identical in all areas, being 11,500 kw. "preferred standard" type turbines with four non-controlled extraction points for feedwater heating.

For greatest reliability it was decided to adopt the "unit system" of operation for the generation equipment, having one boiler and one set of auxiliaries per turbine generator. The "units" would operate independently of each other, thereby minimizing the effect of operating troubles.

A number of preliminary plant layouts were considered and many studies made before a firm plot plan and general arrangement were finally developed. Preliminary drawings of an outdoor type power house were prepared following authorization for the construction of Building #184-R. After reviewing these drawings, the du Pont Atomic Energy Division advocated the design of a more enclosed structure, particularly for the turbine room. This resulted in an inspection of various power plants throughout Florida by du Pont Design personnel in order to study operating conditions at these installations and to compile information on the advantages and disadvantages of both the indoor and outdoor types of power houses.

Following this investigation, Design authorized work to proceed on approval drawings for an enclosed turbine room power house, although at this time no definite agreement had been reached with respect to firm design of the power house buildings. This was done to meet a commitment to have concrete drawings in the Field by mid-September 1951.

Later it developed that difficulty would be experienced in procuring the required supply of structural steel for a building of this type. As a result, the authorized design was reviewed by AED and Design and a decision reached to alter these plans to provide a more open type of structure. Approval prints of this third design were signed by AED early in October, 1951, and construction was authorized to proceed accordingly.

Building No. 184-RPLK - POWER HOUSE

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Building No. 184-RPLK- POWER HOUSE

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This series of developments resulted in designing Buildings #184-RPL&K as semi-outdoor power plants. The turbo-generators were located outdoors with the feedwater heaters and deaerators. The boilers, economizers, dust collectors, and fans also were located outdoors. The boiler fronts and firing aisles were completely enclosed, and condensers and auxiliaries were located in an enclosed basement underneath the turbo-generator floor.

Central control rooms were provided for power house operation to reduce operating labor requirements. The facility, not requiring blast protection, was designed as a Class III structure. However, this item was given consideration where costs were not appreciably affected and efforts were made to avoid the "flying missile" type of hazard that might result from blast with certain types of construction. The stacks, for instance, were constructed of reinforced concrete because of the resistance of such structures to blast damage.

The shortage of steel mentioned earlier resulted in the substitution of alternate available materials where possible. It had been planned to use steel coal bunkers for the boilers, but reinforced concrete coal silos were substituted when steel became scarce. Each coal silo was designed to have a storage capacity of 750 tons which is sufficient for approximately 48-hour operation of the boilers at full load. This storage space was located in the upper part of the silo, the lower levels being used for office space, locker rooms and boiler chemical feed equipment.

Final heat balances indicated that two 140,000 lbs. per hr. boilers could produce adequate steam for each #100 Area, and orders were placed for this equipment. Boiler steam conditions of 600 p.s.i.g. 825°F. TT were selected as desirable from considerations of economy and compatibility with the generating equipment most readily obtained.

Spreader stokers were selected as the most economical for fuel firing. Future firing by either oil or natural gas was considered, and boiler manufacturers were instructed to leave space for the installation of oil or gas burners. It was learned that when firing oil or natural gas, the higher furnace temperatures obtained would raise the steam temperature 50°F. Accordingly, the material of the superheater tubes was chosen to accommodate the possibility of the higher tube temperatures.

Conventional coal handling equipment was provided with sufficient capacity to deliver 120 tons of coal per hour from the track hoppers to the coal silo and 40 tons per hour from the coal silo to the boilers. Consideration was given to providing alternate means of driving the coal handling equipment. However, it was decided that back-up

of electrical circuits and the existence of generation within the #100 Area power plants would provide sufficient protection against outage. Alternate drives were not installed.

In general, these power houses presented no unusual problems in equipment design as they incorporated standard units in general use throughout the power industry.

BUILDING #184-C - POWER HOUSE

The major consideration in the design of this boiler house was economy and minimum cost. As no turbo-generators were required in this area, the steam generating requirements were small in comparison with the power plants designed for the other four #100 Areas. Therefore, on the basis of this relatively small amount of boiler capacity (the smallest quantity required for any area of the Savannah River Plant) and also for reasons of economy, it was decided that, where possible, design of this power house should be similar to that for the power house at the Camden, S.C. Orlon Plant, one of the du Pont Company's most modern and lowest cost commercial plants.

To achieve this maximum economy of design a minimum of building enclosure was provided. The steam generators, economizers, dust collectors, F.D. and I.D. fans, feedwater pumps, and ash handling equipment were all located outdoors. Only the control room was covered. In order to accommodate the operating personnel under such an arrangement, a small service building, Building #184-2C, was designed, adjoining the power plant proper, to house toilet and locker rooms and other necessary facilities which required complete weather protection. Where possible, excess materials procured for other Savannah River Plant facilities were utilized in the design of this power plant.

A primary factor in establishing the steam requirements was the method proposed for purifying the heavy water moderator and coolant in Building #105-C. Although purification by ion exchange had been selected for Buildings #105-RPL&K, consideration was being given to purification by evaporation in Building #105-C. This latter method would require approximately 30,000 lbs. per hour more steam than purification by ion exchange.

At this stage, a peak winter boiler load of 96,500 lbs./hr. was indicated for the #100-C Area, with a summer peak load of 55,650 lbs./hr. In order to provide this quantity of steam, and yet allow for a retraction in steam requirements should AED decide not to employ the evaporation purification method, design of the #100-C Area power house was instituted on the basis of several different boiler arrangements. These involved boiler units of both 50,000 and 35,000 lbs. per hr. capacity arranged in pairs and fired by either coal or oil; and groupings

Building No. 184-1 & 2C - POWER HOUSE AND SERVICE BUILDING

Hubbs & Hill Inc. Engineers - Constructors. New York, Los Angeles.

of three 25,000 lbs. per hour capacity boiler package units, also fired by either coal or oil.

Later the steam requirements for Building #105-C were revised downward to reflect the elimination of the evaporation method and a return to ion exchange purification of the heavy water system. By this time a peak boiler load of approximately 73,000 lbs. per hour of steam was indicated for the #100-C Area, with a summer peak load of approximately 33,000 lbs. per hour. The capacity requirements having been established, the choice of steam generating units then resolved itself into an economic evaluation of package unit boilers vs. conventional boilers. Evaluation indicated that two 35,000 lbs. per hour conventional boilers would provide a more economical installation than three 25,000 lbs. per hour package type boilers, and that coal would be a more economical fuel than oil. Therefore, two conventional coal fired boilers, each of 35,000 lbs. per hour capacity, capable of delivering saturated steam at a pressure of 325 p.s.i.g., were selected.

Design specified that the boiler feedwater treatment system be made as simple as possible. Therefore this system, and the coal and ash handling systems, for the #100-C Area power house were designed on the same basis as the corresponding systems installed in the #300/700 Area power house, Building #784-A.

A steam-driven, as well as a motor-driven, air compressor was specified in order to insure an instrument air supply in the event of electric power failure. The basic factor in the design of the control system was simplicity.

The major equipment was arranged in two identical units, with one unit capable of carrying the expected peak summer load so that maintenance and repairs necessary for either boiler could be accomplished during the summer period.

For maximum reliability, steam-driven basic auxiliaries were specified, with dual motor drives on the stokers and a motor drive on one of the three boiler feed pumps to provide flexibility.

A spreader stoker with a continuous cleaning, forward discharge grate of new design was specified for firing coal in each steam generating unit. However, the stoker foundation was designed so that a conventional continuous forward traveling grate might be installed in the future without changing the underground concrete work, in case the operation of the installed grate should prove unsatisfactory.

Provisions were made for the future installation of two additional steam generating units to double the capacity of the power house, if required.

STEAM SUPPLY - #200 AREAS

GENERAL

The original premise for the boiler house design in the #200-F&H Areas was to provide steam for a "three-batch" operation in each area. The original maximum steam load estimates, made in early 1951, were 135,000 lbs./hr. in the "F" Area and 90,000 lbs./hr. in the #200-H Area. The estimated loads increased steadily, and by 1953 Blaw-Knox issued a report on steam and water requirements including load curves which reflected the scheduling of equipment operation to iron out peaks. The resultant estimated export peaks were 156,300 lbs./hr. in the "F" Area and 97,400 lbs./hr. in the "H" Area.

Operation beyond the "three-batch" level had been considered since the inception of the job, therefore, Blaw-Knox also prepared load figures for a "four-batch" operation which indicated that, with careful scheduling of equipment operation, it could be accomplished with relatively minor process changes and additions. Late in 1954, a further increased capacity load study was made by du Pont Process and Power Design personnel. The latest data issued 1-11-55, indicated the following steam loads for the #200-F and H Areas.

AREA	"F"		"H"	
Batches Per Day	3	4	3	4
#221 Process Continuous	6,097	7,695	6,097	7,695
#221 Process Intermittent	10,109	10,109	5,681	5,681
#221 Process Cyclic	25,258	30,000	23,328	28,070
#211 Process Continuous	10,436	13,476	10,436	13,476
#211 Process Intermittent	340	340	340	340
#211 Process Cyclic	15,850	15,850	4,095	4,095
#221 H&V Plus Misc.	14,800	14,800	14,800	14,800
#211 H&V Plus Misc.	<u>1,900</u>	<u>1,900</u>	<u>1,000</u>	<u>1,000</u>
Bldgs. #221 & #211 Process Plus H&V Total -	84,790	94,110	65,777	75,157
#221A Process (Both areas operating at same rate)	9,010	10,140	5,800	6,250
#221A H&V	3,000	3,000	-	-
#232 Proc. & H&V	3,400	3,400	2,000	2,000
#235 H&V	2,000	2,000	-	-
#241 Proc. & H&V	2,600	2,600	1,300	1,300
#292 Process	1,300	1,300	1,000	1,000
#294 Proc. & H&V	400	400	400	400
#701 H&V	300	300	200	200
#704 H&V	800	800	400	400

AREA	"F"		"H"	
Batches Per Day	3	4	3	4
#709 H&V	200	200	-	-
#717 Proc. & H&V	3,800	3,800	-	-
#723 Proc. & H&V	4,800	4,800	-	-
#772 Proc. & H&V	15,500	15,500	-	-
Sanitary H ₂ O	<u>5,000</u>	<u>5,000</u>	<u>3,000</u>	<u>3,000</u>
Area Total -	136,900	147,410	79,877	89,707
2% Line Losses	<u>2,800</u>	<u>2,950</u>	<u>1,600</u>	<u>1,800</u>
Total Export Steam	139,700	150,360	81,477	91,507
284 (PH Auxil = 22.5%)	<u>31,400</u>	<u>33,840</u>	<u>18,323</u>	<u>20,593</u>
Required Boiler Output	171,100	184,200	99,800	112,100

In the above tabulation continuous loads are those which operate 24 hrs./day, intermittent loads are those which operate at irregular intervals on an unscheduled basis, and cyclic are those which operate on a regular schedule to maintain proper operating sequence. H&V refers to heating and ventilating loads.

No electrical power generation facilities were included in the #200-F&H Areas. Process consideration required the operation of one boiler in each area for a minimum of eight hours following an electric power failure.

BUILDING #284-F&H - BOILER HOUSES

Buildings #284-F&H were located as close as possible to the largest steam users within the respective areas. When design was started on these buildings, boiler house designs for Building #784-A and Buildings #184-RPL&K were either completed or well underway. Considerable time was saved by utilizing as much of these designs as possible. Boilers identical to those used in Building #784-A were found to meet the load requirements of the #200-F&H Areas. Three 60,000 lbs./hr. capacity units were installed in the #200-F Area and two similar units were installed in the #200-H Areas. In each case the summer loads were such that the boilers could be taken out of service one at a time, during the summer season, for annual overhaul. As was the case for the #300/700 Area, a distribution pressure of 300 p.s.i.g. was selected for greatest over-all economy. Being identical to the boiler units in the #300/700 Area, these boilers were equipped with spreader stokers for burning coal.

In order to conserve steel, a reinforced concrete silo was provided for coal storage at each boiler house instead

of overhead steel bunkers as used in Building #784-A. Each of the silos was designed to provide for a 500-ton storage of coal with available floor space at two levels (one at grade and one 10 ft. above grade), to be used for locker room, battery room, a simple maintenance shop and office facilities. Entrances were provided at ground and operating floor levels and Class III construction was used throughout since the nature of the steam loads was not sufficiently critical to justify Class I facilities. The possible expansion of boiler house capacities to double the initial quantities was anticipated in the design.

As in the #300/700 Area, the boiler houses for the #200 Areas are semi-outdoor in nature. The boilers are located out-of-doors without roofs, as are the air heaters, dust collectors, forced and induced draft fans, and ash handling equipment. The front walls of the boilers form a part of the enclosed section of the building housing the boiler feed pumps and softener controls on the ground floor and the firing aisle, which is located 10 ft. above the ground floor. The deaerators are located out-of-doors on the roof over the firing aisle. Pumping facilities for service water, domestic water and the fire system are located out-of-doors on a concrete pad adjacent to the enclosed portion of the building.

The return of condensate from all users throughout the area was considered. However, due to the wide-spread nature of the proposed condensate collection system, it could not be justified on an economic basis. The boilers are supplied, therefore, with 100 per cent make-up, the water (taken from deep wells within each area) being supplied to the deaerators by service water pumps taking suction from the storage tanks, Buildings #282-F&H. Because of the anticipated high load factor on the #200-F&H Area boilers, it was considered necessary to install boiler feedwater softening equipment. Softeners were located outside of Buildings #284-F&H on the Building #282-F&H pump pads. The softener controls were extended through the walls of the buildings, thereby permitting operation from the ground floor.

Ash sluicing water was taken from the cooling tower basins. This represented an operating economy since the water would have been discharged from the cooling tower in any case as blowdown to control dissolved solids. This arrangement and the location of natural disposal areas within reasonable distance of the power house in each area made wet ash sluicing systems feasible.

The use of an emergency generator to furnish power for steam generating equipment during an outage of the normal power supply was considered. However, it was found more economical to provide steam turbine drives for essential

Building No. 282-F - RESERVOIR AND PUMP HOUSE
& Building No. 284-F - POWER HOUSE

Gilbert Hill Inc - Engineers, Constructors. New York, Los Angeles.

equipment and to provide additional battery capacity for lighting, circuit breaker operation and control circuits. Contributing to this decision was the fact that process steam loads during a power outage in the summer season were expected to drop to a level which would have made boiler operation difficult without the stabilizing effect of the additional load for turbine-driven auxiliaries.

One steam-driven boiler feed pump was provided for each boiler. Also, one electric motor-driven feed pump was provided in each boiler house as a spare unit, each having sufficient capacity to provide water to one boiler at full load.

Design of these facilities presented no major problems of an unusual nature since the equipment was of a type in general use throughout the power industry.

In early 1955, process steam loads in the #200-H Area were increased as a result of process changes for 6 Batches/Day operation. These loads are tabulated as follows:

200-H Area - Winter Peak Steam Loads - Lbs./Hr.
6B Operation

Total Process, H&V & Misc.	113,000
Line Losses (2%)	<u>2,300</u>
Total Export	115,300
Power House Auxiliaries (22.5%)	<u>25,900</u>
Total Boiler Capacity Required	141,200

Accordingly, one new 60,000 lbs./hr. spreader stoker fired boiler and auxiliaries were added to the Power House, Bldg. #284-H. The coal and ash handling systems were extended to accommodate the new installation, and a second stack was added. A new deaerating heater, and additional facilities for feedwater supply and treatment were also included. Start-up of this unit was scheduled for early 1956.

REFRIGERATION

GENERAL

Refrigeration equipment was required throughout the plant for air conditioning purposes and process cooling. Most of this equipment, however, was installed as small package units within the individual buildings and does not fall within the scope of the power facilities design development section of this history. The units actually installed

in power facility buildings (for control room air conditioning) were procured as package units and involved no unusual design problems.

In only one area were refrigeration requirements great enough to justify the installation of a large central refrigeration facility. This was the #300/700 Area where a number of buildings required relatively large amounts of chilled water for air conditioning purposes.

REFRIGERATION - #300/700 AREA

Chilled water refrigeration was necessary for Buildings #703-A, #708-A, #719-A, #720-A, #735-A, #736-A, #773-A, and #777-M. When it was realized that the total refrigeration requirement amounted to approximately 3000 tons, the advantages of a central system versus individual refrigeration units at each building location were considered. The following are some of the advantages of a central system.

1. It permitted the elimination of numerous cooling towers scattered throughout the Administration Area and the resultant noise and moisture discharge to the atmosphere.
2. In a central system with one unit down for repair, cooling could be maintained with the remaining equipment. When a unit was down for repair or out of service in a unit system, no cooling would be available without standby machines.
3. Maintenance costs would be considerably higher in the unit system due to the large number of compressors, heat exchangers, pumps, cooling towers, etc., required.
4. Space requirements would be much greater in the unit system.
5. Total electrical power consumption would be greater in the unit system. This would be particularly true at part load operation when all pumps must still be operated in the unit system whereas pumps could be taken out of service in the central system.
6. A central refrigeration system could be operated by one man on each of three shifts. This might not be feasible with nine separate systems at different locations.
7. The central system could employ steam drives to utilize the excess steam available and keep one boiler running near the point of maximum efficiency during the summer months.

In view of the above considerations it was decided to proceed with the installation of a central refrigeration plant in the Administration Area.

In June of 1951, Design was advised by AED that 10 motor-driven centrifugal refrigeration units were available for transfer from the Hanford Plant of the AEC, and Design was asked to determine whether this equipment was of a suitable type and in satisfactory condition for re-use in the proposed Savannah River central refrigeration plant. Engineering conferences were held with York Corporation (the original vendor), and it was decided that these units could produce 1350 tons of chilled water refrigeration each, with the following alterations to their basic design:

1. Change the coolers from single pass to two pass;
2. Increase the compressor speed from 3200 r.p.m. to 3520 r.p.m.;
3. Install new hot gas by-pass connection on each machine for low load operation;
4. Remove the eliminators in the water coolers and install new eliminators by cutting new manholes in the coolers; and
5. Install new oil coolers for the compressors.

With this information established, the next step was to determine whether the units were in a satisfactory condition for re-use. To accomplish this a York Corporation representative and a du Pont inspector were sent to the Hanford Plant. Satisfactory reports were returned by each man and the transfer of three complete units was arranged. All equipment to be re-used, including the refrigeration machines, the speed reducing gears and the synchronous motor drives were returned to the original manufacturers for necessary changes and complete reconditioning before being sent to the Savannah River Plant. The re-use of this equipment resulted in a reduction in initial investment of \$126,000 and indicated a net saving of \$54,000 over an 8.6 year operating period. For this service these machines required approximately 7 g.p.m. per ton of condenser cooling water, double the normal cooling water requirements for chilled water service. This cooling water was obtained from a cooling tower, Bldg. #785-A, and the cost of the resultant increase in size of this tower and the increase in pumping costs were duly considered in evaluating the foregoing estimates of dollar savings.

The minimum chilled water temperature capability of the Hanford units was 45°F., but Buildings #703-A, #719-A, #735-A and #773-A required relatively small quantities of 40°F. water to provide lower dew points for special conditions. To supply this need a single 300-ton capacity booster refrigeration machine was provided. All of the water was first

chilled to 45°F. in the large units, and the necessary portion passed thru the booster unit for further chilling to 40°F. The chilled water is distributed to all points of use in two separate supply systems, one for 45° water and one for 40° water. A single return system is used, the water temperature being approximately 53° to 54°F. the supply and return lines were run underground with a minimum of 30 in. of cover. The economics of insulating these lines versus leaving them bare were evaluated and insulation could not be justified.

The housing of the refrigeration machines was kept to a minimum. Since the 2000 hp. synchronous motors driving the York machines were of the open type and the machines and control equipment were all originally designed for indoor installation, it was necessary to house them. Accordingly, a prefabricated steel frame building with flat asbestos siding was designed to house the refrigeration machines, electrical equipment, locker and change room facilities and a battery room. All dumping facilities are located out-of-doors.

A bridge crane was not provided over the refrigeration units because the prefabricated steel building frame was not strong enough to support a crane and the addition of structural steel supports was not justifiable. Hatchways were provided in the building roof through which heavy equipment could be handled by a mobile crane.

In April of 1952, Design was advised that start-up of the refrigeration building to supply air conditioning for Bldg. #703-A would be required on July 1, 1952. The condenser cooling water pumps, scheduled for installation over the sump of the cooling tower basin, were not scheduled for delivery until September. As a temporary measure it was decided to use three of the four chilled water circulating pumps transferred from Hanford for supplying condenser water and leave the one remaining chilled water pump for its intended service. The capacity of this one remaining pump was sufficient for the needs of Bldg. #703-A. Drawings were made for the temporary piping arrangement and the change-over was started. However, in June of 1952, Design was advised that the anticipated partial occupation of Bldg. #703-A could not be accomplished earlier than September 1. Accordingly, the drawings were voided and all pumps were returned to their original intended service.

The system requirements were:

<u>Bldg. No.</u>	<u>Gallons Per Minute</u>	<u>Temperature Range</u>
#703-A	830	40-53°F.
#703-A	160	45-53°F.

<u>Bldg. No.</u>	<u>Gallons Per Minute</u>	<u>Temperature Range</u>
#708-A	460	45-53°F.
#719-A	310	40-53°F.
#720-A	60	45-53°F.
#735-A	50	40-53°F.
#735-A	1140	45-53°F.
#736-A	120	45-53°F.
#773-A	140	40-53°F.
#773-A	4330	45-53°F.
#777-M	300	45-53°F.
<hr/>		
Total	7900 g.p.m. thru 53-45° machines 1330 g.p.m. thru 45-40° machines	(2960 tons) (305 tons)

The rated system capabilities were:

- 3 - 1350 ton 45° machines - 10,800 g.p.m.
(2 units normally operating - one spare)
- 1 - 350 ton 40° machine - 1330 g.p.m.

SECTION IV
ASSISTANCE TO CONSTRUCTION

IV - ASSISTANCE TO CONSTRUCTION

The construction of power facilities at the Savannah River Plant required very close liaison between the du Pont Design and Construction Divisions in order to meet the accelerated construction schedules. Design Division power engineers visited the field during the early stages of construction to review with Construction Division personnel the scope of work, design and construction schedules and other related problems. This program was especially important for such facilities as the electric power generation system and the extensive river water supply system to the #100 Area where close scheduling was necessary to meet project start-up requirements. Other facilities requiring early start-up also necessitated the adoption of a similar program.

As construction work progressed, Design engineers made field trips in order to assist Construction in defining the intent of design and to aid in interpreting drawings and specifications. This liaison continued during most of 1952, the trips being scheduled so that one engineer was in the field each week to review critical problems. In many cases du Pont power engineers made joint field trips with engineers from the Design subcontractor, Gibbs & Hill, Inc.

In the latter part of 1951, it was decided to establish a field office for Gibbs & Hill so that this organization might work more closely with Construction forces in solving problems relative to interpretation of drawings and specifications, substitution of materials and installation of equipment. This field office also expedited delivery of advance design information to Construction.

In September 1952, a du Pont Power Design Engineer was assigned as resident at the Savannah River Plant to supervise and supplement the activities of the Gibbs & Hill field organization and to coordinate the activities of field representatives of the Blaw-Knox Company which performed design work on a portion of the power facilities in the #200 Areas. The du Pont Power Design Field Office also maintained close liaison with other du Pont Field Design representatives in the various areas. Other du Pont Power Design engineers continued to visit the field, as required, to assist in start-up of facilities, functional testing, and other specific problems.

Prior to actual start-up of any major power facility, an extensive review of the particular installation was made by Power Design Engineers familiar with its design intent and details. These reviews and inspections were generally carried out in the presence of Construction Division and

Operating Department personnel. Such reviews frequently resulted in the listing of minor changes or additions required in order to complete the design intent. These items usually fell into two categories: (1) those items for which detailed instructions could be given immediately to the Construction Division for completion of work; and (2) items which would require further investigation and action on the part of Design personnel. Items falling into the first category were documented and released immediately to the Construction Division for action, and items falling into the second category were expedited so that complete design information could be released to Construction personnel without delaying start-up dates. These design reviews resulted in a minimum number of start-up problems and eliminated many delays that might have otherwise occurred.

All power liaison with the plant Operating Department was conducted by the du Pont Power Design Field Office, and all plant Operating Department requests for minor additions and design changes also were processed by this office. The mechanics for handling these additions and changes were consistent with those used by the Resident Design Engineers in the various process areas.

Following start-up of a facility, certain problems usually became apparent during the early periods of operation. Field Design personnel, working directly with the plant Operating Department, were able to determine quickly the extent of the problem and recommend and implement the necessary changes to eliminate it, working, as required, with Design personnel in the Wilmington offices.

In mid-1953, a drafting force was assigned to the Savannah River Plant by the Design Division. This force was utilized by the Field Power Design office to make minor drawing changes and to issue new drawings required to complete the design intent, thereby expediting the release of design information to Construction.

In November, 1953, a second Power Design engineer was assigned to the Field Power Design office.

As construction work neared completion, the size of the Gibbs & Hill field force was reduced and in March, 1954, that Field Office was closed and the remaining work was assumed by the du Pont Power Design Field Office. This was a gradual transition, additional work being progressively undertaken by the du Pont office as the Gibbs & Hill force was reduced.

In October, 1954, one engineer and two draftsmen were obtained on a loan basis from the Construction Division to assist in the completion of remaining Power design items to be concluded in the field.

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START-UP AND TESTING

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V - START-UP AND TESTING

GENERAL

The responsibilities of the du Pont Engineering Department were not concluded at the end of the design and construction phases of the work. Before the Operating Department's acceptance could be obtained it was necessary to place the facilities in operation and demonstrate that the performance was in accord with the design intent.

START-UP

Representatives of three groups normally were present during the start-up of a new power facility. Design representatives were on hand to observe the adequacy of design, to clarify questions regarding design intent, and to assist with difficulties that might arise. Construction representatives were present to perform various functions involved in getting the equipment into proper operation. Operating Department supervision and operators were present to operate the equipment and to observe equipment performance and adequacy. Also, with most major pieces of equipment, manufacturer's representatives were on hand to assist with start-up.

During the initial period of operating new facilities a number of adjustments generally were required and often minor design changes were needed for proper performance. These changes were made by Construction personnel, with Design representatives approving design changes as required. Those design changes requiring additional study or review were referred to the Design group involved. Where equipment performance deficiencies were concerned, vendors representatives were contacted for corrections.

This manner of handling the facility start-ups resulted in satisfactory operation with minimum delays or difficulties.

PERFORMANCE TESTS

During the start-up period it was usually not difficult to determine in a general way if individual pieces of equipment functioned according to design intent, but it was not always possible to determine if specified performance was met. To check this phase of work, a test group was organized to conduct performance tests for the major pieces of power equipment consisting primarily of boilers and boiler auxiliaries,

turbo-generators, cooling towers and pumps. This test organization was known as the "PEAT" (Power Equipment Acceptance Test) group and was composed jointly of members of the Explosives Department - Atomic Energy Division and the Engineering Department - Engineering Service Division.

If it was found, as these tests progressed, that equipment failed to meet the specified performance, the vendors were advised of deficiencies and requested to take corrective action.

FUNCTIONAL TESTS

The start-up procedure and performance tests dealt primarily with individual pieces of equipment. After it was determined that the units performed as specified, it was usually necessary to test the over-all operation of a system involving a number of pieces of equipment. Such tests were designated "functional" tests. Formal functional tests were specified for the following systems:

1. Main water supply to the #100 Areas, checking characteristics of the entire system from the river pump houses to the cooling water effluent discharges from the areas;
2. "On-Line" and "Emergency" power systems for the #100 Areas; and
3. Cooling water supply and return systems for the #200 Areas, including operation of the emergency cooling water systems.

Details of these tests are given in subsequent paragraphs.

The method used for developing each formal functional test procedure was as follows:

1. The Design groups involved prepared a scope of work indicating in detail the various tests desired (and in many cases specifying the results required);
2. This scope of work was forwarded to Wilmington AED personnel for their approval and for the addition of supplementary tests if so desired to meet operating conditions;
3. After review and revision, the scope of work was forwarded to Plant Operating Personnel where it was developed into a step-by-step operating procedure;

4. The actual test work was carried on by Operating and Construction personnel assisted by Design representatives; and
5. Adjustments and/or modifications were made if required to enable the system to meet design intent.

In addition to these functional tests for which formal procedures were prepared, a number of similar tests of other facilities were made informally during the start-up period.

#400-D AREA

WATER TREATING FACILITY - BLDG. #483-D

Start-Up

Design assistance was not furnished during the start-up of the Bldg. #483-D facilities except as required for the following items.

1. When water from the power house condensers was discharged to waste through the "waste flow valve", pulsations were set up in the valve which eventually fractured the bell crank. These pulsations were eliminated by removing the elbow on the discharge side of the valve and altering the piping so as to provide free, open discharge from the valve to the sewer manhole.
2. Carbon steel tubes in the caustic heat exchangers failed due to caustic embrittlement after a short period of operation. This problem was solved by replacing the tube bundles with new units fabricated with nickel tubes.
3. Difficulty was experienced in getting proper suction for the process water conditioning acid feed pumps and caustic feed pumps. This problem was eliminated by installing head tanks on the suction side of the pumps to insure positive pressure at this point.
4. Erratic operation of the dry feeders in the chemical building was encountered when handling lime because an arch of lime would form in the hoppers and prevent a steady flow to the feeder. This problem was eliminated by installing vibrators on the hoppers.

5. After operating the softeners for several months, it was observed that protective coating used for lining the acid softener sumps, trenches and degasifier clearwell were not resisting the effects of the low pH water. Acid-proof brick linings were installed at these locations to eliminate this problem.

Performance ("PEAT") Tests

The following power equipment acceptance tests were made by the "PEAT" group.

1. Both boiler feed make-up pumps (located at Building #483-D) were tested. The tests demonstrated that the pumps met purchase specifications in both capacity and efficiency.
2. The circulating water pumps for the power house condensers (located at Building #483-D) were tested and found to meet capacity and efficiency guarantees.
3. Both boiler feed booster pumps were tested and found to meet the purchase specification. However, it was determined later that the shutoff head of the pumps was in excess of the test pressure of the silica absorbers to which they discharged. Consequently, these two pumps were replaced by pumps with lower shutoff heads. These latter pumps were not tested by the "PEAT" Group.
4. The boiler auxiliary pumps were tested and found to meet performance guarantees.
5. Tests demonstrated that the process raw water pumps met performance specifications. However, difficulties were encountered in the operation of these pumps as several of the drive shafts failed from fatigue. The manufacturer was contacted and it was determined eventually that the shaft was not sufficiently strong to take the loads imposed upon it. Larger shafts were substituted by the manufacturer.
6. Process make-up and process booster pumps were tested and found to meet the purchase specifications within the accuracy of the tests.

Functional Tests

No formal functional tests were scheduled for Bldg. #483-D facilities. However, informal operating tests were made to demonstrate that the facility met design intent.

POWER HOUSE - BLDG. #484-D

Start-Up

Before putting the new boilers into service, the settings were dried out with a slow fire and the internal surfaces of the boilers were cleaned with a caustic solution during a "boiling out" period. The primary purpose of this caustic cleaning was to remove all protective coatings applied in the shop during manufacture and to remove lubricants used in the erection of the equipment. Following the "boiling out" period, the internal surfaces of the boilers were also cleaned with inhibited hydrochloric acid to remove acid soluble foreign matter such as mill scale and rust which had not been removed or loosened by the prior cleaning treatments. Procedures for carrying out these operations were prepared by the Engineering Department and the satisfactory results led to the adoption of similar procedures for boilers in the #100 RPL&K Areas where electric power generation was also involved.

Only the low pressure turbo-generator units were started up initially because there was insufficient electric load to warrant starting up the high pressure units. Under these conditions, the boilers were operated at reduced pressure. With the increase in electric demand, the boilers were brought up to rated pressures and the high pressure turbo-generator units were started.

Design representation was on hand during the start-up of these facilities, together with representatives of the Construction Division, Operating Department and certain vendors. The start-up was made without serious difficulties, but a few problems did arise which were of sufficient significance to merit special mention.

1. As a result of receiving wet coal, considerable clogging of the hoppers, chutes and conveyors of the coal handling system was experienced. Additional vibrators were added to the hoppers, and alterations were made to the conveyor system in accordance with manufacturer's recommendations.
2. Several months before the scheduled start-up date, a design review of the characteristics of the boiler feed pumps indicated the possibility of unstable pump operation. Contrary to the performance characteristics originally specified and proposed for these units by the vendor, the factory acceptance tests indicated a drooping characteristic both at the high capacity and low capacity ends of the curve. The highest head was indicated with a delivery of approximately 400 g.p.m. from each pump. The problem was

discussed with the manufacturer and arrangements were made to replace the impellers to assure suitable operation. Realizing that replacement impellers could not be built and furnished in time for start-up, modification to the boiler feed piping was made to allow by-passing part of the water from the pump discharges back to the deaerating heater. It was possible with this pump loading system to keep the units in the stable portion of their operating curve.

3. After the process area had been in operation for several months, it became apparent that the instrument air demand would exceed the installed air drier capacity. For this reason an additional 1000 c.f.m. air drier was installed in the power house.
4. During the summer, after all equipment was in operation, the air temperatures in parts of the boiler room were found intolerable. This condition was corrected by the addition of louvers on both the north and south sides of the building, the installation of three roof ventilators, and the addition of two axial flow fans at the deaerator level.

Performance ("PEAT") Tests

The following power equipment acceptance tests were made by the "PEAT" group.

1. All of the high pressure turbo-generator units were tested. The turbines were found satisfactory, but the generator output was limited by rotor overheating. The vendor was contacted and, after several meetings, agreed to make modifications to the rotors to increase capacity in order to meet purchase specifications. The work of altering these rotors was done in the vendor's Pittsburgh factory. While one rotor was being prepared, a spare rotor, on loan from the vendor, was used in its place.
2. All of the low pressure turbo-generator units were tested and found to meet the manufacturer's guarantee.
3. The four high pressure boilers, including pulverizers and induced and forced draft fans, were tested to determine their performance at the rated load. The capacities and efficiencies of the various units were equal to or better than the guarantee and were therefore acceptable. Additional tests were performed on one of the boilers to determine the maximum capacity that could be carried continuously. From this test it was found that several of the auxiliaries needed

minor modification to permit operation with loads above rating. These modifications were made and the boiler retested. This new test indicated that the boiler was capable of generating steam at least 20 per cent above its rating.

4. The feed water heaters for one boiler were tested to determine: (1) the lowest boiler load at which the feedwater temperature regulator could control the exit temperature of the superheater at the design point, and (2) the ability of the heaters to meet manufacturer's predicted heat transfer rates and pressure drop. The feedwater heaters and regulators were found acceptable.
5. The coal conveyor from the track hopper to the crusher, and the conveyor from the reclaiming hopper to the crusher, were tested for capacity and performance. It was found that this equipment did not meet rated capacity and corrective measures were adopted to eliminate this condition.
6. One cell of the two-cell condenser water cooling tower (Building #485-D) was selected for testing (the cooling water demand at the time was not sufficient to maintain design flow to more than one cell). The tower approach to the wet bulb temperature was within 5 per cent of the predicted approach which was considered satisfactory. Tests on the fan indicated also that the power consumption was within satisfactory limits.

Functional Testing

No formal functional testing was scheduled for this facility. All components were of conventional design and miscellaneous operating tests established to insure that the intent of design was satisfied.

#300/700 AREA

START-UP

The construction of Building #784-A was completed in September of 1952. Prior to start-up, Design representatives visited the site and made a check list of work items needing attention. This list was discussed and agreed upon by Construction personnel, and all items were taken care of before the start-up was made.

However certain minor difficulties were experienced during start-up as might normally be expected. The most important of these was the problem of obtaining proper adjustment of the combustion control system for satisfactory low load operation on automatic control while at the same time establishing maximum openings of boiler dampers throughout the entire load range for power saving and reduction of fan speed.

Excessive stoker grate key replacements because of overheating became a problem after start-up. A program of investigation resulted in several equipment design changes including moving the back-stop plates forward, installing new feeder end blades and increasing grate speeds. These changes improved the situation considerably, but grate key burning was not completely eliminated, so investigations of other grate key materials were instituted to replace the plain cast iron.

PERFORMANCE ("PEAT") TESTS

The following tests were made by the Engineering Service Division personnel of the Power Equipment Acceptance Test Group.

1. No. 1 Boiler was capacity-tested and judged satisfactory for loads of 70,000 lbs./hr. At rated capacity of 60,000 lbs./hr. the boiler met purchase specifications.
2. The fire pumps were tested for head and capacity and were found to meet purchase specifications.
3. The domestic water pumps were tested and found to be low in capacity at design head. However, after review by the AED and the "PEAT" and Design Groups it was agreed that the small deficiency did not warrant corrective action.
4. The service water pumps were tested and found to be low in capacity at design head. Design personnel contacted the vendor who furnished, without charge, a new set of impellers for the four pumps involved.
5. The #785-A Cooling Tower was capacity-tested and was found to exceed design specifications.

FUNCTIONAL TESTS

Start-up of the #300/700 Area power facilities did not involve special functional testing.

#100 AREAS - WATER FACILITIES —

START-UP

The construction of the facilities for water supply to buildings in the R Area was completed during early 1953, the check out, start-up, and run in of these facilities being made during that period. The building start-up did not follow a normal pattern in that the Building #183-2, Filter and Softener Plant, was started up on well water supplied from the construction temporary well water system and not on treated river water from the clarification plant, Building #183-1. This was done to permit start-up of the Bldg. #184-R power plant which was needed before river water could be supplied to Bldg. #183-2. It was not until the late Spring of 1953 that the river water system was placed in operation to supply river water to the R Area.

The start-up of the water supply buildings in the P, L, K and C Areas followed at intervals in accordance with the construction schedule.

In general, the start-up of these buildings was accomplished with very little difficulty. Design assistance was rendered only as required and then usually for specific problems. The following are some of the more important items or problems that were encountered.

Building #183-1R - Clarification Plant

Chlorine Unloading System

Difficulty was encountered with the unloading of liquid chlorine from the tank car to the bulk storage tanks. The cause of the trouble was inability to suitably vent chlorine gas to atmosphere without creating a safety hazard. This problem was solved by relocating several pipe connections on the storage tanks so that chlorine gas as well as the chlorine liquid could be used in the chlorinators.

Chlorine Solution Rotometers

While the chlorine solution rotometers were being tested hydrostatically at operating pressures one of the units failed. In reviewing this failure it was determined that these rotometers would not successfully hold the water pressure to which they could be subjected under service conditions. The source of the trouble was due to location of the rotometer downstream of a chlorine gas eductor that was required to operate at a water pressure higher than the rotometer would stand; hence, if the chlorine solution line downstream

of the rotometer were shut off, the pressure would build up in the rotometer and cause failure. This problem was solved by revising the piping downstream from the rotometer so that a by-pass line or loop seal was installed around the shut-off valve, making it impossible to put full water pressure on the rotometer.

Chlorine Evaporators - Expansion Volume

Some time after start-up a pressure gauge in the chlorine line of one of the chlorine evaporators failed and discharged chlorine gas throughout the #183-1R Chemical Building. Following investigation, the cause of the accident was attributed to a faulty gauge. As a result all of the chlorine pressure gauges on similar equipment at SRP were replaced by the vendor. Furthermore, it was developed during the investigation that the chlorine evaporators were so designed that the expansion chamber of the unit had only sufficient volume to provide for expansion of liquid chlorine introduced at a temperature of 70°F. In order to provide for expansion at temperatures below 70°F., it was necessary to provide additional operating volume in each unit. This change was obtained on all evaporators by lowering the outlet connection inside the units so that sufficient volume was provided for expansion at an inlet chlorine temperature of 20°F.

Building #183-2 - Filter and Softener Plant

After some months of service the red brass pipe in the hydrogen softener unit acid regeneration system developed several small leaks. Investigation indicated a loss of metal due to corrosion. The red brass pipe was replaced with Uscolite pipe in all five areas.

Building #183-4 - Clarification Plant

Chlorine System Changes

In general, it was necessary to make the same changes in the chlorine system of Buildings #183-4 PLKC as were made in Building #183-1R. The revamping applied also to similar equipment used in Building #186-RPLK&C.

Addition of Priming Jets to Booster Pumps

During the start-up period it was observed that, at a water level in the reservoir 3 to 4 ft. below normal (a very unusual condition when the area is in operation), it was impossible to prime the booster pumps. Since this condition could happen in case of an interruption in the supply of electric power, steam jet eductors were installed in order to permit priming the pumps regardless of the reservoir level.

Building #186 - Reservoir

Butterfly Valves

Considerable difficulty in the nature of high maintenance was experienced with the 42-in. butterfly valves in the inlet water lines to each area. Upon investigation it was found that the vendor had supplied an undersized valve operator and had failed to provide satisfactory limit switches in the valves. Study work on the river water supply system, which was completed at about the time this problem was being investigated, indicated that the loading on each valve could be somewhat greater than the value for which the valve was originally designed. Accordingly these valves were returned to the vendor for revamping to make them suitable for performance at the revised design values.

Dow Pivot Valves - Valve Revamping

As mentioned above in the problems with the 42-in. butterfly valves, a re-check of the design of the complete river water system indicated that the loading on these valves could be somewhat greater than expected under the original design conditions. For the Dow Pivot valves a larger valve operator was required as a replacement for the operator originally furnished. Modification of these valves was performed at the site.

Building #190 - Pump House

Loose Flywheels

After start-up of Bldg. #190 cooling water pumps it was found that several of the flywheels were loose on the shaft although the design had specified that the parts were to be assembled with an interference fit. A check was made of each pump unit at the site and approximately half of the units were found to have loose flywheels. The vendor reworked all units replacing the flywheel shaft where necessary to give the required interference fit.

Butterfly Valves

Difficulty was experienced with the operation of the 24-in. butterfly valves in the cooling water pump discharge lines. Due to a change in the method of operation, these valves were subjected to loads greater than those for which they were designed. Accordingly, changes were made to the valves, consisting of (a) adding a mounting bracket of increased size (b) adding springs in the diaphragm motor operator, and (c) adding a dash pot to each unit. The valves were returned to the vendor's plant to make these changes.

PERFORMANCE TESTS

One performance test of the water supply facilities was made by the Power Equipment Acceptance Tests Group.

Bldg. #190 - Capacity Test of One Cooling Water Pump

1. A capacity test of one cooling water pump in Building #190-R was performed by the "PEAT" Group. The test indicated that the unit met the vendor's guarantee.

FUNCTIONAL TESTS

No formal functional tests were carried out on the water supply facilities as individual facilities. However, the reactor buildings were given a formal functional test and, since the water supply buildings were service buildings of Bldg. #105, they were included in the testing program. These tests were performed to check the operation of the various water supply systems under simulated operating conditions and operation procedures.

The conclusions developed from the functional tests of the water services were that, under all conditions of operation, the water supply facilities were found to operate within the intent of design and to be functionally acceptable.

#100 AREAS - BUILDING #108-1&2-RPLK&C

START-UP

Facilities in the diesel Engine Houses, Bldgs. #108-1&2R, were started-up during April and May of 1953, except for the air compressors which were put into operation earlier to supply compressed air for construction purposes. Diesel engine houses for subsequent areas were started-up at later dates, but start-up problems were similar and will not be covered separately in this history.

There were few start-up problems of consequence in this building and design assistance was rendered only as requested by Construction for specific problems.

1. Vibration of the discharge lines from the air compressors was experienced during the start-up. This difficulty was eliminated by making modifications to the pipe supports.

2. The noise level in the engine houses with the engines operating was found to be excessive for continuous operator occupancy. This problem had been given previous consideration in the original design and was really not a start-up problem except that it was desirable to obtain actual noise level readings before sound proofing measures were approved. Studies indicated that the most economical means of overcoming this problem was to install soundproof enclosures around the operator control center, and such installations were made. Ear muffs were to be made available to persons exposed directly to room noise for extended periods.
3. Excessive pitting and cracking of exhaust valves for the "on-line" diesel engines was experienced. This was a problem that had not shown up on the previous endurance tests for these engines and it was found that valves of a different type than those used in the test engines were installed in many of the plant engines. The vendor was contacted for a solution to this difficulty with the result that new exhaust valves were furnished for all of the "on-line" engines.
4. It was found necessary to store some of the "on-line" diesel engines obtained for use in the later #100 Areas for a considerable time before installation. Due to concern over possible deterioration of these engines, an investigation was made to determine proper storage procedures and a program was initiated at the plant to carry out this proper storage. A later inspection indicated that the measures had been completely effective in preventing corrosion or other deterioration.

PERFORMANCE TESTS

There were no field performance tests carried out for the Bldg. #108 equipment. Such tests were not necessary because witnessed performance tests of the diesel generating equipment were made in the vendor's shops prior to shipment.

FUNCTIONAL TESTS

The functional test requirement specified for Bldgs. #108-1&2 was that the compressed air and electrical generating facilities should satisfactorily provide all of the #105 Building requirements during the extensive #105 Building functional tests. It was found during these test periods that the #108 Building facilities were acceptable functionally.

In addition to the testing of The main functions of Bldg. #108, observations were made for the following service facilities.

1. The 8 in. pipe line supplying cooling water to each Bldg. #108 was sized to provide design water flows for the equipment involved. It was found possible during tests to pass water quantities considerably in excess of design flows through the #108 Building equipment which included booster pumps, thereby causing excessive pressure drops in the supply line. This resulted in very low pressure at the building entrance and in some cases caused negative pressure at the pump suction lines to the booster pumps, particularly through the vent line from the supply header to the "on-line" engines. Difficulty with air-binding of pumps was encountered. This situation was aggravated particularly in the L, K & C areas where the supply pressures to the buildings were less than anticipated in the design. The following measures were taken to correct this situation.
 - a. Flow limiting orifices were placed in the individual cooling water circuits of the diesel engines to prevent excessive flows of water through this equipment.
 - b. A water seal was provided for the vent line from the supply header to the "on-line" engines to prevent air leakage into the header from this source.
 - c. Additional air vents were provided for the supply line to further reduce the possibility of air interference with the system operation.
 - d. Alterations were made in Bldg. #105 piping in the #100-LK&C Areas to increase the cooling water supply pressure for the #108 Buildings to the anticipated design values.
2. The adequacy of fuel oil handling system, including the Bldg. #108-3 unloading facilities, was checked and found adequate.
3. Lubricating oil handling facilities were checked and found adequate after unloading lines had been extended through the building roof at grade level to eliminate unloading difficulties otherwise encountered.

4. Ventilation system was checked and found adequate.
5. The room noise level was tested and found tolerable after the addition of the operator's sound-proofed enclosure discussed earlier.
6. The compressed air system was checked and found functionally acceptable.

#100 AREAS - BUILDINGS #184-RPL&K

START-UP

The construction of the Power House, Bldg. #184-R was completed during early 1953 and the check-out and start-up of these facilities was made during that period. Because subsequent #100 Area power houses (Buildings #184-PL&K) were essentially duplicates of Bldg. #184-R and the problems encountered were the same, only the account of the #184-R facilities will be generally included in this section of the history.

As might be expected with a new installation of this type, some difficulties were encountered during the start-up period.

1. Numerous leaks developed in the economizer tubes of the boilers for the #100-RPL&K Areas. The vendor was contacted and an investigation made which disclosed that the difficulty was due to poor workmanship in the welding. To eliminate this trouble, a program was initiated to obtain gamma ray pictures of the field welds involved. Welds that appeared to be a possible source of future leakage were cut out and new welds made. Further gamma ray pictures were taken of the new welds. This procedure was continued on all boilers until pictures indicated that the poor welds had been eliminated.
2. Some difficulty was experienced in obtaining stable operation of the combustion control. The source of trouble appeared to be improper functioning of the combustion control and/or the fan turbine governor causing cycling of the air supply to the boilers. The turbine vendor as well as the combustion control vendor was contacted and tests were made to determine the best method of eliminating the trouble. Alterations were made to the turbine governor which eliminated the cycling condition and allowed stable operation.

3. It was found that sediment in the turbine oil was not properly diverted to the Bowser oil conditioning units but was pumped through the lubrication system. Additional baffle plates were installed in the oil reservoirs of the turbo-generators.
4. Excessive steam temperatures were obtained from the superheaters of the boilers as originally installed. The vendor was contacted and requested to correct this condition. Additional baffling was installed in the boilers which partially shielded the superheater tubes from furnace radiation. This change reduced the steam temperatures to that specified in the design.
5. Prior to the start-up of these units, the boilers were "dried-out" and "boiled-out" in accordance with procedures developed by the Engineering Service Division. In addition, all boilers were acid-cleaned before being put into service in an effort to remove all rust, scale and other foreign matter.
6. Early experience in unloading coal for Building #184-P indicated the desirability of having coal car shaking facilities for unloading coal in the #100-RPL&K Areas. This problem was reviewed and it was found that the investment for these shakers could be justified by the savings involved. Installations were made in these areas.

PERFORMANCE ("PEAT") TESTS

The following performance tests were made by the "PEAT" (Power Equipment Acceptance Tests) Group.

1. A representative boiler was tested for efficiency, capacity and general operating characteristics. The boiler was found capable of meeting manufacturer's performance guarantees.
2. One 11,500 kw. and one 12,500 kw. turbo-generator unit were tested for efficiency, capacity and operating characteristics in conjunction with the associated boilers, extraction feed water heating cycle, condensate return system, boiler feed pumps and general feed water equipment. These facilities were found to meet equipment guarantees.
3. The coal handling equipment was tested in conjunction with the boiler test (1) above and found to be short of guaranteed capacity with certain coal conditions. To eliminate this difficulty, operating speed of the

reciprocating feeder under the unloading hopper was increased to eliminate the "bottle-neck" existing at this point.

4. A power house cooling tower (Building #185) was tested. The capacity and temperature approach to ambient were found acceptable.

FUNCTIONAL TESTS

No formal functional tests were carried out for the power house facilities. Equipment and arrangements followed conventional practice and operation was such that informal performance tests by the Operating Department could establish that intent of design was satisfied. The informal tests consisted of subjecting the power house to a wide range of operating conditions to establish that (1) design outputs could be satisfied, (2) that load fluctuations could be satisfactorily handled, and (3) that design was adequate for possible emergency conditions which might arise.

The design was found acceptable functionally.

#200-F&H AREAS

START-UP

Start-up of the #200-F Area power facilities was accomplished in the late fall and early winter of 1953. Prior to start-up Design representatives visited the site and made a check list of work items needing attention. The list was agreed upon by Construction personnel and all items were taken care of before the start-up was made.

Normal start-up difficulties were experienced including the problems of proper adjustment of the combustion control system on the boilers and the elimination of vibration in the cooling tower fan and gear reducer supports.

The stokers and boilers were duplicates of those installed in the #300/700 Area and all design changes previously mentioned for that Area were incorporated in the #200-F&H Area stokers. Tests were initiated in this area to determine the advantages of using special materials for grate key construction.

PERFORMANCE ("PEAT") TESTS

A boiler capability and grate key performance test was conducted on the #2 boiler in the #200-F Area in June of 1955.

A PEAT test on boiler #3 in #200-F Area in March of 1954 had indicated a boiler efficiency less than the manufacturer's guarantee. The test conducted on the #2 boiler, operating on coal conforming to design specifications, indicated a boiler efficiency comparable with the guarantee, within the accuracy of test measurements. A limitation in the under re-injection system was detected and corrected. Operation of the boilers in the #200 Areas prior to and during the test showed high maintenance of grate keys resulting from excessive grate key temperatures. This was corrected by replacing the cast iron keys with Pyrocast keys.

A performance test was made on the Cooling Tower, Bldg. #285-F. The capacity and temperature approach to wet bulb temperature were determined to be acceptable.

FUNCTIONAL TESTING

The #200-F Area Cooling Water System, including cooling tower, supply pumps, normal and segregated gravity return systems, monitoring stations, delay basins and return pumps together with all automatic valves and instrumentation, was tested functionally to determine its adequacy to meet the intent of design.

The system performed satisfactorily with the same exceptions.

1. The delaying basins did not provide the required hold up time for design flows. This was partially solved by changing the baffles in the #281-1F delaying basin from the over-and-under type to the serpentine type. Similar changes were made in the segregated system delaying basin Bldg. #281-5F. Some improvement was gained but temperature stratification still prevented satisfactory time delays being reached. It was decided that further baffle changes including air agitation should be added.

The #281-1H delaying basin was altered to include the #281-1F revisions. Because the #281-5H basin was much deeper than the #281-5F basin, one-half of its volume was sufficient to provide storage of the segregated water flow for the delay period desired. Accordingly the basin was divided into two sections with valving so arranged that one side can be filled while the other side is draining. Manual valve operation will be employed to maintain the filling and draining cycle.

RIVER PUMP HOUSE AND ASSOCIATED RIVER WATER LINES - BLDGS.
#681-1&3G AND BLDG. #901-G

START-UP

Due to the nature of the river pump houses and the associated river water lines, the start-up was integrated with the functional tests outlined in the following sections. No special problems occurred during this start-up.

PERFORMANCE TESTS

Power equipment acceptance tests were made by the "PEAT" Groups on one pump in each pump house with flows of 10,000 g.p.m., 20,000 g.p.m. and 28,000 g.p.m. Also, additional tests were made on two other pumps in each pump house at 28,000 g.p.m., the rated capacity. The performance of the six units met the purchase specifications and on the basis of these test results it was determined that the pumps were acceptable.

FUNCTIONAL TESTS

Leakage tests were conducted for each component of the river water piping system. The amount of leakage was found to be considerably below that permitted by the American Water Works Association Standards. In a system composed of approximately 50 miles of piping varying in size from 60 in. to 84 in., the total amount of leakage was insignificant.

In addition to the normal run-in of pumping equipment and the aforementioned performance tests on the pumps located in the river pump houses, the following additional tests were conducted at the river pumping stations to determine the capability of pump operation under certain unusual operating conditions to which the pumps might be subjected.

The pumps were operated at capacities higher than rating, up to flows in the order of 45,000 g.p.m. at lower discharge pressure to determine the extent of cavitation on the pumps and also the horsepower requirements of the pumps while operating in this extended range. Although some cavitation noise and vibration were evident at these high range flows, it was concluded that, since the pumps would operate in this range for only short periods of time, the observed conditions were not of a dangerous nature. During these tests it was established that the performance of motors driving the river pumps was satisfactory at all points throughout the operating range of the pumps.

The discharge lines of the river pumps were provided with slow-closing cone plug valves rather than standard check valves with the result that the pumps would rotate in the reverse direction after power failure. It was necessary to determine that the pumps and motors would function properly during reverse rotation. Consequently, tests were performed to determine that the pump and motor design was adequate to withstand the reverse rotation and to be certain that the reverse speed reached would not exceed safe overspeeds recommended by the manufacturer. These tests were conducted with two pumps operating near shut-off conditions with the discharge water going to waste. One of the two running pumps was tripped out of service, thereby simulating a power failure, causing the pump to stop quickly and then to run in the reverse direction. During the occurrence of the reverse rotation the speed slightly exceeded the manufacturers overspeed guarantee. After reviewing this attained overspeed with the manufacturer, however, it was determined that it was satisfactory to operate the pumps and motors at speeds that had been encountered during the testing.

Tests were performed also with reduced flows and no flows in the pump and motor cooling water systems to simulate partial or total failure of the cooling water supply. The purpose of these tests was to ascertain whether instruments for detecting over-heating were located properly and to determine the length of time at which the pumps and motors could be operated under these conditions before the limiting maximum temperatures were reached. The pumps and motors were operated for slightly over an hour at near rated capacity before the motor temperature had reached specified limits with no flow in the motor cooling system.

Because of the great length of individual lines in the river water supply system and also the irregular profile of these lines due to conformity with existing ground surface, water hammer was recognized to be a potential problem with the river water supply system. During the initial design of the system, devices were included for limiting water hammer surge pressures to values less than the design gradient of the piping system. It was considered essential that field tests be conducted on the individual pipe lines and on the system as a whole in order to verify calculations made for water hammer surge pressures. The types of tests conducted on the river water supply system were:

1. Tests to determine pressure surges due to closure of a valve at the area end of the line;
2. Tests to determine up-surge pressures due to reverse rotation after a power failure to one or more pumps;

3. Tests to determine surges due to rejoinder of water columns after a partial or total power failure;
4. Tests to determine surges due to rejoinder of water columns during filling or refilling of a line; and
5. Tests to determine effect of timing of the cone plug valves at the pump discharges on the type of test mentioned in (3) above.

A testing procedure was prepared by Design personnel who participated as advisors during the testing. Actual tests were conducted by Operating Department and Construction Division personnel. For the tests, a control center was established outside one of the river pump houses. Communication between the control center and the pump house control room was accomplished by means of a specially installed public address system. High-speed recording pressure gauges were located at critical points along each of the lines tested. In order to synchronize the efforts of the operators located along the pipe lines, radio communication facilities were established with the control station located at the pump house control center. Several radio-equipped vehicles were provided for the transportation of supervisory and advisory personnel to points along the piping systems as required. Complete control of the water hammer testing was maintained at the pump house control center where diagrams of the system were maintained showing the condition of the system at any given time and where test results were accumulated and interpreted immediately after each test by Design personnel.

The initial testing of the piping system was done on the line to the #100-R Area. The tests consisted of closure of valves at the R Area end of the line; partial and total trip-outs of pumps at the river pump house to determine rejoinder surges and up-surges at the pumps; refilling tests at various rates to determine rejoinder surges; and additional partial and total trip-out tests at varying cone valve closure rates to determine the optimum setting of closing times for the cone valves. The only operating difficulty encountered during the testing was at the quick-opening slow-closing air valves provided at critical points on the pipe lines to minimize the effect of rejoinder surges. After proper adjustment of the closing rates of these valves, no further difficulties were encountered. Following the testing of the R Area line, the lines to each of the areas and the emergency supply lines to each area were tested in a similar manner.

With the completion of testing of the individual lines, the entire river water piping system was put into operation with 15 pumps operating at the two river pump houses and a

series of partial trip-out tests and total trip-out tests were performed on the system. Pressure surges were within design limitations on the piping system in nearly all cases tested. Minor restrictions on methods of operation were recommended to the Operating Department to avoid those cases where surges slightly exceeded the design gradients. These restrictions did not constitute serious limitations on operating flexibility.

These tests also demonstrated that the steam electric generation plants could maintain stable operation with large sudden changes in load.

In addition to the system trip-out tests, a system recovery capability test was conducted. Initially, 12 pumps at the river pump houses were in operation supplying approximately 80,000 g.p.m. to each of the #100 Areas. A constant water demand was maintained in each area reservoir by adjustment of the reservoir drain sluice gates. The 12 operating pumps were simultaneously tripped to simulate a complete power failure to the system. As the water supply to each area ceased and the reservoir level began to decrease, the discharge valves at the ends of the line to the reservoirs were opened to simulate the automatic operation of these valves which would take place under actual plant operation. Twenty minutes after the simulated total power failure, the pumps were placed back in service at one minute intervals until all 16 pumps at the river pump houses were in operation. Steady flow was restored to all areas approximately one hour after the simulated power failure, and the last area reservoir was completely refilled approximately two and one-half hours after the simulated power failure. The results of this test were very satisfactory, and demonstrated the fast recovery capability of the system after a power interruption.

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VI - DESCRIPTION OF FACILITIES

AREAS #100-RPLK&C

BUILDING #108-1R - ENGINE HOUSE

FUNCTION

1. To provide on-line emergency d.c. power to the process heat exchanger pumps in Building #105-R.

2. To provide emergency power to two #105-R sub-stations and, through the use of Buildings #108-1R & 2R bus tie, to two other #105-R Substations. When the bus tie feeder is in use, emergency power can also be supplied to Building #108-3R.

3. To provide instrument air to Building #105-R and plant service air requirements to Buildings #105-R and #108-1R.

PRINCIPAL COMPONENTS

Generators

Four 180 hp. diesel engine-driven d.c. generator sets installed to supply emergency power to the process heat exchanger water pumps in Building #105-R. These were installed approximately 20 ft. below grade.

One 1000 kw. diesel engine-driven a.c. generator installed to provide emergency power to auxiliaries and meet emergency lighting needs in Buildings #105-R and #108-R. This unit is also 20 ft. below grade.

Two 10,000-gal. storage tanks installed adjacent to the building for the storage of diesel fuel oil for all five of the diesel generators.

Air Compressors

Two 480 c.f.m. 150 p.s.i.g. air compressors installed to supply instrument air to Building #105-R and plant service air requirements to Buildings #105-R and #108-1R.

BUILDING FLOOR SPACE

Note: All elevations refer to grade elevation as 0'-0".

	<u>Approx. Sq. Ft.</u>
Battery Room (Elevation - 20'-0")	200
Toilet and Locker Room (Elevation - 20'-0")	125
Main Engine Room	3655
Open Well (for moving heavy equipment)	525
Auxiliary Room Exhaust Housing (Elevation +0'-3")	230
Main Room Air Intake Blast Shield (Elevation +0'-3")	90
Main Room Air Exhaust Blast Shield (Elevation +0'-3")	90

BUILDING DETAILS

This is a Class I structure, rectangular in shape, approx. 102 ft. x 49 ft. x 20 ft. A rectangular open well, 35 ft. x 21 ft., was provided on the east side as an access pit for moving heavy equipment in and out of the building.

The operating floor is 20 ft. $\pm$ below grade. A basement section, 40 ft. x 28 ft., over which the 1000 kw. generator unit was installed, is approximately 29 ft. below grade.

The blast-proof air discharge housing and the air intake housing, for room-air requirements, are located on the roof of the Engine Houses.

Total Area = 6595 sq. ft.
Total Volume = 164,470 cu. ft.

The area of the operating floor is approximately 4000 sq. ft.

CONSTRUCTION DETAILS

Engine House

Foundation - Reinforced concrete mat.
Walls - Reinforced concrete, with membrane waterproofing.
Roof - Reinforced concrete slab, with SM-WC covering.
Flooring - Concrete, with 1 in. cement waterproofing.
Doors - One interior roll-up metal and one exterior blast-proof steel door in access pit.

Battery Room

Partitioning material - Concrete block.
Ceiling - Reinforced concrete.
Floor - Reinforced concrete.

Toilet and Locker Room

Partitioning Material - Concrete block.
Ceiling - Reinforced concrete.
Floor - Reinforced concrete.

Concrete Cells for "On-Line" Switchgear

Walls and Ceiling - Reinforced concrete.
Floor - Finished floor of building.

Open Well

Partitioning Material - Reinforced concrete.
Ceiling - Open.
Floor - Reinforced concrete.
Note: Jib crane anchored to top of east wall.

Auxiliary Room Exhaust Housing

Foundation - Top slab of Engine House.

Walk - Reinforced concrete.
Ceiling - Reinforced concrete.
Floor - Reinforced concrete.

Main Room Air Intake Blast Shield

Floor - Top slab of Engine House.
Walls - Reinforced concrete.
Ceiling - Reinforced concrete.

Main Room Air Exhaust Blast Shield

Floor - Top slab of Engine House.
Walls - Reinforced concrete.
Ceiling - Reinforced concrete.

Heating and Ventilating

Unit heaters were provided.

A dual air supply and exhaust fan system was installed in the Engine House, and another small exhaust fan was installed in the Battery Room. Due to the large amount of heat given off by the engine and electric generator units in this underground structure, a dual manually operated exhaust system was provided. The inlet fans are capable of delivering 15,400 c.f.m., singly or 30,000 c.f.m. when operating in parallel. The main exhaust fan will handle 16,500 c.f.m. and the auxiliary exhaust fan handles 9000 c.f.m.

Lighting

Fluorescent fixtures were installed over the generators and standard industrial incandescent fixtures throughout the rest of the structure.

Communication

Loud-speakers, and sound-powered telephone stations, which are a part of the area intercommunication system, and a Bell telephone station are provided.

EQUIPMENT

Mechanical

- 4 170 hp. 900 r.p.m. Diesel engine generator sets and auxiliaries.
- 1 1000 kw. Diesel generator set a.c. quick-starting and auxiliaries.

- 2 10,000-gallon Diesel storage fuel oil tanks.
- 1 Instrument air dryer.
- 2 Two-stage instrument air compressors (480 c.f.m. - 125 p.s.i.g.) a.c. motors and air receiver tanks.
- 1 Lube oil storage tank (170 gal.)
- 1 Oil tank (for dirty oil - 170 gals.)
- 2 Fuel oil transfer pumps and drives (20 g.p.m. - 25 p.s.i.g. - Storage tanks to day tanks).
- Note: Fuel oil strainers were obtained under Building #108-3R.
- 2 Duplex fuel oil gravity strainers - 1-1/2 in. for 25 lb. test-storage tanks to day tanks.
- 2 Lube oil transfer pumps and drives (10 g.p.m. - 25 p.s.i. - from storage tank to engine).
- 1 Strainer for unloading tanks.
- 2 Duplex lube oil strainers (1-1/2 in. - 25 lb. test - Storage tanks to day tanks).
- 1 1-Ton chain hoist and monorail for station maintenance (manually operated).
- 1 1-Ton jib crane with structural supports for access wells.
- 2 Fuel oil storage tank measuring gauges.
- 1 Fuel oil overflow tank (170 gal.).
- 1 Fuel oil recovery pump (10 g.p.m.).
- 1 Fuel - 1-1/2 in. strainer.
- 3 Control valves.
- 3 Air operated pilot assemblies.
- 1 3 in. Plug Valve.
- 2 Circulating water pumps (50 g.p.m.).
- 1 Lube oil storage and dispensing unit (1 gal./stroke).
- 1 Air pressure reducing valve.
- 1 Strainer.
- 1 Hand barrel pump (10 g.p.m.).

Heating and Ventilating

- 2 32 in. Vane-axial air fans with drives (15,450 c.f.m.).
- 1 32 in. Vane-axial main exhaust fan with drive (16,500 c.f.m.).
- 1 28 in. Vertical vane-axial exhaust fan (9000 c.f.m., can be converted to 13,000 c.f.m.).
- 1 Centrifugal battery room exhaust fan with drive (1300 c.f.m.).
- 2 Unit heaters with drives (each 51,400 B.t.u./hr.).
- 1 Steam pressure reducing valve.

Electrical

- 1 A.c. Lighting distribution panel.
- 1 Lighting panel - 28 circuit.
- 1 Lighting panel - 4 circuit.

- 1 Lighting panel - 14 circuit.
 - 81 Lighting fixtures.
 - 1 Indicating lamp unit.
 - 1 Automatic transfer switch - 30 amp.
 - 2 Safety switches - 30 amp., 250 volt, d.c.
 - 1 Fused safety switch - 400 amp. 250 volt, with 4-400 amp., 250-v. fuses.
 - 1 Fused safety switch - 600 amp. 250 volt with 4-600 amp., 250-v. fuses.
 - 1 Set-bus duct 480 volt diesel generator leads.
 - 1 Set-bus duct bus tie connection.
 - 1 Emergency diesel generator switchgear.
 - 4 Sets "on-line" diesel generator switchgear.
 - 4 D.c. Wattmeters and resistors.
 - 5 Sets of vapor tight doors for switchgear.
 - 1 Alarm and indicating panel on diesel generator station.
 - 1 Temperature indicator instrument.
 - 1 Set of insulators - "on-line" gen.
 - 4 Sets of electric connectors - "on-line" power bus.
 - 2 45 kv.-a., 480 - 120/208-v. transformers.
 - 16 Momentary contact start-stop pushbutton stations.
 - 1 Cabinet.
 - 1 Noise reducing telephone booth.
 - 1 125 v. station battery with two charging units and control panel.
- Receptacles, local switches and connectors were obtained by field procurement.

Architectural

- 1 Pneumatic sewage ejector.
- 2 Duplex single stage vertical sump pumps(100 g.p.m.).
- 1 Water cooler.
- 1 Water heater.
- 1 Chain operated vertical rolling door.

DRAWINGS

- W-137904 - Plan - Sections and Details.
- W-137902 - Plan - Roof.
- W-137889 - Plan - Basement Mat. - Sections.
- W-138218 - Operating Floor - Plan and Details.
- W-138016 - Arrangement of Electrical Equipment and Details.
- W-137848 - One Line Diagram.
- W-136346 - General Arrangement - Plan and Sections "A-A".
- W-137896 - General Arrangement - Plan and Sections "B-B".
- W-137915 - General Arrangement - Plan and Sections "CC-DD".

BUILDING #108-1P - ENGINE HOUSE

This building is identical to Building #108-1R.

BUILDING #108-1L - ENGINE HOUSE

Redesign of Building #105-L plus the lower water table at the building site combined to effect several changes in the design of Building #108-1L.

1. Concrete intake structures housing the air intake filters of the Caterpillar engines and air compressors were eliminated. Instead, the filters were mounted directly on the equipment to draw air from the room.

2. Buildings #105-L and #108-1L were constructed with a common wall.

3. The walls of the building were made 2 ft.-6 in. thick instead of 3 ft.-3 in. thick, and the floor slab was reduced in thickness from 4 ft. to 3 ft.-6 in.

4. The blast resistant air intake structure for the 1000 kw. engine was eliminated and the air intake structure was located directly on the engine.

5. The four stand-by pumps for the 1000 kw. engine were eliminated.

6. The exhaust header system leading to a single stack was eliminated.

7. The two 15,450 c.f.m. fans purchased for air supply were utilized as exhaust fans and a 42 in., 30,800 c.f.m. fan was procured for air supply.

In all other respects Building #108-1L is identical to the engine houses installed in the #100-R&P Areas. See W-139340 - Plan - Sections and Details, and W-142138 - Operating Floor Plan and Details, Building #108-1L.

BUILDING #108-1K & #108-1C - ENGINE HOUSES

These buildings are identical to Building #108-1L.

BUILDING #108-2R - ENGINE HOUSE

This building is practically identical to Building #108-1R and to avoid duplication, the detailed description has been eliminated here. Only the differences between the two buildings are enumerated.

The most significant of these differences is found in their locations - on opposite ends of the south side of Building #105-R - and in the fact that Building #108-2R also contains emergency pumping facilities. The pump room which houses these facilities is located on the north side of #108-2R and is immediately between the engine room of the building and Building #105-R.

FUNCTION

In addition to performing services similar to those provided by Building #108-1R, this building also houses emergency pumping facilities for handling cooling water to the process heat exchangers in Building #105-R.

PRINCIPAL COMPONENTS

This building contains the same engine room equipment as did #108-1R except that there is one air compressor only in this facility.

Water Pumps

Three 6000 g.p.m. pumps were installed in this building to comply with the emergency pumping requirements. These afford sufficient capacity to allow safe limited operations and shut down as outlined in the process section of the discussion of Building #105-R.

BUILDING FLOOR SPACE

The addition of the valve and pump room to this building accounts for the following additional space over that contained in #108-1R:

Valve Room (El. -20'-0")	367 square feet
Emergency Pump Room (El. -20'-0")	2160 square feet

BUILDING DETAILS

The addition of the valve and pump room to the building increased total area and volume to the following amounts:

Total Area	-	7200 square feet
Total Volume	-	232,630 cubic feet

CONSTRUCTION DETAILS

Emergency Pump Room

Foundation - Reinforced concrete mat.
Partitioning Material - Reinforced concrete.
Ceiling - Reinforced concrete (with removable concrete slab sections).
Floor - Reinforced concrete.

Valve Room

Foundation - Reinforced concrete mat.
Partitioning Material - Reinforced concrete.
Ceiling - Reinforced concrete (with removable concrete slab sections).

EQUIPMENT

The installation of the additional pump equipment in this building and the resultant increase in miscellaneous electrical and ventilating equipment, are the only deviations from quantities shown for Building #108-1R.

DRAWINGS

Mechanical

W-137789 - General Arrangement - Plan and Sections.
W-137898 - General Arrangement - Roof and Sections.
W-138105 - General Arrangement - Basement Plan.

Plumbing, Drainage, Heating and Ventilating

W-137945 - Heating and Ventilation
W-137862 - Plumbing and Drainage

Electrical

W-138450 - Arrangement of Electrical Equipment and Details.

Architectural

W-136638 - Plans - Details.

BUILDING #108-2P - ENGINE HOUSE

This building is identical to Building #108-2R.

BUILDING #108-2L - ENGINE HOUSE

The factors which led to changes in the design of Building #108-1L influenced the design of Building #108-2L also. Since both buildings are similar except for their orientation with respect to Building #105, the same changes were made in each building. See the following drawings of Building #108-2L:

- W-139790 - Plans - Details.
- W-139394 - General Arrangement - Plan and Section "A-A".
- W-139395 - General Arrangement - Basement and Section.
- W-142340 - General Arrangement - Roof and Sections.

BUILDINGS #108-2K AND #108-2C - ENGINE HOUSES

These buildings are identical to Building #108-2L.

BUILDING #108-3R - FUEL UNLOADING FACILITIESFUNCTION

All diesel fuel oil to be used in Building #108-1R and #108-2R is unloaded from railroad tank cars or trailer-trucks at this building, temporarily held for sampling, then transferred to the main storage tanks of the Engine House.

PRINCIPAL COMPONENTSRailroad Tank Car Unloading

A 100 g.p.m., 25 p.s.i.g. unloading pump is installed at the car unloading spot on the railroad siding adjacent to Building #194-R, Power House. All piping, valves and strainers necessary to transfer the fuel oil from the railroad tank cars to the unloading tanks have been provided.

Truck-Trailer Unloading

Provisions have been made near the service road west of Building #105-R to unload all trucks and trailers. A 100 g.p.m., 25 p.s.i.g. pump is installed to transfer the oil to tanks.

Storage and Transfer

Two 10,000-gallon underground storage tanks are installed and can be filled from either of the unloading spots. The underground structure contains a portion of each tank, two 100 g.p.m. fuel oil transfer pumps, metering equipment and

accessory equipment necessary to deliver the oil to the main storage tanks. Facilities also are provided for loading tank trucks from the storage tanks. Two unloading spots are provided at each of the Engine Houses for emergency tank truck unloading.

Waste Oil Pit

An earth pit, approximately 50 feet square at the top, has been constructed near the building for disposal of any waste oil or water seepage. The pit bottom is six feet below grade and a three foot dike surrounds it. Any seepage is pumped from the underground structure by a 150 g.p.m. pump.

BUILDING DETAILS

Of Class III construction, the facility is rectangular, completely underground, 23 ft. x 22 ft. x 16 ft. high. The underground floor area is 19 ft. x 18 ft.

Area - 510 sq. ft.
Volume - 8,000 cu. ft.

CONSTRUCTION DETAILS

Foundation - Reinforced concrete mat 2 ft. thick. On two sides the mat extends about 12 ft. beyond the pit walls to support concrete cradles on which the tanks rest.
Walls - Reinforced concrete 2 ft. thick.
Roof - Reinforced concrete 2 ft. thick.
Lighting - Explosion-proof industrial fixtures.
Ventilation - Roof ventilator.

EQUIPMENT

Mechanical

- 2 Diesel fuel oil unloading tanks, 10,000 gallons each.
- 1 Fuel oil flowmeter for unloading operation.
- 1 Fuel oil storage tank measuring gauge.
- 2 Fuel oil transfer pumps, 100 g.p.m., 50 p.s.i.g.
- 1 Fuel unloading pump, from railroad spot to unloading tanks, 100 g.p.m., 25 p.s.i.g.
- 1 Fuel unloading pump, 100 g.p.m., 25 p.s.i.g., to unload trucks and trailers.
- 1 Sump pump, 150 g.p.m.
- 2 Single gravity fuel oil strainers, 4 in. - 25-lb. test.

- 1 Duplex fuel oil strainer, 3 in. - 50 lb. test.
- 1 3 in. Plug valve.
- 2 4 in. Plug valves.

Heating and Ventilating

- 1 Roof ventilator, 1710 c.f.m. through the head at 15 in. S.P., 1400 c.f.m. under gravity conditions.

Electrical

- 1 1-kv.-a. 480/120 Transformer.
 - 1 250 Motor starter switch.
 - 2 Combination starters, NEMA III.
 - 3 Combination starters, 30 amp. NEMA I, NEMA IX.
 - 4 600 a.c. Transfer switches.
 - 1 2-Unit momentary contact start-stop pushbutton station.
 - 4 4-Unit momentary contact start-stop pushbutton stations.
 - 3 Lighting fixtures.
 - 1 Explosion-proof receptacle and plug.
- Necessary cable.

DRAWINGS

- W-138658 - Arrangement and Detail of Fuel Oil System - Railroad Unloading Station to Unloading Tanks.
- W-138457 - Arrangement of Electrical Equipment and Conduits.
- W-138231 - Unloading Tanks, Pit and Foundation.

BUILDING #108-3P - FUEL UNLOADING FACILITIES

This building is identical to Building #108-3R.

BUILDING #108-3L - FUEL UNLOADING FACILITIES

Alterations in area layout and some design changes in process facilities in the #100-L Area resulted in the design of a dual truck and tank car unloading spot for this area. The two 10,000-gallon temporary storage tanks are located above ground on saddles and adjacent to a 17 ft. x 27 ft. concrete pad. A steel grating is installed over the piping section.

In all other respects the equipment in this building is identical to that in Buildings #108-3R and #108-3P. See the following drawings of Building #108-3L:

- W-142296 - Arrangement and Details of Fuel Oil System - R. R. Unloading Station to Unloading Tank.
- W-142259 - Fuel Oil Unloading Tank Platform and R. R. Unloading Station.

BUILDINGS #108-3K AND #108-3C - FUEL UNLOADING FACILITIES

These buildings are identical to Building #108-3L.

BUILDING #183-1R - CLARIFICATION PLANT (COOLING WATER)

FUNCTION

This facility clarifies approximately 80,000 g.p.m. of raw river water to a maximum turbidity of 5 p.p.m. for distribution within the #100-R Area or, simultaneously, supplies the Reservoir, Bldg. #186-R, with clarified and/or raw river water while supplying 3100 g.p.m. of clarified water to the Filter and Softener Plant, Bldg. #183-2R.

PRINCIPAL COMPONENTS

This installation includes three basic components; (1) chemical storage facilities; (2) a chemical building; and (3) clarification units.

Chemical Storage Facilities

Liquid chlorine is received and stored in two horizontal steel storage tanks each having a capacity of 14,900 gallons. Normally, the chlorine is discharged from these tanks to the chlorinators in the Chemical Building under its own vapor pressure.

Sodium silicate is received and stored in four welded steel tanks, each with a capacity of 17,000 gallons. Two submerged 100 g.p.m. transfer pumps are provided to convey the sodium silicate solution from these tanks to the Chemical Building.

One 17,000 gallon concentrated acid storage tank receives and stores 66° Baume sulfuric acid. A submerged 100 g.p.m. acid pump in this tank conveys the acid to the Chemical Building.

Alum and lime are received and stored in four circular reinforced concrete chemical storage silos of 10,800 cu. ft. capacity each - two for alum, two for lime. Both alum and lime are discharged from the silo. The alum feeding equipment consists of two belt-type gravimetric feeders having a range of 30-3000 lb./hr., and two dissolving chambers. The alum solution is pumped directly to the chemical mixing chamber from each silo by 50 g.p.m. pumps - two pumps per silo, one of which is a stand-by.

The lime feeders are identical with the alum feeders except that the feeding range is 150-1500 lb./hr. Each feeder is equipped with a lime slaker of 1500 lb./hr. slaking capacity. The solution is pumped to the chemical mixing chamber in the same fashion as in the alum solution.

Chemical Building

This is a single-story structure, with the exception of a second floor over the activated silica room. The building has six separate sections.

1. A laboratory equipped for chemical and physical analysis of the raw and treated water.
2. An office, change room, and wash room section.
3. A chlorine room, containing two electrically-operated liquid chlorine evaporators and two manually controlled solution feed vacuum chlorinators - one of 6000 lb./day capacity, the other of 1000 lb./day capacity.
4. An activated silica room in the upper floor containing an acid storage tank, acid weigh tank, and acid dilution tank arranged in series, and a sodium silicate measuring tank.
5. An activated silica room on the ground floor where dilute sulfuric acid fed from the floor above is reacted with sodium silicate to produce an activated silica solution. The section contains two mixing and aging tanks of 17,000 gallons capacity each; a 600 g.p.m. transfer pump for transferring a batch of activated silica from one mixing and aging tank to the other; and two 80 g.p.m. capacity activated silica solution feed pumps which discharge this solution to the chemical mixing chamber.
6. An air compressor room containing two air compressors - one for chlorine unloading and one for instrument air - with air receivers, air dryers, and aftercoolers.

Clarification Units

These units comprise a stilling chamber, a chemical mixing chamber, flocculation basins, and settling basins. River water enters the sectionalized chemical mixing chamber from the stilling chamber. Four rapid flash mixers, each driven by a 15 hp. motor, are installed in the mixing chamber. Water from the mixing chamber is conveyed to five flocculation basins via a distribution channel through sluice gates and stop-gate openings. Each basin measures 80 ft. x 70 ft. x 20 ft. deep with approximately 10 ft. of depth above and 10 ft. below grade. Four rows of flocculating paddles, driven by a 7.5 hp. 4-speed gear-motor, are

installed in each basin with a baffle between each set of paddles.

Three dry wells, each measuring approximately 17 ft. in diameter by 68 ft. deep, are located between adjacent pairs of flocculation basins.

Five settling basins, each measuring 265 ft. x 90 ft. x 20 ft. deep with approximately 10 ft. of depth above and 10 ft. below grade, receive water from the flocculation basins. Each basin is equipped with a monorake sludge collecting mechanism and a sludge hopper, with two 12 in. sludge drain lines connecting each sludge hopper with man-holes located south of flocculation basins.

An adjustable steel V-notched weir is anchored to the concrete effluent channel along the north side of each settling basin. The effective length of the weir is approximately 270 ft. made up of three sections each 90 ft. long.

In addition to the foregoing components, this facility is also served by a substation, a 1000 kv.-a. 13.8 kv./480 v. outdoor double-ended unit with appurtenances and associated low voltage control centers installed to supply power and controls.

All necessary venturi meters and control valves are installed to measure and regulate the flow of water received and discharged.

Under certain operating conditions (these are discussed under "Outline of Plant's Operation - Alternate Methods") clarification units 1, 2, and 3 must be isolated from units 4 and 5. A unit comprises one flocculation basin and one settling basin. This requires pumping about 4000 g.p.m. of water from the mixing chamber to units 4 or 5. To provide for this contingency, two 4000 g.p.m. motor-driven low-lift pumps were installed adjacent to the chemical mixing chamber.

BUILDING FLOOR SPACE

Approx. Sq. Ft.

Total Treatment Plant Area	158,000
Chemical Building (Total Area)	2640
Laboratory	565
Office	150
Toilet No. 1	75
Toilet No. 2	40
Locker Room	195
Chlorine Room	250
Air Compressor Room	265
Activated Silica Room	875

River Water Stilling Chamber —	4450
Chemical Mixing Chamber	1300
Exhauster Building (near lime silo)	130
Substation	400
Unloading Platform over Chemical Storage Tanks	76

BUILDING DETAILS

The facilities are of Class III construction.

Chemical Building

Shape - Rectangular
 Horizontal dimensions - 71 ft. x 37 ft.
 Location - East of silos and south of treatment facilities
Area - 2640 sq. ft.
Volume - 46,870 cu. ft.

River Water Stilling Chamber (Including Two Trunks)

Shape - Rectangular
 Horizontal dimensions - 105 ft. x 56 ft.
Area - 4450 sq. ft.
Volume - 60,500 cu. ft.

The instrument room which houses the transmitters controlling the Bldg. #183-1R operations is located on top of this chamber.

Chemical Mixing Chamber

Shape - Irregular
 Horizontal dimensions - 34 ft. x 50 ft.
Area - 1300 sq. ft.
Volume - 43,000 cu. ft.

Exhauster Building

Shape - Rectangular
 Horizontal dimensions - 13 ft. x 10 ft.
Area - 130 sq. ft.
Volume - 1200 cu. ft.

Substation

Shape - Rectangular
 Horizontal dimensions - 31 ft. x 13 ft.

Unloading Platform over Chemical Storage Tanks

Shape - Rectangular

Horizontal dimensions - 19 ft. x 4 ft.

CONSTRUCTION DETAILS

Chemical Building

Foundation - Reinforced concrete spread footings
Frame - Steel
Roof - Girder beam - concrete slab, built-up roofing.
Wall siding - Corrugated cement asbestos
Interior partitions - Cement asbestos board
Flooring - Reinforced concrete slab.
Floor covering - Class I concrete finish and asphalt tile.
Stairs - Steel
Windows - Standard commercial steel, externally projected.
Doors - Hollow metal.

River Water Stilling Chamber

Foundation - Reinforced concrete mat.
Frame - Reinforced concrete wall.
Roof - Flat - reinforced concrete.
Floor - Reinforced concrete mat.
Doors - Two watertight hatches in roof.

Chemical Mixing Chamber

Foundation - Reinforced concrete mat.
Frame - Reinforced concrete
Roof - Reinforced concrete
Walls - Reinforced concrete
Floor - Reinforced concrete
Stairs - Reinforced concrete
Doors - Access grating covers at roof levels.

Flocculation Basins

Reinforced concrete throughout with removable wood baffles.
Paddles supported by reinforced concrete columns.

Dry Wells

Reinforced concrete throughout, slab roof and walls.
Drive shafts supported by reinforced concrete piers.
Door in south wall at grade level.
Reinforced concrete stairs.

Settling Basins

Reinforced concrete throughout. The monorake sludge collecting mechanism is located on the reinforced concrete wall separating the basins.

Sludge Hoppers

Reinforced concrete throughout.

Sludge Manholes

Reinforced concrete throughout.

Exhauster Building

Foundation - Reinforced concrete spread footing.
 Frame - steel.
 Roof - Concrete slab.
 Siding - Corrugated asbestos.
 Stairs - Steel.

Substation

Reinforced concrete mat 8 in. above grade.

Platform over Chemical Storage Tanks

This platform is constructed of structural steel.

Miscellaneous

Heating and air exhaust units were installed in the Chemical Building proper, partitioned rooms, and all other enclosed areas.

Fluorescent lighting was generally adopted and emergency lighting-power provisions were made.

Six area intercommunication telephone stations were provided, four in noise-reducing telephone booths.

Three Bell telephone stations were installed at this location, a fire alarm station and gong were provided, and two safety alarm loudspeaker assemblies were installed.

EQUIPMENTMechanical

1 lot - Chemical unloading equipment, 10 tons/hr.

- 1 lot - Chemical feed equipment.
- 1 lot - Liquid level control system.
- 1 lot - Clarification equipment, 96,000 g.p.m.
- 1 lot - Process chlorination system.
- 4 - Reinforced concrete chemical storage silos, approx. 9800 cu. ft.
- 1 lot - Laboratory equipment.
- 1 - Liquid level indicator, acid.
- 1 - Sluice gate.
- 1 - Vertical, single-stage air compressor, 105 c.f.m.
- 1 - Vertical, single-stage air compressor, 82 c.f.m.
- 1 - Silica gel air drier, 100 c.f.m.
- 1 - Silica gel air drier, 150 c.f.m.
- 4 - Heat exchangers for sodium silicate tanks to maintain 17,600 gal. at 55°F.
- 1 lot - Laboratory furniture.
- 4 - Liquid level indicators, sodium silicate.
- 1 set - Model test equipment on stilling chamber.
- 4 - Liquid sodium silicate tanks, each approx. 17,600 gal.
- 2 - Chlorine storage tanks, each approx. 14,000 gal.
- 1 - Acid storage tank, 17,700 gal.
- 1 - Sodium silicate unloading pump, motor-driven, 100 g.p.m.
- 1 - Acid transfer pump, motor-driven, 15 g.p.m.
- 2 - Sodium silicate transfer pumps, motor-driven, 30 g.p.m.
- 2 - Low-lift, single-stage pumps with two motor drives, each 4000 g.p.m.
- All necessary valves, hose flow meters, saddles and flanges.

Heating and Ventilating

- 1 - Heating and ventilating unit, Chemical Building, motor-driven, 2400 c.f.m., 119,000 Btu/hr.
- 1 - Unit heater in Compressor Room, motor-driven, 438 c.f.m., 23,100 Btu/hr.
- 4 - Unit heaters in Silica Room, 2 - 438 c.f.m., 23,100 B.t.u./hr. 2 - 710 c.f.m., 42,000 B.t.u./hr.
- 5 - Unit heaters, general use, motor-driven:
 - 4 - 736 c.f.m. - 71,000 B.t.u./hr.
 - 1 - 3 kw. - 200 c.f.m. 10,236 B.t.u./hr.
- 1 - Unit heater in Chlorine Room, motor-driven, 438 c.f.m., 23,100 B.t.u./hr.
- 1 - Toilet exhaust fan, motor drive, 600 c.f.m.
- 1 - Power roof vent in Chlorine Room, motor drive, 1200 c.f.m.
- 1 - Roof ventilator in Silica Room, motor drive, 3500 c.f.m.
- 1 - Roof ventilator in Compressor Room, motor drive, 635 c.f.m.

- 4 - Propeller fans, general use, motor drive, 1650 c.f.m.
- All necessary pressure relief dampers, thermostats, valves, and appurtenances required for the satisfactory operation of the above heating and ventilating units.

Electrical

- 2 - 75 kv.-a., 480 v. Transformers.
 - 1 - 3 kv.-a., 120/240-480 v. Transformer.
 - 1 - Blackout contactor, 200 amp. with d.c. contactor and relay.
 - 1 - 24-circuit 208/120 v. Lighting panel.
 - 1 - 18-circuit 208/120 v. Lighting panel.
 - 1 - 8-circuit Lighting panel.
 - 1 - 200 amp. a.c. Lighting distribution panel.
 - 4 - 600 v. Distribution panels.
 - 1 - 208/120 v. Distribution panel.
 - 2 - 24-circuit 208/120 v. Panels.
 - 1 - 200 amp. Transfer switch.
 - 1 - 30 amp. 250 v. Automatic transfer switch.
 - 1 - 480 v. 100 amp. Receptacle for 480 v. outlets.
 - 6 - Intercommunication system assemblies with splash-proof telephone stations.
 - 2 - Loudspeaker assemblies.
 - 1 - Pushbutton station, two unit "on-off".
 - 10 - Momentary pushbutton stations start-stop.
 - 2 - Selector switch stations.
 - 7 - Combination motor starters, 30 amps.
 - 5 - Combination motor starters, 100 amps.
- Lighting fixtures.
Lighting reflectors.
All necessary pull boxes, cable, grounding cable, hardware, conduit, and fittings.

Architectural

- 1 - Water cooler.
- 1 - Water heater and storage tank.

PLANT OPERATION

Basic Flow Pattern

The basic operational pattern entails chemical treatment of the entire flow of 80,000 g.p.m. for clarification, disinfection, and algae control.

Water for the Clarification Plant, Bldg. #183-1R, is supplied from the Savannah River, normally pumped from the River Pump House, Bldg. #681-1G, at a rate of 80,000 g.p.m. through reinforced concrete pipe. The chemical mixing chamber

receives this water through two concrete pipe lines, one of which is an emergency line, via a stilling chamber and flumes. Water enters the chamber through four openings in the bottom slab, at which point chlorine, alum, lime, and activated silica solutions are added. As the water passes up through the chamber, these chemicals are thoroughly diffused through the raw water by flash mixers.

Chlorine is pumped to the mixing chamber from the chlorinators in the Chemical Building at a designed feed rate of 5 p.p.m. for algae control and as an aid to coagulation. Dilute sulfuric acid is reacted with sodium silicate in the Chemical Building to produce an activated silica solution which is pumped to the mixing chamber at a designed feed rate of 5 p.p.m. This solution is used as an aid to coagulation to increase the density of the floc particles.

Liquid alum is pumped at a designed feed rate of 35 p.p.m. to the mixing chamber from chemical feeders located at the base of each storage silo. Alum reacts with the natural and induced alkalinity of the water to form a nucleus for building up floc particles. Lime is also pumped at a designed feed rate of 17 p.p.m. to the mixing chamber from chemical feeders located at the storage silos. Lime is added as a source of alkalinity for reaction with the alum.

A distribution channel conveys the chemically impregnated water from the mixing chamber to the flocculation basins. Water flows from this channel through sluice gates and stop-gate openings to the feed channel of each flocculation basin, from which it is distributed across each basin through openings spaced at equal intervals in the bottom slab of the feed channel. In general, velocity variations in the channels and through the openings range from 2-5 f.p.s., which is sufficient to prevent settling yet does not result in high head loss.

Within the flocculation basins, precipitation is accelerated by the action of the paddles. Detention time is approximately 45 minutes, the water then flowing into the settling basins to which the flocculation basins are directly connected.

The suspended floc settles to the bottoms of the settling tanks, detention time here being approximately three and one-half hours. A monorake sweeps each basin bottom and conveys the settled solids to a sludge hopper located near the influent end of each basin. Collected sludge is then removed from the basins through sludge lines connecting the hoppers with manholes located south of the clarification units. A contact actuated by the monorake starts a timer which operates the sludge blowdown.

Clarified water flows over the weir plates of the basins and in to the effluent channel at an average rate of 76,000 g.p.m., this water being taken off for the Reservoir, Bldg. #186-R, to which it is delivered through two pipe lines. Effluent pipe lines through the walls of the settling basins take off 4000 g.p.m. of water for the Filter and Softener Plant and clarified water pumps. Units 1, 2, and 3 each have one pipe connected to a header to the filters. The take-offs are located below the water surface in the basins.

Alternate Methods

Clarified Water to Filtration Plant and Raw Water to Reservoir

Under this scheme of operation, clarification units 1, 2, and 3 are operated independently of units 4 and 5. Water passing through the first three units do not receive chemical treatment, although some clarification may result because of the detention time allowed in the basins. This water is supplied to the Bldg. #186-R at a rate of 92,000 g.p.m. for cooling and service use; 3100 g.p.m. of clarified water from units 4 and/or 5 will be fed to Building #183-2R for filtration and softening.

In this flow pattern, water flows to the reservoir through the same units as in the basic pattern. However, the water which is to be clarified chemically and filtered for domestic and process use is pumped directly to units 4 and 5 from the mixing chamber by the low-lift pumps, bypassing the influent flume. Chemical treatment for this water involves injections of chlorine, alum, and lime solutions into the pump suction lines, the chemical feeders being paced by a metering device in each pump discharge line. Sufficient mixing is provided in the flow of the water through the pumps.

After flowing through the settling basins, the water is taken off through outlets connected to the header to the filters. The water level in these basins is maintained low enough so no flow will occur over the effluent weirs to the effluent channel since this flume is used exclusively for cooling and service water which is not chemically treated. Therefore, clarification units 1, 2, and 3 contribute flow only to Bldg. #186-R for cooling and service use, while units 4 and 5 are connected to the filters for process and domestic use.

In order to allow the larger flow through basins 1, 2, and 3 (40,000 g.p.m. maximum flow per basin instead of 16,000 g.p.m. as designed for the basic flow pattern), additional stop-plank openings were provided in the walls of these units.

Clarified Water to Filtration Plant and Clarified and Raw Water to the Reservoir

This plan of operation entails the chemical clarification of a portion of the water, 4000 g.p.m. of which is supplied to the Filter and Softener Plant, Bldg. #183-2R, and 44,000 g.p.m. to one or two compartments of the Reservoir, Bldg. #186-R, for process use. The remaining portion of the water flowing through this plant, 48,000 g.p.m. of raw water, is delivered to other compartments of the reservoir.

Chemical clarification can be accomplished in units 1, 2, and 3 or units 3, 4, and 5, while raw water is passing through units 4 and 5 or units 1 and 2. In this case, the filter plant is supplied 4000 g.p.m. from those basins in which chemical clarification is effected. Since unit 3 takes either raw or treated water, the influent and effluent flumes for this unit are provided with removable planks to permit this flexibility. As in the case with the foregoing alternate method, maximum flow through each unit when passing river water is 40,000 g.p.m. instead of the clarified water flow rate of 16,000 g.p.m.

This method necessitates the use of both emergency raw water lines and meters and the chemical mixing chamber. This chamber is divided through the center, one half being isolated from the other, with the chemical feed lines so valved that feed can be sent to either section. This is a removable division while that in the chamber beneath is fixed. This alternate method does not require the use of the low-lift pumps.

Controls for this plant were designed with sufficient flexibility to permit operation by any of the three methods outlined above.

DRAWINGS

Water Treatment

- W-136285 - Area Arrangement Plan.
- W-137740 - Flow Diagram - Sheet #1 of 2.
- W-138688 - Flow Diagram - Sheet #2 of 2.
- W-138068 - Chemical Building - Arrangement, Plans, and Section.
- W-136253 - Clarification Basins - Arrangement Plan.
- W-136370 - Clarification Basins - Arrangement Sections.
- W-138093 - Silos - Chemical Feeder Piping Arrangement Plan.
- W-142030 - Transfer Pumps and Piping - Arrangement, Plans, Sections and Details.

W-138142 - Clarification Basins - Arrangement, Flocculation Basin and Effluent Weir Details.

Architectural

W-138154 - Plans and Details.
 W-138155 - Elevations - Sections and Details.
 W-138502 - Plan of Chemical Silo and Door Details.

Electrical

W-138120 - One Line Diagram - 400 v. and 208Y/120 v.

BUILDING #183-2RPLK&C - FILTER AND SOFTENER PLANT

The discussion of these facilities is based upon Building #183-2R. The Filter and Softener Plants in the other four #100 Areas are essentially identical with each other and differ from Bldg. #183-2R in only a few minor details, noted under a subsequent section, "Design Changes by Areas".

FUNCTION

This installation serves to treat further the clarified water received from Building #183-1R to provide: (1) chlorinated filtered water for domestic use in the #100-R Area and for operational use in Building #105-R; and (2) softened chlorinated filtered water for boiler feed make-up in the Power House, Building #184-R, and for Building #105-R.

PRINCIPAL COMPONENTS

This facility comprises two basic components. a filter plant and a softener plant.

Filter Plant

Four filter units, each measuring 13 ft. x 25 ft. x 12 ft. average depth, reduce clarified water from a turbidity of 5-10 p.p.m. to less than 1 p.p.m. at a designed capacity of 3100 g.p.m. The filtered water is discharged into a two-section clearwell, one section for domestic water with a 38,000-gal. capacity, the other for operational water with a 92,000-gal. capacity. The top slab of the clearwell is utilized as a pump platform on which are mounted:

- 3 - Domestic water pumps rated at 400 g.p.m. against a total head of 175 ft. - one motor-driven and two turbine-driven.

- 3 - Filtered water pumps, motor-driven, rated at 1300 g.p.m. against a total head of 60 ft.
- 2 - Boiler feed water make-up pumps rated at 150 g.p.m. against a total head of 200 ft. - one motor-driven, one turbine-driven.
- 1 - Filter backwash pump, motor-driven, rated at 6100 g.p.m. against a total head of 50 ft.
- 1 - Surface wash pump, motor-driven, rated at 175 g.p.m. against a total head of 230 ft.

Softener Plant

Two Zeo-Karb "H" hydrogen exchangers and two Permutit "S" silica absorbers are located on either side of the Softener Building, a single-story structure housing the softener operating room, an office and laboratory, a change room, a chlorine room, and a polyphosphate room.

The operating room contains acid and caustic regeneration equipment and caustic feed equipment for pH adjustment of the treated water (boiler feed make-up) after it leaves the absorbers. This latter apparatus consists of an 80-gal. dilute caustic tank and two 1.7 g.p.h. chemical feed pumps, one a spare.

The chlorine room contains two automatic control solution feed vacuum type chlorinators which feed chlorine to the domestic water section of the filter clearwell at a dosage of approximately 3 p.p.m. Chlorine is supplied the chlorinators from 150-lb. cylinders, space for five such cylinders being provided, and is applied to the water as a sterilizing agent and for algae and slime control within the pipe lines of the system.

The polyphosphate room contains two 150-gal. polyphosphate dissolving tanks and two motor-driven 10 g.p.h. chemical feed pumps which feed polyphosphate solution to the domestic water section of the clearwell at a maximum dosage of 4 p.p.m. This solution is applied to the water as protection for pipe lines and equipment against the corrosive action of the clarified water.

The softener plant equipment is designed to treat continuously 120 g.p.m. of filtered water.

Miscellaneous

One 2000-gal. caustic storage tank and one 1000-gal. sulfuric acid storage tank are located north of the clearwell.

Each is provided with a 3 g.p.m. transfer pump and each serves as storage for the chemicals employed to regenerate the softener units.

Two motor-driven clarified water pumps, each rated at 1000 g.p.m. against a total head of 190 ft., are located at the south-east corner of the plant. These take suction from the clarified water header and discharge clarified water to Building #105.

Two 750-kv.-a. 13.8 kv./480-v. outdoor, double-ended unit substations with all associated low-voltage control equipment are located in the north-west corner of this plant to provide required power and control.

BUILDING FLOOR SPACE AND COMPONENT DIMENSIONS

	Approx. Sq. Ft.	
	<u>#183-2R</u>	<u>#183-2P-L-K-C</u>
Over-all Plant	5140	5000
Chlorine Room	160	135
Polyphosphate Room	155	175
Change Room	110	100
Laboratory and Office	190	None
Operating Room	340	310
Pipe Gallery and Waste Channel -	12 ft. x 12 ft. x 69 ft.	
Effluent Flume -	6 ft. x 9 ft. x 69 ft.	
Waste Flume -	4 ft. x 6 ft. x 72 ft.	
Clearwell -	69 ft. x 27 ft. x 13 ft.	
Switchgear Pad -	49 ft. x 13 ft. x 1 ft.	

FOUNDING DETAILS

The softener and silica absorber building of Class II construction, is rectangular in shape, measuring approx. 67 ft. x 14 ft. in the R Area and 56 ft. x 13 ft. in Areas PLK & C. The over-all height to the top of the peaked roof is 14 ft.

	<u>#183-2R</u>	<u>#183-2PLK&C</u>
Area -	1150 sq. ft.	760 sq. ft.
Volume -	12,900 cu. ft.	10,870 cu. ft.

CONSTRUCTION DETAILS

Softeners and Silica Absorber Building

Foundation - Reinforced concrete mat.

Frame - Steel.
Roof - Standard beam and girder.
Roof covering - Corrugated asbestos.
Wall siding - Corrugated asbestos.
Flooring - Reinforced concrete.
Windows - Standard steel commercial, projected sash.
Doors - Hollow metal.
Interior Partitions - Cement asbestos board.
Unit heaters and exhaust and ventilator fans were installed throughout this plant.
Fluorescent lights were generally adopted and provisions were made for emergency lighting power.
One safety alarm amplifier cabinet and three safety alarm loudspeaker assemblies were installed, together with a fire alarm gong, an area intercommunication telephone station, and one Bell telephone station.

EQUIPMENT

Mechanical

- 1 lot - Filtration equipment, 3100 g.p.m.
- 1 lot - Boiler feedwater treatment equipment, 120 g.p.m.
- 1 lot - Instrumentation equipment.
- *2 lots - Laboratory equipment.
 - 1 lot - Polyphosphate solution feeder, 10 g.p.h.
 - 1 lot - Domestic chlorination equipment, 75 lbs./24 hrs.
 - 1 - Acid storage tank, 1000 gal. } Each with transfer
 - 1 - Caustic storage tank, 2000 gal. } pump, heat exchanger
)& associated equipment.
- *3 - Integrators.
 - 3 - Domestic water pumps - one motor-driven, two turbine-driven, each 400 g.p.m.
 - 2 - Boiler feed make-up pumps - one motor-driven, one turbine-driven, each 150 g.p.m.
 - 3 - Filtered water pumps with motor drives, each 1300 g.p.m.
- ***2 - Clarified water pumps with motor drives, each 1000 g.p.m.
 - 1 - Filter backwash pump with motor drive, 1300 g.p.m.
 - 1 - Surface wash pump with motor drive, 175 g.p.m.
 - 1 - Liquid level indicator, acid.
- All necessary valves and hose.

Electrical

- ```
*2 - 750-kv.-a. 13.8 kv./480-v. Outdoor unit substation.
*1 - 1 kv.-a. 480-208/120-v. Transformer.
 2 - 30 kv.-a. Dry type transformers.
 1 - 18-circuit Lighting panel, indoor.
 1 - 12-circuit Lighting panel, outdoor.
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- \*1 - 4-circuit Lighting panel, indoor.
- 1 - 3-circuit a.c. Distribution panel.
- All necessary receptacles and fixtures.
- 1 - Air pressure switch.
- 1 - 60 amp. Contactor and relay.
- \*\*1 - 1500-kv.-a. 13.8-kv./480-v. Double-ended outdoor unit substation.
- \*\*1 - Combination starter.
- \*1 - 30 amp. Automatic Transfer switch.
- 1 - 100 amp. Automatic Transfer switch.
- All required fused safety switches and cable.
- 1 - Safety alarm amplifier cabinet.
- 3 - Loudspeaker assemblies.
- 1 - Splash-proof telephone station.

#### Heating and Ventilating

- 1 - Chlorine room exhaust fan with back-draft damper, 1450 c.f.m.
- 1 - Toilet room exhaust fan with back-draft damper, 1450 c.f.m.
- 1 - Polyphosphate room exhaust fan with back-draft damper, 1450 c.f.m.
- 1 - Power driven roof ventilator, 2060 c.f.m.
- 1 - Chlorine room unit heater with thermostat, 735 c.f.m., 40,000 B.t.u./hr.
- 1 - Toilet room unit heater with thermostat, 438 c.f.m., 22,000 B.t.u./hr.
- 1 - Laboratory room unit heater with thermostat, 735 c.f.m., 40,000 B.t.u./hr.
- 2 - Operating room unit heaters with thermostats, each 735 c.f.m., 40,000 B.t.u./hr.
- 2 - Pipe gallery unit heaters, each 438 c.f.m., 22,000 B.t.u./hr.
- 1 - Polyphosphate room unit heater with thermostat, 735 c.f.m., 40,000 B.t.u./hr.

#### Architectural

- 1 - Water cooler.
- 1 - Electric water heater, 40°F. to 180°F., approx. 80 g.p.h.

- \* Provided for Bldg. #183-2R only.
- \*\* Not provided in Bldg. #183-2R.
- \*\*\* Assigned to Bldg. #183-2R only.

## PLANT OPERATION

### Filtration and Distribution

Approximately 3100 g.p.m. of clarified water flows by gravity to Building #183-2R from clarification unit No. 4 or No. 5 of Building #183-1R. This water enters the filters influent channel and is distributed to the four filters through sluice gates installed between the influent channel and each filter. Filtration is accomplished at a capacity rate of 2.4 g.p.m. per square foot of rapid-sand-filter area. The backwashing rate per filter is 6100 g.p.m. equivalent to 19 g.p.m. per square foot of surface area.

The rate of flow of water through the filtration units is controlled automatically by water levels in the domestic and filtered water sections of the clearwell. These elements set the opening of the rate-of-flow controller on each filter, which in turn regulates the water flow through the filters.

The effluent from each filter discharges into a concrete channel connected to the clearwell by an orifice in the concrete wall. Filtered water passes through the domestic water section of the clearwell and flows over a dividing wall into the second section. An overflow weir, so arranged that its elevation is lower than that of the dividing wall between the two sections of the clearwell, prevents backflow of water into the domestic water section. Any backflow which results thereby flows over the overflow weir to waste.

Chlorine and polyphosphate solutions are charged into the water at the entrance of the domestic water section of the clearwell by feeding equipment located in the Softener Building.

The domestic water pumps take suction from the first section of the clearwell, discharging 500 g.p.m. of chlorinated filtered water to various distribution points within the #100-R Area. This domestic water system furnishes water for fire protection, as a separate fire protection system was not provided.

Filtered water, boiler feed make-up, backwash, and surface wash pumps take suction from the second section of the clearwell. Filtered water is discharged to Building #105 at a maximum rate of 2400 g.p.m. and the boiler feed make-up pumps discharge approximately 120 g.p.m. to the softeners. Average allowance for backwash is approximately 100 g.p.m.

An orifice is installed in the discharge line of each pump system to measure the flow, and flows and pressures also are indicated, recorded, and/or totalized at an instrument panel installed in the office of the Softener Building.

All pumps are primed by steam ejectors and/or an auxiliary air system.

### Feedwater Treatment

To provide demineralized water to Building #105 and boiler feed make-up water practically free of silica and hardness, the boiler feed make-up pumps discharge 120 g.p.m. of filtered water from the clearwell to the softener plant where it is passed through ion exchange units. The cation exchanger is a Zeo-Karb unit in which metallic ions are replaced with hydrogen ions. The anion exchanger is a silica absorber unit which removes silica. Each cation exchanger has a rated capacity of 120 g.p.m. at 7.5 g.p.m. per square foot, and each anion exchanger has a rated capacity of 120 g.p.m. at 6.1 g.p.m. per square foot. These units are regenerated by acid (cation) and caustic (anion) regeneration apparatus housed in the operating room.

Switch-over selectors and indicator lights for use with the softener and absorber units are incorporated on the office instrument panel. Indication and annunciation of the completion of softener runs are also effected at this control panel.

The pH of the boiler feed make-up water is adjusted after leaving the anion exchangers. A 1% caustic solution, discharged from a dilute caustic tank in the operating room by a chemical feed pump, is injected into the boiler feed make-up line to the Power House, Bldg. #184. A pH recorder, with alarm contact, measures the pH of water in the discharge pipe from the anion exchanger, and paces the caustic feeder.

The flow of this water to the boilers is at a designed rate of approximately 100 g.p.m.

A take-off from the boiler feed make-up line delivers demineralized water to Building #105 at a designed rate of 2 to 10 g.p.m.

### DESIGN CHANGES BY AREAS

Whereas Building #183-2R receives clarified water from the #183-1R Clarification Plant, Buildings #183-2PLK&C are supplied from Clarification Plants #183-4PLK&C respectively.

This is the result of a decision to construct Building #183-1 with a designed capacity of 96,000 gallons in R Area only. Originally, plans called for construction of a 96,000 gallon capacity clarification plant in each of the five #100 Areas, but AED subsequently revised its estimate of clarified water requirements downward to 4000 g.p.m. per #100 Area. Building #183-1R was already under construction when it became evident that the 96,000 g.p.m. clarification facilities would not be required. However, its completion was authorized under a revised design plan permitting clarification of all or part of this plant's operating capacity, by-passing raw river water to the #186-R Reservoir and Building #105-R. This is discussed in some detail under Building #183-1R, "Development of Design".

As only 3100 g.p.m. of filtered water are required per area, four relatively small clarification plants, #183-4PLK&C, were designed to supply 4000 g.p.m. of clarified water each, 3100 g.p.m. of which are furnished Filter and Softener Plants, Bldgs. #183-2PLK&C respectively. The Bldg. #183-4 plants replaced the originally planned Bldg. #183-1 plants for the PLK&C Areas.

Although the foregoing discussion of the clarified water supply for the #183-2 buildings overlaps the design development of other buildings in the Area, these factors are interrelated with the development of the subject facilities.

Buildings #183-2PLK&C are identical installations, differing from Bldg. #183-2R only in certain minor features. Whereas Building #183-2R has two 750-kv.-a. unit substations, Buildings #183-2PLK&C each have a single 1500-kv.-a. unit substation. Over-all area of Building #183-2R is somewhat larger than that of the other four buildings. The R Area Softener Building contains a laboratory, the others do not. The floor space of the various rooms in the #183-2R Building is generally greater than that of the respective rooms in PLK&C Areas.

Because of the absence of a laboratory in the PLK&C Areas, the Softener Buildings do not contain the laboratory equipment provided in Building #183-2R. Due to the difference in substations, the PLK&C Buildings are not provided with certain items of electrical equipment with which Building #183-2R is equipped.

The 1000 g.p.m. clarified water pumps taking suction from the clarified water header at Building #183-2R are assigned to this building. However, in the PLK&C Areas, these pumps were assigned to Building #183-4.

DRAWINGS

Bldg. #183-2R

Water Treatment

- W-136336 - Filter and Softener Plant - Arrangement - Plan and Sections.
- W-137965 - Softener Plant - Arrangement - Plan and Sections.
- W-137736 - Flow Diagram.

Electrical

- W-138375 - 480-v. Outdoor Substation - Installation and Details.

Architectural

- D-117575 - Softeners and Silica Absorbers Building - Plan, Elevations and Details.
- D-117587 - Filters and Pumping Platform - Plan, Elevations and Sections.

Bldg. #183-2P

Water Treatment

- W-136614 - Filter and Softener Plant - Arrangement - Plan and Sections.
- W-136695 - Softener Plant - Arrangement - Plan and Sections.

Electrical

- W-137167 - 13.8-kv./440-v. Outdoor Substation - Installation and Details.

Architectural

- D-117601 - Softeners and Silica Absorbers Building - Plan, Elevations and Details.
- D-117598 - Filters and Pumping Platform - Plan, Elevations and Sections.

Bldg. #183-2L

Water Treatment

- W-136918 - Filter and Softener Plant - Arrangement - Plan and Sections.

W-136813 - Softener Plant - Arrangement - Plan and Sections.

Electrical

W-137368 - 13.8-kv./440-v. Outdoor Substation - Installation and Details.

Architectural

D-117622 - Softeners and Silica Absorbers Building - Plan, Elevations, and Details.

D-117623 - Filters and Pumping Platform - Plan, Elevations, and Sections.

Bldg. #183-2K

Water Treatment

W-139184 - Filter and Softener Plant - Arrangement - Plan and Sections.

W-139186 - Softener Plant - Arrangement - Plan and Sections.

Electrical

W-139173 - 13.8-kv./440-v. Outdoor Substation - Installation and Details.

Architectural

W-139167 - Softeners and Silica Absorbers Building - Plan, Elevations, and Details.

W-139168 - Filters and Pumping Platform - Plan, Elevations, and Sections.

Bldg. #183-2C

Water Treatment

W-139648 - Filter and Softener Plant - Arrangement - Plan and Sections.

W-142603 - Softener Plant - Arrangement - Plan and Sections.

Electrical

W-142589 - 13.8-kv./440-v. Outdoor Substation - Installation and Details.

## Architectural

W-142585 - Softeners and Silica Absorbers Building - Plan, Elevations, and Details.

W-142586 - Filters, and Pumping Platform - Plan, Elevations, and Sections.

### BUILDING #183-4PLK&C - CLARIFICATION PLANT

These buildings are identical with the exception of orientation, so Building #183-4 identifies each plant in the following discussion.

#### FUNCTION

These installations provide clarified water for Buildings #183-2PLK&C (Filter and Softener Plants) and #105PLK&C respectively. The clarified water is pumped directly to each Bldg. #105 without passing it through Bldg. #183-2.

#### PRINCIPAL COMPONENTS

The principal components of each plant are a chemical building, two precipitators, four transfer pumps, and two chlorine storage tanks. The approximate capacity of each plant is 4000 g.p.m.

##### Chemical Building

The Chemical Building contains the following compartments and major pieces of equipment.

1. Chemical Feed and Storage Room - two lime feeders and two alum feeders, one of each a spare, with a chemical extension hopper, dissolving tank, and solution pump for each feeder.

2. Air Compressor Room - one instrument air compressor, rated capacity 105 s.c.f.m. at 100 p.s.i., and one chlorine unloading compressor, rated capacity 82 s.c.f.m. at 150 p.s.i., with associated equipment and air dryers.

3. Chlorine Room - one manual control solution feed vacuum chlorinator, capacity 1000 lbs./24 hrs., connected in an electrically heated evaporator. Chlorine gas pressure between these units is regulated by a pneumatic pressure reducing valve.

4. Laboratory - supplied with the necessary testing equipment and storage facilities. The instrument panel board serving this plant is also located here.

5. Office.
6. Change Room.
7. Electrical Control Room.

In addition to the foregoing subdivisions of the Chemical Building, there is also a chemical handling elevator, a machine room, and storage space on both floors.

#### Precipitators

Two Spaulding precipitators, designed to operate on the upflow sludge blanket principle, are provided for clarification. Each has a rated capacity of 2000 g.p.m., is 14 ft. high, and has a top diameter of 55 ft. with a bottom diameter of approximately 41 ft. A distribution chamber (inlet flume) connects the precipitators with a chemical flash mixer.

Each precipitator is composed of a steel tank housing two truncated cones - the inner cone (in which flocculation occurs) centered in the outer cone, the apex of each pointed in diametrical directions.

#### Transfer Pumps

Two low-lift transfer pumps, one a spare, each motor-driven and rated at 4000 g.p.m. against a head of 20 ft., take suction from the header from Building #186 and supply the precipitators.

Two clarified water transfer pumps, one a spare, each motor-driven and rated at 1000 g.p.m. against a total dynamic head of 190 ft., discharge clarified water to Building #105.

#### Chlorine Storage Tanks

Two chlorine storage tanks, of 14,900-gallon capacity each, are located adjacent to the Chemical Building. Liquid chlorine is delivered to the area in railroad tank cars from which it is transferred pneumatically to the storage tanks by air supplied by the compressor in the Chemical Building. Chlorine is fed into the system from the storage tanks under its own vapor pressure.

These storage tanks supply Building #186 as well as Building #183-4.



Miscellaneous

Electric power is supplied by the substation at Building #183-2, Filter and Softener Plant, which ties in with two 440-v., 3-phase, 3-watt distribution panels located with the #183-4 Clarification Plant.

A safety alarm pilot circuit was provided, with amplifiers and loudspeakers located within the Chemical Building. An extension from the inter-building communication system out of Building #105 and an extension from the water treatment operating intercommunication system were also provided.

BUILDING FLOOR SPACEApprox. Sq. Ft.

|                                            |      |
|--------------------------------------------|------|
| Chemical Building                          | 2940 |
| Laboratory                                 | 470  |
| Office                                     | 155  |
| Locker Room (Change Room)                  | 130  |
| Toilet #1                                  | 70   |
| Toilet #2                                  | 40   |
| Chlorine Room                              | 250  |
| Air Compressor Room                        | 440  |
| Chemical Feed and Storage Area - 1st Floor | 830  |
| Chemical Feed and Storage Area - 2nd Floor | 830  |
| Elevator and Adjacent Stair Shaft          | 300  |

BUILDING DETAILS

These facilities are of Class III construction.

The Chemical Building is irregular in shape, with over-all dimensions being 71 ft. x 37 ft., excluding the stair and elevator shaft which is 26 ft. x 11 ft. The building is part one-story and part two-story. The two-story portion is 48 ft. x 25 ft. The structure has a flat roof at three different elevations, the highest portion being over the elevator shaft.

Area - 2940 sq. ft.  
Volume - 44,410 cu. ft.

CONSTRUCTION DETAILSChemical Building

Foundation - Reinforced concrete.  
Superstructure - Structural steel frame.  
Corrugated asbestos cement siding.  
Concrete floor slab.

Concrete roof slabs. —  
Interior Partition - Cement asbestos board.

### Precipitators

The precipitators are set at grade elevation on a concrete slab foundation.

A reinforced concrete transfer pump pit, 10 ft. x 14 ft. x 10 ft. deep, was provided with an adjacent antechamber for the butterfly control valve operation.

### Heating and Ventilating

Mechanical ventilation was provided in the laboratory, toilet and locker areas.

Power roof ventilators and adjustable wall louvers were installed for the chlorine room, air compressor area and chemical hopper area. Similar ventilation provisions were made in the chemical room except that propeller exhaust fans with back-draft dampers were used instead of roof ventilators.

The basis for the ventilation system design was to provide an air handling unit complete with heating coil and filters. This system supplies 100 per cent outside air during the summer and recirculates a portion of the air during the winter. A pressure relief damper was provided for summer operation. The design is such that no recirculated air is taken from the toilet and locker areas. A separate exhaust was provided for this purpose.

Unit heaters were installed throughout the plant.

### Drainage

The drainage design for this building provides three distinct systems.

1. Sanitary system.
2. Laboratory and equipment waste system.
3. Steam condensate waste system.

This design eliminates excessive drainage into the septic tanks. It also provides Schedule 80 steel pipe to convey the high temperature discharge.

### Services

The utility services to this plant include domestic cold water, hot water, gas and vacuum.

Gas is supplied from petroleum gas bottles stored immediately outside the building. All other services are typical for this type facility.

### Lighting

Incandescent lighting with dust and vapor-tight fixtures are generally used. Fluorescent lighting is provided in the office and laboratory. Emergency lighting provisions were made.

## EQUIPMENT

### Power

- 1 lot - Water Treatment Equipment - Clarification - with all appurtenances, 4000 g.p.m.
- 1 - Chemical handling elevator.
- 2 - Low-lift pumps with motor drives, each 4000 g.p.m. at 20 ft. head.
- 1 - Chlorine flow recorder.
- 1 - Chlorinator evaporator with exhaust, 1000 lbs./24 hrs.
- 1 - Instrument air compressor, 105 s.c.f.m. at 100 p.s.i. with air driers.
- 2 - Chlorine storage tanks, capacity of each 14,900 gals. allowing 15% for liquid expansion.
- 1 - Chlorine unloading air compressor with drier, 82 s.c.f.m. at 150 p.s.i.
- 1 lot - Instrument panel and control instruments.
- 1 lot - Water laboratory furniture.
- 1 - Lift truck, 2500 lbs.
- 60 - Wooden pallets.
- Laboratory equipment.
- 2 - Clarified water pumps with motor drives, each 1000 g.p.m. 190 ft. head.
- 4 - Hydraulic ejectors, 2 for lime and 2 for alum.

All necessary hose, valves and gauges.

Major equipment units which were procured as package units include associated electrical equipment.

### Electrical

- 1 - Blackout contactor, 200 amp., with d.c. contactor and relay.
- 1 - 200 amp. TPDT Transfer switch.
- 2 - 45-kv.-a. Lighting transformers.
- 1 - 208/120-v. Outdoor a.c. distribution panel.
- 1 - Air pressure switch.
- 1 - 440-v. Outdoor distribution panel, 12 breakers.
- 1 - 440-v. Outdoor distribution panel, 14 breakers.

- 3 - Water treatment assembly-intercommunication system units.
- 4 - Splash-proof telephone stations.
- 1 - Lighting distribution panel, 4-circuit.
- 3 - Lighting panels, each 24 circuits.
- 1 - Normal emergency power panel, 4-circuit, for safety alarm.
- 1 - Safety alarm cabinet.
- 1 - 30 amp. Automatic transfer switch.
- 1 - 1-kv.-a. 480/120/208-v. Transformer.
- Necessary low bay pendants and fluorescent strips.
- Miscellaneous relays, starters, pushbuttons and control switches.

### Heating and Ventilating

- 1 - Air handling unit, 150,000 B.t.u./hr. 5 p.s.i.g. steam, 40°F. entering air, 2860 c.f.m. at 7/8 in. external SP, including filter.
- 2 - Projection type unit heaters, each 54,000 B.t.u./hr.
- 3 - Projection type unit heaters, each 93,000 B.t.u./hr.
- 1 - Projection type unit heater, 20,000 B.t.u./hr.
- 2 - Horizontal type unit heaters, each 23,000 B.t.u./hr.
- 1 - Horizontal type unit heater, 18,200 B.t.u./hr.
- NOTE:** All unit heater capacities are based on 5 p.s.i.g. steam, 70°F. entering air.
- 1 - Centrifugal exhaust fan, 820 c.f.m. 1/4 in. SP.
- 1 - Centrifugal exhaust fan, 3000 c.f.m. 1/4 in. SP.
- 2 - Propeller type fans, each 1450 c.f.m. 1/8 in. SP.
- 2 - Roof ventilators, 3000 c.f.m. 0.15 in. SP.
- 1 - Roof ventilator, 1350 c.f.m. 0.15 in. est. SP.
- 1 - Roof ventilator, 660 c.f.m. 0.15 in. SP.

### Architectural

- 1 - Water cooler.
- 1 - Water heater and storage tank.

### PLANT OPERATION

Raw water to be treated in Building #183-4 flows from compartment No. 1 of the Cooling Water Reservoir, Building #186, through a pipe line to the suction header of the two low-lift pumps. Raw water is then pumped to the inlet of the flash mixer. Flow in this line is controlled by a butterfly valve.

The clarification process consists of chemical feeding, flash mixing, flocculation, and floc removal. This process reduces turbidity of the river water from 50-550 p.p.m. to approximately 10 p.p.m. Alum and lime are measured in dry form, mixed in solution tanks, and pumped into the piping system.

Alum is used for coagulation and is fed in solution at an average rate of one grain per gallon of water. The actual dosage varies throughout the year, depending upon the prevailing turbidity of the river water.

Lime is used for alkalinity adjustment and is fed in solution at an average rate of 0.25 grains per gallon of water.

Chlorine solution is prepared in the chlorinator for application at a maximum dosage of 5 p.p.m. Pre-chlorination treatment is applied to the water to control algae, inhibit the formation of biological slime, and promote flocculation.

The alum, lime, and chlorine solutions flow through overhead pipe lines from the Chemical Building and are injected into the water either at the inlet end of the flash mixer or at the low-lift pump suction, if mixing is desired in the pumps. These chemical solutions are mixed with the raw water flowing through the flash mixer to the distribution chamber. Distribution of the chemically impregnated water to either or both of the precipitators is accomplished by sluice gates installed in the sides of this chamber.

Flocculation and floc removal take place in the two precipitators. Water flows through the sluice gates via influent flumes into the top of the inner cone of each precipitator. Flocculation is accomplished in this section of the precipitator, the process being accelerated by the action of agitator paddles attached to a vertical shaft in the center. The floc in suspension flows under the bottom edge of the inner cone and rises toward the surface of the water in the outer cone. The upward velocity is such that it maintains the floc suspended in a blanket of sludge but will not carry the floc to the surface. Clarified water is collected in radial channels at the surface of the outer cones.

Total detention eye control permits automatic removal of part of the accumulated sludge when the floc increases the sludge blanket above a maximum upper level. Perforated sludge headers placed around the inside circumference of the outer cone are first back-flushed, then the sludge is blown down to waste.

The effluent of the two precipitators flows through down-comers to a header to the filters, Building #183-2, at a maximum rate of 3100 g.p.m. Flow measurements through orifices installed in the down-comers facilitate setting the sluice gates in the distribution chamber for equalizing the flow to each precipitator.

Water from the filter inlet header is taken off through a pipe to the clarified water sump at a maximum rate of 900 g.p.m. The clarified water transfer pumps take suction from this sump and discharge water to Building #105 as required.

The instrument panel located in the laboratory of the Chemical Building is equipped with various instruments which indicate and/or record flow, pressure, pH, conductivity, and temperature conditions throughout the plant. An annunciator on the panel signals abnormal operating conditions at all pertinent equipment and pipe lines.

A precipitator inlet control system maintains a maximum inlet flow up to normal precipitator operating level, throttles flow above this level, and stops flow at a maximum operating level. This system also controls the chemical feeds.

A clarified water control system prevents an excessive acceleration of flow through the precipitators which might upset the sludge blanket.

As indicated, a control system at each precipitator provides for automatic sludge blow-down.

## DRAWINGS

### Bldg. #183-4P

#### Water Treatment

- W-142184 - General Plot Plan.
- W-142188 - Chemical Building - Arrangement, Plan and Sections.
- W-142213 - Arrangement - Plan and Sections.

#### Electrical

- W-142111- Plot Plan and Outdoor Equipment.

#### Architectural

- W-142202 - Chemical Building - Plans.
- W-142203 - Chemical Building - Elevation and Details.
- W-142204 - Chemical Building - Elevation and Details.

Bldg. #183-4L

W-139554 - General Plot Plan.

Bldg. #183-4K

W-142647 - General Plot Plan.

Bldg. #183-4C

W-142706 - General Plot Plan.

No other drawings are listed for Building #183-4LK&C as the structures in each facility are identical to those listed for #183-4P.

BUILDING #184-RPL&K - POWER HOUSE

## FUNCTION

The primary functions of these power houses are to provide process steam and electric power for the respective #100 Areas, and to provide supplementary stand-by power to the transmission systems.

## PRINCIPAL COMPONENTS

Steam Generating Units

Two Riley Stoker Corporation two-drum, bent tube steam generators designed for a working pressure of 675 p.s.i.g. are installed in each of the subject power houses. Each unit has a normal operating capacity of 140,000 lbs./hr. at a pressure of 625 p.s.i.g., 825°F. (plus or minus 10°F.) at the super heater outlet when feedwater is supplied at 270°F.

Each boiler is equipped with a traveling grate, spreader stoker with four overthrowing feeders, each of which is driven through its own disconnecting clutch from a common power shaft, which in turn is driven by either a steam turbine or a motor.

Heat recovery equipment for each boiler consists of a two-pass, bare tube economizer having an effective heating surface of 8200 sq. ft. A dust collector removes fly ash from the economizer exit gases.

A single retractable pneumatically operated soot blower is installed with each boiler.

One F.D. fan, with a capacity of 41,000 c.f.m., is installed with each boiler unit to supply combustion air. The products of combustion are removed by an 86,000 c.f.m. I.D. fan. Air to the F.D. fan is controlled by variable inlet vanes at the air intake, while the flow of boiler exit gases is regulated by inlet louver dampers on the intakes of the I.D. fan. Both fans are mounted on a common shaft driven through a reduction gear by a steam turbine and are located at ground elevation outside the power plant structure.

Each steam generating unit is supplied with all necessary associated equipment such as flues, ducts, breeching, safety valves, miscellaneous tanks, and motors. A single reinforced concrete stack, 125 ft. high by 10 ft. I.D., serves both boilers.

#### Coal Handling Equipment

Coal handling equipment for each power house consists of a car puller to place coal cars; double track hopper to receive coal from the cars; a reciprocating plate feeder; a belt conveyor; a weightometer; a magnetic pulley to remove tramp iron; a coal crusher; a continuous bucket elevator; a scraper conveyor to transfer coal from the bucket elevator to the coal silo; a stocking-out chute; and a concrete coal storage silo 100 ft. high by 30 ft. inside diameter. Only the upper 50 ft. of this silo is utilized for coal storage.

The coal handling system delivering coal from the silo to the furnace bunkers consists of two identical sets of equipment, each capable of supplying the requirements of both boilers. Each set consists of three reciprocating plate feeders and one scraper conveyor. The feeders deliver coal to the corresponding scraper conveyor which runs along the top of the coal bunkers and normally delivers coal to both sets of bunkers, one located in front of each boiler.

#### Ash and Dust Handling Systems

Furnace ash from each boiler is discharged from the stoker front into a 1000 cu. ft. refractory-lined steel plate hopper. Four ash quenching nozzles wet the ashes at the entrance to the ash hoppers, from which they are transported by a series of high pressure nozzles and concrete sluiceways into a concrete ash sump between the two units.

Three sets of motor-driven pumps, one pump in each set a stand-by, service the ash system.

2 - Vertical ash water supply pumps, rated capacity 2000 g.p.m., 20 ft. TDH.



2 - Horizontal ash sluicing pumps, rated capacity 1000 g.p.m., 290 ft. TDH.

2 - Horizontal hydroseal ash pumps which take suction from the ash sump, discharging the ash-water mixture at a designed rate of 1650 g.p.m. at a velocity of 11 ft. per second through an 8 in. line to the ash disposal basin, Building #188.

Dust accumulated in the dust collector hoppers is discharged through a hydrovac dust system into the ash sump at a capacity disposal rate of 15 tons per hour. A vacuum is produced by the action of the hydrovac which is supplied with water from the discharge of the high pressure ash sluicing pumps. Each hydrovactor is equipped with a vacuum breaker for opening the system to atmosphere in the event the water supply to the hydrovactor fails.

#### Condensate and Feedwater Systems

Each steam generating unit is provided with two boiler feed pumps - one motor driven for summer operation, and one turbine driven for winter operation. Each pump is rated at 350 g.p.m. at 1890 ft. total head, and operates in conjunction with an independent heat regenerative cycle comprising three stages of feedwater heating.

A low pressure feedwater heater with integral drain cooler and a deaerator are installed on the suction side of the boiler feed pumps in each unit. The heaters have an effective surface of 680 sq. ft. and are designed for operating pressure of vacuum and 75 p.s.i.g. on the shell side, and 250 p.s.i.g. on the tube side, which has four passes.

The deaerators have a maximum outlet capacity of 159,500 lbs./hr. each, and are designed for an operating pressure of 30 p.s.i.g. Each is mounted on a 6150-gallon storage tank and is equipped with vent condenser, spray valves, relief valve, automatic overflow valve, and all necessary components.

A high pressure feedwater heater with integral drain cooler is installed on the discharge side of the boiler feed pumps in each unit. These heaters have an effective surface of 496 sq. ft. and are designed for an operating pressure of 75 p.s.i.g. on the shell side, and 1000 p.s.i.g. on the tube side, which has four passes.

Make-up water is fed into the turbo-generator condensers, the condenser pumps discharging turbine exhaust steam condensate along with make-up water to the low pressure feedwater heater. Condenser equipment is described under "Turbo-Generator Units".

### Chemical Feed System

Two systems of chemical feeding are employed in the treatment of boiler feedwater. A phosphate solution, applied to reduce scale formation, is charged directly into each boiler drum by a pump taking suction from a phosphate mixing tank. These are motor driven duplex pumps with a rated capacity of 12 g.p.h. per cylinder at a discharge pressure of 1000 p.s.i.g.

A sulfite solution, applied to the feedwater as a corrosion inhibitor, is charged into each deaerator outlet by a pump taking suction from sulfite mixing tank. These also are motor driven duplex pumps with a rated capacity of 4.3 g.p.h. per cylinder at a discharge pressure of 150 p.s.i.g.

This mixing and feeding equipment is housed in a chemical feed room located in the lower section of the coal silo.

### Turbo-Generator Units

Buildings #184-RP&L each contain two preferred standard turbo-generator units with each steam turbine rated at 11,500 kw. with a capability of 12,550 kw., designed to operate at 600 p.s.i.g., 825°F. total temperature, 2 in. Hg absolute exhaust pressure, with four extractions. Each turbine is direct coupled to an 11,500 kw. synchronous generator with a power factor of 0.85 and a capability of 13,529-kv.-a. The generators are 2-pole, 3600 r.p.m., 3-phase, 60 cycle, 13,800-v., complete with direct connected d.c. exciter rated at 60 kw., generator surface air coolers and accessories.

Twin oil coolers are installed for each unit lubricating oil system.

The turbo-generator units installed in Building #184-K are the same as the foregoing except that they possess greater generating capacity. Two 12,500 kw. synchronous generators, each with a power factor of 0.80 and a capability of 15,625 kv.-a., are installed in the Bldg. #184-K. The steam turbines are identical with those installed in Power Houses #184-RP&L.

Each turbo-generator unit operates in conjunction with a 9500 sq. ft. surface condenser. The designed capacity of each condenser is 84,000 lbs. of steam per hour. The condenser hotwell has a capacity of 300 gallons. Exhaust steam condensate is pumped from each condenser by two motor driven condensate pumps, one a stand-by, each rated at 270 g.p.m. against a total head of 175 ft. One

twin-element, 2-stage steam jet air injector, with a capacity of 150 lbs. of air-vapor mixture per hour, is installed with each condenser.

### Controls

Combustion control equipment is installed for each steam generating unit to control steam pressure, steam flow, air flow, fuel feed, and furnace draft. The combustion control system normally functions automatically, but in an emergency the controls may be operated manually from sub-panels located in the central control room.

A three-element feedwater control system is installed for each boiler to measure the flows of steam and feedwater and the level in the boiler drum. Feedwater flow to the boiler is regulated automatically with provision for remote manual control.

An automatic by-pass system is installed in the discharge of the boiler feed pumps servicing each boiler in order to prevent an excessive temperature rise when power losses in the pumps are converted into heat and transferred to the feedwater passing through the pumps under low load conditions.

Each unit is equipped for the automatic control of water levels in the following components of the condensate and feedwater systems: (1) condenser hotwell; (2) deaerator storage tank; (3) condensate storage tank; (4) low pressure feedwater heater; and (5) high pressure feedwater heater.

A continuous blowdown flash tank level control is also provided for each boiler unit.

### Compressed Air System

Equipment for two compressed air systems, one supplying instrument air and the other general plant air, is installed on the basement floor of each power house. The instrument air system consists of two compressors (one a stand-by), each having a piston displacement of 242 c.f.m. and free air delivery of 149 c.f.m. with a discharge pressure of 115 p.s.i.g. Each compressor is driven by a 40 hp. motor.

Instrument air passes through an air dryer before entering the various control units. This dryer has a capacity of 150 c.f.m. of entering air at 105°F. saturated summer conditions to an effluent dew point of 40°F. for an 8-hour period before reactivation.

The plant air system also comprises two compressors, one a stand-by. The compressor normally in use is driven

by a 60 hp. motor. This compressor has a piston displacement of 364 c.f.m. and free air delivery of 247 c.f.m. with a discharge pressure of 115 p.s.i.g. The stand-by compressor is steam driven, consuming approximately 28 lbs. of steam per 100 cu. ft. of air delivered with steam pressure at 160 p.s.i.g. saturated. This compressor delivers air at a rate of 97 c.f.m. at 115 p.s.i.g. discharge pressure.

Both the instrument and plant air compressors are equipped with air receivers and aftercoolers.

### Substations

The following electric power supply facilities were provided for each power house to feed all motor-driven pumps, coal and ash handling systems, and all other electrically operated equipment.

2 - 2500-kv.-a., 13,800/2400-v. a.c. unit substations with necessary feeder circuit breakers and bus-tie breaker.

2 -- 750-kv.-a., 2300/480-v. a.c. unit substations with circuit breakers and bus-tie breaker.

### Miscellaneous

The control room in each power house is equipped with an air conditioning system.

The meeting and lunch room is heated by the central heating system.

Domestic and sanitary water supply provisions were made for approximately 32 operating personnel. The toilet and locker areas are equipped with an exhaust fan.

Incandescent and fluorescent fixtures are installed throughout each plant, those in the control rooms being installed in the dead spaces between the eggcrate and acoustical ceilings. Long-life fluorescent lamps were installed where accessibility presented a problem, and emergency lighting was provided. All outside lights are controlled by the black-out system.

### BUILDING FLOOR SPACE (PER BUILDING)

### Approx. Sq. Ft.

|                       |     |
|-----------------------|-----|
| Oil Conditioning Room | 325 |
| Office                | 110 |
| Battery Room          | 120 |
| Electrical Room       | 140 |

|                                   |     |
|-----------------------------------|-----|
| Toilet and Locker Room No. 1—     | 330 |
| Toilet No. 2                      | 70  |
| Locker Room No. 2                 | 75  |
| Slop-sink Closet                  | 15  |
| Control Room                      | 860 |
| Supervisors Room                  | 150 |
| Meeting and Lunch Room            | 350 |
| Results and Clerical Room         | 200 |
| Chemical Feed Room                | 700 |
| Control House (for crusher house) | 145 |

## BUILDING DETAILS

The walled section of these power houses are of Class III construction throughout. Each installation is irregular in shape, its over-all horizontal dimensions being approximately 135 ft. x 76 ft. The control room roof is 33 ft. high, the conveyor roof 48 ft. high, and silo 100 ft. high. There are four primary floors of operation. The area of the basement is 10,915 sq. ft. The enclosed portion of the operating floor has an area of 3472 sq. ft., while the area of exposed portion is 4476 sq. ft. The upper part of the firing aisle covers an area of 2683 sq. ft., as does the conveyor floor.

Several intermediate floors and platforms were provided for the support of an access to the elevated equipment.

The coal handling control house is a separate rectangular structure, approx. 17 ft. x 9 ft. x 10 ft. high with a sloping roof.

The crusher house is an open steel frame structure.

|                     |                   |
|---------------------|-------------------|
| Power House area    | - 8173 sq. ft.    |
| Power House volume: |                   |
| Open structure      | - 206,420 cu. ft. |
| Enclosed structure  | - 194,142 cu. ft. |

## CONSTRUCTION DETAILS

### Power House

Foundation - Reinforced concrete spread footings.  
 Frame - Steel.  
 Roof - Reinforced concrete.  
 Roof Covering - Exposed concrete.  
 Wall Siding - Corrugated asbestos.  
 Flooring - Reinforced concrete except for intermediate platforms where gratings are installed to obtain free air ventilation.

Floor Covering - Generally exposed concrete except in certain partitioned areas which have asphalt tile flooring.

Stairs - Steel with precast concrete treads.

Windows - Steel - commercial projected.

Doors - Hollow metal. All roll-up doors are of steel.

Interior Partitions - Cement asbestos board.

#### Coal Handling - Control House

Foundation - Reinforced concrete.

Frame - Steel.

Walls and roof covering - Corrugated asbestos.

#### Crusher House

Foundation - Reinforced concrete.

Frame - Steel.

Structure - Open.

### EQUIPMENT

#### Mechanical

- 2 - Steam generators, each 140,000 lbs./hr.
- 2 - Turbine oil conditioners.
- 2 - 11,500-kw. Turbo-generators, two-12,500-kw. turbo-generators in Bldg. #184-K.
- 2 - Condensers, each 9500 sq. ft.
- 4 - Hotwell vertical pumps with motor drives, each 270 g.p.m.
- 4 - Circulating water vertical pumps with motor drives, each 6900 g.p.m.
- 2 - Air ejectors.
- 2 - Flues and ducts.
- 1 - Stack.
- 1 - Dust and ash handling system, 15 t.p.h.
- 2 - Sets combustion control equipment.
- 2 - Deaerators, water outlet capacity 159,500 lbs./hr. each - storage tank capacity 6150 gal. each.
- 2 - Low pressure heaters, duty of each 8,778,000 B.t.u./hr. with
  - 2 - integral drain coolers, duty of each 522,000 B.t.u./hr.
- 2 - High pressure heaters, duty of each 6,960,000 B.t.u./hr. with
  - 2 - integral drain coolers, duty of each 270,000 B.t.u./hr.
- 2 - Boiler feed pumps with motor drives, each 350 g.p.m.
- 2 - Boiler feed pumps with turbine drives, each 350 g.p.m.

All necessary piping and controls.

- 2 Sets Boiler feed pump by-pass controls.
  - 1 Set Blow-down and blow-off equipment with 2 continuous blow-down tanks, capacity of each 14,000 lbs/hr.
  - 2 Chemical feed systems.
    - 2 Phosphate duplex motor driven pumps, each 12 g.p.h./cylinder.
    - 2 Sulfite duplex motor driven pumps, each 4.3 g.p.h./cylinder.
  - 1 Set Coal handling equipment.
    - From Track Hopper to Coal Silo, 120 t.p.h.
    - From Silo to Boilers, 40 t.p.h.
  - 2 Sets Feed water regulating equipment.
  - 1 Coal storage silo, 720 tons.
  - 2 Instrument air compressors with motor drives, each 149 c.f.m.
  - 1 Plant service air compressor, V-belt motor drive, 247 c.f.m.
  - 1 Air drier for instrument air, 150 c.f.m.
  - 1 Bulldozer.
  - 2 Car pullers with motor drives.
  - 1 Coal car shaker.
  - 1 Process steam pressure reducing station, boiler to process, 65,000 lbs./hr. max.
  - 1 Desuperheating station to process, 54,050 lbs./hr.
  - 1 150 p.s.i. Pressure reducing station, 9000 lbs./hr. max.
  - 1 150 p.s.i. Desuperheating station, 12,780 lbs./hr.
  - 2 Pressure reducing stations, process steam to deaerator, each 6500 lbs./hr. max.
  - 2 Pressure reducing stations, No. 3 bleed steam to deaerator, each 6500 lbs./hr.
  - 2 Pressure reducing stations, No. 1 bleed steam to process, each 14,000 lbs./hr. max.
  - 2 Turbine-driven F.D. fans, at design point - each 41,000 c.f.m.
  - 2 Turbine-driven I.D. fans, at design point - each 86,000 c.f.m.
- All necessary control panels and instruments.
- 2 Condensate storage tanks, 12 ft. O.D. x 43 ft. each approx. 4800 gal.
  - 1 Blowoff tank 5 ft.-6 in. O.D. x 6 ft.-4 in., approx. 150 gal.
  - 1 Service water head tank 5 ft. O.D. x 5 ft., approx. 95 gal.
  - 4 Chemical mixing tanks, 42 in. O.D. x 6 ft.-8 in., each approx. 60 gal.
  - 2 Desuperheater injection pumps with motor drives, each 25 g.p.m.
  - 2 Ash water supply pumps with motor drives, each 2000 g.p.m.
  - 2 Ash sluicing pumps with motor drives, each 1000 g.p.m.

- 2 Sets of Condensate level-controls.
  - 2 Boiler make-up water control systems.
  - 1 Steam driven air compressor, locomotive type, cross compound, 97 c.f.m.
  - 1 Service water return vertical pump with motor drive, 100 g.p.m.
  - 1 Track hopper sump pump with motor drive, 15 g.p.m.
  - 1 Portable crane and steel platform, including three hand-operated trolley hoists, two - 10-tons and one - 1-1/2-tons, for use in all four areas.
  - 1 Electric hoist with motor drive, 500 lbs.
- All necessary valves, traps, strainers, coils and filters.

### Electrical

- 1 150-kv.-a. 480-208/120-v. a.c. Double-ended, lighting load center.
  - 2 2500-kv.-a. 13,800/2400-v. a.c. Unit substations with necessary feeder circuit breakers and bus-tie breaker.
  - 2 750-kv.-a. 2300/480-v., a.c. Unit substations with circuit breakers and bus-tie breaker.
  - 2 24-circuit Indoor lighting panels.
  - 1 22-circuit Lighting panel.
- All necessary gauge boards and lights.
- 1 600-v., a.c. Distribution panel for coal handling equipment.
  - 2 208/120-v., Indoor distribution panels.
  - 2 Turning gear motor control panels.
  - 1 Ash handling control station.
  - 4 480-v., a.c., Motor control centers.
  - 1 Duplex generator control board.
  - 2 Blackout control cabinets, one open and the other closed contacts.
  - 1 Safety alarm public address main equipment cabinet.
  - 2 Control cabinets for safety alarm system.
  - 1 8-circuit Lighting panel.
  - 1 40-circuit Lighting panel.
  - 1 20-circuit Lighting panel.
  - 1 125-v. Station battery with 2 changing sets and control panels.
  - 1 3-kv.-a. 480/120-v. Transformer.
- All necessary indicating lights.
- 4 480-v., a.c. Power receptacles with necessary safety switch and appurtenances.
  - 8 250-v., Explosion-proof receptacles with necessary plugs.
  - 5 30-amp., 250 volt Automatic transfer switches.
- All necessary generator terminal equipment, motor starting equipment, neutral and field breaker equipment, switches, line material and hardware.



- 11 Intercommunication telephone hand sets with four noise reducing booths.
- 24 Loudspeaker assemblies.
- All necessary lighting fixtures, receptacles and appurtenances.

### Architectural

- 3 Water coolers.
- 1 Hot water heater, 300 g.p.m.
- 1 Hot water storage tank, 255 gal.

### Heating and Ventilating

- 1 Toilet exhaust fan with motor drive, 2700 c.f.m.
- 1 Lunch room air handling unit with motor drive and control system, 1900 c.f.m.
- 1 Chemical room exhaust fan with motor drive, 3925 c.f.m.
- 1 Control room air conditioning unit with motor drive and control system, 2700 c.f.m., 122,000 B.t.u./hr.
- 2 Firing aisle exhaust fans with motor drives, each 5475 c.f.m.
- 2 Conveyor roof ventilators with motor drives, each 3000 c.f.m.
- 1 Battery room exhaust fan with motor drive, 550 c.f.m.
- 1 Electrical room exhaust fan with motor drive, 380 c.f.m.
- 1 General air handling unit with V-belt motor drive and control system, 3340 c.f.m.
- 1 General supply fan with V-belt motor drive, 9500 c.f.m.
- 1 Chemical room heater with motor drive, 150,700 B.t.u./hr.
- 1 Office unit heater with motor drive, 41,500 B.t.u./hr.
- 1 Battery room exhaust fan with motor drive, 550 c.f.m.
- 1 Electrical room exhaust fan with motor drive, 380 c.f.m.
- 1 General air handling unit with V-belt motor drive.
- 1 General supply fan with V-belt motor drive, 9500 c.f.m.
- 1 Chemical room heater with motor drive, 150,700 B.t.u./hr.
- 1 Office unit heater with motor drive, 41,500 B.t.u./hr.
- 1 General use unit heater with motor drive, 114,500 B.t.u./hr.

## PLANT OPERATION

### Steam Flow

Steam generated at 615 p.s.i.g. and 825°F. at the superheater outlet maintains a constant pressure of 600 p.s.i.g. and 825°F. in the main steam pipe at all steaming rates. This high pressure steam line takes steam directly from the superheater outlet header of each boiler unit. Take-offs from each main steam line supply high pressure steam to the generator turbines, the stoker and fan turbines, the boiler feed pump turbines, and the condenser air ejectors.

Steam is extracted from each generator turbine in four stages. The first extraction is at 160 p.s.i.g., this steam being used to make up the difference between the required low pressure process steam and the available exhaust steam. Before entering the low pressure process steam line, the extraction steam passes through a pressure regulating valve which opens on a drop in pressure in the process line.

Steam at 53 p.s.i.g. is extracted from the No. 2 bleed openings of the turbines to serve the requirements of the high pressure feedwater heaters.

All the steam-driven auxiliaries are designed to exhaust at 40 p.s.i.g. into an exhaust steam header which supplies steam for process use after passing through a desuperheater to reduce the steam temperature to saturation temperature. At peak load conditions, 54,050 lbs./hr. of steam at 40 p.s.i.g. and 290°F. are exported to process through the exhaust steam header.

High pressure process steam requirements are supplied from the main steam header through a combination pressure reducing and desuperheating station where pressure is reduced to 190 p.s.i.g. and temperature to 400°F. At peak load conditions, 10,600 lbs./hr. of steam are exported to process. See Page 21 for details of steam flow.

### Feedwater Flow

Steam is exhausted from the main turbines at 2 in. Hg absolute and condensed in surface condensers. Make-up water required to compensate for the plant losses in the form of process steam flow, wasted continuous blowdown water, and building heating constitutes approximately 25 per cent of the boiler feedwater flow. Make-up water is supplied from a filtration plant, Building #183-2, and is pumped to the condensate storage tanks as required being introduced into each turbo-generator condenser through the hot well level control.

Exhaust condensate and make-up water is pumped from the condenser hotwells through air ejectors to the low pressure feedwater heaters, from which it is passed to the deaerator heaters. The boiler feed pumps take suction from the deaerator storage tanks and pump the feedwater to the high pressure feedwater heaters from which it is passed through the economizers where it is heated to a final temperature of 270°F. by the furnace exit gases and introduced into the boiler drums at a pressure somewhat in excess of the boiler operating pressure of 615 p.s.i.g.

Feedwater flow to the boilers is regulated automatically with provisions for remote manual control at a remote loading subpanel located in the power house control room.

#### Continuous Boiler Blowdown

To limit the silica concentration in the boiler water, a continuous boiler blowdown is maintained at a rate proportional to the make-up. This blowdown is discharged into the continuous blowdown flash tank at 5 p.s.i.g. where approximately 30 per cent of its weight flashes into steam. The flashed steam flows to the deaerator heater while the drain is discharged to the sewer.

#### Coal Firing

Coal passes from each boiler coal hopper down to a reciprocating feeder block which pushes it over the lip of a trajectory plate to the rotating blades of the stoker feeders. The length of the stroke of each reciprocating feeder block governs the amount of coal fed to its rotating feeder. The stroke of each feeder block can be varied either manually or by means of automatic control.

Each stoker grate is split longitudinally in two halves, and the motor or turbine can drive either or both halves of the grate. Each half of the grate is subdivided into three lateral zones. The middle zone is open to the air from the plenum chamber, but both the rear and front zones have hand-operated sliding type dampers. Dividing the grate in this manner makes it possible to use as little as one-sixth of the total grate area and improves combustion at low loads.

The grate is driven by a hydraulic oil pump and ram system, and travels at the manually set constant speed that best suits the fuel characteristics and fuel bed thickness requirements.

Over-fire air is used to break up the heavy furnace gases and to assist combustion of the fuel. An over-fire air fan takes suction from either the boiler room or from the stoker front air space, and discharges through a series of nozzles located in the rear wall of each furnace.

## Ash and Dust Handling

Fly ash from the boilers, economizers, and dust collector soot hoppers is reinjected into the respective furnace by means of a fan which takes suction from the boiler room and discharges through nozzles located in the furnace side walls.

To effectively remove the fly ash from the economizer exit gases, a dust collector with decantation is installed with each boiler unit. These dust collectors are arranged in two stages with collection from the first stage being returned to the respective furnace, as stated above. Collection from the second stage is removed by hydrovactors (part of the ash handling system).

Operation of the systems which remove ash and dust from the power houses as waste is noted under "Principal Components - Ash and Dust Handling Systems".

## DRAWINGS

### Bldg. #184-R

#### Mechanical

- W-138476 - Heat Balance Diagram.
- W-135636-B - Flow Diagram - Auxiliary Steam & Main Steam.
- W-135636-C - Flow Diagram - Boiler Feed Discharge.
- W-135636-D - Flow Diagram - Turbine Extraction.
- W-135685-A - Flow Diagram - Chemical Feed.
- W-135685-D - Flow Diagram - Service Water.
- W-135664-A - Flow Diagram - Boiler Feed Suction.
- W-135664-C - Flow Diagram - Condensate.
- W-135664-D - Flow Diagram - Exhaust Steam.
- W-135754-A - Flow Diagram - Circulating Water - Cooling Tower Connections - Ash Handling Water.
- W-136278 - Main Steam Piping Arrangement - Sections, Plan.
- W-136297 - Main Steam Piping Arrangement - Sections.
- W-136306 - Main Steam Piping Arrangement - Sections.

#### Architectural

- W-136164 - Basement Floor Plan - General Arrangement.
- W-136165 - Operating Floor Plan - (El. 17') - General Arrangement.
- W-136166 - General Arrangement - Section.

#### Electrical

- W-137959 - Switchgear Installation and Floor Details.

W-138035 - 13.8-kv. Main One-Line Diagram - Buildings #184-R and #151-2R.

W-136121 - One Line Diagram 2300-v.

Except for plant orientation and the increased generator capacity in Building #184-K., Buildings #184-RPL&K are identical installations. Therefore, with the exception of the basement floor plan for Building #184-K, the corresponding drawings above are not listed for Buildings #184-PL&K.

W-139261 - Basement Floor Plan - El. 0'-0" - Building #184-K.

### BUILDING #184-1C - POWER HOUSE

#### FUNCTION

This facility supplies process and heating steam for the #100-C Area. No electricity is generated in this building.

#### PRINCIPAL COMPONENTS

##### Steam Generating Units

Two Babcock & Wilcox integral furnace, two drum, bent tube steam generators designed for a working pressure of 350 p.s.i.g. are installed in this building. Each unit has a normal operating capacity of 35,000 lbs./hr. at a pressure of 325 p.s.i.g. at the drum outlet when feedwater is supplied at 220°F.

Each unit is equipped with a continuous cleaning, forward discharge, spreader stoker. The feeders have both turbine and motor drives for flexibility of heat balance.

One F.D. fan with a capacity of 12,000 c.f.m. at 4.2 in. H<sub>2</sub>O, 105°F., is installed with each steam generator to supply combustion air, together with one I.D. fan, capacity 25,000 c.f.m. at 6 in. H<sub>2</sub>O, 500°F., to remove the products of combustion. Each F.D. fan is equipped with a louver damper on the discharge for regulation of air delivery, and each I.D. fan is equipped with a similar type damper in the inlet box for regulation of the gas removed. Both fans are mounted on a common shaft driven through a reduction gear by a steam turbine.

Heat recovery equipment for each boiler consists of a continuous tube economizer with 490 sq. ft. of heating surface. Each unit is equipped with a dust collector with

decantation to remove the fly ash and cinders from the gases of combustion leaving the steam generator.

Each steam generating unit is also equipped with all necessary associated equipment such as soot blowers, flues, ducts, breeching, safety and regulator valves, and motors. A single reinforced concrete stack, 75 ft. high by 4 ft. I.D., serves both units.

#### Coal Handling Equipment

Coal handling equipment consists of a double track hopper to receive coal from railroad cars; a belt conveyor; a weightometer; a magnetic pulley to remove tramp iron; a coal crusher; a bucket elevator; a stocking-out chute; and a flight conveyor to transfer coal from the bucket elevator to the furnace bunkers.

#### Ash Handling System

A dry ash removal system was provided for this power house. Cinders and fly ash from the boiler hoppers, dust collectors and stack are carried pneumatically through piping to an ash storage silo. The system has a capacity of 10 tons per hour. The storage silo is of tile construction and has a capacity of 45 tons of ash.

#### Feedwater System

A single spray type deaerator having a normal outlet capacity of 65,000 lbs./hr. and designed for operating at a normal pressure of 3 p.s.i.g. is installed for both steam generating units. Storage capacity to normal water level is 2500 gallons, which amounts to approximately 20 minutes at full boiler rating.

Three centrifugal pumps, each rated at 100 g.p.m. at 985 ft. total head, are installed for pumping feedwater from the deaerator boilers. Two of these pumps are turbine-driven and one is motor-driven to provide flexibility of heat balance. One pump will supply the normal requirements for one boiler.

#### Chemical Feed System

Two systems of chemical feeding are employed in the treatment of boiler feedwater. A phosphate solution, applied to reduce scale formation, is charged directly into each boiler drum by two motor-driven proportioning pumps (one per boiler) taking suction from a dissolving and feed tank. A sulfite solution, applied as a corrosion inhibitor, is charged directly into the deaerator outlet by a motor-driven proportioning pump taking suction from a sulfite dissolving and

feed tank. A fourth chemical feed pump of the same type is installed as a spare for use by either system.

#### Compressed Air System

A motor driven air compressor is installed as the nominal supplier of instrument air. This compressor is a single-stage, double-acting, water-cooled type with carbon ring construction for oilless cylinder operation, having a discharge pressure of 115 p.s.i.g. with an actual free air delivery of 105 c.f.m. It is equipped with an aftercooler having a capacity of 105 c.f.m., together with an air filter and receiver.

The air filter is connected to a dual absorber silica-gel air dryer having a handling capacity of 100 c.f.m. of air entering at a pressure of 100 p.s.i.g. and saturated at a temperature of 105°F. under summer conditions and 75°F. in winter.

A steam driven air compressor is installed for use in the event of power failure. This is an 8-1/2 in. locomotive type compressor having a capacity of 100 c.f.m.

#### Combustion Control System

A combustion control system is installed in the power house to regulate properly the fuel and air supply to the boilers in proportion to their load. The system is of the manual-automatic type, the automatic control normally being in continuous use for loads of 25 per cent full load and higher. This system is operated from a centrally located panel board remote from the controlled apparatus, but local manual control is provided at each regulating device.

A master pressure controller mounted on the panel board converts changes in the standard steam pressure of 325 p.s.i.g. to changes in master loading air pressure. This loading pressure is sent to various controllers which regulate fuel feed and air flow.

A 25-point annunciator and alarm system is mounted on the panel board and a horn sounds a warning in the event of trouble.

The rear of the combustion control panel is inside the wall of the Service Building, #184-2C. A roof extends from this wall to the furnace bunkers and three steel roll-up doors are installed around the other three sides of the control room to protect the equipment during inclement weather. This is the only covered part of the Power House.

### Substation

Power is supplied from a 600-kv.-a. 13.8-kv./440-v. double-ended outdoor type unit substation.

### Miscellaneous

Sound-powered telephones, loud-speaker assemblies, fire alarm provisions, emergency lighting, and other safety alarm installations were provided.

| BUILDING FLOOR SPACE                                  | <u>Approx. Sq. Ft.</u> |
|-------------------------------------------------------|------------------------|
| Operating Floor - Elevation 286.85'<br>(ground floor) | 3800                   |
| Chemical Feed Platform - Elevation 296.85'            | 150                    |
| Deaerator Level - Elevation 305.85'                   | 700                    |

### BUILDING DETAILS

This is an irregular building of Class III construction, with maximum rectangular dimensions of approximately 80 ft. by 55 ft.

|               |   |                              |
|---------------|---|------------------------------|
| Over-all Area | - | 4648 sq. ft.                 |
| Total Volume  | - | 12,000 $\frac{1}{2}$ cu. ft. |

### CONSTRUCTION DETAILS

The only enclosed part of this power house is an 8 ft. by 19 ft. area surrounding the combustion control panel. Both roofing and siding are of corrugated asbestos. Steel roll-up and hollow metal doors give access from the power house to the adjacent service structure, Bldg. #184-2C.

Foundation - Reinforced concrete.  
 Frame - Steel.  
 Flooring - Concrete.  
 Stairs - Steel.

### EQUIPMENT

#### Mechanical

- 2 - Steam generating units, 35,000 lb./hr. capacity each.
- 2 - F.D. fans, 12,100 c.f.m. each at 4.2 in. H<sub>2</sub>O, 500°F. capacity.



- 2 - I.D. fans, 25,000 c.f.m. each at 6.5 in. H<sub>2</sub>O, 500°F. capacity.
- 2 - Combination F.D. - I.D. turbine drivers.
- 1 - Dry ash handling system, capacity 10 tons/hr.
- 1 - Ash storage silo, gross capacity 58 tons.
- 1 - Coal handling system, capacity 60 tons/hr.
- 1 - Track hopper sump pump, 50 g.p.m.
- 1 - Deaerator feedwater heater and storage tank, 65,000 lbs./hr. outlet capacity.
- 3 - 100 g.p.m. at 985 ft. t.d.h. boiler feed pumps.
- 2 - Boiler feed pump turbine drives.
- 1 - Boiler feed pump motor drive.
- 1 - Boiler chemical feed system.
- 1 - Motor-driven air compressor, capacity 105 c.f.m.
- 1 - Instrument air dryer, capacity 100 c.f.m.
- 1 - Steam-driven locomotive type air compressor, 100 c.f.m.

### Electrical

- 1 - 208/120-v. Distribution cabinet.
- 1 - 12-circuit Lighting panel.
- 1 - 18-circuit Lighting panel.
- 1 - 208/120-v. a.c. Blackout lighting panel - NEMA III.
- 1 - Outdoor 440-v., 3 phase, 60 cycle motor control center for boiler auxiliaries and coal handling.
- 2 - 12-circuit Panels - one for coal handling lighting and one for miscellaneous power.
- 1 - 1-kv.-a. 480/120-v. Transformer.
- 2 - 45-kv.-a. 480-208/120-v. Lighting transformer.
- 5 - Manual starters, 2 phase, 250-v. NEMA IV.
- 4 - Combination starters, 3 phase, 440-v. NEMA IV.

### PLANT OPERATION

#### Steam Flow

Steam is generated at 325 p.s.i.g. and flows to a main steam header serving both boilers. A single export line from this header supplies the process and heating steam required throughout the #100-C Area at a nominal pressure of 300 p.s.i.g. Steam for the turbine drivers for the I.D. and F.D. fans, feedwater pumps, stoker drives, locomotive type air compressor, air dryer, and ash handling ejector system is taken also from the main steam header.

Exhaust steam from the auxiliary turbine drivers, the continuous blowdown flash tank, and the turbine drives in Bldg. #183-2C is piped to the deaerator for feedwater heating. If this supply of low pressure steam to the deaerator is deficient, low pressure make-up steam is supplied through a

pressure reducing station installed off the main steam manifold. See Page 21 for details of steam flow.

#### Feedwater Flow

The boilers require 85 per cent make-up water at full load to compensate for exported steam, as there is no condensate return. Treated make-up water is supplied from Bldg. #184-2C, and is introduced directly into the deaerator through a regulating valve. Boiler feedwater is collected in the deaerator tank, from which the boiler feed pumps take suction. One pump will supply the normal water requirements of one boiler.

#### Continuous Boiler Blowdown

In order to limit the solids in the concentrated boiler feedwater to a maximum of 3000 p.p.m., a continuous boiler blowdown is maintained at a rate proportional to make-up. This blowdown is discharged into the continuous blowdown flash tank at low pressure. As noted, the flashed steam is utilized in the deaerator. The blowdown drain is wasted.

#### Coal Firing

A flight conveyor transfers coal from the bucket elevator to the furnace bunkers, from which it is discharged through chutes to the stoker feeder hoppers. Each steam generating unit is fired by a continuous cleaning forward discharge spreader stoker with grates arranged to impart a slow reciprocating motion back and forward. This motion moves the ashes forward where they are discharged into a hopper at the front of the boiler.

Combustion air is supplied at outside temperature to the zone under the grates through underground concrete ducts from the F.D. fan.

#### Ash and Dust Handling

A dust collector with decantation hopper removes fly ash and cinders from the combustion gases leaving each steam generating unit. The large particles of ash which contain a high percentage of carbon are caught in the decantation hopper and reinjected into the furnace, together with the carry-over from the boiler hoppers, through the cinder return system. This material is returned to the furnace pneumatically through piping to each side of both steam generating units where it is discharged through nozzles for reburning.

The remaining fine fly ash is caught in the main dust collector hoppers and discharged into the ash handling

system. This system removes cinders and fly ash from the boiler hoppers and stack as well as the dust collector hoppers and, by means of a multi-jet steam exhaustor operating on the ejector principal, discharges this material through piping to an ash storage silo. Ash is removed from the bottom of the silo through a rotary unloader into trucks directly beneath.

#### DRAWINGS

W-141772 - Architectural Plans and Sections.  
 W-141741 - General Arrangement - Plans.  
 W-141742 - General Arrangement - Elevations.  
 W-141780 - One Line Diagram (electrical).  
 W-141782 - Plot Plan (electrical).  
 W-141785 - 440-v. Outdoor Substation - Plans and Sections.

#### BUILDING #184-2C - SERVICE BUILDING (FOR POWER HOUSE)

#### FUNCTION

This building is a service facility for the adjoining Power House, Bldg. #184-1C.

#### PRINCIPAL COMPONENTS

This building contains two toilet rooms, two locker rooms, an office, a meeting and lunch room, and a shop. Miscellaneous plumbing, heating, and ventilating systems and equipment are installed for the convenience of the power house operating personnel.

#### BUILDING FLOOR SPACE

|                        | <u>Approx. Sq. Ft.</u> |
|------------------------|------------------------|
| Toilet Room No. 1      | 70                     |
| Locker Room No. 1      | 70                     |
| Toilet Room No. 2      | 75                     |
| Locker Room No. 2      | 75                     |
| Meeting and Lunch Room | 90                     |
| Office                 | 90                     |
| Shop                   | 275                    |

#### BUILDING DETAILS

This is a single-story, rectangular building of Class III construction measuring approximately 23 ft. by 36 ft. by 11 ft. high.

Over-all Area - 995 sq.-ft.  
 Total Volume - 13,845 cu. ft.

#### CONSTRUCTION DETAILS

Foundation - Reinforced concrete with spread footings and grade beams.  
 Frame - Steel.  
 Roof - Standard girder beam (steel beams and purlins).  
 Roof Covering - Corrugated Asbestos.  
 Wall Siding - Corrugated Asbestos.  
 Flooring - Concrete Class I finish, except asphalt tile in the office and lunch room.  
 Windows - Commercial projected steel sash.  
 Doors - Hollow metal.  
 Partitioning - Steel studs with cement asbestos board, Keene's cement plaster wainscot 5 ft.-6 in. in toilet rooms.  
 Ceiling - Corrugated asbestos.  
 Floor - Reinforced concrete.

#### EQUIPMENT

- 1 - Air handling unit, 5620 c.f.m. summer, 2810 c.f.m. winter.
- 1 - Propellor fan, 2700 c.f.m. summer, 350 c.f.m. winter.
- 1 - Heating and ventilating control system.
- 1 - Projection type unit heater.
- 1 - Water heater, 180 g.p.m., and storage tank, 170 gal.

#### DRAWINGS

- W-141775 - Service Building Plan, Elevations and Details.
- W-141778 - Service Building Plumbing, Drainage and Piping.
- W-141779 - Heating and Ventilating.

#### BUILDING #185-RPL&K - COOLING TOWER

#### FUNCTION

Each of these facilities supplies cooling water for two 9500 sq. ft., two-pass surface condensers installed with the turbo-generators in Buildings #184-RPL&K respectively. Each facility also supplies the water required to sluice ash from two spreader stoker fired boilers installed in each of these four power houses.

## PRINCIPAL COMPONENTS AND OPERATION

These are identical installations, each consisting of a cooling tower, cooling water basin, pump suction bay, chemical building, and electrical substation.

### Cooling Towers

Each tower is of the four-cell induced draft type designed to cool 27,500 g.p.m. of water from 103°F. to 88°F., based on 76°F. wet bulb temperature. Two cells, arranged on a unit basis normally serve each turbo-generator condenser. Four induced draft fans with motor drives are mounted on the roof of each tower.

### Cooling Water Basins

Each cooling tower is erected on a concrete foundation which also serves as the cooling water basin, having a capacity of approximately 400,000 gallons. This capacity is adequate to furnish 1750 g.p.m. of water for ash sluicing over a maximum period of three hours without jeopardizing the condenser circulating water supply or seriously affecting the efficiency of the cooling tower.

Each basin is divided into two equal sections for unit operation. The basin floor slopes toward the adjacent pump suction bay.

### Pump Suction Bays

Adjoining the cooling water basin is a deeper pump suction bay covered by a reinforced concrete slab. This bay consists of two sections, one a circulating water pump section and, the second, an ash sluicing pump suction bay. Both sections are divided into two halves for unit operation.

Two circulating water pumps, each motor driven and rated at 6900 g.p.m., 55 ft. TDH, draw from each half of the circulating water pump suction bay. These four pumps are mounted on the concrete slab covering the pump suction bay and discharge in units of two into steel headers, through which cooling water is circulated to each condenser. These pumps are charged to Buildings #184-RPL&K, Power Houses.

Two low-head ash sluicing pumps, each motor driven and rated at 2000 g.p.m., 20 ft. TDH, take suction from the ash sluicing pump suction bay. These pumps, one of which is a spare, are mounted over each section of the ash sluicing pump suction bay on the covering slab. The operating pump discharges into a line through which water is delivered to the ash sluicing system in the respective area power house.

A vertical weir between the circulating pump suction bay and the ash sluicing pump suction bay prevents lowering the cooling water basin water level to a point where conditions in the former would be jeopardized with the turbo-generators in operation.

### Chemical Buildings

A small structure was provided adjacent to each cooling tower to house the chlorination and lime treatment facilities. Chlorine is added to the water in the basin for algae control; lime is applied to minimize corrosion of the circulating water lines.

Chlorination equipment consists of one vacuum type solution feed chlorinator, capacity 2000 lbs./24 hrs.; four 1-ton chlorine storage cylinders; a monorail hoist for handling these cylinders; and one air compressor.

Lime treatment equipment consists of a lime feeder, capacity 5 to 200 lbs./hr.; a mixing tank; one pH two-point recorder; and lime storage facilities.

### Substations

A 2400-v./480-v., outdoor, double-ended unit substation consisting of two 500 kv.-a. transformers with all associated motor controls and equipment was installed adjacent to each cooling tower to provide the necessary electric power for pumps, fans and chemical feeding equipment.

## BUILDING DETAILS

All structures comprising these facilities are of Class III construction.

### Cooling Tower

Rectangular in shape, 97 ft. by 63 ft. by 25 ft. high; occupies an area of 6110 sq. ft.; volume approximately 150,000 cu. ft.

### Cooling Water Basin

Rectangular in shape, 97 ft. by 63 ft. by 10 ft. deep; area 6110 sq. ft.; volume 61,110 cu. ft.

### Pump Suction Bay

Irregular in shape, the over-all dimensions are approximately 24 ft. by 37 ft. by 14 ft. deep; area 700 sq. ft.; volume 9860 cu. ft.

Chemical Building

Rectangular in shape, 26 ft. by 16 ft. by 15 ft. high; area 416 sq. ft.; volume 8240 cu. ft.

CONSTRUCTION DETAILS

The cooling water basins have concrete piers in both directions 6 ft. on centers. The walls of the basins are one-foot thick, as are the foundation mats. The structural components of the basins and pump suction bays are of reinforced concrete.

Cooling tower framework, casings and drift eliminators are constructed of California redwood.

The chemical buildings have reinforced concrete foundations, steel frames, standard girder-beam peaked roofs, and corrugated asbestos siding, and are provided with louvers and standard windows and doors.

Unit heaters and a ventilation fan are installed in each chemical building.

The lighting was designed to penetrate the water vapor, with vapor-proof incandescent fixtures being used. All lighting is connected with the area blackout control system.

EQUIPMENTMechanical

- 1 Cooling Tower, package unit including all necessary fan, motor-drives and appurtenant equipment, rated capacity is 27,500 g.p.m.
- 1 Chlorination equipment with motor-drive, capacity 2,000 lbs./24 hr.
- 1 Sluice gate 30 in. x 30 in.
- 1 Chain hoist, hand-operated, 4000 lbs.
- 1 Line feeder equipment.
- 1 pH two point recorder.

Electrical

- 1 2400/480-v. Unit substation consisting of two 500 kv.-a. transformers, outdoor type.
- 2 30-kv.-a. Dry type transformers, outdoor.
- 1 3-kv.-a. Transformer.
- 1 A.c. distribution panel and cabinet.
- 3 208/120-v., a.c. Lighting panels, 12-circuit outdoor, weatherproofed.

- 1 8-circuit Lighting panel.
  - 1 Blackout control cabinet.
- All necessary motor starters, lighting fixtures, reflectors, switches and cable.

### Heating and Ventilating

- 2 Unit heaters with thermostats and motor drives, in Chemical Building, capacity 34,150 B.t.u./hr. each.
- 1 Vent fan with back-draft damper and motor drive, capacity 2300 c.f.m.

### DRAWINGS

#### Building #185-R

- W-137704 - Cooling Tower - Foundation Plan & Sections.
- W-137711 - Cooling Tower - Sections & Detail-Sheet #1.
- W-138180 - Cooling Tower - Sections & Details-Sheet #2.
- W-138209 - Cooling Tower - Sections & Details-Sheet #3.
- W-138801 - Chlorine Building.
- W-142061 - Chlorine Building - Arrangement - Plan & Details.

As these are identical installations differing only in plant orientation, the corresponding drawings for Buildings #185-PL&K are not listed.

#### BUILDING #186-RPLK&C - COOLING WATER RESERVOIR

The following discussion of these facilities is based on Building #186-R. The reservoirs in the #100-PLK&C Areas are identical with each other and differ from the #186-R Reservoir only in a few details described in the section headed "Design Differences in PLK&C Areas".

### FUNCTION

Each of these facilities stores cooling water for use in its respective #105 Building and service water for the requirements throughout the respective #100 Area.

### PRINCIPAL COMPONENTS

Building #186-R is a three-compartment open reservoir designed to store approximately 25,000,000 gallons of raw and/or clarified river water. This reservoir includes three inlet chambers, three storage compartments, a pump suction well, traveling and stationary screens, and chlorination facilities.



### Inlet Chambers

Each compartment is served by a concrete inlet chamber located outside the reservoir. These chambers were designed to operate also as a reservoir overflow, drain, and outlet. A U-shaped overflow trough extends across the full width of each chamber, with adjustable steel plate weirs on each overflow edge.

Each chamber is connected to its respective reservoir compartment by a concrete flume. Water from the inlet chamber flows through two sluice gates installed in each chamber, and into the adjacent reservoir compartment via the connecting flume. Compartment drainage through the inlet chamber is accomplished by means of two sluice gates located at the bottom of the chamber.

### Storage Compartments

Each of the three storage compartments measures 266 ft. by 248 ft. and is separated from the adjacent compartment by concrete dividing walls. Average water depth is approximately 17 ft. which allows a freeboard of 2 ft. The base slab is approximately 11.5 ft. below grade and the top of the walls extend approximately 7.5 ft. above grade. The center compartment is connected to the two outer compartments by two sluice gates installed in each dividing wall.

### Pump Suction Well

A two-section pump suction well (from which the Building #190-R pumps draw) is located at the north end of the center (No. 2) storage compartment. Each section is 131 ft. long by 26 ft. wide at the top and is covered with a reinforced concrete slab.

Flow of water from the three reservoir storage compartments to the suction well is controlled by manually-operated sluice gates installed in the walls separating the suction well from the storage compartments. Flow between the two sections of the pump suction well is also controlled by sluice gates.

### Screens

Four traveling water screens are installed on the upstream side of the pump suction well - one screen in compartment No. 1, two in compartment No. 2 and one in compartment No. 3. A rear action water spray system was installed for backwashing the screens.

Stationary screens were also installed - one in each of the

side reservoir storage compartments and two in the center compartment. These screens prevent debris from entering the pump suction well from the storage compartments.

### Chlorination Facilities

One solution feed vacuum type chlorinator, having a capacity of 6000 lbs./hr. and one electrically-operated liquid chlorine evaporator, with associated piping, valves, and diffusers, are installed in a small structure designated the Chlorine Building. These facilities were provided for the application of chlorine to the suction well water in order to maintain the minimum chlorine residual which will prevent biological slimes and algae from forming in the supply lines to Building #105.

### BUILDING FLOOR SPACE

### Approx. Sq. Ft.

|                                                                   |         |
|-------------------------------------------------------------------|---------|
| 3 Reservoir Compartments, each 266 ft. x 248 ft.                  | 65,968  |
| Total area of 3 compartments                                      | 197,900 |
| Chlorine Building, 20 ft. x 11 ft.-6 in. x 10 ft. average height. | 230     |

### BUILDING DETAILS

This reservoir is of Class III construction, rectangular in shape. Its total volume is 3,958,000 cu. ft.

The Chlorine Building is rectangular in shape with a volume of 2300 cu. ft.

### CONSTRUCTION DETAILS

The reservoir and pump suction well are constructed of reinforced concrete. The Chlorine Building is a steel frame structure with a peaked roof, the walls and roof being covered with corrugated asbestos.

A loudspeaker assembly was provided primarily for safety alarms.

A unit heater and ventilation fan are provided for the Chlorine Building.

All lighting is connected to the blackout control system.

**EQUIPMENT (Each item in all five reservoirs unless otherwise specified.)**

**Mechanical**

- 4 Traveling screens, 1/16 in. openings.
- 6 30 in. Sluice gates.
- 24 60 in. Sluice gates.
- 1 30 in. Gate valve.
- \*2 42 in. Butterfly valves.
- 1 Portable floor crane with hand-powered winch, 1200 lbs.
- 10 Fixed screens (By Field).
- 7 84 in. R.C. pipe, bell wall fittings.
- \*5 60 in. R.C. bell wall fittings.
- \*1 24 in. R.C. bell wall fitting.
- \*2 42 in. Motorized dow pivot valves.
- 1 84 in. Spigot plug with 30 in. outlet.
- \*4 Companion flanges.
- \*\*2 Standard 84 in. spigot plugs.
- \*\*4 4 in. Water service valves.
- \*\*2 6000 lbs./24 hr. Chlorinators, electric evaporators (12 kw.) and accessories (transferred from #183-1P - rotameters transferred from #183-1L).
- \*2 Air release valves.

**Electrical**

- 1 60 amp. Combination motor starter.
- 1 115 kv. Relay.
- 1 Loudspeaker assembly and transformer.
- 55 Lighting fixtures, 93 fixtures in #186-R.
- 1 24-circuit Lighting panel, 36-circuit in Bldg. #186-R.

**Heating and Ventilating**

- 1 Ventilating fan with back-draft damper and motor drive, 1635 c.f.m.
- 1 Unit heater with thermostat and motor drive, 40,980 c.f.m.

\* Not installed in #186-R.

\*\* Only 1 of these items installed in #186-R.

**PLANT OPERATION**

Raw and/or clarified river water flows by gravity from the Clarification Plant, Bldg. #183-1R, through two reinforced concrete pipes into the inlet chambers of the #186-R reservoir. One line enters the inlet chamber of reservoir compartment No. 1 and extends across to compartments Nos. 2 and 3, connecting all three compartments. The hydraulic distribution of the system is such that approximately the same quantity of water flows through each header.

Water in each inlet chamber flows through two sluice gates and enters the respective reservoir compartment through the concrete flume connecting the two. The inlet chamber sluice gates permit the flow of raw and/or clarified river water from Building #183-1R to be directed into all three reservoir compartments or any combination thereof. The sluice gates installed in the dividing wall of each compartment equalize water levels between compartments.

Water normally flows from reservoir compartment No. 1 into the west section of the pump suction well through a traveling screen and two sluice gates - or through a third sluice gate with a stationary screen when the traveling screen is inoperable.

Water from compartment No. 2 flows into either the west or the east section of the suction well, or both. Each section is served by one sluice gate with traveling screen and one sluice gate with a stationary screen.

Water from compartment No. 3 flows into the east section of the suction well in the same manner as water from compartment No. 1 flows into the west section.

The flow of water through the #186-R Reservoir is controlled by conditions in the #183-1R Clarification Plant and the #190-R Cooling Water Pump House. The Reservoir is designed for a normal flow of 92,000 g.p.m. of water through the three compartments to the pump suction well, but the hydraulic design is such that this flow can be taken through only two of the three compartments.

Chlorine solution pumped from the chlorinator is discharged into each section of the pump suction well from two headers at a maximum dosage of 5 p.p.m. Each header is provided with a rotameter for regulating the amount of chlorine solution applied to the water. The headers extend overhead along the concrete deck slab of the suction well, with hose and diffusers connected to the headers at the point of application.

Each reservoir compartment may be drained through the inlet chamber by two sluice gates at the bottom of the chamber. Overflow and drainage from the reservoir flows through a drain which extends from the inlet chamber to a manhole in a 72 in. drain line.

#### DESIGN DIFFERENCES IN PLK&C AREAS

Whereas Building #186-R receives water from the #183-1R Clarification Plant, Buildings #186-PLK&C receive river water

directly from the River Pump House #681-1G. Two supply lines from Building #681-1G transport water to each reservoir, and are designated as the River Water Supply Line and the Emergency Water Supply Line. In P Area these lines are 72 in. in diameter. In LK&C Areas, they are 54 in. in diameter.

Both supply lines are carried over the reservoir walls at the points where the dividing walls bounding the center compartment of each reservoir meet the south wall. The river water supply line discharges through two butterfly valves into reservoir compartments Nos. 2 and 3. These valves are mounted in a horizontal position to fittings connected to the supply line so as to discharge diagonally across each compartment. The emergency water supply line similarly discharges through two Dow pivot valves into reservoir compartments Nos. 1 and 2.

The combination inlet, overflow and drain chambers in Buildings #186-PLK&C are located in the center of the inlet side wall of each reservoir compartment, not outside the reservoir wall as in the case in Building #186-R. A reinforced concrete pipe (inlet header) connects the three chambers for parallel operation of the reservoir compartments. Either of the outside compartments may be connected with the center one, or all three connected together by means of sluice gates installed in each chamber dividing wall.

A line from the combination inlet-outlet chamber of reservoir compartment No. 1 supplies 4000 g.p.m. of reservoir water to the #183-4 Building in the respective Area.

The overflow weir in front of each chamber has an effective length of 36 ft. Water flows over this weir and through a flume under the chamber to a 60 in. drain connecting all three chambers. As is the case in Building #186-R, two sluice gates installed in each chamber permit the reservoir compartments to be emptied to waste.

The chlorination equipment in Buildings #186-PLK&C includes a spare chlorinator and evaporator. Liquid chlorine is stored in tanks at Building #183-R rather than in the chlorine building of each reservoir. It is piped to the #186-PLK&C chlorinators from these storage tanks through overhead lines.

## DRAWINGS

### Bldg. #186-R

- W-136257 - Plan and Sections - Arrangement.
- W-136290 - Pump Suction Well - Arrangement, Plan and Sections.
- W-136415 - Inlet Chambers Arrangement - Plans and Sections.

- W-139068 - Chlorine Building and Piping - Arrangement, Plans, Sections, and Details.

Bldg. #186-P

- W-136283 - Plan and Sections - Arrangement.
- W-137064 - Pump Suction Well - Arrangement, Plan, and Sections.
- W-136342 - Inlet Chambers Arrangement - Plans and Sections.
- W-142042 - Chlorine Building and Piping - Arrangement, Plans, Sections, and Details.

Bldg. #186-L

- W-139097 - Plan and Sections - Arrangement.
- W-139027 - Pump Suction Well - Arrangement, Plan, and Sections.
- W-139028 - Inlet Chamber Arrangement - Plans and Sections.
- W-139029 - Chlorine Piping Arrangement - Details.

Bldg. #186-K

- W-139213 - Plan and Sections - Arrangement.
- W-139214 - Pump Suction Well - Arrangement, Plan and Sections.
- W-139215 - Inlet Chambers Arrangement - Plans and Sections.
- W-139216 - Chlorine Piping Arrangement - Details.

Bldg. #186-C

- W-139649 - Plan and Sections - Arrangement.
- W-142697 - Pump Suction Well - Arrangement, Plan and Sections.
- W-142705 - Inlet Chamber Arrangement - Plans and Sections.
- W-142696 - Chlorine Piping Arrangement - Details.

BUILDING #188-RPL&K - ASH DISPOSAL BASIN

FUNCTION

These facilities were provided as settling basins for the disposal of ashes discharged from the Power Houses, Bldg. #184.

GENERAL DESCRIPTION

These disposal basins are of earth dike construction, irregular in shape. The dikes vary in height and width

because the top elevation of each dike was maintained throughout its perimeter over uneven terrain.

Ash from each Power House is delivered to the basin in its respective area by a sluicing system through an elevated pipe line. Ash from the sluicing line settles in the basin, while the sluicing water is drained from the basin by a 24 in. overflow line installed through the dike at its lowest base elevation.

The size, volume, and capacity of each basin is as follows.

|                   | #188-R            | #188-P            | #188-L             | #188-K            |
|-------------------|-------------------|-------------------|--------------------|-------------------|
| Perimeter length  | 3100 ft.          | 3000 ft.          | 3200 ft.           | 2860 ft.          |
| Average depth     | 15 ft.            | 15 ft.            | 12 ft.             | 16 ft.            |
| Area              | 13 acres          | 11 acres          | 20 acres           | 11 acres          |
| Storage volume    | 6,500,000 cu. ft. | 6,720,000 cu. ft. | 10,500,000 cu. ft. | 7,700,000 cu. ft. |
| Designed capacity | 8 years           | 10 years          | 10 years           | 7 years           |

#### DRAWINGS

#188-R - Map No. 3305 - Sheet #619 - Location.  
#188-P - Map No. 3305 - Sheet #553 - Location.  
#188-L - Map No. 3305 - Sheet #553 - Location.  
#188-K - Map No. 3305 - Sheet #580 - Location.

#### BUILDING #190-RPLK&C - COOLING WATER PUMP HOUSE

The description of these facilities is based upon Building #190-R. Such differences of arrangement as exist among these five structures are noted at the conclusion of this building description under "Design Differences By Areas".

#### FUNCTION

These pump houses were installed to supply cooling and service water to the corresponding Buildings #105 and service water to the corresponding Buildings #184 and #185 as well as other facilities within the #100 Areas.

## PRINCIPAL COMPONENTS

This structure is divided into two rooms, a pump room and a switchgear room.

The pump room houses eight process cooling water pumps, each rated at 14,000 g.p.m., 90 ft. total head, and four service water pumps, each rated at 3000 g.p.m., 175 ft. total head. The pump room also contains all the necessary equipment to control and screen the water supplied. The major equipment in this room operates as two separate units, each of the two headers leaving the building being supplied by a group of four process cooling water pumps and two emergency by-pass lines. Two groups of two service water pumps, located at each end of the room, supply a common header. The pump room is located adjacent to the pump suction well of the cooling water reservoir, Building #186.

Two air compressors, one a spare, each having a capacity of 105 c.f.m. at 100 p.s.i., were installed in this room with two aftercoolers and one air receiver to furnish air to the chlorinator in the reservoir and instrument air for the pump house. An office, lavatory, control board, residual chlorine recorder, a traveling crane and a telephone booth were also installed in the pump room.

The adjoining switchgear room contains four 13.8/2300-v. indoor unit-type substations and controls for auxiliary services, a lighting transformer, control panels, a station battery and charger.

The operating floor levels of both the switchgear and pump room are below grade to keep the pumps primed and to afford protection against bomb blast. With this arrangement it was necessary to install an access pit adjacent to the building for equipment handling.

## BUILDING FLOOR SPACE

### Approx. Sq. Ft.

|                           |        |
|---------------------------|--------|
| Pump House, total area    | 11,960 |
| Pump Section of Pump Room | 9370   |
| Office                    | 120    |
| Locker Room               | 95     |
| Switchgear Room           | 2545   |

## BUILDING DETAILS

The Pump Room portion of the structure is of modified Class III construction with reinforced concrete walls and floors. It has a peaked, corrugated asbestos roof and measures 214 ft. x 42 ft.-6 in. x 36 ft. high. The Switchgear



Room is of Class I construction, of reinforced concrete with a flat concrete roof, and measures 143 ft. x 20 ft. x 20 ft. high. The over-all structure measures 214 ft. x 62 ft.-6 in.

Total Volume - 338,755 cu. ft.

## CONSTRUCTION DETAILS

Foundation - Reinforced concrete spread footings.

Superstructure -

Frame - Reinforced concrete walls.

Stairs - Concrete (exterior).

Windows - None (louvers only).

Doors - Hollow metal and steel roll-up.

Pump House Roof - Peaked steel truss.

Switchgear Room Roof - Flat reinforced concrete.

Pump House Roof Covering - Corrugated asbestos.

Flooring - Concrete and steel gratings.

Office - Pump House

Partitioning Material - three walls concrete block, one wall reinforced concrete.

Ceiling - Reinforced concrete.

Locker Room - Pump House

Partitioning Material - Two walls concrete block, two walls reinforced concrete.

Ceiling - Reinforced concrete.

Roof ventilators, exhaust and supply fans, ventilator sets and unit heaters are installed for the safety of the plant personnel and for comfort within the office and change room areas.

Care was taken in design to provide maximum illumination at panels and vital equipment installations.

Loudspeaker assemblies were installed for safety alarm warning signals.

## EQUIPMENT

### Mechanical

8 Horizontal, single-stage, cooling water pumps with motor drives, each 14,000 g.p.m.

4 Horizontal, single-stage, service water pumps with motor drives, each 3,000 g.p.m.

All necessary gate, throttle and check valves.

All necessary instrumentation and control equipment.

1 Traveling hand-operated crane, hoist and motor drive, 5 tons.

- 2 Air compressors, V-belt motor drive, each 105 c.f.m.
- 1 Instrument air dryer, 100 c.f.m.
- 1 Chlorine residual recorder.

### Electrical

- 2 2000 kv.-a., 13.8/2.4 kv., 4-Breaker unit substations.
  - 2 2000 kv.-a., 13.8/2.4 kv., 3-Breaker unit substations.
  - 1 300 kv.-a., 2400/480 v. Double-ended substation.
  - 2 45 kv.-a., 480-208Y/120-v. a.c. Transformers, for lighting panels.
  - 1 1 kv.-a., 480/120-v. Transformer.
  - 2 20-circuit 208/120-v. a.c. Lighting panels.
  - 1 Lighting panel - NEMA III.
  - 1 200 amp. a.c. Lighting distribution panel.
  - 1 208/120-v. a.c. Distribution panel.
- All necessary automatic transfer switches, receptacles, relays, air pressure switches, motor starters, push-button stations, cable trays, connectors, conduits and appurtenances, cable and lighting fixtures.
- 1 Battery with rack and one group of 2 - 2 kw.
  - 1 Battery charger MG sets with control panels.
  - 1 Blackout control cabinet.
  - 1 Safety alarm main equipment rack.
  - 6 Loudspeaker assemblies.
  - 1 Noise reducing telephone booth.

### Heating and Ventilating

- 4 Roof ventilators with motor drives, each 15,000 c.f.m.
- 1 Electric bay supply fan with motor drive, each 14,430 c.f.m.
- 1 Ventilator set V-belt motor drive, 680 c.f.m.
- 1 Pressure reducing valve, 370 lbs./hr. steam.
- 4 Unit heaters with motor drives, for general use, each 1082 c.f.m., 76,800 B.t.u./hr.
- 1 Unit heater with motor drive and thermostat, office, 577 c.f.m., 26,850 B.t.u./hr.
- 1 Unit heater with motor drive and thermostat, 577 c.f.m., 26,850 B.t.u./hr., for toilet.

### Architectural

- 1 Water cooler, 10 g.p.h.
- 1 Vertical duplex sump pump with motor drive, 100 g.p.m.
- 1 Pneumatic sewage ejector, 50 g.p.m.
- 1 Electric water heater with pressure gauge, 80 g.p.h., storage capacity 66 gallons.

## PLANT OPERATION

The pump house discharges water through four lines, two 42 in. headers for process cooling and two 24 in. lines for service water. Each 42 in. header is serviced by four pumps and two by-pass lines in the pump house. Water from the suction pit of the reservoir enters each cooling water pump through a suction pipe, the flow being controlled by a gate valve. Water is pumped into the 42 in. header through a 24 in. line equipped with a tilting disk check valve and a butterfly valve for throttling control. This system is designed for furnish up to 84,000 g.p.m. of cooling water to Building #105.

In cases of power failure, check valves in the by-pass lines will open to allow an additional flow of water into the header beyond that which is flowing through the pumps. At such times the pump lines will also allow gravity flow even though the impellers might be frozen. On each of the by-pass lines a check valve is flanked by gate valves. All are manually operated. A test connection is installed between the check valve and gate valve on the discharge side of the line. A residual chlorine recorder is installed in the cooling water lines to Building #105.

At each end of the pump room two service water pumps discharge into a 24 in. line which, in turn, discharges into a common 24 in. service water header.

## DESIGN DIFFERENCES BY AREAS

The general arrangement of Building #190-P is identical to that of Building #190-R. The arrangement of Buildings #190-LK&C, which are identical to one another, differs from Buildings #190-R&P in the 42 in. header layout, office and locker room arrangement and future pump provisions.

The 42 in. headers in Buildings #190-R&P are parallel to the front walls of the buildings and turn through these walls to a 45° angle. The headers in Buildings #190-LK&C go straight along the front walls and out the two side walls, with a 90° bend to the respective Building #105 made outside the corresponding pump house.

No provisions were made for future pumps in Buildings #190-R&P. Two additional suction well wall castings as well as electric conduit for two additional pumps were installed in #190-LK&C.

The locker room and office arrangement in Buildings #190-LK&C differs from that in Building #190-R&P because

of the 42 in. headers extending under these rooms in the three former buildings. The office is located over the headers whereas in Buildings #190-R&P the lavatory is in that location.

## DRAWINGS

### Bldg. #190-R&P

W-136267 - Arrangement - Plan and Section.  
W-136390 - Arrangement - Plan.  
W-136361 - Arrangement - Sections.

### Bldg. #190-LK&C

W-139251 - Arrangement - Plan and Section.

## BUILDING #801-RPLK&C - PIPE SUPPORTS

## FUNCTION

This facility supports all outside overhead pipe lines to and from various buildings within the area.

## PRINCIPAL COMPONENTS

Throughout the plant all overhead pipe lines, except the ash sluicing lines, are hung above ground by single or double rod pipe hangers suspended from cross arms of single or double poles. The piping is supported to prevent vibration, and is anchored sufficiently to prevent undue strains on poles and supports, permitting free expansion and contraction of pipe between anchors. Where wood poles and supports are used for steam or fluids of temperatures above 250°F., the pipes are properly insulated and kept away from the wooden members to prevent dangerous heating. At road crossings the elevated lines are carried on columns with foundations and crossbeam supports.

In the #100-R Area the lines supported include the 16-inch steam header from Bldg. #184 to Bldg. #105, a 4-inch branch header serving a number of buildings through 2 and 3-inch lines; a 4-inch steam header from Bldg. #184 to Bldg. #105 and several 3-inch branch lines; and a 6-inch exhaust steam line. The two 1-inch compressed air lines, for plant and instrument use, are suspended from the 3-inch gas line between Bldgs. #105 and #110. The ash sluicing lines from Bldg. #184 to Bldg. #188 are supported on wood poles and concrete piers.

BUILDING #801-PL&K

Same as Building #801-R.

BUILDING #801-C

General design is the same as Building #801-R.

Facilities are provided for the support of a steam header between #184 and #105 with branch lines to #183-2, #190, and #701-1 with tap to #704; a steam line between #105 and #110; an exhaust steam line from #183-2 to #184; a gas line between #110 and #105 with one instrument air and one plant air line suspended from it. The exhaust steam line parallels and is at the same elevation as the branch steam line to #183-2. The main steam header from a point adjacent to #183-2 to the Power House #184, also parallels and is at the same elevation as the exhaust line. In each case, one line of supports was provided for parallel lines.

The branch steam line at the east side of #105 is suspended from a larger branch line. A single line of supports serves the steam, gas, and instrument and plant air lines running between #105 and #110. Both air lines are suspended from the gas line as messenger. These supports are utilized also for the branch steam line to #105 at this location.

## EQUIPMENT

All procurement for these facilities was handled in the field.

## DRAWINGS

- Map 3313 - Outside Overhead Lines - Sheets 619, 467, 523, 580 and 732 - RPLK&C, respectively.  
 - Sheets, 649, 496, 553, 581, 762 - RPLK&C, respectively.  
 - Sheets 497 and 610 - P&K, respectively.  
 - Sheet 611 - K only.

BUILDING #802-RPL&K - STEAM LINES (INCLUDING GAS AND AIR LINES)

## FUNCTION

These lines distribute high and low pressure steam, instrument and plant air and helium gas.

## PRINCIPAL COMPONENTS

### Steam Lines

#### Building #802-R

One 16-inch steam header from Building #184-R, Power House, transports a maximum load of 48,850 lbs./hr. at 25 p.s.i.g. and 290°F. to Building #105-R, with a 4-inch branch header delivering steam to the following buildings through separate take-off lines:

- (1) 100 lbs./hr. to Building #110-R.
- (2) 200 lbs./hr. to Building #122-R.
- (3) 1200 lbs./hr. to Building #704-R.
- (4) 700 lbs./hr. to Building #701-R.

One 4-inch steam header from Building #184-R transports a maximum load of 7100 lbs./hr. at 175 p.s.i.g. and 400°F. to Building #105-R, with branch lines delivering steam to the following buildings:

- (1) 1400 lbs./hr. to Building #183-1R.
- (2) 400 lbs./hr. to Building #190-R.
- (3) 3000 lbs./hr. to Building #183-2R.

#### Building #802-P

The routing and line sizes are the same as those in Building #802-R with the following major exceptions: no low pressure steam is delivered to Building #122, and there is no high pressure steam take-off line corresponding to that to Building #183-1R since this building was not constructed in the PLK&C Areas.

#### Building #802-L

One 16-inch steam header from Building #184-L transports a maximum load of 60,750 lbs./hr. at 25 p.s.i.g. and 290°F. to Building #105-L, with a 4-inch branch header delivering steam through take-off lines to the following buildings:

- (1) 1200 lbs./hr. to Building #704-L.
- (2) 700 lbs./hr. to Building #701-L.

One 4-inch steam header from Building #184-L transports a maximum load of 10,950 lbs./hr. at 175 p.s.i.g. and 400°F. to Building #105-L, with branch take-offs delivering steam to the following buildings:

- (1) 3000 lbs./hr. to Building #183-2L.
- (2) 450 lbs./hr. to Building #190-L.

The 4-inch header is independently supported on wood poles rather than suspended from the 16-inch header as is the case in the R and P Areas.

Building #802-K

Same arrangement as Building #802-L.

#### Exhaust Steam, Gas and Air Lines - RPL&K Areas

In these areas a 6-inch line returns approximately 300 lbs./hr. of exhaust steam at 25 p.s.i.g. to the 16-inch header from the turbine-operated pumps in the respective #183-2 Buildings.

A 3-inch line transports helium gas from each #110 Building to the respective #105 Buildings. A short length of 4-inch helium line is required also because of the wide spans between supports at road crossings

Two 1-inch lines transport instrument and service air from headers in each Building #105 to the respective #110 Buildings. In each area these lines are suspended from the helium gas line which acts as messenger.

#### EQUIPMENT

All piping and accessory equipment was obtained by field procurement.

#### PROCESS

Process and heating steam from the Power Houses is first passed through controlled pressure reducing and desuperheating stations. It is then transported to consuming buildings within the five #100 Areas through the lines detailed under "Principal Components".

All condensate from outside steam lines is trapped and discharged to atmosphere through French drains.

#### DRAWINGS

##### Bldg. #100-R

- W-137803 - Outside Overhead Lines - Steam Flow Diagram - Buildings #802-R, #803-R, #807-R.
- Map 3313 - Sheets 619 and 649 - Outside Overhead Lines.

Beyond the low pressure branch lines to Building #105-C, a 3-inch branch line from the main supplies up to 2000 lbs./hr. of 25 p.s.i.g. steam to Buildings #704-C and #701-C through a pressure reducing station. Another 3-inch branch line supplies a small quantity of 175 p.s.i.g. steam to Building #190-C.

The main steam line terminates at Building #105-C, supplying 175 p.s.i.g. steam to this building together with a 4-inch line suspended from it. These lines supply up to 19,000 lbs./hr. of process steam to Building #105-C.

Exhaust steam from the pump turbine drives in Building #183-2C is returned to the Power House through a 4-inch line which parallels the 3-inch high pressure steam supply line to this facility.

A 3-inch line transports helium gas from Building #110-C to Building #105-C. This line serves as messenger to support a 1-inch instrument air line and a 1-inch service air line supplying Building #110-C from the compressors in Building #105-C.

All outside line condensate is trapped and discharged to atmosphere through French drains.

#### EQUIPMENT

All piping accessory equipment, with the exception of pressure reducing valves and safety valves procured by a subcontractor, were obtained by field procurement.

#### DRAWINGS

W-141692 - Steam Flow Diagram.

Map 3313 - Sheets 732 and 762 - Outside Overhead Lines.

#### BUILDING #808-RPLK&C - CHLORINE LINES

This facility consists of the liquid chlorine lines running from the Clarification Plants, Buildings #183-1R and #183-4PLK&C, to Building #186, the Cooling Water Reservoir, which were part of the over-all design for Buildings #183-4PLK&C and Building #186-RPLK&C.

The liquid chlorine and chlorine solution lines serving Buildings #183-1R and #183-4PLK&C were part of the over-all design for these buildings.

The overhead lines with their connecting facilities are shown on the drawings for Buildings #801 and #802.



Bldg. #100-P

- W-138303 - Overhead Piping and Supports with Details.
- W-138276 - Outside Overhead Lines - Steam Flow Diagram - Building #802-P, #803-P, #807-P.
- Map 3313 - Sheets 467, 496, and 497 - Outside Overhead Lines.

Bldg. #100-L

- W-142103 - Overhead Piping and Supports with Details.
- W-142092 - Outside Overhead Lines - Steam Flow Diagram - Buildings #802-L, #807-L.
- Map 3313 - Sheets 523 and 553 - Outside Overhead Lines.

Bldg. #100-K

- W-142357 - Overhead Piping and Supports with Details.
- W-142356 - Outside Overhead Lines - Steam Flow Diagram - Buildings #802-K, #807-K.
- Map 3313 - Sheets 580, 581, 610 and 611 - Outside Overhead Lines.

BUILDING #802-C - STEAM, AIR AND GAS LINES

## FUNCTION

These lines distribute process and heating steam, service and instrument air, and helium gas throughout the area.

## PRINCIPAL COMPONENTS

Process and heating steam is exported from Bldg. #184-C, Power House, at full boiler saturated pressure and temperature through an 8-inch steam main and branch lines ranging in size from 3 to 12 inches in diameter. A 3-inch take-off from the export main supplies up to 3000 lbs./hr. of 300 p.s.i.g. steam to Building #183-2C. Just beyond this branch-off, a pressure reducing station, installed in the main, reduces steam pressure in the line from 300 to 175 p.s.i.g. and the diameter of the main is increased to 10 inches.

Low pressure steam in quantities up to 41,000 lbs./hr. is supplied Building #105-C through two branch lines, 12 inches and 4 inches in diameter, from the export main. Pressure reducing stations installed in both branch lines reduce the steam pressure from 175 to 24 p.s.i.g.

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## BUILDING #809-RPL&K - ASH SLUICING LINES

### FUNCTION

These lines convey ashes and sluicing water from the Power Houses, Bldgs. #184, to the Ash Disposal Basins, Bldgs. #188 in the #100-R,P,L and K Areas.

### PRINCIPAL COMPONENTS

The lines are of Ashcolite pipe fabricated in 16-foot flanged sections and bolted together in the field. Supports are so located at each joint that individual sections can be rotated to extend the life of the pipe.

The sluicing line for each area is a single 8-inch pipe line with an ash handling capacity of 30 tons per hour. Each line is pitched so that it can be drained, and at the low points a plug valve has been provided to permit complete drainage as freeze-up protection to the lines during cold weather.

These lines are supported on wood poles and concrete piers. Some steel poles were used in the P and K Areas.

### EQUIPMENT

All equipment required for these facilities, except the supporting units obtained by field procurement, was a part of the ash handling equipment package unit for Building #184.

### DRAWINGS

#809-R - P.F. 4544 - 4546 - Ash Sluicing Piping  
#809-P - P.F. 4600 - 4602 - Ash Sluicing Piping  
#809-L - P.F. 4583 - 4585 - Ash Sluicing Piping  
#809-K - P.F. 4603 and 4604 - Ash Sluicing Piping

## BUILDING #901-RPLK&C - WATER LINES

### FUNCTION

Raw river water is delivered to the treatment and storage facilities and clarified, domestic, softened, demineralized and cooling water is distributed to the points of use in the #100 Areas through these lines.

Lines also are provided to deliver fuel oil from the Building #108-3 unloading spots to Buildings #108-1 and 2, Engine Houses, and other lines provide a fuel oil distribution system between Buildings #108-1 and 2.

#### PRINCIPAL COMPONENTS

The raw river water lines, with all necessary valves, structures, and appurtenances, are included as a part of this facility for accounting purposes only. They are within the fenced #100 Areas and terminate at Buildings #183-1R and #186-PLK&C, but the actual design of these lines is a part of Building #901-G. These lines are a continuation of the raw river water delivery lines from the river pump house headers. One line taken from the river lines to the #105 Buildings is for emergency use.

Water is piped from Building #183-1R to Buildings #186-R and #190-R for distribution; to the Filter Plant, Building #183-2R; and to Building #105-R for emergency use.

A comparable distribution is effected in PLK&C from Building #186 to #190 for distribution, #183-4 precipitators, and to #105 for emergency use.

Two lines, one from each header, are installed from Building #190 to #105 for process cooling water. Two lines are installed from and interconnected outside the building to deliver service water from Building #190 to Buildings #105-R, #183-1R, #183-2R, #184-R and #185-R and from #190-PLK&C to #105-PLK&C, #183-2PLK&C, #183-4PLK&C, #184-PLK&C and #185-PLK&C. Filtered water for process requirements is distributed from #183-2 to #105. Domestic water of filtered quality is distributed to all area buildings which require water for domestic purposes. Deionized water is supplied to #105-RPLK&C from #183-2RPLK&C. Filtered and softened water is piped from #183-2 to #184 for boiler feed make-up requirements. A cooling water by-pass pipe line is installed from #186 to #108-2. Water flows to the emergency pump room by gravity. A pipe line emanating from #107 and terminating at #186 is provided as an emergency measure for recirculating water through Buildings #186-RPLK&C, #190-RPLK&C, and #105-RPLK&C.

River water by-pass is carried through reinforced concrete pipe, cooling water is circulated through reinforced concrete and steel pipe, service water through cast iron mechanical joint pipe, clarified water through cast iron mechanical joint pipe, domestic water through copper tubing and cast iron mechanical joint pipe, softened and filtered water through cast iron mechanical joint pipe and deionized water through stainless steel pipe. Fuel oil is distributed through steel pipe.

## EQUIPMENT

Equipment for water services includes reinforced concrete pressure pipe 30-in. and 84-in. in diameter; carbon steel pipe in sizes ranging from 30-in. to 42-in.; cast iron mechanical joint pipe from 3-in. through 24-in.; one inch copper tubing; and 20-in. stainless steel pipe. For fuel oil carbon steel pipe ranging in size from 1-1/2-in. to 4-in. was used.

Along with the piping mentioned above, the necessary valves and fittings were also equipment requirements for these facilities.

## DRAWINGS

### #100-R Area

Map 3314 - Sheet 649 - Location  
 Map 3314 - Sheet 619 - Location  
 W-137819 - Flow Diagrams - Domestic Water  
 W-137831 - Flow Diagrams - Clarified Water  
 W-137832 - Flow Diagrams - Soft, Raw and Process  
 Auxiliary Water.

### #100-P Area

Map 3314 - Sheet 496 - Location  
 Map 3314 - Sheet 497 - Location  
 W-138320 - Flow Diagram - Domestic Water  
 W-138321 - Flow Diagram - Clarified Water  
 W-138322 - Flow Diagram - Soft, Raw and Process Auxil-  
 iary Water.

### #100-L Area

Map 3314 - Sheet 523 - Location  
 W-142804 - Flow Diagrams - Domestic Water  
 W-142085 - Flow Diagrams - Raw Water

### #100-K Area

Map 3314 - Sheet 610 - Location  
 Map 3314 - Sheet 611 - Location  
 Map 3314 - Sheet 580 - Location  
 Map 3314 - Sheet 581 - Location  
 W-139596 - Flow Diagram - Domestic Water  
 W-139595 - Flow Diagram - Raw Water

### #100-C Area

Map 3314 - Sheet 732 - Location  
 Map 3314 - Sheet 762 - Location

W-142991 - Flow Diagrams - Domestic Water  
W-142992 - Flow Diagrams - Raw Water

#### AREAS #200-F&H

#### BUILDING #280-1F - CHEMICAL FEED BUILDING

##### FUNCTION

This building houses facilities for the chlorination of the cooling tower system and for the testing and treatment of water from three deep wells which supply the domestic, service and fire water systems within the #200-F Area.

##### PRINCIPAL COMPONENTS AND PROCESS

The building contains a laboratory for routine water analyses, a chlorine room which houses feed facilities for both the domestic and cooling tower water systems, and a chemical feed room housing lime and polyphosphate feed facilities for all well water entering the domestic, service and fire water storage tanks.

##### Chlorine Room

The domestic water system is serviced by two chlorinators, one a spare, each having a rated capacity of 75 lbs./24 hrs. These units are solution feed vacuum chlorinators controlled by a differential converter receiving impulses from an orifice installed in the riser to the domestic water storage tank. A motor-driven water booster pump, installed on the inlet side of the chlorinators, supplies the units with approximately 10 g.p.m. of domestic water at a pressure sufficiently high for operating conditions.

Chlorine consumption is measured on a 1000-lb. capacity scale with a platform sized for five 150-lb. cylinders which are manifolded into a supply line to the chlorinators.

The cooling tower water system is serviced by a chlorinator having a rated capacity of 1000 lbs./24 hrs. This is a semi-automatic control, solution feed vacuum unit, air operated, and actuated from a program timer.

Chlorine consumption in this system is measured on an 8000-lb. capacity scale with a platform sized for two 1-ton cylinders manifolded into the chlorine supply line to the chlorinator. A third cylinder, for emergency purposes, is located adjacent to this scale.

A monorail is provided to handle the 1-ton cylinders.

#### Chemical Feed Room

A 10 per cent polyphosphate solution is prepared in a 150-gallon rubber-lined dissolving tank equipped with a stainless steel dissolving basket and motor-driven agitator. The polyphosphate solution flows to a feed tank directly below the dissolving tank. Two simplex pumps, one a spare, take suction from the feed tank and discharge the polyphosphate solution through two overhead lines into the raw well water header. Each pump has a capacity of from 0 to 7.5 g.p.h. A stainless steel pressure relief valve is installed in the discharge line of each pump. Feed rate is controlled by time duration of impulse from a chronoflow transmitter which is proportional to the rate of well water flow.

A 1 per cent lime slurry solution is prepared and conveyed to the raw well water header by equipment also installed in the chemical feed room. This consists of a volumetric proportioning type lime feeder, having a feeding range of 1 to 120 lbs./hr. and equipped with an integral hopper agitator; a feeder hopper having a capacity of approximately 400 lbs. of hydrated lime, and equipped with an external agitator and dust collector; a dissolving chamber with integral make-up tank and motor-driven agitator; and two motor-driven centrifugal feed pumps, one a spare, taking suction from the dissolving chamber and discharging lime slurry through two overhead lines into the raw well water header. Each pump has a rated capacity of 50 g.p.m. A monorail is installed for moving dry chemicals from the storage space to the charging platforms of the chemical feeders.

#### Laboratory

A wall table, storage cabinets, and necessary equipment for water analyses are installed in the laboratory. Recorders for flow and pH of the water being treated are also installed here.

The larger pumps are powered from a 440-v. panel, with miscellaneous smaller motors, heaters, ventilation fans and other auxiliaries fed off a 120/208-v. lighting panel. Both panels are installed in the laboratory. The source of power for this facility is the #284-F Power House motor control center.

#### BUILDING FLOOR SPACE

#### Approx. Sq. Ft.

Chlorine Room

410



Chemical Feed Room  
Laboratory

350  
200

### BUILDING DETAILS

This is a one-story rectangular structure, 34 ft. by 30 ft., of Class III Construction. It has a peaked roof.

Area - 1020 sq. ft.  
Volume - 17,340 cu. ft.

### CONSTRUCTION DETAILS

Foundation - Concrete piers on square footings under columns, with connecting grade beams.  
Frame - Structural steel.  
Roof - Truss and purlin.  
Roof Covering - Corrugated cement asbestos board.  
Wall Siding - Corrugated cement asbestos board.  
Floor - Concrete slab.  
Partitioning Material - Steel stud and 1/4 in. cement asbestos board.  
Ceiling - Exposed truss.

### EQUIPMENT

#### Mechanical

1 lot pH Recorder  
1 set Cooling water chlorination equipment, 1000 lbs./day.  
1 lot Domestic chlorination equipment with necessary scale and pump, 75 lbs./day.  
1 lot Polyphosphate solution feeder equipment with motor drive, 10 g.p.h.  
1 Solution tank, 150 gal.  
1 lot Lime feeder equipment with motor drive, 120 lbs./hr.  
1 lot Laboratory furniture.  
1 lot Laboratory equipment.  
1 Chain hoist, 4000 lbs.  
1 Hand-operated trolley hoist, 1000-lb.  
1 Lifting clamp for chlorine cylinders.

#### Heating and Ventilating

1 Unit Heater, down-blast, with necessary thermostat and motor drive, Chlorine Room, 41,800 B.t.u./hr.

- 2 Unit Heaters, horizontal-blast, with necessary thermostat and motor drives, Chlorine Room, 23,100 B.t.u./hr.
- 1 Unit Heater, down-blast, with thermostat and motor drive, Chemical Room, 41,800 B.t.u./hr.
- 1 Unit Heater, horizontal-blast, with thermostat and motor drive, Chemical Room, 35,200 B.t.u./hr.
- 1 Unit Heater, down-blast, with thermostat and motor drive, Laboratory, 79,400 B.t.u./hr.
- 1 Exhaust fan with back-draft damper and motor drive, Laboratory, 1650 c.f.m.
- 1 Roof ventilator with motor drive, 2730 c.f.m.

#### DRAWINGS

- W-137734 - Plan, Elevations and Details - Architectural.
- W-138239 - Foundation Plan, Sections and Details - Structural.
- W-138486 - Plans and Sections - Arrangement.

#### BUILDING #280-1H - CHEMICAL FEED BUILDING

##### FUNCTION

This building houses facilities for the chlorination of the cooling tower system and for treatment of water from two wells which supply the domestic, service and fire water systems within the #200-H Area.

With the exception of elevations and orientation, Building #280-1H is identical to Building #280-1F.

#### BUILDING #280-2F - CHEMICAL FEED BUILDING

##### FUNCTION

This building houses facilities for the treatment of water from the two deep wells which supply the #241-F Heat Exchanger Cooling System with once-through cooling water, the exit water constituting make-up to the #285-F Cooling Tower.

##### PRINCIPAL COMPONENTS AND PROCESS

This building is a single room housing polyphosphate and lime feeding equipment and associated facilities.

The polyphosphate equipment consists of a 200-gallon rubber-lined dissolving tank fitted with a stainless steel dissolving basket and a motor-driven agitator. Two simplex pumps (one a spare) discharge a 10 per cent solution to the raw well water header at a constant rate which is set manually at from 0 to 9 g.p.h.

Lime slurry is prepared in a volumetric feeder fitted with an extension hopper, vibrator, dust collector, and a dissolving chamber with agitator. The lime slurry is discharged through overhead lines to the raw well water header by two centrifugal pumps, one a spare, having a rated capacity of 50 g.p.m.

Recorders for treated water flow and pH are installed in this building.

Dry chemicals are moved by monorail from storage space to the platform for charging the chemical feeders.

The larger pumps and unit heaters are powered from a 480-v. distribution panel, with the unit heater fans, ventilating fan, small motors, and other auxiliaries being wired from a 120/208-v. 12-circuit lighting panel.

#### BUILDING DETAILS

This building is of Class III construction, rectangular in shape approximately 19 ft. by 21 ft., and has a peaked roof.

Area - 400 sq. ft.  
Volume - 5700 cu. ft.

#### CONSTRUCTION DETAILS

Foundation - Concrete piers on square footings under columns, with connecting grade beams.  
Frame - Structural steel.  
Roof - Beam and purlin.  
Roof Covering - Corrugated cement asbestos board.  
Wall Siding - Corrugated cement asbestos board.  
Flooring - Concrete slab.  
Stairs - Metal with precast concrete treads.

#### MISCELLANEOUS

Two 7-1/2 kw. unit heaters with thermostats are provided.  
One roof ventilator is installed.  
Lighting is incandescent.

The safety alarm provisions for area-wide protection are considered sufficient for this facility.

## EQUIPMENT

### Mechanical

- 1 lot Polyphosphate solution feeder with motor drive, 10 g.p.h.
- 1 Polyphosphate solution tank, 200-gal.
- 1 pH Recorder
- 1 Lime feeder equipment, 23 lbs./hr.
- 1 Hand operated trolley hoist, 1/2-ton.

### Heating and Ventilating

- 1 Roof ventilator with motor drive, 2380 c.f.m.
- 2 7-1/2 kw. Unit heaters with thermostat and motor drive, each 25,590 B.t.u./hr.

## DRAWINGS

- W-138798 - Plan, Elevation and Details - Architectural
- W-142074 - Plans and Sections - Arrangement

## BUILDING #280-2H - CHEMICAL FEED BUILDING

### FUNCTION

This building houses facilities for the treatment of water from the deep wells which supply the #241-H Heat Exchanger Cooling System with once-through cooling water, the exit water constituting make-up to the #285-H Cooling Tower.

With the exception of elevations and orientation, Building #280-2H is identical to Building #280-2F.

## COOLING WATER RETURN SYSTEM - #200-F AREA

The #200-F Area Cooling Water Return System comprises the following facilities.

- Building #281-1F - Delaying Basin
- Building #281-2F - Pump Basin
- Building #281-3F - Retention Basin
- Building #281-4F - Sampling House
- Building #281-5F - Delaying Basin for Segregated Return System.

Building #281-6F - Monitoring House for Segregated Return System.

In addition, the system includes all underground gravity flow collection lines, mains between the facilities listed above, and the return line to the cooling tower.

SYSTEM DESCRIPTION

General

All cooling water used in the #200-F Area outside the power block is supplied from the #285-F Cooling Tower. A small portion of the total supplies once-through users and then is wasted to the sewer at the point of use, never re-entering the system. The balance of the cooling water is included in this system, and all returns fall into one of three classifications.

1. Water that has been used where no chance of radioactive contamination exists. This water is picked up in a separate system and flows by gravity back to the #281-2F Pump Basin. This water is not monitored.

2. Water that has been used where chances of radioactive contamination do exist due to line breaks or equipment failures, however remote the chance may be. This water is picked up in a separate gravity return system. On the way to the #281-2F Pump Basin samples are drawn off for continuous monitoring in Building #281-4F. From the monitoring point this water flows through a delaying basin, Building #281-1F, where a 10-minute delay provides adequate time for the results of the monitoring to be determined. If no radioactivity is recorded, flow continues to the #281-2F Pump Basin. If radioactivity is indicated sufficient time remains to divert the flow from the pump basin without permitting the contaminated water to enter the cooling tower system. This is accomplished through the automatic closing of a motor-operated valve in the line between the delaying basin and the pump basin and the automatic opening of a second motor-operated valve in a gravity discharge line from the delaying basin to the #281-3F Retention Basin located outside the area fence.

3. Water that has been used in various process vessels where the chance of radioactive contamination is much greater than in Class 2 above. Here the risk of jeopardizing the cleanliness of the cooling tower system does not warrant the return and reuse of this water. Consequently the effluent from process vessels using steam and water alternately in their operating cycles is collected in a separate gravity flow system which has its own monitoring facilities, Building #281-6F, and delaying basin, Building #281-5F. If radio-

activity is not found, this water is discharged into the storm sewer. But if monitoring indicates radioactivity, sufficient time is provided in the delaying basin to divert the flow to the #281-3F Retention Basin without contaminating the sewer system.

All water returned to the #281-2F Pump Basin under conditions (1) and (2) is pumped back to the #285-F Cooling Tower.

#### Flow

A portion of the water from the cooling tower system is used for air conditioning and refrigeration purposes only. This is classified under (1) in the general description above and is collected from Buildings #221-F, #717-F, #235-F, and #232-F. These lines join in a 24 in. main which conducts the flow directly to the pump basin, Building #281-2F, without being monitored. From here the water is pumped back to the cooling tower for recirculation in the system.

Process cooling water from the cooling tower system, classified under (2) in the general description, is returned to the cooling tower through an independent cooling water return system. A 24 in. header from each side of Building #221-F, a 24 in. header from Building #211-F, and a 6 in. pressure return from Building #235-F collect used process cooling water and return it to a common manhole. Water collected in this manhole flows by gravity through a 36 in. main to another manhole where an automatic water activity sampler, located in Building #281-4F, tests a continuous sample of the return water for radioactivity.

Condensate from Buildings #221-F, #211-F, and #235-F is drained through the cooling water return headers and becomes part of the return to the cooling tower.

In normal operation, the process cooling water is returned to the cooling tower in the following sequence: (1) flow by gravity from the sampling manhole to a delaying basin, Building #281-1F, which has a minimum hold-up time of 10 minutes; (2) from the delaying chamber it flows by gravity to the pump basin, Building #281-2F, where it is collected in a pump suction well; (3) from here it is pumped back to the cooling tower for recirculation in the system.

In the event that the automatic water activity sampler detects radioactive contamination in the process cooling water return, an alarm sounds in Building #221-F and an electrical circuit closes the valve in the line from the delaying basin to the pump basin and opens a valve in a line from the delaying basin to the retention basin, Building #281-3F. The water thus is diverted to the retention basin

to prevent the contaminated water from flowing to the pump basin and being recirculated through the cooling tower system. When this situation occurs, only refrigeration cooling water return is circulated through the system. There is not sufficient refrigeration cooling water return to permit full operation of the plant, and an orderly shut-down of the process is started when the alarm is sounded. The source of trouble then is located and repaired.

Many vessels in the Building #221-F canyons and other process areas use both steam and cooling water in their operating cycle and are considered to be more susceptible to the development of leaks. Condensate and exit cooling water, classified under (3) in the general description above, from these vessels is returned in a segregated system in order to avoid gross contamination of the entire cooling water system in the event of leak. This water is never returned to the cooling tower being either wasted to the storm sewer or held in the retention basin in the following manner.

Segregated cooling water is collected by gravity from Buildings #221-F and #211-F through separate lines which join in a 16 in. main leading to a manhole where an automatic water activity sampler, located in Building #281-6F, tests the return water for radioactivity. From the manhole the return main continues to the delaying basin for the segregated return system, Building #281-5F, which has a minimum hold-up time of one hour. Two motor-operated valves ahead of this basin are controlled from the monitor building for the segregated return system, Building #281-6F. Normally, the segregated cooling water flows through the #281-5F Delaying Basin and into the storm sewer system to waste. If radioactivity is detected at the monitoring station, an electrical circuit is energized, closing the valve through which it is diverted to a by-pass line emptying into the retention basin.

Radioactive water contained in the retention basin is dissipated gradually through ground seepage or is discharged to the river when sampling indicates that it has cooled to a degree that it is no longer dangerous.

See drawing W-158728 - Flow Diagram, #200-F Cooling Water Return System, for a schematic representation of this system.

#### BUILDING #281-1F - DELAYING BASIN

##### FUNCTION

This facility delays for ten minutes the return of process cooling water exposed to the possibility of radioactive contamination to permit its monitoring. Normally this water passes

through the delaying basin to the #281-2F Pump Basin. However, if monitoring indicates contamination, water in this delaying basin is diverted to the #281-3F Retention Basin to prevent contamination of the cooling tower recirculating system.

#### PRINCIPAL COMPONENTS

This is an open top, reinforced concrete basin comprised of a baffled delaying chamber and a connecting valve pit containing two 36-in. motor operated gate valves. Nine vertical baffles are installed in the delaying chamber to produce the required time delay by inducing over-and-under flow. The two gate valves control the flow of cooling water from the delaying chamber to either the #281-2F Pump Basin or the #281-3F Retention Basin. These valves are controlled from the #281-4F Monitor Building.

An 18 in. overflow line is installed at the discharge end of the chamber approximately 10 ft. above the bottom. A drain line with gate valve is installed in each of the baffled sections of the delaying chamber for draining and cleaning use.

#### BUILDING AND CONSTRUCTION DETAILS

Both the delaying chamber and the valve pit are rectangular structures. The inside dimensions of the delaying chamber are approx. 40 ft. by 100 ft. by 15 ft. average depth from the top of the 12-in. thick walls. Inside dimensions of the valve pit are 9 ft. by 25 ft. by 15 ft. average depth. The total facility covers an area of 4554 sq. ft. and occupies a volume of approximately 69,500 cu. ft.

A safety pipe railing is installed around the top of the delaying chamber.

#### EQUIPMENT

No mechanical equipment, other than the motor-operated gate valves, is installed in this facility.

#### DRAWINGS

- W-148126 - Equipment Arrangement.
- W-148489 - Process Piping.
- W-148125 - Plans, Sections, and Details - Concrete.



BUILDING #281-2F - PUMP BASIN

## FUNCTION

This basin receives cooling water returned from the #281-1F Delaying Basin (monitored) and the refrigeration and air-conditioning facilities (non-monitored). Water collected from these sources is pumped back to the #285-F Cooling Tower for recirculation through the system.

## PRINCIPAL COMPONENTS

Pump Well

A reinforced concrete basin set into the ground and covered by a concrete slab receives the cooling water returns and serves as the pump suction well. It has a holding capacity of approximately 275,000 gallons. Monitored process cooling water is returned to this basin through a 36 in. line from the #281-1F Delaying Basin. Air-conditioning and refrigeration effluent cooling water is brought into the pump basin through a separate 24 in. line.

An overflow line is installed in the basin wall approximately 5 ft. below the covering slab, with the water level below this point being controlled by a leveltrol.

Cooling Water Return Pumps

Four vertical cooling water return pumps, each rated at 5000 g.p.m., against a total head of 115 ft., and driven by a 200 hp. motor, are mounted on the slab covering the basin. They take suction from the pump well, discharging water to the #285-F Cooling Tower. These pumps are started and stopped by automatic sequence control, depending on the water level in the basin. A butterfly valve is installed in the discharge line of each pump for throttling the flow, to prevent short cycling. These lines discharge into a 36 in. header.

## BUILDING AND CONSTRUCTION DETAILS

The inside dimensions of the pump basin are 30 ft. by 60 ft. by 20 ft.† deep to the covering slab. The concrete walls are 1-1/2 ft. thick and the basin covers an area of 2080 sq. ft. having a volume of approximately 58,000 cu. ft. Outdoor lighting is provided.

## EQUIPMENT

- 4 Motor-driven pumps, rated capacity of each 5000 g.p.m. against a total head of 115 ft.
- 4 200 hp. Motors.
- Sequence pump start-stop control equipment.
- Leveltrol for stop-start control.
- 4 Butterfly type pump discharge throttling control valves.
- Outdoor lighting equipment.

## DRAWINGS

- W-148126 - Equipment Arrangement.
- W-148489 - Piping Arrangement.
- W-148127 - Plans, Sections, and Details - Concrete.
- W-148394 - Power and Lighting Plan.
- W-148538 - Instrument Diagram.

## BUILDING #281-3F - RETENTION BASIN

### FUNCTION

This basin receives radioactive return cooling water from the #281-1F Delaying Basin and the #281-5F Delaying Basin for the Segregated Return System. Water in this basin is dissipated through ground seepage or discharged to the Savannah River through a pipe line after sampling indicates the decay of the radioactive contaminating agents.

### PRINCIPAL COMPONENTS

This is an earth-diked uncovered retention basin having a capacity of approximately 600,000 gallons. Water enters through a 36 in. reinforced concrete pipe and spills over a riprap apron. The outlet line at the opposite end of the basin is also a 36" reinforced concrete pipe.

### BUILDING AND CONSTRUCTION DETAILS

Inside dimensions of this rectangular basin are approximately 120 ft. by 200 ft. by 7 ft. deep. The top of the dike is 4 ft. wide, with an inside slope of 3 to 1 and an outside slope of 1-1/2 to 1. The overflow line is located approximately 5 ft. above the bottom of the basin.

## DRAWINGS

W-149454 - Plan & Details - Concrete & Civil.

BUILDING #281-4F - MONITOR BUILDING

## FUNCTION

This building houses the facilities which continuously monitor cooling water from the #200-F Area process users prior to the return of this water to the #285-F Cooling Tower for recycling. If radioactivity is detected in the cooling water, controls automatically operate valves which divert the water in the #281-1F Delaying Basin, to which return water in this system flows, to the #281-3F Retention Basin. Otherwise, the water in the delaying basin flows to the #281-2F Pump Basin from which it is returned to the cooling tower.

## PRINCIPAL COMPONENTS

Building

This is a single-story one room structure housing duplicate automatic water activity samplers, an amplifier rack, and associated accessories. The building is adjacent to a manhole opening into the common line to which cooling water to be monitored by this facility is discharged.

Automatic Water Activity Sampler

This mechanism consists of two metal reels feeding and rewinding an aluminum tape, a die for dimpling the tape, a metering pump with 1/64 in. nozzles, and a radiant heater. The entire instrument is enclosed. Water is supplied the metering pump from two 20 g.p.m. sampling pumps installed in the manhole on the 36 in. process cooling water header.

## BUILDING DETAILS

Class - III.

Size - Approximately 16 ft. x 16 ft. x 10 ft.-6 in. from top of finished floor to bottom of truss of double-pitched roof.

Area - 256 sq. ft.

Volume - 3200 cu. ft.

## CONSTRUCTION DETAILS

Foundation - Reinforced concrete with spread footing.

Superstructure - Prefabricated steel framing with corrugated asbestos siding and roofing. This structure has a single metal door with a glass panel, and three screened windows with commercial projected sash. The roof is double-pitched with a cement asbestos ridge roll.

Heat is supplied by two unit heaters, and ventilation is by means of a roof ventilator.

## EQUIPMENT

- 2 Automatic water activity samplers.
- 1 Amplifier rack.
- 2 Stainless steel 20 g.p.m. sampling pumps.
- 1 Process cooling water diversion valve control relay.
- 2 Overhead unit heaters.
- 1 Storage cabinet.

## OPERATION OF SAMPLER

A moving aluminum tape, 1-1/2 in. wide by 0.004 in. thick, travels from a feed to a take-up reel during which it is dimpled by a die which presses 1 in. x 1 in. x 1/16 in. depressions 1/8 in. apart in its center. The dimpling operation is followed by the deposition of a 1 cc. sample of cooling water return per dimple by a metering pump. Next the tape passes under a radiant heater which evaporates the water. The dried residue is monitored by two scintillation screens, one beta-gamma screen, one alpha, each separately recorded in the dispatcher's office of Building #221-F. Finally, the tape is flattened and reeled up.

Five minutes elapse during the passage of the sample through the activity sampler to the scintillation screens. The standard elapsed time from the instant the sample is withdrawn until a response is obtained on the recorder is 10 to 12 minutes.

The metering pump obtains its samples from a 20 g.p.m. 12 ft./second (minimum flow) sample line circulating water in a closed system from and back to the process cooling water header. A fault circuit with alarm detects such operational failures of the instrument as broken tape, heater element failure, power failure, and tape movement failure.

Sample activity is recorded in the dispatcher's office in Building #221-F by two scintillation screens with photo-multipliers, two curve drawing attachments, two scalars, and

one recorder. The special curve-drawing attachments allow the samplers to operate in conjunction with the recorder. High level activity sounds an alarm in both this location and in Building #281-4F and causes the actuation of motor-operated valves to divert the process cooling return water to the retention basin.

#### DRAWINGS.

- W-149542 - Architectural - Plan and Elevation.
- W-149596 - Equipment Arrangement.
- W-149829 - Piping - Plans and Sections.
- W-149306 - Instrument Diagram for Activity Sampler.
- W-152388 - General Arrangement of Automatic Activity Sampler.

#### BUILDING #281-5F - DELAYING BASIN FOR SEGREGATED RETURN SYSTEM

##### FUNCTION

This basin provides a one hour time delay in the flow of segregated cooling water return to waste from process vessels using both steam and water alternately in their operating cycle. Normally, this water flows through the #281-5F Delaying Basin into the storm sewer system. However, if monitoring indicates radioactive contamination, this water is diverted to the #281-3F Retention Basin through a line which by-passes the delaying basin.

##### PRINCIPAL COMPONENTS

This is an open top, reinforced concrete basin comprising a delaying chamber with a capacity of approximately 250,000 gallons, and a valve pit adjoining the intake end of the delaying chamber.

Nine vertical baffles are installed in the delaying chamber to produce the time delay by inducing over and under flow. Six drain lines with gate valves are installed in the baffled section of the chamber through which contaminated water which might have entered the chamber can be drained into the by-pass line. An overflow line is installed in the wall at the discharge end of the chamber approximately 8 ft. above the bottom.

Two motor-operated gate valves are installed in the valve pit to control the flow of segregated cooling water to either the storm sewer system, through the delaying basin, or the #281-3F Retention Basin, via the by-pass line. These valves are controlled from the #281-6F Monitor Building.

## BUILDING AND CONSTRUCTION DETAILS—

Both the delaying chamber and the valve pit are rectangular structures, the inside dimensions of the delaying chamber being 40 ft. by 100 ft. by 12 ft. average depth. Inside dimensions of the valve pit are 16 ft. by 15 ft. by 11 ft. deep. The complete facility covers an area of 4524 sq. ft. and has a volume of approximately 56,500 cu. ft.

A handrail is installed around the top of the delaying chamber.

## EQUIPMENT

No mechanical equipment is installed. All equipment other than the following control valves was obtained by field procurement:

- 2 16 in. Motor operated gate valves.
- 6 6 in. Gate valves.

## DRAWINGS

- W-158740 - Equipment Arrangement.
- W-158441 - Piping Plan and Sections.
- W-158739 - Concrete Plan, Sections and Details.

## BUILDING #281-6F - MONITOR BUILDING

### FUNCTION

This building houses facilities which continuously monitor the cooling water and condensate collected from the cooling coils of the Building #221-F canyon process vessels which use both steam and water in alternate parts of their operating cycle. This water is discharged normally to the river from the #281-5F Delaying Basin; but in the event radioactivity is detected, automatic controls actuate valves which divert the water in this delaying basin to the Retention Basin, Building #281-3F.

### PRINCIPAL COMPONENTS

Same as Building #281-4F.

## BUILDING FLOOR SPACE

Same as Building #281-4F.

## BUILDING DETAILS

Same as Building #281-4F.

## CONSTRUCTION DETAILS

Same as Building #281-4F.

## EQUIPMENT

Same as Building #281-4F.

## OPERATION

Same as Building #281-4F.

## DRAWINGS

- W-158744 - Equipment Arrangement.
- W-158439 - Piping - Plan and Sections.
- W-158092 - Architectural - Plan and Sections.

COOLING WATER RETURN SYSTEM - #200-H AREA

The #200-H Area Cooling Water Return System comprises the following facilities.

- Building #281-1H - Delaying Basin.
- Building #281-2H - Pump Basin.
- Building #281-3H - Retention Basin.
- Building #281-4H - Sampling House.
- Building #281-5H - Delaying Basin for Segregated Return System.
- Building #281-6H - Monitoring House for Segregated Return System.

In addition, the system includes all underground gravity flow collection lines, mains between the facilities listed above, and the return line to the cooling tower.

With the exception of orientation, this system is essentially identical to the #200-F Cooling Water Return System.

## BUILDING #282-F - RESERVOIR AND PUMP HOUSE

### FUNCTION

This facility stores the water from three deep wells and supplies the #200-F Area with water for service, fire, and domestic use and boiler feed make-up.

### PRINCIPAL COMPONENTS

Building #282-F consists of a domestic water ground storage tank, a fire and service water ground storage tank, and required pumping facilities. The tanks are of pre-stressed concrete with domed roofs and concrete bases at grade. The pumping facilities are located outdoors on a concrete pad adjacent to Building #284-F, Power House.

#### Domestic Water Tank

The domestic water storage tank, 24 ft. in diameter and 25 ft. high, has a capacity of 100,000 gallons. A pneumatic-operated level control valve, actuated by a float-operated pilot in the tank, is installed in the inlet riser. This valve closes when the water level is at the spring line and opens when the water level in the tank drops 4 in. A by-pass valve is installed around the control valve. A float-operated target board gauge is mounted outside for visual indication of the water level within the tank.

This tank is provided with a 12 in. overflow at the spring line and a 12 in. drain at the base. In the base of the tank, a 12 in. connection takes off from a sump to the suction header of the domestic water pumps. Provisions were made to by-pass the tank and run well water directly to the domestic water pumps when the tank is out of operation for maintenance.

#### Fire and Service Water Tank

This tank has a total capacity of 600,000 gallons with 500,000 gallons reserved for fire use only. It is 65 ft. in diameter and 24 ft. high to the spring line. A pneumatic pilot-operated level control valve is installed in the tank inlet riser, and facilities for drainage, overflow, venting, and level indication are similar to those for the domestic water storage tank. A connection from the sump in the base of the tank supplies both the fire and service water pump suction headers, and a by-pass for emergency use is installed around the tank from the incoming well water line to the pump suction line. A removable spool piece is provided in this by-pass for complete separation from the domestic supply system.



### Pumps

Domestic water is discharged into a 10 in. header by four pumps, three motor-driven and one turbine driven. Each pump has a rated capacity of 450 g.p.m. against a total head of 140 ft.

Service water is discharged into a 10 in. header by three pumps, two motor-driven and one turbine-driven. Each of these pumps is identical in all respects to the domestic water pumps.

Fire water is discharged into a 24 in. header by five pumps, two motor-driven and three turbine-driven, each having a rated capacity of 2000 g.p.m. against a total head of 231 ft.

A connection from the service water pump discharge header to the fire water pump discharge header maintains water pressure in the fire water system without running a fire pump. A check valve is installed to prevent reverse flow from the fire system into the service water system.

All of the foregoing pumps are single stage, centrifugal units.

### Substation

A 1500 kv.-a. 13.8 kv./480 v. double-ended outdoor unit substation was installed as a component of this building to provide power supply and control both to this facility and to the #284-F Power House. This switchgear is located on the outdoor concrete pump pad between the storage tanks and the Power House.

### BUILDING DETAILS

The entire installation is located outdoors.

A rectangular concrete pad (pump platform), 40 ft. by 82 ft., supports the pumps, water softeners and silica absorbers, and switchgear. It covers an area of 3280 sq. ft.

Four water softener units and four silica absorbers are installed on this platform along the north wall of the #284-F Power House, and are components of the Power House rather than of Building #282-F. These units are described under "Building #284-F, Power House".

The lighting designed for the pump platform and water storage tanks consists of elliptical angle reflectors and play-area type flood lights mounted on pipe standards. The reflectors are arranged to give an upward component of light.

## EQUIPMENT

- 1 Fire and service water storage tank, 600,000 gals.
- 1 Domestic water storage tank, 100,000 gals.
- 5 Fire pumps - two motor-driven and three turbine-driven, each 2000 g.p.m.
- 3 Service water pumps - two motor-driven and one turbine-driven, each 450 g.p.m.
- 4 Domestic water pumps - three motor-driven and one turbine-driven, each 450 g.p.m.

## DRAWINGS

- W-138304 - General Plan.
- W-138465 - Pumps and Softener Units - Arrangement.
- W-138526 - Pump Platform - Plan and Details - Concrete.
- W-138576 - Water Storage Tanks - Foundation Plans and Details - Concrete.

BUILDING #282-H - RESERVOIR AND PUMP HOUSE

## FUNCTION

This facility stores the water from two wells and supplies the #200-H Area with water for service, domestic and fire use, and boiler feed make-up.

With the exception of elevations and orientation, Building #282-H is identical with Building #282-F.

BUILDING #284-F - POWER HOUSE

## FUNCTION

This facility supplies the process and heating steam required in the #200-F Area. No electric power is generated in this building.

## PRINCIPAL COMPONENTS

Steam Generating Units

Steam is generated by three Combustion Engineering - Superheater, two-drum, bent tube, 60,000 lbs./hr. steam generators designed for a maximum working pressure of 350 p.s.i.g. and operating at 325 p.s.i.g. Each boiler unit is

equipped with a dual drive traveling grate spreader stoker having a firing rate of 5300 lbs. of coal per hour when operating at design capacity. Each stoker is equipped with a 3000 lb. capacity hopper which supplies coal to three dual drive feeders.

Each boiler unit is equipped with one forced draft fan for supplying combustion air, and one induced draft fan for removing the products of combustion. Both fans are on a common turbine drive. The F.D. fan has a rated capacity of 19,500 c.f.m. of air at 100°F. at a pressure of 4.75 in. W.G., while the I.D. fan has a rated capacity of 38,500 c.f.m. of gas at 460°F. at a draft of 9.5 in. W.G.

Each unit includes one tubular air preheater having a total heating surface of 2760 sq. ft., a tubular dust collector, three soot blowers, and a cinder recovery system. All necessary ducts, flues, breeching, safety valves, steam pressure gauges, water gauges, an overfire air system, and other auxiliaries are provided with each unit.

Two stacks, each 100 ft. high by 6 ft. top diameter, serve this power house. Boilers No. 1 and No. 2 connect to one stack, while boiler No. 3 connects with the other - which is also designed to serve an additional future boiler unit.

#### Coal Handling Equipment

The coal handling system has a capacity of 66 tons/hr., and consists of the following components: (1) a car puller for placing coal cars; (2) a double track hopper consisting of two 12 ft. by 12 ft. hoppers; (3) a reciprocating feeder; (4) a 30 in. wide belt conveyor; (5) a weightometer; (6) a magnetic pulley for tramp iron removal; (7) a crusher; (8) a 94 ft. center-to-center bucket elevator; (9) a stocking-out chute; (10) a 73 ft. high by 30 ft. I.D. coal silo having a capacity of 400 tons with the lower section housing a chemical feed room, offices, a meeting and lunch room, an electrical facility room and locker rooms (11) two reciprocating feeders located at the bottom of the silo coal storage space; and (12) two flight conveyors running to the stoker feeder hoppers.

The reciprocating feeders and flight conveyors are normally motor-driven, but an auxiliary turbine drive is provided should an electric power failure occur. One feeder and flight conveyor can handle full load demands.

#### Ash and Dust Handling Systems

Fly ash and dust are removed pneumatically by a hydroveyer, mixed with water, and discharged to a Jetpulsion pump. Furnace ash from the boiler is discharged from the stoker fronts into

three ash hoppers, each having a capacity for eight hours of ash production. Ash from these hoppers is conveyed by water jets to the Jetpulsion pump which discharges through the ash sluicing line into the Ash Disposal Basin, Building #288-F. The furnace ash system is designed to handle 30 tons per hour, and at full load the hydroveyor will handle 12 tons per hour.

A cinder recovery blower system removes carry-over material from the ash hopper and dust collector decantation hoppers and reinjects this material through nozzles placed on the sides of the furnaces.

The foregoing equipment includes sluice liners, pump, blower, drives, valves, piping, ash sump, and all necessary accessories.

#### Feedwater System

Make-up feedwater is taken from the service water system and softened, before it enters the heat exchangers, by the following equipment.

4 Hydrogen (cation) ion exchangers, capacity of each 120 g.p.m. at 7.5 g.p.m./sq. ft.

4 Silica absorber (anion) units, capacity of each 120 g.p.m. at 6.1 g.p.m./sq. ft.

One 80-gallon caustic feed tank and two 3.4 g.p.h. caustic feed pumps are provided to control the alkalinity of the feedwater make-up, discharging a dilute caustic solution into the outlet line of the silica absorbers. Alkalinity of this water is indicated by a pH recorder with an alarm contact.

This boiler feedwater make-up treatment equipment is located on the #282-F pumping station pad outside the north wall of the firing aisle, with the softener controls inside the #284-F Building.

After softening, boiler feedwater make-up is passed through two blowdown heat exchangers ahead of the deaerators. Each heat exchanger has a capacity of 100,000 lbs. of water per hour, and is designed for a maximum operating pressure of 75 p.s.i.g.

Two deaerators, each having an outlet capacity of 123,000 lbs./hr. and designed for an operating pressure of 15 p.s.i.g., are installed on the roof of the building directly above the firing floor. Each is mounted on a horizontal 500 cu. ft. storage tank, and is equipped with overflow controls, level gauge, water inlet control valve, safety valve, and a vent condenser having a surface of 38 sq. ft.

Four boiler feed pumps, three turbine-driven and one motor-driven, are located directly below the deaerator storage tanks, from which they take suction. Each pump is rated at 170 g.p.m. against a total head of 955 ft.

Two chemical feed systems are provided for the application of phosphate and sulfite to the feedwater. Six simplex pumps, each with a capacity of 8.7 g.p.h. against a maximum head of 800 p.s.i.g., inject chemicals into the system - three pumps injecting phosphate directly into the boiler drums, and two pumps injecting sulphite into the deaerator outlet or boiler feed pump suction lines. One pump is a spare for either service. These systems are complete with storage, dissolving and feed tanks, and platform scales, and are installed in a room located in the silo. An electric hoist is used to raise bulk chemicals from ground elevation to the storage room in the silo.

### Controls

An automatic-manual, air operated, full metered type combustion control system regulates the supply of fuel and air to each boiler, maintaining constant steam pressure and optimum combustion efficiency. Normally, the automatic control is in operation from a centrally located panel board remote from the control apparatus. Remote manual control can also be placed in operation from the central panel. Local manual control is provided at each regulator for use during emergency and special operating conditions such as loss of air pressure.

A Copes flowmatic boiler feedwater regulator controls the flow of boiler feedwater at such a rate as to maintain a safe water drum level for all steam outputs, whether steady or fluctuating. This regulator has two control elements, one responding to changes in boiler water level, the other responding to variations in steam flow as measured by the pressure drop across an orifice in the steam line.

A control and instrument panel board is located in front of each boiler. Two 15-point annunciators and an alarm system are mounted on the master panel board which is located in front of the No. 3 boiler.

### Compressed Air Supply System

Two motor driven, single stage, double acting, water cooled air compressors supply instrument air. Each has a terminal pressure of 115 p.s.i.g. and an actual free air delivery of 105 c.f.m. The system includes a 105 c.f.m. capacity after-cooler, air filter, air receiver, and air dryer.

An emergency steam driven air compressor, with an approximate capacity of 100 c.f.m. of free air, was provided for use in the event of electric power failure. A by-pass around the instrument air dryer is provided for use during operation of this compressor on an emergency basis.

No provisions for plant air are included in this system.

### Electrical Equipment

Electric power for this facility is supplied from the 1500-kv.-a., 13.8-kv./480-v. double-ended unit substation installed on the pump platform adjacent to the pump house.

This substation is a component of Building #282-F - Reservoir and Pump House.

Two 75-kv.-a., 480/120/308-v. transformers, one 3-kv.-a. 480-120/208-v. transformer, and all necessary panels, control boards, switches, and associated equipment required for the power supply and control of this facility were provided.

### BUILDING FLOOR SPACE

### Approx. Sq. Ft.

|                                        |       |       |
|----------------------------------------|-------|-------|
| Ground Floor                           | 3,000 |       |
| Operating Floor                        | 3,000 |       |
| Upper Part of Firing Aisle             | 2,000 | 2,450 |
| Chemical Feed Room, in silo -          | 650   |       |
| Meeting and Lunch Room, in silo -      | 350   |       |
| Toilet and Locker Room #1, in silo -   | 350   |       |
| Results and Clerical Office, in silo - | 200   |       |
| Supervisor's Office, in silo -         | 150   |       |
| Electric Room, in silo -               | 140   |       |
| Battery Room                           | 120   |       |
| Locker Room #2, in silo -              | 75    |       |
| Toilet #2, in silo -                   | 70    |       |
| Slop Sink Closet, in silo -            | 15    |       |
| Crusher House, Separate structure      | 180   |       |

### BUILDING DETAILS

The building, of Class III construction, is irregular in shape with a flat roof and with overall horizontal dimensions, including irregularities, of approximately 34 ft. by 127 ft. There are three primary floors of operation: the ground floor, the firing floor and the upper platform.

### Approx.

Over-all Area (Power House) - 3,275 sq. ft.

|               |         |                 |
|---------------|---------|-----------------|
| Volume        |         |                 |
| Enclosed Area | 93,000  | 70,700 cu. ft.  |
| Open Area     | 105,000 | 78,500 cu. ft.  |
| Total volume  | 208,000 | 149,200 cu. ft. |

The Crusher House is a separate building of Class III construction. It is rectangular in shape with over-all dimensions of 13 ft. by 16 ft. The floor is approximately 12 ft. above grade, and the structure is supported by steel columns. The height of the building is 14 ft., making the top of the peaked roof approximately 26 ft. above established grade.

|                        |   |              |
|------------------------|---|--------------|
| Area                   | - | 200 sq. ft.  |
| Volume (Floor to Roof) | - | 2270 cu. ft. |

## CONSTRUCTION DETAILS

### Power House

Foundation - Reinforced concrete spread footing.  
 Frame - Steel.  
 Roof - Reinforced concrete.  
 Roof covering - Exposed concrete.  
 Wall siding - Corrugated asbestos.  
 Flooring - Reinforced concrete (except some intermediate platforms which are steel grating).  
 Floor covering - Exposed concrete except asphalt tile in certain rooms.  
 Stairs - Steel with precast concrete treads.  
 Interior Partitions - Cement asbestos board on steel stud, cement plaster wainscot in toilet rooms.  
 Windows - Steel, commercial projected.  
 Doors - Hollow metal (roll-up door is steel).

### Crusher House

Foundation - Reinforced concrete.  
 Support - Steel columns.  
 Frame - Steel.  
 Roofing and wall siding - Corrugated transite.  
 Stairs - Steel.

### Heating and Ventilating

Heating and ventilating is divided into three general sections.

#### Silo

The toilets, locker rooms, lunch and meeting room, and offices are heated by means of two air-handling units providing

filtered air, heating and ventilating requirements.

The capacity of the unit supplying the electrical room, toilets, and locker rooms on the ground floor is 2640 c.f.m. at  $3/8$  in. static pressure for summer operations and 1320 c.f.m. at  $1/4$  in. static pressure for winter operation. The heating capacity of this unit is 94,000 B.t.u./hr.

The air-handling unit supplying the meeting and lunch room, supervisor's office and the results office has a capacity of 2340 c.f.m. at  $3/8$  in. static pressure for summer operation, 1170 c.f.m. at  $1/4$  in. static pressure for winter operation. The heating capacity is 88,600 B.t.u./hr.

In addition to the air-handling units, propeller-type exhaust fans in the toilets, locker rooms, electrical room, lunch and meeting room and offices were provided.

#### Ground Floor (Power House)

Heating is provided on the ground floor of the Power House. Ventilating air is supplied by means of louvers located in the entrance doors. Two propeller-type fans each of 3525 c.f.m. capacity exhaust the air.

#### Operating Floor (Power House)

The operating floor is provided with ventilation units only. Louvers are installed for intake air and the air is exhausted by propeller fans which discharge between the boiler units. The propeller exhaust fans have a capacity of 9125 c.f.m. each.

#### Lighting

Fluorescent lighting is installed in the meeting and lunch room and in the offices, with incandescent lighting in the locker rooms and toilets.

The electric room was provided with fluorescent lighting, and special Holophane Controlens, fabricated in the field, were installed at the control boards on the operating floor.

The ground floor was provided with incandescent lighting. In other areas of this project the boiler feed pump sections are illuminated by fluorescent lighting but here incandescent fixtures were installed because the ceiling is much lower.

Incandescent vapor and dust proof lighting fixtures were generally adopted for this facility.



Three panels are provided for lighting control. Two of these are controlled by the remotely located blackout control system. The third panel is not connected to the blackout control system and provides assurance of lighting at main operating points during blackouts. These vital points were provided with other blackout measures such as curtains, screens or doors.

Another unusual feature adopted in the #200 Areas, but not in the other areas of this project, is the inclusion of all blackout contactors in one cabinet. This provides a concentrated control center although individual control when desired.

#### Communication

A safety alarm loudspeaker system, comprising ten stations at this Power House, one at the #251-F Primary Substation, and one at Building #280-1F Chemical Feed Building, was provided.

The sound-powered telephone system in this Power House is composed of six stations, one in a noise-reducing booth, and three extensions, one to the #280-1F Chemical Feed Building, one to the #282-F Reservoir and Pump House, and one to the #285-F Cooling Tower. Four Bell telephone stations also were installed.

#### Drainage

An under-slab drainage system was provided for roof gutter down-spouts, drains at equipment installations, general floor drainage and overflow.

The sump pump for the track hopper empties effluent into the storm sewer system.

EQUIPMENT *Note: Revision revisions indicate changes made on Project 55-1625*

#### Mechanical

- 4 ~~3~~ Steam generating units, each 60,000 lbs./hr.
- 2 Stacks, each 100 ft. high by 6 ft. top diameter.
- 3 Forced draft fans, each 19,000 c.f.m. capacity.
- 3 Induced draft fans, each 35,000 c.f.m. capacity.
- 1 Wet-type ash handling system.
- 1 Combustion control system for three boilers, with control panels.
- 1 Coal handling system:
  - 1 Emergency reciprocating feeder with turbine drive.
  - 1 Emergency flight conveyor with turbine drive.
- 1 Vertical track hopper sump pump with motor drive, 50 g.p.m.

- 2 Deaerating heaters, 121,800 lbs./hr. outlet capacity each.
- 5 4 Four-stage boiler feed pumps, one motor-driven and three turbine-driven, each 170 g.p.m., 855 ft. TDH.
- 2 Continuous blow-down and blow-off systems for three boilers.
- 1 Boiler feedwater treatment system.
- 1 Boiler chemical feed system.
- 2 Instrument air compressors with motor drives, after-coolers and receivers, each 105 c.f.m.
- 1 Steam driven air compressor, 97 c.f.m.
- 1 Instrument air drier, 100 c.f.m.
- 1 Electric hoist.
- 1 1" Air filter for steam-driven air compressor.
- 2 Chemical scales.
- 1 Reinforced concrete coal storage silo 30 ft. I.D., 400 tons capacity.
- 1 Acid storage tank, 5 ft. O.D. by 6 ft. long - 1000 gals., used in conjunction with #282-F.
- 1 Liquid caustic storage tank 5 ft. O.D. by 13 ft. - 2000 gals., used in conjunction with #282-F.
- 1 Car puller with motor drive, three loaded cars at 45 f.p.m. - 5000 lb. pull.
- 1 Radial planimeter.

### Electrical

- 1 Boiler house control switchboard.
- 6 Assemblies for intercom. system.
- 4 3 440-v. Motor control centers, boiler auxiliaries.
- 2 440-v. Motor control centers, water and air compressor.
- 1 440-v. Motor control centers, coal handling.
- 2 75-kv.-a. 480-120/208-v. Transformers.
- 1 3-kv.-a. 480-120/208-v. Transformer..
- 1 A.c. Distribution panel.
- 1 Miscellaneous power panel, 18-circuit.
- 1 3-phase 600-v. Distribution panel.
- 1 Emergency power panel, 8-circuit.
- 2 Two-section lighting panels.

### Heating and Ventilating

- 1 Chemical room exhaust fan with motor drive and back draft damper, 3925 c.f.m.
- 1 Chemical room unit heater with thermostat and motor drive, 2150 c.f.m., 162,000 B.t.u./hr.
- 1 Toilet air handling unit with combination starter and pushbutton station with motor drive, 2640 c.f.m., 94,000 B.t.u./hr.
- 1 Office air handling unit with combination starter, pushbutton station and motor drive, 2340 c.f.m., 88,600 B.t.u./hr.

- 1 2-Speed toilet exhaust fan with back draft damper and motor drive, 1650 c.f.m.
- 1 Electric room exhaust fan with back draft damper and motor drive, 335 c.f.m.
- 1 Battery room exhaust fan with back draft damper and motor drive, 335 c.f.m.
- 1 Basement exhaust fan with back draft damper and motor drive, 3925 c.f.m.
- 3 Operating floor exhaust fans with V-belt motor drives and back draft dampers, each 9135 c.f.m.
- 2 Unit heaters, each 670 c.f.m., 37,500 B.t.u./hr.

### Architectural

- 1 Hot water heater, 300 g.p.h.
- 1 Hot water storage tank, 255 gals. capacity.

## PLANT OPERATION

### Steam Generation and Flow

Each steam generator is fired by a continuous ash discharge spreader stoker feeding a mixture of 3/4 in. nut and slack Eastern bituminous coal at a rate of 5300 lb./hr. when the boiler is operating at 60,000 lbs. of steam per hour. Each stoker is fed by a 3000-lb. capacity hopper which supplies coal to three dual drive feeder units. The grate has a continuous forward motion and also operates on dual drive.

Combustion air is supplied to each boiler through an air preheater by a single F.D. fan at 290°F. Air is admitted to the stoker in three zones arranged across the furnace under the grate. These underfire air intake zones are regulated by dampers located at the sides of the boilers. The products of combustion are removed from each boiler by one double inlet I.D. fan.

An automatic-manual type combustion control system regulates the supply of fuel and air to each boiler in proportion to its steam load, maintaining constant steam pressure and optimum combustion efficiency. Normally, the automatic control is in continuous use.

The over-all boiler efficiency at the 60,000 lb./hr. firing rate is 82.5 per cent.

Steam is generated at 325 p.s.i.g., saturated, at the drum outlet. An export line from the steam header system supplies the heating and process steam required throughout the #200-F Area.

Within the Power House the following turbine drives are supplied directly from the main steam header: three boiler feedwater pump drives; three combined F.D. and I.D. drivers; three stoker drivers; and three coal feeder drivers. Steam for the emergency reciprocating feeders and flight conveyors of the coal handling system is taken also from the main steam header.

The following pumps in Building #282-F are turbine driven and, when in operation, are supplied from a loop off the main steam header: one of 4 domestic water pumps; one of 3 service water pumps; and three of 5 fire water pumps.

One turbine driven cooling tower circulating water pump is also supplied by a branch line off the main steam header.

The exhaust from these turbines is collected in a low pressure steam system for feedwater heating use in the deaerators.

A small quantity of low pressure make-up steam is required from the pressure reducing station.

See Page 21 for details of steam flow.

#### Feedwater Flow and Treatment

One-hundred per cent make-up water is required to compensate for steam exported for heating and process use as there is no condensate return. Make-up water is taken from Building #282-F, Ground Storage Tank, which is supplied by deep wells within the Area. This make-up water, which constitutes approximately 83 per cent of the boiler feedwater requirements, is pumped through the softener and silica absorber units by the service water pumps. The pH of the softened water is adjusted by the application of dilute caustic solution in the outlet line of the silica absorbers. The treated make-up water then passes through the blowdown heat exchangers and regulating valves into the deaerators where undissolved gases are vented off through the vent condensers and the temperature of the water is raised to approximately 250°F.

The other 17 per cent of the boiler feedwater required is supplied to the deaerators as low pressure steam. Fifteen to twenty minutes of deaerated feedwater supply is maintained in the deaerator storage tanks. Feedwater flows from the bottom of the storage section of the deaerator to the main boiler feed pump suction header. Sulphite is injected into the deaerator outlet lines as a corrosion inhibitor.

The boiler feed pumps discharge feedwater through the main and auxiliary boiler feed headers into the boiler drums.

Phosphate solution is injected directly into the boiler drums to reduce scale formation.

#### Continuous Boiler Blowdown

To limit the solids concentration in the boiler feedwater to a maximum of 3000 p.p.m., a continuous boiler blowdown is maintained. This blowdown is discharged into two blowdown flash tanks connected into the low pressure 20 p.s.i.g. steam system. The drain from the flash tanks discharges through the shells of the blowdown heat exchangers for further transfer of useful heat into the make-up feedwater ahead of the deaerators. From the heat exchangers the blowdown water is discharged to waste.

#### Coal Handling

On the basis of three boilers each generating 60,000 lbs. of steam per hour continuously, this plant requires 215 tons of coal per day. To meet this requirement, the coal handling facilities noted under "Principal Components" were provided.

Coal is supplied to these facilities over a spur track which is extended beyond the track hopper to allow space for 10 cars of 50-ton capacity each. Coal is emptied into the double track hopper and is fed onto an inclined belt conveyor by reciprocating feeders. The belt conveys coal to the crusher platform from where it is passed to the boot of the bucket elevator from whence it travels through the crusher or through the crusher by-pass.

Coal is passed from the top of the elevator to the silo or to the stocking-out pile via chutes and by means of flop gates. At the bottom of the coal storage space of the silo the coal drops into two reciprocating feeders. These supply two flight conveyors which, in turn, supply coal to the stoker hoppers in front of each boiler.

#### Ash and Dust Handling

The operation of this system is described under "Ash and Dust Handling System - Principal Components".

DRAWINGS *Notes: Revised revision 2-10-60 to Page 18 ES-1025*

#### Structural

- W-137967 - Foundation Plan.
- W-138422 - Floor Plan at Elevation 318 ft.-8 in.
- W-137873 - General Arrangement of Building #284-F.

Architectural

- W-138011 - Operating Floor Plan at Elevation 328 ft.-8 in. and Ground Floor Plan at Elevation 318 ft.-8 in.
- W-138069 - Roof and Boiler Platform - Plans - Elevation 338 ft.-8 in. to Elevation 362 ft.-0 in.

Mechanical

- W-138001-A - Flow Diagram - Main Steam.
- W-138001-B - Flow Diagram - Auxiliary Exhaust.
- W-138001-C - Flow Diagram - Boiler Feed Discharge.
- W-138001-D - Flow Diagram - Boiler Feed Suction and Make-up.
- W-138017-F - Flow Diagram - Service Water Piping.
- W-138018-M - Flow Diagram - Chemical Feed.
- W-138468-H - Heat Balance Diagram.
- W-138390 - Arrangement of Coal Conveying System.
- W-138474 - Ash Disposal System.

BUILDING #284-H - POWER HOUSEFUNCTION

This facility supplies the process and heating steam required in the #200-H Area. No electric power is generated in this building.

DIFFERENCES BETWEEN BUILDINGS #284-H AND #284-F

The steam requirements in the #200-H Area are not as great as those in the #200-F Area, the winter peak load in #200-H being estimated at 141,000 lbs./hr. and a corresponding peak load of approximately 175,000 lbs./hr. in #200-F. Whereas Building #284-F contains three 60,000 lbs./hr. steam generating units, Building #284-H originally contained only two such units, exact duplicates of those installed in Building #284-F. Later a third 60,000 lb./hr. boiler was installed in #284-H. All other basic equipment comprising the #200-H steam generating plant is essentially identical to that installed in Building #284-F.

Building #284-H contains five hydrogen ion exchangers and five silica absorbers.

The major equipment in Building #284-H is arranged in three essentially identical units, with two units capable of carrying the expected peak summer load so that maintenance and necessary repairs can be accomplished during the

summer period of reduced steam requirements. As is the case in Building #284-F, this facility is designed so that one boiler can run at low load for a period of eight hours after electric failure.

Provision was made for the future installation of one additional steam generating unit.

#### DRAWINGS

- W-138128 - Power Block Plot Plan - #200-H Area.
- W-138414 - General Arrangement of Bldg. #284-H.
- W-138313-A - Main and Auxiliary Steam.
- W-138313-C - Boiler Feed Discharge.
- W-138313-D - Boiler Feed Suction and Make-up.
- W-139432 - Arrangement of Coal Conveying System.
- W-139688 - Ash Disposal System.

#### BUILDING #285-F - COOLING TOWER

##### FUNCTION

This facility supplies the process and air-conditioning cooling water requirements of the #200-F Area, and the ash sluicing water requirements of the #284-F Power House.

##### PRINCIPAL COMPONENTS

The installation consists of a cooling tower, a cooling water storage basin, a pump suction bay with associated pumps, and electrical substations.

##### Cooling Tower

This is a six-cell induced draft tower designed to cool 15,000 g.p.m. of water from a maximum temperature of 125°F. to 85°F., based on a wet bulb temperature of 78°F. Water returns to the cooling tower through a single 36 in. header with branches leading to the top of each tower cell. Six induced draft fans are installed on the roof, one over each cell.

##### Cooling Water Basin

The cooling tower is supported on a concrete foundation, part of which also serves as the cooling water basin with a maximum depth of 6 ft. A weir is provided in the basin to limit the usage of ash sluicing water to the top 8 in. of water, approximately 38,400 gallons, in the basin. Below this level

approximately 307,000 gallons of water are available for process cooling. A minimum of 1000 g.p.m. of make-up water is provided to the cooling tower basin at all times from the Building #905-F-37 and #905-F-49 well pumps. These well pumps continuously provide once-through cooling water to the Building #241-F cooling system heat exchangers, and on to the cooling tower as make-up water. Any additional cooling water required is taken from the service water system in Building #284-F. Make-up water may be admitted either over the cooling tower or into the basin as dictated by its temperature.

#### Pump Suction Bay

Adjoining the cooling water basin is a pump suction bay to which water from the cooling basin flows through a collecting trough. Double screens are installed at the entrance to each pump suction chamber, and chlorine is fed into the chamber from the #280-1F Building. The following pumps are mounted on a concrete slab over the suction bay.

Four vertical cooling water pumps, three motor-driven and one turbine-driven, each having a capacity of 5000 g.p.m. against a total head of 150 ft.

Two vertical motor driven ash sluicing pumps, one a spare, each having a capacity of 900 g.p.m. against a total head of 306 ft.

The cooling water pumps discharge to a 36 in. header in which water is delivered to the process area. The ash sluicing pumps discharge into a 10 in. line to the #284-F Power House. Ash sluicing water may be pumped for a period of 30 minutes every eight hours.

#### Substations

A 4000-kv.-a. 13.8/2.4 double-ended unit substation and a 440-v. unit substation, together with a pump control panel and all other necessary panels, cabinets and cable are provided to supply the required power and control for this facility. These substations are installed on an outdoor concrete pad adjacent to the cooling tower.

#### BUILDING DETAILS

The cooling tower is of Class III construction, rectangular in shape and approximately 158 ft. by 42 ft. by 42 ft. high. The bottom of the foundation is approximately 8 ft. below established grade.



The circulating cooling water basin is rectangular in shape, approximately 158 ft. by 9 ft. by 6 ft. deep and covered by a concrete slab.

The pump suction bay is approximately 18 ft. by 35 ft. by 7 ft. deep.

Both the circulating water basin and the pump suction bay have a capacity of approximately 35,000 gallons each.

The switchgear pad is "L" shaped, with over-all dimensions of 75 ft. by 47 ft. The width of the longer side is 16 ft., that of the shorter side 15 ft.

The total installation covers an area of 8200 sq. ft. and occupies a volume of 300,000 cu. ft.

## CONSTRUCTION DETAILS

### Foundations

The circulating cooling water basin and the pump suction bay are constructed of reinforced concrete throughout and are utilized to serve respectively as the foundation for the cooling tower structure and the foundation for the pumps and associated equipment.

The switchgear pad is also constructed of reinforced concrete.

### Superstructure

The cooling tower framework, casing and drift eliminators are constructed of California redwood.

Vapor-proof incandescent fixtures are used, with the lighting designed to penetrate the steam vapor.

## EQUIPMENT

### Mechanical

- 1 Cooling tower, 15,000 g.p.m. cap. at 85°F.
- 6 Two-stage vertical circulating water pumps, three five motor-driven, and one turbine-driven, each 3000 g.p.m.
- 2 Six-stage vertical ash sluice pumps, motor-driven, one a spare. Each 900 g.p.m.

*(each 3000 g.p.m.)*

*Submer cooling from 101°F to 85°F with 78°F ambient WB*

*Note: Pencil revisions indicate changes made on Project 58-1025*

*A. E. J.*

### Electrical

- 1 4000 kv.-a., 13.8/2.4-kv. Double ended outdoor unit substation.
- 1 440-v. Outdoor unit substation.

### DRAWINGS

- W-138307 - General Arrangement of Cooling Tower - Plan.
- W-138329 - General Arrangement - Elevation and Details.
- W-138235 - Foundation Plan - Concrete.
- W-138404 - Piping Layout.

### BUILDING #285-H - COOLING TOWER

#### FUNCTION

This facility supplies the process and air-conditioning cooling water requirements of the #200-H Area, and the ash sluicing water requirements of the #284-H Power House.

#### DIFFERENCES BETWEEN BUILDINGS #285-H AND #285-F

The cooling water requirements of the #200-H Area are not so great as those of the #200-F Area. As a consequence, the #200-H Cooling Tower has a smaller capacity, 12,500 g.p.m., than the #200-F Cooling Tower, 15,000 g.p.m. Whereas the Building #285-F Cooling Tower is a six-cell unit, the #285-H Cooling Tower is a five-cell unit. These two units are of the same width and height, but the #285-F unit is approximately 26 ft. longer. All of the other basic equipment comprising the #285-H Cooling Tower is identical to that installed in Building #285-F, but in reduced quantity in the following instance.

Building #285-H contains five induced draft cooling tower fans instead of six. Two ash sluice water pumps and motor drives are installed in each building, but the pumps possess different operating characteristics; the #285-F pumps each have a rated capacity of 900 g.p.m. against a TDH of 306 ft., whereas the #285-H pumps have a rated capacity of 1350 g.p.m. against a TDH of 240 ft. The rated speed of both types of pumps is identical.

The Building #285-H cooling water basin is proportionately smaller than the #285-F basin, having a total capacity of approximately 286,000 gallons as contrasted with the #285-F basin capacity of approximately 345,000 gallons.

Provisions were made in the design of this facility for future expansion to a unit having a capacity of 25,000 g.p.m. and for the future addition of two circulating water pumps with motor drives.

#### DRAWINGS

W-137724 - Cooling Tower - Arrangement Plan - Elevation -  
Sections.  
W-137725 - Piping Layout.

#### BUILDING #288-F - ASH DISPOSAL BASIN

##### FUNCTION

This facility was provided as a settling basin for ashes discharged from the #284-F Power House.

##### GENERAL DESCRIPTION

Of earth dike construction, the basin covers an area of approximately seven acres. The circumferential dike is 2646 ft. in length and varies in height from 2 ft. to 17 ft. in relation to terrain. The basin has a storage volume of approximately 3,156,000 cubic feet with a 2 ft. freeboard allowance, which is a designed storage capacity of twelve years ash accumulation, based on current anticipated operation of the #284-F Power House.

Ash is delivered to this basin by a sluicing system through an above-ground pipe line capable of handling approximately 30 tons of ash per hour.

An overflow line is installed through the dike at its lowest base elevation for draining off sluicing water.

#### DRAWINGS

Map No. 3305 - Sheet #854 - Location.  
Map No. 3302 - Sheet #854 - Location.  
W-138838 - Outside Lines - Drain for Basin.

#### BUILDING #288-H - ASH DISPOSAL BASIN

##### FUNCTION

This basin was provided as a settling basin for ashes discharged from Building #284-H - Power House.

#### GENERAL DESCRIPTION

Of earth dike construction, the basin covers an area of approximately thirteen acres. The circumferential dike is 3220 ft. in length with an average depth of 9 ft. The basin has a storage volume of approximately 3,660,000 cu. ft. with a 2 ft. free-board allowance, which is a designed storage capacity of fifteen years ash accumulation, based on present planned operations.

Ash is delivered to this basin by a sluicing system through an elevated pipeline capable of handling approximately 30 tons of ash per hour.

An overflow line is installed through the dike on the west side at its lowest elevation for draining off sluicing water.

#### DRAWINGS

Map No. 3302 - Sheet #766 - Location  
W-138837 - Outside Lines - Drain for Basin

#### BUILDING #619-F & H - DIESEL OIL STORAGE FACILITIES

#### FUNCTION

This facility in each of the two #200 Areas provides storage for diesel fuel oil required for use in the emergency diesel generators throughout both areas. Fuel is pumped directly to the units in Building #221 and #292, while a truck filling station is provided for automotive transportation of supply to small users.

#### PRINCIPAL COMPONENTS (Each Area)

- 1 - Underground Storage Tank, 13,450-gal. cap.
- 1 - Truck loading assembly.

#### DRAWINGS

W-157446 - Arrangement and Details.

**BUILDING #910-F & H - FUEL OIL LINES****FUNCTION**

These lines supply diesel fuel oil from the storage facility, Building #619-F&H, to the emergency diesel generators in Buildings #221 and #292.

**PRINCIPAL COMPONENTS**

Approximately 2000 ft. of 2 in. schedule 40 black steel pipe and fittings in each area, buried at an average depth of 3 ft. There is an equal amount of underground electrical conduit for use with control system.

- 2 - Motor-driven fuel oil transfer pumps, 25 g.p.m., 1-1/2 hp. motors.
- 1 - Control system for remote start-stop of pumps.

**DRAWINGS-**

W-157446 - Arrangement and Details.

**BUILDING #801-F - PIPE SUPPORTS****FUNCTION**

This facility supports all outside overhead pipe lines to and from various buildings within the area.

**PRINCIPAL COMPONENTS**

For general design see Building #801-R.

A 12-inch diameter header transports steam from Building #284-F to branch lines serving the several buildings in the area.

The 1-inch instrument air line is hung from the main steam line and the 3-inch chlorine line is suspended from the same supports as the 8-inch exhaust steam line.

Poles are used as supports for the 8-inch ash sluicing line between Building #284-F, Power House, and Building #288-F, Ash Disposal Basin. Where necessary, concrete supports were placed along the line.

## EQUIPMENT

All materials and equipment for this facility were obtained by field procurement.

## DRAWINGS

W-142041 - Miscellaneous Details.  
W-139911 - Miscellaneous Details.  
Map 3313 - Sheets #853, #854 and #884.  
PF-4547 - Plan, Sections and Details.

## BUILDING #801-H - PIPE SUPPORTS

### FUNCTION

This facility supports all outside overhead pipe lines to and from various buildings within the area.

### PRINCIPAL COMPONENTS

For general design see Building #801-R.

A 12-inch diameter header transports steam from Building #284-H to branch lines serving the several buildings in the area.

The 1-inch instrument air line is hung from the main steam line and an 8-inch condensate line connects Building #285-H with the deaerator in Building #284-H.

Poles are used as supports for the 8-inch ash sluicing line between Building #284-H, Power House, and Building #288-H, Ash Disposal Basin. Where necessary, concrete supports are placed along the line.

## EQUIPMENT

All necessary equipment and materials for this facility were obtained by field procurement.

## DRAWINGS

PF-4582 - Plan, Sections and Details.  
W-142041 - Miscellaneous Details.

BUILDING # 802-F - STEAM LINES

## FUNCTION

These pipe lines distribute steam from the Power House, Building #284-F, to all buildings requiring steam in the #200-F Area.

## PRINCIPAL COMPONENTS

Steam requirements outside the power block limits are carried at 300 p.s.i.g. through steel pipe. Within the power block limits the system consists of a main steam header and instrument air line from the Power House to the power block limits, a steam supply line and steam exhaust return line between the Power House and the #285-F Cooling Tower, a steam line around the #282-F pump slab, a steam line from the Power House to the Chemical Feed Bldg., #280-1F, and a chlorine line between #280-1F and the Cooling Tower. The instrument air line is suspended from the main steam header. The chlorine line is a rubber-lined steel pipe.

## EQUIPMENT

All piping and accessory equipment required for these lines were obtained by field procurement.

## DRAWINGS

W-142041 - W-139911 - Miscellaneous Details.  
PF-4547, 4582, 5001, 2, 5, 6, 7, 8 & 19 - Profiles.  
Map 3313 - Sheets 853, 854, 884.

BUILDING #802-H - STEAM LINES

## FUNCTION

This facility provides overhead piping for high and low pressure and exhaust steam, caustic feed and return, steam tracer, acid feed and return, instrument air, lime, polyphosphate and chlorine to facilities within the power block limits as well as steam and instrument air lines to service facilities in the #200-H Area outside of the power block limits.

## PRINCIPAL COMPONENTS

The system includes a main steam header from the Power House, Building #284-H, to the edge of the power block; a high pressure steam header off the main header to transport steam to the pumps at the Cooling Tower, Building #285-H, and another header off this branch header for high pressure steam requirements to the western limits of the power block. An instrument air line is carried from the Power House to the power block limit suspended from the main steam header. There are also a low pressure steam line between the Power House and the #280-1H Chemical Feed Building; two caustic lines and a steam tracer line between the Power House and the outside caustic storage tanks; an acid feed line and a return line between the Power House and the outside acid tanks; an instrument air line between the Power House and the Domestic Water Storage Tank, the Chemical Feed Building and other buildings requiring this service; a lime solution feeder line and a polyphosphate line between #280-1H and the flow nozzle manhole adjacent to the Domestic Water Tank; a rubber lined chlorine line between #280-1H and the point of application at the Domestic Water Storage Tank. All lines between the Power House, the Chemical Feed Building and the Water Storage Tanks are carried by the same supporting unit.

## EQUIPMENT

All piping and accessory equipment required for this installation were obtained by field procurement.

## DRAWINGS

W-142041 - Miscellaneous Details.  
PF-4582 - Plan, Sections and Details.

## BUILDING #803-F&H - AIR LINES

## FUNCTION

This facility in the F Area supplies instrument air from Building #284-F to Building #281-2F and the domestic storage tanks, and from Building #221-F to various points of use in #221-F and #211-F. Instrument air in the H Area is supplied from Building #284-H to #280-1H, #281-6H, #282-H and the caustic tanks, and from #221-H to points of use in that building, to #221-H "A" Line, #211-H and the transfer tank basin. Plant air is supplied from #221-F to points of use in that facility and to #211-F and #291-F, while in the H



Area plant air is supplied to #221-H, #221-H "A" Line, #291-H and #294-H from Building #221-H.

## PRINCIPAL COMPONENTS

Both instrument and plant air are carried in steel pipe, suspended for the most part from the main overhead steam line. For some short distances the line is installed underground.

## EQUIPMENT

All piping equipment was obtained by field procurement.

## DRAWINGS

### #200-F Area

Map 3313 - Sheet 854 - Outside Overhead Lines.

Map 3314 - Sheet 854 - Underground Lines.

PF 5001 - Outside Overhead Lines (Overhead Piping & Supports)

|           |   |   |   |   |   |   |
|-----------|---|---|---|---|---|---|
| PF 4547 - | " | " | " | " | " | " |
| PF 4593 - | " | " | " | " | " | " |
| PF 5019 - | " | " | " | " | " | " |
| PF 5008 - | " | " | " | " | " | " |

### #200-H Area

Map 3313 - Sheet 796 - Outside Overhead Lines

PF 5020 - Outside Overhead Lines

|           |   |   |   |
|-----------|---|---|---|
| PF 4582 - | " | " | " |
| PF 4594 - | " | " | " |
| PF 5013 - | " | " | " |
| PF 5015 - | " | " | " |

## BUILDINGS #809-F & H - ASH SLUICING LINES

## FUNCTION

These pipe lines transport ashes from the Power Houses, Buildings #284-F&H, to the Ash Disposal Basins, Buildings #288-F&H.

## PRINCIPAL COMPONENTS

The ash sluicing lines are above ground, "Durite", light alloy pipe arranged in 16 ft. flanged sections and supported by concrete piers, wood poles, and steel poles with foundations and crossbeam supports over road crossings. Supports are located in a manner which permits rotating each individual section of pipe to distribute wear and prolong life.

Each line is designed to handle approximately 30 tons of ash an hour and is pitched so that all sections may be drained. Plug valves are installed at low points to permit complete drainage for freeze-up protection during cold weather.

## EQUIPMENT

All equipment and material required for the facilities, except the line supports which were obtained by field procurement, are part of the ash handling equipment purchased for Building #284.

## DRAWINGS

PF 4576 - Ash Sluicing Piping - #200-F Area.  
PF 4577 - Ash Sluicing Piping - #200-F Area.  
PF 4571 - Ash Sluicing Piping - #200-H Area.  
PF 4572 - Ash Sluicing Piping - #200-H Area.  
PF 4573 - Ash Sluicing Piping - #200-H Area.

## BUILDING #901-F - WATER LINES

## FUNCTION

The piping system designated Building #901-F delivers water from the area wells to the fire and service water storage tank and the domestic water Storage Tank, Building #282-F. This system also provides piping for the distribution of service, domestic and refrigeration water within the #200-F Area and the supply and return of process cooling water to and from Building #285-F, Cooling Tower.

## PRINCIPAL COMPONENTS

The water line piping may be separated into the several "use" classifications of Ground Storage Tanks Supply, Process Cooling Water Supply and Return, Domestic Water, Refrigeration

Water, Cooling Tower Make-up, and Service Water. Piping inside the buildings is of one and two-inch copper tubing, while the underground piping is made up of cast-iron mechanical joint pipe, steel pipe, and prestressed concrete pipe in sizes ranging from three-inch to 36-inches.

#### EQUIPMENT

The reinforced concrete pipe was furnished by a subcontractor. All other piping, fittings and accessories were obtained by field procurement.

#### DRAWINGS

- W-158728 - Flow Diagram.
- W-138360 - Underground Lines and Piping - Plan - Water Treatment.
- W-158745 - Segregated Water Return System from Bldg. #221-F.
- Map 3314 - Sheets 853, 854 and 884 - Outside Line Underground Piping.

#### BUILDING #901-H - WATER LINES

##### FUNCTION

These lines carry water from the Building #905-H deep wells to the fire and service water and the domestic water ground storage tanks.

Service, domestic and fire protection water is distributed from the ground storage tanks for use in the process area and to all points within the Power Block area - boiler feed make-up water to the Power House, Building #284-H; make-up water to the Cooling Tower, Building #285-H; ash sluicing water to the Power House; domestic and service water to the Chemical Feed Building, #280-1H; and to supply service and domestic water headers to the Power Block.

##### PRINCIPAL COMPONENTS

Installations for this facility consist of copper tubing inside the buildings, mechanical joint pipe, prestressed concrete pipe and some steel pipe. The flow nozzle manholes on the waterline at the Chemical Feed Buildings, #280-1 and #280-2H, are constructed of reinforced concrete.

## EQUIPMENT

The reinforced concrete piping was furnished by a sub-contractor. All other piping, fittings and accessories were obtained by field procurement.

## DRAWINGS

- W-139863 - Reservoir and Pump House Flow Nozzle  
Manhole - Concrete.
- W-142385 - Underground Piping Anchors - Concrete.
- W-142214 - Underground Lines and Piping - Plan -  
Water Treatment.

## BUILDING #902-F - FIRE LINES

## FUNCTION

This pipe line carries fire protection water to all facilities within the #200-F Fenced Area from the fire pumps located in Building #282-F.

## PRINCIPAL COMPONENTS

These underground fire lines are made up of 6, 8, 12, 14 and 24-in. cast iron mechanical joint pipe running to hose boxes each of which is equipped with valves and approximately 150 lin. ft. of fire-hose.

## EQUIPMENT

All piping, fittings and accessories were obtained by field procurement.

## DRAWINGS

- W-158232 - Line Index.
- Map 3312 - Sheets 853, 854 and 884 - Outside Lines Fire  
Protection.
- W-148351 - Sections and Details.

BUILDING #902-H - FIRE LINES

## FUNCTION

This pipe line carries fire protection water to all facilities within the #200-H fenced area from the fire pumps located on the Building #282-H outdoor pump pad.

## PRINCIPAL COMPONENTS

These underground fire lines are made up of 6, 8, 12, 14 and 24-inch cast iron mechanical joint pipe running to hose boxes, each of which is equipped with valves and approximately 150 lin. ft. of fire hose.

## EQUIPMENT

All piping, fittings and accessories were obtained by field procurement.

## DRAWINGS

W-158351 - Line Index.  
 W-149333 - Sections and Details.  
 W-161900 - Sections and Details.  
 Map 3312 - Sheet #796 - Outside Lines Fire Protection.

BUILDING #905-F - WELLS AND PUMPS

## FUNCTION

These facilities provide all water required within the #200-F Area.

## PRINCIPAL COMPONENTS

The following deep wells and pumps were provided:

| <u>Well No.</u> | <u>PUMP</u><br><u>Capacity</u> | <u>Driver HP</u> | <u>COLUMN PIPE</u><br><u>Depth</u> | <u>PIPE</u><br><u>Size</u> | <u>No. of Pump</u><br><u>Stages</u> | <u>Depth</u> |
|-----------------|--------------------------------|------------------|------------------------------------|----------------------------|-------------------------------------|--------------|
| F-21            | 1000 g.p.m.                    | 125              | 200'                               | 8"                         | 5                                   | 825'         |
| F-24            | 1000 g.p.m.                    | 125              | 240'                               | 8"                         | 6                                   | 830'         |
| F-37            | 1000 g.p.m.                    | 150              | 190'                               | 8"                         | 7                                   | 790'         |
| F-39            | 1000 g.p.m.                    | 125              | 230'                               | 8"                         | 6                                   | 820'         |

|      |             |     |      |    |   |                                                                   |
|------|-------------|-----|------|----|---|-------------------------------------------------------------------|
| F-49 | 1000 g.p.m. | 150 | 230' | 8" | 7 | Originally<br>820' Plugged<br>at 690'<br>depth after<br>reworking |
|------|-------------|-----|------|----|---|-------------------------------------------------------------------|

The chemical treatment of the water delivered from Wells F-21, F-24 and F-39 is provided by the treating facilities within the #280-1F Chemical Feed Building. These wells supply all fire, domestic and service water. The chemical treatment for wells F-37 and F-49 is provided by the #280-2F Chemical Feed Building. These two wells are located outside the Power Block and supply cooling water for once-through use in the #241-F heat exchangers from which it is used as make-up to the #285-F Cooling Tower.

The pumps at Wells F-21 and F-39 are electric motor-driven, the motor starter being mounted on a concrete pad at F-21. The pump at F-24 is provided with both electric motor and steam turbine drives.

The pumps at F-37 and F-49 are electric motor-driven, but for reliability of operation a single diesel engine was provided. This engine is normally located at F-37, where a Class I, above-ground housing is provided, but it can be moved to F-49. Right angle gear drive units are provided at both locations for the diesel. Power is supplied by the secondary transformers.

#### BUILDING FLOOR SPACE (STRUCTURE AT F-37)

|                                            | <u>Approx. Sq. Ft.</u> |
|--------------------------------------------|------------------------|
| Main Building                              | 320                    |
| Annex (Vestibule)                          | 80                     |
| Two Blast Shield Annexes (each 40 sq. ft.) | 80                     |

#### BUILDING DETAILS

The structure at Well F-37 is a Class I single-story, rectangular building approx. 18 ft. by 24 ft. by 13 ft. high, with a flat roof. An annex, 7 ft. by 12 ft. by 16 ft. high, extends on the north side. Two other annexes are elevated projections, one being 4 ft. by 14 ft. by 5 ft. deep, and the other 4 ft. by 13 ft. by 6 ft. deep. These were provided essentially as hollow air shafts (blast shields).

Total Area - 480 sq. ft.  
Total Volume - 8506 cu. ft.

## CONSTRUCTION DETAILS

Construction is completely of reinforced concrete. The floor slab is 2 ft. thick, the walls of the main structure 1 ft. 6 in. thick, and the roof slab 20-in. thick. The walls of the vestibule are 12 in. thick and the walls of the blast shield projections are 8 in. thick.

The installation at the other wells was made on 8-in. thick reinforced concrete pads with the following dimensions:

F-24 - 10' x 15'  
 F-49 - 14'-6" x 21'-4"  
 F-21 - 11' x 20'  
 F-39 - 11' x 14'

The general outside area safety-alarm provisions for the #200-F Area were deemed sufficient for these facilities.

Incandescent lighting was provided and all necessary heating and ventilating provisions were included in the structure at Well F-37.

## EQUIPMENT

### Power

- 1 Vertical, 5-stage, deep well pump and drive, 1000 g.p.m.
- 2 Vertical, 6-stage, deep well pumps and drives,  
1000 g.p.m.
- 2 Vertical, 7-stage, deep well pumps and drives,  
1000 g.p.m.
- 1 Diesel engine, 4 cycle, 6 cylinder, portable, 159 hp.
- 1 Turbine drive for deep well pump, 100 hp.
- 2 Pressure gauges.
- 1 Steam separator.
- 5 Test orifices were procured under #282-F, one for each well.

### Heating and Ventilating

- 1 Unit heater.
- 1 Exhaust fan.
- 1 Back-draft damper.

### Electrical

- 1 3-kv.-a. Transformer.
- All necessary receptacles, color coded wire and conduit were obtained by field procurement.

## DRAWINGS

Hydro

- W-142052 - Wells - Plans and Sections - Arrangement.
- W-142107 - Well Pumps Arrangement - Details.
- W-142304 - Well Pumps F-37 and F-49 - Arrangement.

Structural

- W-142246 - Well Pump House - F-37 - Plan, Sections and Details.

BUILDING #905-H - WELLS AND PUMPS

## FUNCTION

These facilities provide all water required within the #200-H Area.

## PRINCIPAL COMPONENTS

The following deep wells and pumps are provided:

| <u>Well Pump<br/>No.</u> | <u>Capacity</u> | <u>Type<br/>Drive</u>       | <u>Driver<br/>HP</u> | <u>Column<br/>Depth</u> | <u>Pipe<br/>Size</u> | <u>No. of<br/>Pump<br/>Stages</u> | <u>Depth</u> |
|--------------------------|-----------------|-----------------------------|----------------------|-------------------------|----------------------|-----------------------------------|--------------|
| H-48                     | 1000 g.p.m.     | Motor                       | 150 hp.              | 230 ft.                 | 8"                   | 7                                 | 880'         |
| H-43                     | 1000 g.p.m.     | Motor &<br>Turbine          | 125 hp.              | 230 ft.                 | 8"                   | 6                                 | 860'         |
| H-44                     | 1000 g.p.m.     | Motor &<br>Diesel           | 150 hp.              | 230 ft.                 | 8"                   | 7                                 | 835'         |
| H-35                     | 1000 g.p.m.     | Motor                       | 125 hp.              | 230 ft.                 | 8"                   | 6                                 | 860'         |
| H-45                     | 1000 g.p.m.     | Motor &<br>Future<br>Diesel | 150 hp.              | 230 ft.                 | 8"                   | 7                                 | 880'         |

A test orifice is provided at each of the five wells. The chemical treatment of the water delivered from Wells H-48, H-43, and H-35 is provided by the treating facilities within the #280-1H Chemical Feed Building. These wells are located in the Power Block and supply all fire, domestic, and service water. The chemical treatment for Wells H-44 and H-45 is provided by the #280-2H Chemical Feed Building. These two wells are located outside the power block and supply cooling water for the #241-H heat exchangers. The pumps at H-48 and H-35 are electric motor-driven. The motor starter



at H-48 is mounted on a concrete pad. The pump at H-43 is provided with both electric motor and steam turbine drives.

The pumps at H-44 and H-45 are electric motor-driven but for reliability of operation a single Diesel engine is provided. This engine is normally located at H-44, where a Class I housing is provided, but it can be moved to H-45. Right angle gear drive units are provided at both locations for the Diesel. Power is supplied by secondary transformers.

#### BUILDING FLOOR SPACE (Structure at H-44)

|                          | <u>Approx. Sq. Ft.</u> |
|--------------------------|------------------------|
| Main Building            | 320                    |
| Annex (Vestibule)        | 80                     |
| Blast-Shield Annexes (2) | each 40                |

#### BUILDING DETAILS

The building at Well H-44 is of Class I construction, a one-story, rectangular 18 ft. by 24 ft. by 13 ft. high with a flat roof. There is an annex on the south side 7 ft. by 12 ft. by 13 ft. high. The other two annexes are elevated projections. One is 4 ft. by 14 ft. by 5 ft. deep and the other is 4 ft. by 13 ft. by 6 ft. deep. They are provided essentially as hollow air shafts (blast shields).

Total Area - 480 square feet  
Total Volume - 8506 cubic feet

#### CONSTRUCTION DETAILS

The structure at Well H-44 is entirely of reinforced concrete. The floor slab is 2 ft. thick, the walls of the main structure are 1 ft.-6 in. thick and the roof slab is 20 in. thick. Vestibule walls are 12 in. thick and the walls of the blast-shield projections are 8 in. thick.

The installations at the other wells are on 8-in. thick reinforced concrete pads with the following dimensions:

H-35 - 11' x 14'  
H-43 - 10' x 15'  
H-45 - 14'-6" x 21'-4"  
H-48 - 11' x 20'

The general outside area safety-alarm provisions for the #200-H Area were deemed sufficient for this facility. Lighting is incandescent. All necessary heating and ventilating provisions are included in the H-44 structure.

## EQUIPMENT

### Power

- 1 - Vertical, 7-stage, deep well pump and drive, 1000 g.p.m., - H-48.
- 1 - Vertical, 6-stage, deep well pump and drive, 1000 g.p.m., - H-43.
- 1 - Vertical, 7-stage, deep well pump and drive, 1000 g.p.m., - H-44.
- 1 - Vertical, 6-stage, deep well pump and drive, 1000 g.p.m., - H-35.
- 1 - Vertical, 7-stage, deep well pump and drive, 1000 g.p.m., - H-45.
- 1 - Diesel engine, 4 cycle, 6 cylinder, portable, - 159 hp.
- 1 - Turbine drive for deep well pump, 100 hp.
- 2 - Pressure gauges
- 1 - Steam separator
- 5 - Test orifices were procured under #282-H, one for each well.

### Heating and Ventilating

- 1 - Unit heater.
- 1 - Exhaust fan.
- 1 - Back-draft damper.

### Electrical

- 1 - Battery trickle charger, for portable starting unit.
- 2 - Motor starters, 2300-v., combination fused disconnect and contactor type, NEMA III.
- 1 - Motor starter, 2300-v., combination fused disconnect and contactor type, NEMA I.
- 2 - Momentary contact pushbuttons.
- 1 - 3-kv.-a. Transformer.
- 1 - Manual motor starter - NEMA I.
- 1 - Motor starter switch, 3 pole, 440-v., NEMA I.
- 1 - Combination motor starter, NEMA I.
- 1 - Pushbutton maintain-contact start-stop, NEMA IV.
- 5 - Lighting fixtures.

## DRAWINGS

### Hydro

- W-139302 - Piping Arrangement - Deep Well Water Pumps - H-43, H-44 and H-45.
- W-139597 - Piping Arrangement - Deep Well Water Pumps - H-35 and H-48.

W-139726 - Arrangements - Deep Well Water Pumps - H-44 and H-45.

### Electrical

W-139671 - Arrangement of Electrical Equipment and Conduits - H-44 and H-45.

### Structural

W-139686 - Well Pump House - H-44 - Sections and Details.

AREA - #300-M

### BUILDING #801-M - PIPE SUPPORTS

#### FUNCTION

These supports carry the overhead pipe lines within the #300 Area.

#### PRINCIPAL COMPONENTS

For general design see Building #801-R.

Overhead lines in the area are limited to steam mains varying in size from 3 to 8 inches in diameter. The 10-inch header from Bldg. #784-A supplies branch lines leading to Buildings #305-M, #313-M, #320-M, #704-M and #777-M.

#### EQUIPMENT

All equipment and material for this facility were obtained by field procurement.

#### DRAWINGS

Map 3313 - Sheet #1123 - Location.  
 PF-4515 - 4525 - Overhead Piping and Supports - Plans, Sections, and Details.  
 PF-4527 - 4528 - Overhead Piping and Supports - Plans, Sections, and Details.  
 PF-4530 - 4531 - Overhead Piping and Supports - Plans, Sections, and Details.  
 PF-4533 - 4535 - Overhead Piping and Supports.

W-138022 - Piping and Supports - Details.  
W-137951 - Steam Flow Diagram.

### BUILDING #802-M - STEAM LINES

#### FUNCTION

This facility provides steam distribution from the Boiler House, Building #784-A, to the following buildings within the #300 Area: #305-M, #313-M, #320-M, #704-M and #777-M.

#### PRINCIPAL COMPONENTS

Steel pipe, ranging in size from 3 to 8 inches, is used for the steam lines in this area. In conjunction with the wood pole supports (Bldg. #801-M) the pipe is placed at a minimum height of 7 feet for normal yard clearance, 17 feet over roads and 22 feet over railroad tracks.

#### EQUIPMENT

All piping and accessories were obtained by field procurement.

#### DRAWINGS

Map 3313 - Sheet #1123 - Location.  
PF-4515 - 4525 - Overhead Piping and Supports -  
Plans, Sections and Details.  
PF-4527 and 4528 - Overhead Piping and Supports -  
Plans, Sections and Details.  
PF-4530 and 4531 - Overhead Piping and Supports -  
Plans, Sections, and Details.  
PF-4533 - 4535 - Overhead Piping and Supports.  
W-138022 - Piping and Supports - Details.  
W-137951 - Steam Flow Diagram.

### BUILDING #901-M - WATER LINES

#### FUNCTION

These lines distribute well water to the reservoir and service and domestic water to various points within the area.

**PRINCIPAL COMPONENTS**

The water distribution system is constructed of 3, 4, 6 and 8-inch cast iron pipe.

**EQUIPMENT**

All piping, fittings and accessories were obtained by field procurement.

**DRAWINGS**

Map 3314 - Sheet #1123 - Location.  
Map 3314 - Sheet #1153 - Location.  
W-136195 - Details - Underground Piping.  
W-138675 - Chilled Water Lines - Piping Details.

**BUILDING #902-M - FIRE LINES****FUNCTION**

These pipe lines carry water for fire protection from the Reservoir, Bldg. #782-A, to hydrants at vital locations within the #300 Area.

**PRINCIPAL COMPONENTS**

The system consists of 6, 8 and 10-inch underground mechanical joint cast iron piping, and includes the necessary hydrants, post indicator valves and accessories.

**EQUIPMENT**

All piping, hydrants and accessories were obtained by field procurement.

**DRAWINGS**

Map 3312 - Sheet #1123 - Location.  
Map 3312 - Sheet #1153 - Location.

**AREA #400-D****BUILDING #480-1-2-3-D - CHEMICAL FEED BUILDINGS**

## FUNCTION

### Building #480-1D

This facility treats water from the #905-D Deep Wells Nos. 1 and 2 for domestic use. Chlorine is added to sterilize the water, and polyphosphate to eliminate an undesirable iron taste and to protect the water side of the cast iron distribution main. A portion of the water so treated is delivered directly to the #400 Process Area as drinking water, while the remainder is stored in the #487-D Elevated Tank.

### Building #480-2D

Equipment housed in this building is used to treat water from Deep Well No. 41 for process cooling within the #400 Area. Treatment consists of adding polyphosphate solution to prevent precipitation of iron and to minimize scale formation in the cooling water system.

### Building #480-3D

This equipment was provided to treat circulating cooling water in the basin of the #485-D Cooling Tower. Chlorine and lime are applied to the water to minimize corrosion, scale formation, and slime growth on heat exchanger surfaces and other components of the circulating system, thereby promoting optimum heat transfer values. This chemical infusion also minimizes algae formation in the Cooling Tower Basin.

## PRINCIPAL COMPONENTS AND PLANT OPERATION

### Building #480-1D

This building houses two automatic control solution feed vacuum chlorinators and two polyphosphate dissolving tanks, from which chlorine and polyphosphate solutions are pumped directly into the water main from the wells.

Each chlorinator has a capacity of 25 lbs. of chlorine per day one being in operation while the other serves as a stand-by. The rate of feed is set manually, the quantity of chlorine solution injected being based on the flow in the main and the chlorinator being actuated by a differential converter. A chlorinator pump takes suction from the water main and provides water at sufficient pressure to actuate the chlorinator and inject chlorine solution into the main at an approximate rate of 4.5 g.p.m.

The polyphosphate dissolving tanks, of 75 gal. capacity each, are furnished with motor driven agitators. Two pumps, one of which is a stand-by, discharge the solution from these tanks into the well water main at a maximum rate of 3.5 g.p.m. Pump discharge is controlled by an adjustable stroke, while the volume of solution injected is controlled by a Chronoflow transmitter actuated by an orifice in the main.

#### Building #480-2D

This facility is equipped with one 50-gal. polyphosphate dissolving tank provided with a motor driven agitator and a stainless steel dissolving basket. Two pumps, one of which is a spare, discharge the polyphosphate solution into the well water main at a maximum rate of 3.5 g.p.m. The volume of polyphosphate solution injected into the main is controlled manually by adjustment of the length of the pump stroke.

#### Building #480-3D

Two 1-ton chlorine containers mounted on a dial-type scale supply a semi-automatic solution-feed chlorinizer of 1000 lbs. per day capacity. Rate of feed is set manually and operation of the chlorinizer is controlled automatically by a program timer. Auxiliary equipment for this chlorine feed facility includes solenoid valves, chlorine hose, tank manifold, chlorine solution injector, and a chlorine residual testing kit.

Lime is fed to a 500-gal. slurry tank from a lime feeder having a maximum feed rate of 3 lbs./hr., the rate of feed being set manually. By means of a program timer, the amount of lime fed is geared to the quantity of lime solution fed from the slurry tank, which is provided with a motor driven agitator and a gauging device.

A flowmeter actuates the program timer and provides a measurement of total make-up flow to the Cooling Tower.

A flowmeter, timer, and control valve control blowdown from the cooling tower basin.

A pH recorder measures the pH of the circulating cooling water.

#### BUILDING DETAILS

All three of these buildings are of Class III construction. The #480-1D & 2D buildings are rectangular in shape and approximately 16 ft. wide by 17 ft. long by 11 ft. high.

Building #480-3D is 24 ft. square and 19 ft. high.

|          | <u>#480-1D</u> | <u>#480-2D</u> | <u>#480-3D</u> |
|----------|----------------|----------------|----------------|
| Area -   | 270 sq. ft.    | 270 sq. ft.    | 576 sq. ft.    |
| Volume - | 2775 cu. ft.   | 2775 cu. ft.   | 9655 cu. ft.   |

## CONSTRUCTION DETAILS

### Foundation

Reinforced concrete with spread footings.

### Superstructure

Steel frame structure.  
Steel beam peaked roof.  
Corrugated asbestos siding and roof.  
Concrete floor.  
Hollow metal doors.  
Steel sash.

### Building #480-3D Chlorine Room

Steel stud and cement asbestos board partition.  
Corrugated asbestos ceiling 9 ft. high.

## EQUIPMENT

### Building #480-1D

2 Chlorinators, 25 lb. of mixed solution in 24 hr.  
Polyphosphate equipment, 48 lb. in 24 hr.  
3 Unit heaters.  
2 Ventilating fans.

### Building #480-2D

Polyphosphate equipment, 38 lb. in 24 hr.  
1 Unit heater.  
1 Propellor fan.

### Building #480-3D

Chlorination equipment, 6000 lb. per month.  
Lime solution feeder equipment, 0.5 to 3.0 lb./hr.  
All necessary meters and valves.  
pH Recorder  
Chain hoist and lifting clamp.  
2 Unit heaters.



- 1 Roof ventilator.
- 1 Propellor fan.

## DRAWINGS

### Building #480-1D

- W-136211 - Wiring Diagram - Conduit Plans and Sections.
- W-136214 - Chlorine Building.

### Building #480-2D

- W-135976 - Electric Plot Plan
- W-138376 - Chemical Feed - General Arrangement

### Building #480-3D

- W-138698 - Foundation Plan and Details
- W-138795 - Building
- W-137745 - Building

## BUILDING #483-D - WATER FILTRATION AND TREATMENT PLANT

## FUNCTION

This facility is the water distribution center of the #400 Area. Its primary functions are to receive and store water from the #681-5G Water Pump House and to condition and distribute it for use in the process area, the #484-D Power House, and the administration area.

## PRINCIPAL COMPONENTS

### Pump Reservoir

This is an L-shaped elevated concrete basin of three basic divisions: (1) an inlet chamber; (2) a mixing chamber for blending condenser return water with the river water; and (3) a process raw water storage basin having a capacity of 30-minutes detention time at average process raw water pumping rates.

Four 10,500 g.p.m. motor-driven condenser circulating pumps, one of which is a spare, are mounted on a concrete slab along the west wall of the reservoir, taking suction from the inlet chamber.

Four 13,000 g.p.m. motor-driven raw water pumps, one a spare, are mounted on a concrete slab along the south wall of the reservoir, taking suction from the raw water storage basin. A 24-in. continuous backwash strainer is mounted in the discharge line of each of these pumps.

#### Clarification Unit

The principal elements comprising this unit are a Chemical Building, a flash mixer, and three precipitator basins of 355,000 gallons capacity each.

The Chemical Building is a two-story structure housing lime and clay feeding and storage equipment, two alum feed pumps, and other equipment necessary for the application of chemicals to the flash mixer. A 20-in. venturi meter mounted in the flash mixer inlet line serves as a control on the rate of flow and paces the chemical feeders.

#### Filtration Unit

This unit consists of six rapid-sand filters and a concrete clearwell. An enclosed pipe gallery and a pump platform are mounted over the clearwell, from which filtered water is distributed throughout the Water Treatment Plant and the Area.

The following motor-driven pumps take suction from the clearwell: four 2200 g.p.m. process feed pumps, one of which is a spare; two 2100 g.p.m. boiler feed make-up pumps, one a spare; and two 600 g.p.m. power house auxiliary pumps. Two 1000 g.p.m. fire water pumps, one turbine-driven and one motor-driven, also take suction from this clearwell.

#### Ion Exchange Unit

The principal segments of this unit are four Zeo-Karb "H" softeners; two degasifiers mounted over a clearwell; two 1900 g.p.m. motor-driven boiler feed booster pumps, one of which is a spare; four Permutit "S" silica absorbers; and acid and caustic soda regeneration equipment. An enclosed pipe gallery is located between the softeners and absorbers.

#### Acid Treatment Unit

This unit consists of an acid mixing tank and two acid feed pumps, one of which is a spare; three 40,000-gallon vacuum deaerators; a caustic mixing tank and two caustic feed pumps, one a spare; a 200,000-gallon storage tank; and four 2200 g.p.m. motor-driven process feedwater booster pumps, one a spare.

Switchgear Building

This is a prefabricated structure housing switchgear, control panels, and other related electrical equipment.

## BUILDING FLOOR SPACE

Chemical BuildingApprox. Sq. Ft.

|                  |      |
|------------------|------|
| First floor      | 1700 |
| Second floor     | 1850 |
| Laboratory       | 700  |
| Toilet           | 40   |
| Feeder pump room | 525  |

## BUILDING DETAILS

All buildings in this facility are of Class III construction and of the following approximate sizes.

Switchgear Building

Rectangular in shape, 60 ft. x 32 ft. x 18 ft. high.  
 Area - 1900 sq. ft.  
 Volume - 27,000 cu. ft.

Chemical Building

A two-story rectangular structure, 66 ft. x 30 ft. 28 ft. high.

Area - 2000 sq. ft.  
 Volume - 55,500 cu. ft.

Softeners and Silica Absorbers Building

Rectangular in shape, 62 ft. x 14 ft. x 18 ft. high.  
 Area - 900 sq. ft.  
 Volume - 15,500 cu. ft.

Loading Platform

An "L"-shaped structure, 76 ft. x 28 ft. x 8 ft.-3.5 ft. above grade.

Area - 861 sq. ft.  
 Volume - 6900 cu. ft.

Flash Mixer and Pipe Gallery

A rectangular, flat-roofed structure, 131 ft. x 13 ft. x 14 ft. high.

Area - 1700 sq. ft.  
Volume - 23,800 cu. ft.

Precipitators

Over-all horizontal dimensions for the three rectangular open precipitator basins, 115 ft. x 107 ft. x 15.5 ft. deep.

Total area - 12,300 sq. ft.  
Total Volume - 190,725 cu. ft.

Filters

Over-all rectangular dimensions for the six open filter basins, 60 ft. x 140 ft. x 14.5 ft. deep.

Total area - 8400 sq. ft.  
Total volume - 121,800 cu. ft.

Pumping Platform

A rectangular structure, 140 ft. x 24 ft. x 13.5 ft. high.

Area - 2360 sq. ft.  
Volume - 45,350 cu. ft.

## CONSTRUCTION DETAILS

Switchgear Building, and Softeners and Silica Absorbers Building

Foundation - reinforced concrete with spread footings.  
Superstructure - structural steel frame; peaked roof; corrugated asbestos siding and roof covering.

Chemical Building

Foundation - reinforced concrete with spread footings.  
Superstructure - First floor - reinforced concrete.  
Second floor - structural steel frame.  
Roof - rigid frame (peaked).  
Roofing and siding - corrugated asbestos.  
Flooring - concrete.  
Floor covering (in lab. only) - asphalt tile.  
Stairs - steel frame with precast concrete treads.

Interior Partitions - standard steel stud partitioning with Keene's cement wainscot in toilet room and 1/4 in. asbestos board elsewhere; concrete ceiling.

Windows - standard commercial projected steel sash.

Doors - hollow metal.

#### Flash Mixer and Pipe Gallery

Foundation - reinforced concrete with spread footings.

Superstructure - north and west sides structural steel frame; the other sides formed by the reinforced concrete first floor walls of the Chemical Building.

Floor - reinforced concrete.

Roof - concrete.

Wall siding - corrugated asbestos on north and west sides.

Windows - steel.

Doors - hollow metal.

#### Precipitators

Foundation - reinforced concrete with spread footings.

#### Filters

Foundation - reinforced concrete with spread footings.

Superstructure - steel frame with corrugated asbestos siding.

Roof - concrete.

Stairs - concrete.

Windows - steel.

Doors - hollow metal.

#### Miscellaneous

The following components are constructed of reinforced concrete: Pump reservoir; pump platform; degasifier foundation; mixer tank foundation; transformer foundation; electric, orifice, and collector manholes; overflow flumes and manhole; and the chemical unloading platform.

The deaerators have a reinforced concrete foundation; a structural steel support with stairs, ladder, and under-rail; and a wood platform.

Sufficient unit heaters and fans were provided to heat and ventilate the enclosed areas.

Fluorescent lighting was used.

Provisions were made for emergency power.

## EQUIPMENT

Mechanical

- Clarification equipment, 10,000 g.p.m.
- Filtration equipment, 10,000 g.p.m.
- Boiler, 1900 g.p.m., and process, 6600 g.p.m., water treatment equipment.
- 2 1000 g.p.m. fire pumps, one turbine-driven and one motor-driven.
- 4 Process feed make-up pumps, 2200 g.p.m., motor-driven.
- 2 Boiler feed make-up pumps, 2100 g.p.m., motor-driven.
- 4 Process feed booster pumps, 2200 g.p.m., motor-driven.
- 4 Process raw water pumps, 13,000 g.p.m., motor-driven.
- 4 Continuous backwash strainers, 13,000 g.p.m. each.
- 3 Cold water deaerators.
- 3 Booster ejectors.
- 3 Sets of 3-stage ejectors.
- 1 Concentrated acid storage tank, 17,700 gals. capacity.
- 1 Chemical handling elevator.
- 2 Caustic storage tanks, 17,700 gals. capacity.
- 1 200,000-gal. Ground storage tank.
- 2 Boiler feed booster pumps, 1900 g.p.m., motor-driven.
- 2 Degasifiers, 1900 g.p.m. each.
- 2 Power plant auxiliary pumps, 600 g.p.m., motor-driven.
- 3 Alum storage tanks, rubber lined, 17,700 gal. each.
- 1 Acid unloading pump, 100 g.p.m.
- 1 Caustic unloading pump, 100 g.p.m.
- 1 Liquid alum unloading pump, 100 g.p.m.
- 4 Condenser circulating water pumps, 10,500 g.p.m. motor-driven.
- 1 Caustic feed system.
- 1 Alum feed system.
- 1 Circulating water system and auxiliary equipment.
- 2 Heat exchangers.
- 1 Lift truck.
- 1 Acid transfer pump.
- 1 Caustic solution transfer pump.
- 1 Elevated water tank booster pump.
- 2 Centrifugal boiler feed pumps.
- All necessary valves, piping, hose, gauges, fittings, instruments, and controls.
- Chemical laboratory furniture and equipment.

Electrical

- 2 Motor control centers.
  - 2 5-kv. Switchgear.
  - 1 440-v. Unit load center 600-kv.-a.
  - 1 5000/6250 kv.-a., 13.8/2.4-kv. Auxiliary transformer.
  - 1 75-kv.-a. Lighting transformer.
  - 1 Sound-powered intercommunication system.
  - 7 Loud-speaker assemblies and system.
- All necessary distribution, lighting, and blackout panels.

Heating and Ventilating

- 11 Unit heaters.
- 1 Heating and ventilating unit with controls and accessories.
- 1 Exhaust fan.
- 1 Finned radiator.
- 2 Roof ventilators.

Architectural

- 1 Water cooler.
- 1 Electric water heater, 120 gal.

## PLANT OPERATION

Water Flow

Savannah River water is pumped from the #681-5G River Pump House to the pump reservoir through a 60 in. pipeline at a maximum rate of 70,000 g.p.m.. Flow is controlled by a butterfly valve actuated by the level of the process raw water basin. The river water enters at the bottom of the reservoir inlet chamber and rises through a slotted partition to mix with returning condenser water falling through a partition in the upper level of the chamber. Water from the Power House can be diverted to the inlet chamber or wasted to the sewer. The control for this is located in #483-D where the operator can see the waste flow valve, to return any given part of the rejected condenser water. This valve is located south of the #483-D reservoir.

Three condenser circulating pumps take suction from the inlet chamber and discharge raw water to the turbo-generator condensers in the #484-D Power House at a maximum rate of 23,300 g.p.m.

Three booster pumps take suction from the process raw water storage basin and discharge water through continuous backwash strainers into a pipeline which conveys it to the process area at a maximum rate of 34,000 g.p.m.

Water flows from the reservoir inlet chamber into a flash mixer at a maximum rate of 9800 g.p.m., from which it flows to the precipitator inlet channel. After passing through the precipitators the water flows into a header channel and through the filters. Filtered water is collected in a clearwell from which it is pumped into the following pipelines; fire water, process make-up, boiler feed make-up, Cooling Tower make-up, Power House auxiliary, backwash, surface wash, and miscellaneous.

The boiler feed make-up water is pumped through the softeners and degasifiers and collected in the degasifier clearwell. From there it is pumped through the silica absorbers to the Power House at a maximum rate of 1300 g.p.m.

Process feed make-up water is pumped to an acid mixing tank from which it flows to the deaerators. This deaerated water flows down into an effluent header and through a caustic mixing tank, after which it is collected in a storage tank. From here it is pumped to the process area at a maximum rate of 6600 g.p.m.

## Water Treatment

### Clarification

The clarification process reduces turbidity from approximately 50-55 p.p.m., depending upon the season of the year, to about 10-20 p.p.m. The process involves chemical feeding, flash mixing, flocculation, and floc removal. Liquid alum is used for coagulation and is fed by two proportioning pumps at an average rate of 1.0 grain, as dry alum, per gallon of water. Dry chemical feeders for lime and clay, and a spare feeder for lime, clay, or dry alum, are also employed in the process. Lime is added for alkalinity adjustment at an average rate of 0.25 grain per gallon of water. Clay may be added as a coagulant at times of low river turbidity in amounts up to 2.0 grains per gallon. These dry chemicals are mixed in solution and, together with the liquid alum, pumped into the flash mixer.

The flash mixer consists of a set of arms rotating on a motor-driven vertical shaft in a tank into which chemicals are introduced and mixed with water flowing to the precipitators. This solution is distributed to the flocculation section where precipitates are formed by the reaction of water and chemicals. Two sets of paddles mounted on horizontal shafts maintain the precipitate in suspension long enough to permit an easily removable floc to form.



The suspended floc is caused to rise at a velocity which, while maintaining it suspended in a blanket of sludge, will not carry it to the surface. Surface water above the sludge blanket is then channeled to the filters. Part of the accumulated sludge is removed automatically when the floc increases the thickness of the sludge blanket above a maximum upper level.

Average detention time in each precipitator is 90 minutes at a rate of 3300 g.p.m.; and in the flash mixer, 10 seconds at a rate of 10,000 g.p.m.

### Filtration

Filtration reduces the turbidity of the clarified water from 10-20 p.p.m. to less than 1-3 p.p.m. by passing the water through a top layer of anthrafil, an intermediate layer of sand, and a bottom layer of graded gravel. Clarified water flows through the filters at a rate of 2.5 g.p.m. per sq. ft. of area until the loss of head gauge indicates that the filters are ready for backwashing. This occurs at a rate of 18 g.p.m. per sq. ft. of area, two wash agitators reducing any lumped filter media. When backwashing is completed, filtration is started again. The first run of filtered water is discharged to waste, but after a consistently good quality of filtered water is obtained it is discharged into the clearwell.

### Ion Exchange

To provide boiler feed make-up practically free of silica and hardness, filtered water is passed through ion exchange units with degasification as an intermediate process for removal of gases formed in the cation units. The cation exchanger is a Zeo-Karb unit in which the metallic ions are replaced with hydrogen ions. The anion exchanger is a Permutit "S" silica absorber unit which removes silica and any remaining acids after degasification.

Water flows from the softeners to the top of the degasifiers, from where it cascades over wood slat trays into a clearwell. An air blower maintains a flow of air up through the cascading water, and air and gases are carried out through a vent at the top of the degasifier tank. The degasified effluent is pumped through the silica absorbers to the Power House.

### Acid Treatment

Treatment of water for use as process feed involves the following measures: (1) feeding sulfuric acid to filtered water to reduce the alkalinity to zero; (2) removal of resulting gases by deaeration; and (3) caustic feeding to maintain a minimum pH for the protection of piping and equipment against corrosion.

Sulfuric acid is fed into either an acid mixing tank or directly into the deaerator inlet line. A system of three steam ejectors and two condensers maintains an almost absolute vacuum in each deaerator. This vacuum reduces the vapor pressure of the incoming water, frees the dissolved gases in the water, and removes them through the vapor outlet to the ejector system. The deaerator effluent is collected and mixed with caustic before delivery to the 200,000-gallon storage tank. Both the acid and caustic feeds are controlled by means of pH meters.

## DRAWINGS

- W-135268 - General Plan.
- W-135826 - General Elevations and Details.
- W-135666 - Pump Reservoir - Concrete Plans.
- W-136066 - Chemical Building - Storage, Precipitators, Filter Operating Floor Arrangement Plan.
- W-135281 - Chemical Building - Plan and Sections.
- W-135747 - Pumps and Piping Arrangement Plans.
- W-135386 - Precipitators - Piping General Plan and Sections.
- W-135227 - Filters - Plans and Sections.
- W-135562 - Pump Platform - Plan and Section - Arrangement.
- W-135285 - Softeners and Silica Absorbers - Plans and Sections.
- W-135262 - Water Flow Diagram.
- W-135600 - Flow Diagrams.
- W-135601 - Flow Diagrams.

## BUILDING #484-D - POWER HOUSE

### FUNCTION

The primary functions of this Power House are to provide process steam and electric power for the #400 Area, power for the #681-5G Water Pump House, and to supplement standby power for all areas and start-up power requirements in the #100 Areas.

### PRINCIPAL COMPONENTS

#### Steam Generation

Four boilers with all necessary associated equipment, such as ducts, breeching, F.D. and I.D. fans, four stacks and miscellaneous tanks and motors, were provided.

Pulverized coal is used as fuel, and fuel oil is used for starting up.

#### Fuel Handling and Storage

A belt-conveyor system, with all necessary motor-drives, scales, gates, hopper, and bunkers, was installed.

Provisions were made for installing an additional belt-type conveyor, anticipating expansion.

Four car pullers were installed on the railroad siding.

A turndozzer and carry-all scraper were provided for stocking out.

The coal storage area has a capacity of 243,000 tons, with provisions made for expansion.

#### Dust and Ash - Handling and Storage

A jet-pulsion system, complete with all necessary hoppers, pumps, drives and conveyor piping was provided.

#### Feed Water System

Each steam generating unit is supplied with an electric motor-driven boiler feed pump for normal use and a turbine-driven pump for standby use.

Each unit was provided also with feedwater heaters, which included one deaerating type heater.

#### Turbo-generators and Auxiliaries

Four 7500-kw. high-pressure turbo-generator units and 4 10,000-kw. condenser extracting low-pressure units were installed. These were complete with all necessary condensers, pumps, motors, ejectors, oil-conditioning equipment, and tanks.

A 50-ton traveling bridge crane was provided.

#### Controls

Automatic controls were provided so that all equipment except ash handling could be started and stopped from the Central Control Room.

Necessary air compressors, driers, and auxiliaries were provided to supply required instrument air.

### Piping System

Complete piping systems were installed for steam, water, chemical feed, ignition and lubricating oil, plant and instrument air, and vent and drain systems.

### Miscellaneous

Six chemical feed systems were provided with all necessary pumps, scales and mixing tanks. Three sets of pumps feed phosphate to the drums and three feed sulphite to the deaerators.

One condensate return unit serves all four boilers.

There are three desuperheating water pumps and four desuperheating tanks.

Blower-type heaters were installed for general comfort-heating throughout the building. The control room, offices, and the meeting and lunch room are heated through the central air-conditioning system which is operated the year round - heating in winter, cooling in summer.

An exhaust system was provided for the toilet and locker areas. A propeller fan in the lunch room furnishes conditioned air. A centrifugal fan supplies filtered air to the switchgear bays, and power-driven roof ventilators exhaust the air from these areas.

The general floor drainage and sanitary disposal is handled by two separate systems.

Incandescent and mercury lamps are installed in the high bays and turbine room. Lighting fixtures in the control room are located in the space between the egg-crate and acoustical ceilings. Long-life fluorescent lamps were used where accessibility presented a problem. PAR-type floodlights illuminate control and panel boards and other vital locations. Emergency lighting was provided, and all outside lights are controlled by the blackout control system.

Domestic and sanitary provisions were made for approximately 80 operating personnel.

### Electrical

The switchgear rooms are arranged vertically.

Seven 10,000-kv. (#451-D) transformers were installed adjacent to this Power House.

Four auxiliary transformers, purchased with other Power House equipment, were installed in the #451-D Primary Substation Area.

The 2.4-kv. switchgear controls the large power plant auxiliaries, and the 2.3-kv./440-v. transformers, rated at 5000-kv.-a. feed the boiler turbine auxiliaries and water treatment plant bus.

A double-ended 600-kv.-a. lighting load center was installed.

Two batteries, with necessary charging provisions, were provided.

The intercommunication system comprises a loudspeaker system for safety-alarm and paging, a hand-powered telephone system and six Bell telephone stations.

| BUILDING FLOOR SPACE                                   | <u>Approx. Sq. Ft.</u> |
|--------------------------------------------------------|------------------------|
| Operating Floor (El. 161'-8")                          | 38,700                 |
| Scales and Lower Heater Floor<br>(El. 177'-8")         | 13,600                 |
| Upper Heater Floor (El. 193'-8")                       | 7700                   |
| Deaerator Platforms                                    | 7700                   |
| Conveyor Floor (El. 216'-8")                           | 5250                   |
| Cable Vault (El. 124'-6")                              | 6550                   |
| Oil Room (El. 135'-8")                                 | 675                    |
| Auxiliary Switchgear Room (El. 135'-8")                | 4350                   |
| Auxiliary Switchgear Room (El. 135'-8")<br>N.E. Corner | 14,700                 |
| Battery Room (El. 135'-8")                             | 725                    |
| Cable Room (El. 151'-0")                               | 6700                   |
| Locker Room (El. 151'-8")                              | 400                    |
| Locker Room - Laborers (El. 151'-8")                   | 160                    |
| Toilet Room (El. 151'-8")                              | 215                    |
| Toilet Room - Laborers (El. 151'-8")                   | 135                    |
| Meeting and Lunch Room (El. 161'-8")                   | 450                    |
| Water Area Supervisor's Office (El. 161'-8")           | 160                    |
| Women's Rest Room (El. 161'-8")                        | 70                     |
| Women's Toilet (El. 161'-8")                           | 70                     |
| Shift Supervisor's Office (El. 161'-8")                | 185                    |
| Results and Clerical Office (El. 161'-8")              | 215                    |
| Chief Supervisor's Office (El. 161'-8")                | 160                    |
| Power Supervisor's Office (El. 161'-8")                | 160                    |
| Control Room (El. 161'-8")                             | 2150                   |
| Toilet (El. 161'-8")                                   | 60                     |
| Maintenance Shop (El. 135'-8")                         | 750                    |

## BUILDING DETAILS

This power house is of Class III construction throughout. The over-all installation is of irregular shape, approximately 243 ft. square and 105 ft. in height. There are two major elevations of operation, with several intermediate floors and platforms.

Area - 44,000 sq. ft.  
Volume - 4,029,000 cu. ft.

## CONSTRUCTION DETAILS

### Foundations

Reinforced concrete with spread footings.

Special reinforced concrete foundations were provided for heavy and vibrating equipment.

### Superstructure

Structural steel frame.

The roof, in general, is of standard girder-beam construction, but a truss roof was installed over the turbine section. Purlins were installed throughout.

The wall adjacent to the electrical equipment, and the exterior fingers separating the transformers outside the building were constructed of reinforced concrete.

The ground floor slab and the major operating and supporting elevated floors are constructed of reinforced concrete. Grating platforms, for free air circulation, were installed adjacent to the boilers, over the turbo-generators and in other vital locations. All construction around the electrical equipment is of reinforced concrete. In general, moment connections in lieu of bracing were adopted to afford more interior space.

### Architectural Features

Roofs and exterior walls were covered with corrugated asbestos sheathing.

### Steel Stud Partitions

These were erected between the 2300-v. - 440-v. switchgear section, separating the control room, lunch and meeting room and offices from the rest of the plant; around the maintenance shops; between the battery room and the

switchgear section; around the compressor room; and separating the toilet and locker area from the rest of the plant.

### Interior Concrete Walls

These were constructed around the oil room and between the plant proper and the battery room.

Some of the panels between the offices and the meeting and lunch room, and those enclosing the control room are metal frames with translucent glass in the upper section. All of the partitions separating these areas are 10 ft. high. Mineral board was installed between the metal frame partition top and the ceiling.

An egg-crate-type ceiling 10 ft. high, with a space between it and the acoustical ceiling, was installed in the control room. Acoustical ceilings were also installed in the meeting and lunch room and office areas.

Hollow-metal-type doors and four large roll-up steel doors were provided.

No windows were installed because of blackout requirements.

## EQUIPMENT

### Mechanical

- 4 Boilers complete with all accessory equipment, 330,000 lbs./hr. 900 p.s.i., 900°F. each.
- 4 Boiler feed pumps with motor drives, 810 g.p.m. each.
- 4 Boiler feed pumps with turbines and trip valves, 810 g.p.m. each.
- 4 sets Ducts, breeching and accessories.
- 4 I.D. Fans and driving units, 190,000 c.f.m. each.
- 4 F.D. Fans and driving units, 105,000 c.f.m. each.
- 4 Stacks.
- 3 7500-kw. Back-pressure turbo-generator units with accessories.
- 4 10,000-kw. Low-pressure turbo-generator units with accessories.
- 4 10,000 sq. ft. Condensers and accessories.
- Coal handling equipment and accessories, 350 short tons/hr., min.
- Ash handling system and accessories: sluice system - 60 tons/hr.; fly ash - 60 tons/hr.
- 2 Ash hopper seal pumps and drivers, 800 g.p.m. each.
- 2 Ash handling water pumps, 2000 g.p.m. each.
- Combustion control systems for all units.

- 1 Condensate return unit, 2 motor-driven pumps, 80 g.p.m. each and 300-gallon tank.
- 7 Control panel boards.
- Pressure gauges and accessories.
- Thermometers and wells.
- 16 Sampling coolers.
  - 1 15,000-gallon Light oil storage tank.
  - 3 Light oil, motor-driven pumps, each 5 g.p.m.
  - 1 Dissolving hydrogen and recording unit, portable.
  - 4 Deaerating heaters and accessories, 350,000 lb./hr. each.
- Chemical feed systems, 3 phosphate pumps, motor-driven, 24 g.p.h. max. each, and 3 sulphite pumps, motor-driven, 8.6 g.p.h. max. each.
  - 1 Platform scale.
  - 2 Electric vibrators.
  - 4 Car pullers with drivers.
  - 4 Instrument air compressors with accessories, 472 c.f.m. each, motor-belt driven.
  - 2 Instrument air driers.
  - 1 Electric hoist and trolley, 5 tons.
  - 1 Turbine room crane, 50 tons main hoist; 10 tons aux. hoist.
- 12 Feedwater heaters and accessories, 4 - 385 p.s.i.g. - 325,000 lb./hr. feedwater each; 4 - 120 p.s.i.g. - 325,000 lb./hr. feedwater each; 4 - L.P. - 283,400 lb./hr. feedwater each.
  - 4 Blowdown heat exchangers, 283,400 lb./hr. feedwater each.
  - 2 Plant air compressors with drives and accessories, 497 c.f.m. each motor-belt driven.
- 10 Steam desuperheat stations.
  - 3 Desuperheater water pumps, 185 g.p.m. each.
- Miscellaneous tanks.
- Sump pumps and drives.

### Electrical

- 4 13.8-kv. Metal-clad switchgear sections.
- 4 5-kv. Metal-clad switchgear sections.
- 4 5000/6250-kv.-a. 13.8/2.4-kv. Auxiliary transformers.
- 1 45-kv.-a. Dry type transformer for the coal handling system.
- 1 9-kv.-a. Dry type transformer for the blackout emergency supply from the diesel engines.
- 4 500-kv.-a. 440-v. Unit load centers.
- 1 208/120-v. Lighting unit load center.
- Panel boards and cabinets for lighting, blackout, coal handling, d.c., control, etc.
- 8 Motor control centers.
- 2 Control switchboards.
- Sound-powered telephone system.



- 1 Loudspeaker system.
- 1 Control power transformer 440/110-v.
- 1 Ground testing device.
- Relay and thermal heaters.
- 10 48 in. Roof ventilators, 20,400 c.f.m. air, motor-drive.
- 6 30 in. Roof ventilators, 3 - 6700 c.f.m. air; 3 - 5600 c.f.m. air, motor-drive.
- 3 24 in. Roof ventilators, 4500 c.f.m. air, motor-drive.
- 1 Ventilating fan, 36,400 c.f.m. air, motor-belt drive.
- 1 Air-conditioning unit and accessories, 10,000 c.f.m. air, motor, fan, compressor.
- 1 Exhaust fan, 2190 c.f.m., motor-belt drive.
- 1 Air-handling system with accessories, 1400 c.f.m., motor-belt drive.
- 1 Hot water heater with storage tank, 560 g.p.m. water.
- 13 Unit heaters with accessories
  - 4 ea. 105,500 B.t.u./hr. min., motor-drive.
  - 6 ea. 263,500 B.t.u./hr. min., motor-drive.
  - 1 ea. 157,000 B.t.u./hr. min., motor-drive.
  - 2 ea. 105,000 B.t.u./hr. min., motor-drive.

## PLANT OPERATION

### Steam

Four boilers, each with a capacity of 330,000 lbs./hr. 900 p.s.i., 900°F., fed with pulverized coal are the source of the principal steam systems serving the power house and process and service buildings in the #400 Area. Served by the main 900-lb. system are three 7500 kw. back-pressure turbo-generator units which exhaust at 385 p.s.i.g., four high-pressure auxiliary oil pumps and two reducing and desuperheating stations which take steam at the boiler outlet pressure and reduce it to 385 p.s.i. at a controlled temperature of 718°F. These were installed to assure a constant supply of steam to the low-pressure turbines. The 385-lb. exhaust system from the high-pressure turbines services the four 10,000 kw. low-pressure turbines, four auxiliary low-pressure oil pumps, four boiler feed pumps and one high-pressure heater. Three desuperheating stations on the 385-lb. system off the high-pressure turbines limit the maximum temperature of steam being supplied to the low-pressure turbines and feed the medium-pressure process lines. Three headers off the 385-lb. system service five desuperheating stations, two of which provide process steam at 380 p.s.i. at a controlled temperature of 460°F. A third station feeds the 130-lb. first extraction system and is controlled at 130 p.s.i. and 588°F. A fourth and fifth reducing and desuperheating station service the 55-lb. second extraction system, one controlled at 412°F. and the other at 307°F. The 130-lb.

first extraction system services four forced draft air heaters, the air dryer coils, the steam jet ejectors and condensers. In addition to meeting partial process needs, the 55-lb. second extraction system includes four deaerators, four desuperheater water storage tanks and four continuous blowdown tanks. A third extraction system off the low-pressure turbines, uncontrolled at 7 lbs., serves the low-pressure heaters.

Each boiler is equipped with pneumatically operated automatic combustion controls which are mounted on the boiler turbine panel in the control room. A graphic type steam distribution panel regulates the flow of process steam and controls the desuperheaters. A third panel in the control room, the graphic type circulating water panel, controls the flow of water to the condensers.

### Electric Power

To meet the total electric power requirements, three 7500 kw. high-pressure units and four 10,000 kw. low-pressure units were installed. The high-pressure units take full boiler pressure at the inlet, while the low-pressure units, which discharge to a condenser, have automatically controlled extraction at 130 and 55 p.s.i.g. and uncontrolled extraction at approximately 7 p.s.i.g. One oil conditioner is used for all turbines.

One unit, consisting of a high-pressure and a low-pressure generator, is connected to a 13.8 kv. bus without tie connections to adjacent 13.8 kv. buses. The generator units are paralleled on the 115 kv. system through step-up transformers. The transformer equipment includes seven 10,000 kv.-a., 13.8/115 kv. units and five 5000/6250 kv.-a., 13.8/2.3 kv. step-down units. Each of the 5000 kv.-a. transformers is equipped with a forced air cooling system to increase its capacity to 6250 kv.-a. so that under emergency conditions each transformer is capable of carrying two boiler and turbine auxiliary buses or both water treatment 2.3 kv. buses.

Switchgear installations are sized at 13.8 kv. and 2.4 kv. All transformer controls and instruments are mounted on the electric control board in the control room. The 2.4 kv. switchgear is primarily for the control of the large power plant auxiliary motors and for the 2.3 kv./440 v. transformers feeding the 400 v. load centers.

## DRAWINGS

- W-135228 - Operating Floor Plan, Units 1, 2 and 3 - Elevation 161'-8".
- W-135339 - Basement Floor Plan, Units 1, 2 and 3 - Elevation 135'-8".
- W-135599 - Plans, Units 1, 2 and 3 - Elevations 124'-6", 151'-0", 151'-8" and Intermediate Platforms.
- W-135671 - Basement Floor Plan, Intermediate Platforms and Plans at Elevations 124'-6" and 151'-0".
- W-135272 - Plans, Units 1, 2 and 3 - Elevations 173'-8" and 169'-8".
- W-135672 - Unit 4, Operating Floor Plan - Elevation 161'-8" and Plans - Elevation 173'-8", 177'-8" and 169'-8".
- W-135095 - General Arrangement - Section - Mechanical.
- W-135194 - General Arrangement - Basement Plan - Mechanical.
- W-135196 - General Arrangement - Operating Floor Plan - Mechanical.
- W-135214 - General Arrangement Plan of Heater Floors.
- W-135106 - Steam Flow Diagrams.
- W-135639 - Arrangement of Electrical Equipment, Unit 4 - Elevation 135'-8".
- W-135183 - 13.8-kv. - One Line Diagram.

BUILDING #485-D - COOLING TOWER

## FUNCTION

This facility provides equipment to cool the circulating water for two 10,000 sq. ft. surface condensers installed with two 10,000 kw. turbo-generators in the #484-D Power House.

## PRINCIPAL COMPONENTS AND OPERATION

Cooling Tower

This is a two-cell, double flow, induced draft cooling tower erected on a concrete foundation which also serves as the cooling water basin. The basin is divided into two equal sections separated by a 10 in. concrete wall, with each section emptying into a pump well (sump) at the north end of the structure. The general depth of the basin is approximately 7 ft., while the pump well is approximately 12 ft. deep.

This installation receives Water from two condensers in the #484-D Power House at 104°F. and returns it at 76°F. based on a wet bulb temperature of 76°F. Each cell has a maximum delivery rate of 9250 g.p.m. The tower operates on the principal of subjecting water dropping through the cells to currents of cooling air induced through the louvered sides of the tower by two roof-mounted I.D. motor driven fans.

Three condenser circulating water pumps, each motor driven, are installed over the pump well. These supply a 42 in. underground header.

#### Basin and Well

|          | <u>Circulating Water Basin</u> | <u>Pump Well</u> |
|----------|--------------------------------|------------------|
| Volume   | 19,500 cu. ft.                 | 3500 cu. ft.     |
| Capacity | 146,000 gals.                  | 28,200 gals.     |

#### Switchgear Building

A separate building houses the switchgear, load center, transformer, panel board, and all other electrical equipment.

#### BUILDING DETAILS

Both the Cooling Tower and the Switchgear Building are of Class III construction.

The Cooling Tower is rectangular in shape and is approximately 65 ft. x 51 ft. x 39 ft. high (above basin wall).

The Switchgear Building is approximately 24 ft. square x 13 ft.-6 in. high to under side of trusses. The floor area is 515 square feet.

|        | <u>Cooling Tower</u> | <u>Switchgear Bldg.</u> |
|--------|----------------------|-------------------------|
| Area   | 3250 sq. ft.         | 575 sq. ft.             |
| Volume | 123,500 cu. ft.      | 10,700 cu. ft.          |

#### CONSTRUCTION DETAILS

##### Foundations

The reinforced concrete foundation of the Cooling Tower also serves as the cold water basin and is approximately 50 ft. wide by 65 ft. long. The walls and floor slab are 10 in. thick.

The pump well is approximately 22 ft. wide by 29 ft. long with walls and bottom slab 12 in. thick. An additional reinforced concrete mat was constructed to support the 42 in. pipe.

A reinforced concrete foundation with spread footings was provided for the Switchgear Building.

### Superstructures

The Cooling Tower framework, casing, and drift eliminators are constructed of California redwood. The Switchgear Building is a standard prefabricated structure with a steel frame, steel truss peaked roof, concrete floor and corrugated asbestos siding and roofing.

One metal roll-up door and one hollow-metal door were provided.

No windows were installed.

### Miscellaneous

A sound-powered telephone station with a howler, which is part of the #483-D Treatment Plant system, was installed at the Cooling Tower. A paging and safety alarm loudspeaker, which is a part of the #484-D Power House system, was also installed.

Special lighting was designed for the Cooling Tower to penetrate the steam vapors with vapor-proof incandescent fixtures.

The Switchgear Building was provided with two ceiling-mounted unit heaters and a roof ventilator.

### Mechanical

- 1 Cooling tower, 18,500 g.p.m., motor-driven fan.
- 3 Circulating water pumps, motor-driven, 9300 g.p.m. each.

### Electrical

- 1 5-kv. Metal-clad switchgear.
- 1 300 kv.-a., 440-v. Unit load center substation.
- 1 D.c. Panel with transfer switch.
- 1 Lighting panel (18-circuit).
- 1 Lighting panel (12-circuit).
- 2 30 amp. Combination starters.

Heating and Ventilating

- 2 Electric unit heaters, 760 c.f.m., 25,590 B.t.u./hr.
- 1 Roof ventilator, 24 in., 3200 c.f.m., motor-driven.

DRAWINGS

- W-135976 - Plot Plan - Electrical.
- D-117590 - Architectural Plan.
- W-136401 - Circulating Water Pit and Pump Well - Plan & Sections.
- W-136318 - Arrangement of Circulating Water Pumps and Piping - Plan & Elevations.
- D-117532 - 2300-v. & 440-v. - One Line Diagram.

BUILDING #487-D - ELEVATED WATER STORAGE TANK*DISMANTLED BY PLAN 1994*FUNCTION

This tank is an emergency storage facility for domestic and boiler feed make-up water for the #400 Area.

PRINCIPAL COMPONENTS

Providing dual purpose storage, the installation consists of two 100,000 gallon tanks one on top of the other. The top tank holds domestic water; the lower tank is for boiler feed make-up water.

Softened water (boiler feed make-up) from the water treatment plant normally by-passes the lower tank on its way to the condenser in the power house. In case of an emergency need, softened water is withdrawn from the lower tank through a special pressure reducing valve. This valve opens when the supply pressure drops, thereby furnishing softened water from storage. The water level is maintained by a booster pump controlled from a pressure switch, operating between maximum and minimum levels, which measures the water in the tank.

The domestic water tank, supplied by deep wells in the area, floats on the line. The water level is kept constant by an altitude valve.

## CONSTRUCTION DETAILS

Over-all height of the tank structure is approximately 200 ft., the center line of the bottom and top tanks being approximately 149 ft. and 182 ft., respectively, above the foundation. Each tank is 30 ft. in diameter, with elliptical top and bottom and is encircled by a steel platform. The upper tank is equipped with a revolving ladder with safety cage.

The supporting tower is mounted on four reinforced concrete column footings, 13 ft. square tapering to 4 ft. extending approximately 7 ft. below grade and 1 ft. above grade. The valve chamber is of reinforced concrete, approximately 11 ft. by 20 ft. by 7 ft. deep, with 3 in. planking cover.

## EQUIPMENT

- 1 Elevated dual tank with all necessary accessories.

## DRAWINGS

- W-135861 - Concrete - Plans and Sections.
- W-136018 - Arrangement - Plans and Sections.

## BUILDING #488-D - ASH DISPOSAL BASIN

## FUNCTION

This facility, as the terminus of the ash sluicing lines, Bldg. #809-D, receives ash from the #484-D Power House steam generating units.

## PRINCIPAL COMPONENTS

Two earth diked basins, of approximately equal size and separated by a common dike, form a roughly rectangular basin unit approximately 1850 ft. by 1050 ft. The dikes extend an average of 12 ft. above grade and are 6 ft. wide on top. Ash is transported to the basins through two parallel overhead sluicing lines. A 30 ft. section of rubber hose is attached to the terminus of each line at the basin inlet, just above the center dike. This arrangement enables the flow through the sluicing lines to be manually diverted into either section of the basin.

Ash from the sluicing lines settles in the basin, while the sluicing water is drained off through concrete overflow culverts - one through the west dike of each section. This is accomplished by means of adjustable risers which extend to the water line within the basin, being coupled to the horizontal culverts.

#### DRAWINGS

W-135944 - Plan and Sections.

#### BUILDING #683-D - CHLORINE UNLOADING AND STORAGE FACILITIES

##### FUNCTION

This facility was provided to unload and store chlorine cylinders required at the Water Pump Houses, Bldgs. #681-1G, #681-3G, and #681-5G.

##### PRINCIPAL COMPONENTS

A concrete platform approximately 25 ft. by 56 ft. with cradles, was provided to store forty 1-ton chlorine cylinders in two rows of twenty each. This platform is located adjacent to the #483-D Water Treatment Plant.

Three trailer trucks (Building #615-G), each with a 10-cylinder capacity, were provided to transport the cylinders to the pump houses.

##### EQUIPMENT

Structural materials for this facility were obtained by field procurement. The trailer trucks were provided by Operations.

#### DRAWINGS

W-142328 - Chlorine Unloading and Storage Facilities.



400

## BUILDING #801-D - PIPE SUPPORTS

### FUNCTION

These supports carry the overhead lines within the #400 Area.

### PRINCIPAL COMPONENTS

For general design see Building #801-R.

To conserve steel, treated wood poles were used in several plant areas, but in the #400 Area steel bents or steel poles were used in some locations because of the heavy loads.

Lines carried within the area include the high and low pressure steam lines, treated water lines, instrument and plant air lines and various process lines, as well as the ash sluicing lines.

### EQUIPMENT

Structural steel, wood poles and hardware.

### DRAWINGS

- W-135590 - Outside Lines - Piping Supports - Wood, Steel, and Concrete Details and Standards.
- W-135980 - Overhead Piping Steel Supports (#801-D).
- W-136001 - Overhead Piping Steel Supports (#801-D).
- Map 3313 - Sheet No. 695 - Outside Lines - Overhead Piping.
- Map 3313 - Sheet No. 696 - Outside Lines - Overhead Piping.
- Map 3313 - Sheet No. 725 - Outside Lines - Overhead Piping Plans.
- Map 3313 - Sheet No. 726 - Outside Lines - Overhead Piping Plans.

## BUILDING #802-D - STEAM LINES

### FUNCTION

These pipe lines carry process and heating steam to the battery limits of the #400 Area.

### PRINCIPAL COMPONENTS

Two 16-inch headers from Building #484-D transport approximately 266,000 lbs. of process steam per hour per line at 385 p.s.i.g. and 460°F., from which distribution is made through branch lines to Buildings #411-D, #421-D, #420-D, #412-D, #413-D and #483-D.

One 24-inch steam header from Building #484-D transports approximately 114,000 lbs. of heating steam per hour at 55 p.s.i.g. and 320°F., from which distribution is made through branch lines to Buildings #411-D, #412-D, #413-D, #420-D, #772-D, #717-D, #707-D and #704-D.

The branch lines are constructed of welded steel pipe, as are the headers, and range in size from 3 to 14 inches.

All lines are drained of condensate by a system of drip pockets and thermostatic traps and/or free-blow valves installed at all low points in the line at approximately every 300 feet.

### EQUIPMENT

All pipe and accessories were obtained by field procurement.

### DRAWINGS

See tabulation under Building #801-D.

## BUILDING #803-D - AIR LINES

### FUNCTION

This pipe line distributes compressed air from the Power House, Building #484-D, to buildings within the #400 Area.

## PRINCIPAL COMPONENTS

One 6-inch "Plant Air" header transports approximately 400 c.f.m. of compressed air at 125 p.s.i.g. for distribution to Buildings #411-D, #412-D, #413-D, #420-D, #421-D and #717-D. A 6-inch "Instrument Air" header transports approximately 800 c.f.m. of compressed air at 125 p.s.i.g. for distribution to the same buildings and, in addition, to Building #772-D.

The air system includes pipe sizes ranging from 2 to 6 inches and the necessary valves and associated equipment.

## EQUIPMENT

All equipment was obtained by field procurement.

## DRAWINGS

See tabulation under Building #801-D.

BUILDING #806-D - WATER LINES (OVERHEAD)

## FUNCTION

These lines distribute process feed water throughout the #400 Area.

## PRINCIPAL COMPONENTS

A 20-inch header from Building #483-D transports approximately 6600 g.p.m. of treated water to Buildings #411-D, #412-D and #413-D.

## EQUIPMENT

All equipment was obtained by field procurement.

## DRAWINGS

See tabulation under Building #801-D.

### BUILDING #809-D - ASH SLUICING LINES

#### FUNCTION

This facility conveys waste ash and sluicing water from the Power House, Building #484-D, to the Ash Disposal Basin, Building #488-D.

#### PRINCIPAL COMPONENTS

Two 10-inch cast iron alloy pipe lines are provided. At the ash basin end of these lines each is equipped with 30 feet of 10-inch rubber hose to permit manual transfer of the ash sluicing mixture from one section of the basin to the other.

#### EQUIPMENT

The piping, fittings, and accessories were obtained as part of the Building #484-D ash handling package unit.

#### DRAWINGS

PF-4508 - Ash Sluicing Piping.  
PF-4509 - Ash Sluicing Piping.

### BUILDING #901-D - WATER LINES (UNDERGROUND)

#### FUNCTION

These lines distribute cooling, circulating, and domestic (sanitary and potable) water within the #400 Area.

#### PRINCIPAL COMPONENTS

The water distribution system consists of the following.

1. A circulating cooling water line from Bldg. #483-D to Bldg. #484-D and return.
2. A circulating cooling water line from Bldg. #485-D to Bldg. #484-D and return.

3. A process cooling water line from Bldg. #483-D to Bldgs. #411-D, #412-D, and #413-D. Branch lines serve Bldgs. #420-D and #772-D.

4. Domestic and drinking water lines throughout the area are served from two wells.

5. A boiler feed make-up line carrying filtered water from Bldg. #483-D to Bldgs. #484-D and #487-D.

6. A cooling tower make-up line carrying filtered water from Bldg. #483-D to Bldg. #485-D.

7. A power plant auxiliary line from Bldg. #483-D to Bldg. #484-D.

8. A precipitator bearing cooling water line carrying filtered water serving Bldg. #483-D, several safety showers and the #480 Buildings.

The system is composed of 54-inch steel, 54-inch reinforced concrete, 42-inch reinforced concrete, 36-inch steel, 36-inch reinforced concrete, 12-inch cast iron, 6-inch cast iron, 4-inch cast iron, 3-inch cast iron, and 2-inch copper pipe.

#### EQUIPMENT

Reinforced concrete cylinder pipe, 54-inch diameter, and fittings, 300 ft. head.

Reinforced concrete cylinder pipe, 54-inch diameter, and fittings, 150 ft. head.

Reinforced concrete cylinder pipe, 42-inch diameter, and fittings, 110 p.s.i.

All other piping, fittings and accessories were obtained by field procurement.

#### DRAWINGS

- Map 3314 - Sheets 725, 726 and 696 - Location.
- W-135902 - Plans and Profile.
- W-135732 - Plans and Profile.
- W-135814 - Profile 42-inch Concrete Water Line.
- W-135963 - Pipe Anchors - Concrete - Plan and Sections (Sheet No. 1)
- W-139951 - Pipe Anchors - Concrete - Plan and Sections (Sheet No. 2)
- W-136135 - Orifice Manhole - Plan and Sections.

BUILDING #902-D - FIRE LINES

## FUNCTION

These lines distribute water for fire protection from Building #483-D to vital locations in the #400 Area.

## PRINCIPAL COMPONENTS

The cast iron underground fire lines range in size from 4 to 14 inches. Fire hydrants are provided throughout the process area and the coal storage area, considered the principal installations requiring fire protection.

## EQUIPMENT

All underground mechanical joint pipe, hydrants and accessories were obtained by field procurement.

## DRAWINGS

Map 3312 - Sheets 725, 726, 695 and 696 - Location.

BUILDING #905-D - WELLS AND PUMPS

## FUNCTION

These facilities provide all domestic water requirements within the #400 Area.

## PRINCIPAL COMPONENTS

The following deep wells and pumps were provided:

| <u>Well</u> | <u>Pump Capacity</u> | <u>Driver HP</u> | <u>Column Depth</u> | <u>No. of Stages</u> |
|-------------|----------------------|------------------|---------------------|----------------------|
| #905-1D     | 600 g.p.m.           | 60               | 68 ft.              | 5                    |
| #905-2D     | 400 g.p.m.           | 50               | 100 ft.             | 10                   |
| #905-41D    | 800 g.p.m.           | 75               | 120 ft.             | 6                    |

These wells were drilled for use initially during construction, but economy dictated their adoption for permanent domestic requirements within this area. Two of these wells

provide sanitary and potable water for general use, while the water from the third and largest pumping unit is used exclusively in the process area.

#### BUILDING DETAILS

A reinforced concrete pad on grade, 10 ft. by 13 ft. was installed at each well.

#### EQUIPMENT

- 1 Vertical, 5-stage, deep well pump and drive, 600 g.p.m.
- 1 Vertical, 10-stage, deep well pump and drive, 400 g.p.m.
- 1 Vertical, 6-stage, deep well pump and drive, 800 g.p.m.
- 3 Pressure reducing valves.

All necessary pipe, valves and fittings and power and control accessories were provided through field procurement.

#### DRAWINGS

See tabulation under Buildings #480-1-2-3D.

AREA #600-G

#### BUILDING #681-1G - WATER PUMP HOUSE

##### FUNCTION

This Pump House supplies chlorinated raw river water to the #100 Areas.

##### PRINCIPAL COMPONENTS AND PROCESS

The facility has a designed capacity of 280,000 g.p.m. and an installed capacity of 224,000 g.p.m. The principal systems and associated equipment comprising this installation are:

##### River Water System

This system incorporates the chain of elements between the water source in the Savannah River and the pipe system designated as Building #901-G.

An excavated earth intake channel, about 1900-ft. in length, conveys water from the river to the pump house. The width of the channel base is 50 ft. at the river entrance, narrowing to 10 ft. along most of its course and widening to 135 ft. at the pump house intake structure. The channel slopes up from its base to grade level in two stages.

The pump house is designed on a unit basis, a separate intake bay being provided for each installed or future pumping unit from the intake entrance. Each bay contains trash racks, an intake gate, traveling screens (except bays for future units), a suction chamber, and a sluice gate for isolating any intake bay.

The trash racks are arranged along the outer face of the concrete intake structure and are installed in two rows, inclined from the vertical at a 15° angle, between steel guide slots in the intake piers. They consist of 4-in. by 7/8-in. iron bars spaced 4 in. on centers. Accumulated trash is removed from the racks with a rake raised and lowered by an 8-ton gantry crane supported on a track on the deck of the intake structure. This crane also is used to lift the travelling screens and trash racks.

Two intake gate panels have been supplied for use in any two of the 10 intake bays when dewatering the respective bays. This permits access to the traveling screens, pump suction elbows, and chlorine diffusers, which are located behind the gates.

The screens are used to remove debris larger than 1/2-in. in the water before it enters the pumps. In order to know when the screens are fouled a differential level indicator shows the loss of head through the screens. This indicator is located near the control room in the pump house so that the operator can note the head loss from time to time.

Eight river water pumping units are installed, with provisions made for the future installation of two additional units if required. Each unit consists of a pump, with a rated capacity of 28,000 g.p.m. against a total dynamic head of 350 ft., and a 3000 hp. induction motor drive. The pumps are centrifugal, single stage, double suction, side discharge types arranged horizontally, with motors totally enclosed and water cooled.

Bearings on each pumping unit are lubricated by an independent closed-oil system which consists of an oil reservoir, a heat exchanger, an oil pump driven by the main pump shaft, and the necessary piping, valves, and fittings.



The motors are cooled by coils supplied with strained water from the service water system. A connection is made to supply the oil heat exchanger on each pumping unit with the water required.

Each pump discharges through a 24-in. line which is equipped with a motor-operated gate valve and a hydraulically-operated cone check valve. Operation of the check valve is controlled by solenoid valves and an oil pressure system which opens the valve slowly after the river water pump has built up pressure; closes the valve slowly at an adjustable rate before the pump motor is tripped; and closes the valve more slowly at a different rate in the event of power failure. The gate valves permit the isolation of any one pumping unit for maintenance and repairs.

Each pump discharge line is joined to a 36-in. line by an increaser beyond the gate valve; and each 36-in. line connects with a 66-in. main pump house discharge header, which is sectionalized by two 60-in. motorized gate valves. Two delivery lines take off from the ends of the header, each consisting of a 90° ell turning upward from the header, a reducing ell, a motorized gate valve and finally a 72-in. supply line. All piping is steel up to the 72-in. supply lines which are reinforced concrete pipe.

#### Service Water System

The auxiliary services within the pump house are supplied from the main discharge header by two loop headers: one carrying water for motor cooling and chlorination, and the other delivering water to the traveling screen wash nozzles. The loop headers provide a dual source of water for each of these services, thereby permitting repairs as required without retarding the water supply to any of the unaffected units.

The service water system consists of 8-in. and 10-in. main piping with smaller take-off piping, the necessary gate valves, pressure reducing valves, pressure relief valves, and strainers. Provisions were made in the design of this system to handle additional requirements if the two future pumping units are installed.

Part of the service water piping is used also to drain the main discharge header when required.

#### Drainage and Dewatering Systems

The drainage and dewatering systems are centered about a sump which receives all water from intake bay, header drainage, and floor drainage. The sump is covered by a concrete slab which serves as a foundation for the three pumps which

take suction from the sump. Two of these pumps are motor-driven vertical sump pumps, each rated at 250 g.p.m. against a head of 65 ft., for drainage; and one is a motor-driven vertical dewatering pump, rated at 1000 g.p.m. against a head of 62 ft., for dewatering intake bays and supplying auxiliary motor cooling water. These pumps are set for operation at various levels and are controlled by float switches.

A discharge line from the dewatering pump and one from the two drainage pumps (which join to form a common header) empty into an intake bay beyond the gate panel.

#### Domestic Water System

Two wells (two of several drilled at the site during construction to relieve artesian pressure) provide the source of water for a domestic water system servicing the drinking, sanitary, and air conditioning facilities installed in this building. On completion of construction of the pump house, these two wells were sealed off from the pressure relief system and connected together to serve as the source of domestic water. Either is considered capable of supplying the domestic water requirements of the pump house. Two plunger type reciprocating well water pumps, one a spare, each rated at 28 g.p.m. at 60 p.s.i., pump water from the wells into a 750-gallon pressure tank. Two chemical solution pumps take suction from a hypo-chlorite solution tank and inject this solution into the water supply line between the well pumps and the pressure tank. The various equipment and fixtures are supplied from this tank, the pumps replenishing the water in the tank as the pressure drops.

#### Hydraulic Oil System

Two interconnected hydraulic oil systems were provided so that all cone check valves could be operated from one accumulator, if necessary. Each system consists of the following components; an air compressor which supplies air at 150 p.s.i. to a 200-gallon pressure tank; an oil header from the pressure tank feeding oil to the cone check valve hydraulic cylinders; an oil return header from the cylinders to a 136-gallon oil sump which is under atmospheric pressure; an oil pump, capacity 12 g.p.m. at 150 p.s.i., taking suction from the oil sump and pumping oil back to the pressure tank; and the necessary switches and valves.

#### Pneumatic System

This system, designed to supply general compressed air requirements throughout the pump house, consists of a 100 p.s.i., 60 c.f.m. air compressor, after-cooler, and air receiver. Air hose connections are run to all points of

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possible use. The air compression equipment for the oil accumulator and river water chlorination systems is not part of this particular pneumatic system.

### Chlorination System

Chlorine is applied to the river water to prevent the growth of organic life and deposition of slime in the pipe lines and other components of the pumping and distribution systems. The chlorine solution is diffused into the water in the intake bays at the traveling screens.

Liquid chlorine is supplied from 1-ton cylinders mounted on a trailer outside the pump house. A common header, connected to each of the ten cylinders, enters the building where take-off lines feed to four liquid chlorine evaporators. Chlorine gas from the evaporators is fed to four chlorinators, each having a capacity of 6000 lbs./day.

A small air compressor, with a spare, supplies compressed air as required for the operation of the evaporators and chlorinators, which are fed through a delivery pipe from a common receiver.

Four injector assemblies, placed some distance apart from the main apparatus, are supplied with service water under pressure and suck chlorine gas from the chlorinators into the service water stream to form a chlorine solution. The four injectors discharge into a common rubber-lined header from which the chlorine solution is drawn into each intake bay through a smaller rubber lined pipe which extends downward to the intake floor. The bottom section of each pipe is perforated with small holes to diffuse the solution into the pump suction stream.

The chlorine rooms housing the evaporators and chlorinators are segregated from the rest of the pump house to prevent the possibility of chlorine gas entering the main pump room.

### Instrumentation

All necessary instruments and gauging devices such as thermometers, float switches, pressure gauges, and flow indicators, with required indicator and alarm provisions necessary for the safe and reliable operation of this facility, were provided. The hydro-board, containing flow, temperature, pressure, and level indicating and recording devices, is located in the control room, as are the electric and chlorination boards and the air conditioning control instrumentation.

### Electrical

A 115-kv. switchyard with all necessary switch structures and busses, comprising two 15,000 kv.-a., 115-kv./4150-v. transformers, 115-kv. horngap switches, two 4160-v. indoor line-ups in the pump house, and one 440-v. indoor switchgear line-up, also located in the pump house, were provided for power supply and control.

### Miscellaneous

In addition to the gantry crane which is located outside, two other cranes are installed in the pump house to facilitate the removal and replacement of equipment: (1) a 20-ton low lift crane located in the main pump room; and (2) a 20-ton high lift crane located in the south access shaft of the building.

A passenger elevator was installed to facilitate the movement of operating personnel between the various levels of the building.

### BUILDING FLOOR SPACE

|                                     | <u>Approx. Sq. Ft.</u> |
|-------------------------------------|------------------------|
| Over-all Area                       | 12,843                 |
| Pump Floor - El. 76'                | 7400                   |
| Operating Floor - El. 90'           | 4350                   |
| Control Room - El. 90'              | 150                    |
| Battery Room - El. 90'              | 90                     |
| Toilet and Locker Room - El. 126'   | 60                     |
| Toilet - El. 126'                   | 25                     |
| Chlorine Evaporator Room - El. 126' | 300                    |
| Chlorinator Room - El. 140'         | 300                    |
| Elevator Machine Room - El. 141'    | 50                     |

### BUILDING DETAILS

This building, of Class I construction, consists of two structures, an intake and the pump house proper. The concrete intake structure facing the intake canal is approximately 134 ft. wide by 30 ft. (44 ft. at base) deep by 65 ft. high and is connected by means of retaining walls to the canal embankments on either side.

The pump house is irregular in shape, the maximum rectangular dimensions being approximately 185 ft. by 78 ft. The over-all height approximately 79 ft., of which 26 ft. is above grade and 53 ft. below grade. Two access shafts at opposite sides of the building project above grade, as does

the intake structure. The roof of the main part of the building is below grade. There are two primary levels of operation: the main pump floor, at elevation 76 ft.; and the operating floor at elevation 90 ft.

Area - 16,170 sq. ft.  
Volume - 805,125 cu. ft.

## CONSTRUCTION DETAILS

### Water Pump House

Foundation - Reinforced concrete spread footings.  
Frame - Reinforced concrete.  
Roof - Flat, reinforced concrete.  
Interior Partitions - Concrete block or reinforced concrete.  
Flooring - Asphalt tile in Control Room. All other areas Class I concrete finish.  
Stairs - Steel.  
Windows - Control Room only, metal with insulating glass.  
Doors - Hollow metal and metal roll-up.

### Heating and Ventilation

Necessary unit heaters and ventilating equipment were installed throughout this structure for the comfort and safety of the operating personnel, and for satisfactory operation of the equipment.

### Air Conditioning

An air conditioning unit was installed in the control room due to the heat load given off by the motors during the summer.

### Lighting

The illumination design for the operating floor comprises two continuous rows of 3-lamp industrial fixtures which are mounted close to the ceiling to provide clearance for plant operations.

Three-lamp fluorescent industrial fixtures are installed in the Switchgear Mezzanine. Lighting for the screens and outdoor gantry crane platform is provided by 300-watt elliptical angle reflectors mounted on 16 ft. high pipe standards.

All outdoor lighting units are provided with blackout control - a blackout contactor operated from two 3-way switches. One of these switches is located in the control room, and the other at the gate entrance to the Substation.

The lighting service is transferred automatically to the emergency d.c. lighting source of power upon failure of the normal a.c. source.

### Fire Control

The building is a fire-proof reinforced concrete structure. However, ample hose connections were provided for the protection of major inflammable equipment installations.

### Safety Alarm

Radio installations were made to provide safety alarm warnings.

## EQUIPMENT

### Mechanical

- 8 Centrifugal pumps with 3000-hp. induction motors, each 28,000 g.p.m., 350 ft. head.
- 1 Emergency diesel generating set, 100-kw.
- 1 Starter and charging generator.
- 1 High-lift traveling crane with motor drive, 20-tons.
- 1 Low-lift traveling crane with motor drive, 20-tons.
- 1 Electric traveling gantry crane with motor drive, 8-tons.
- 8 Traveling water screens.
- 2 4-stage Vertical sump pumps with motor drives, each 250 g.p.m., 65 ft. TDH, with 7-1/2 hp. motor.
- 1 2-stage Vertical dewatering pump, 1000 g.p.m., 40 ft. TDH, with 25-hp. motor.
- 2 Hydraulic accumulator systems with cone check valves.
- 1 Lot Chlorination equipment, 6000 lbs./24 hrs.
- 10 Manually operated sluice gates.
- 2 Domestic water pumps with motor drives, each 28 g.p.m.
- 1 Vertical tank 42 in. x 120 in., 755 gals.
- 1 Lot Polyphosphate and chlorine feed equipment with motor drive, 6.5 g.p.h.

Trash racks, steel intake gates and gate guides were obtained by field procurement.

All piping and supports were obtained by field procurement or from stockpile as indicated by the drawings.

### Electrical

- 2 4.16-kv. Switchgear sections A & B.
- 2 15,000/20,000-kv.-a. 115-4.16-kv. Power transformers.
- 2 112.5-kv.-a. 480/208Y/120-v. Lighting transformers.
- 1 440-v. Unit load substation.



Heating and Ventilating

- 1 Supply fan with V-belt motor drive, 20,394 c.f.m.
- 1 Exhaust fan with V-belt motor drive, 16,380 c.f.m.
- 1 Chlorine room vent fan with V-belt motor drive, 3285 c.f.m.
- 1 Toilet room vent fan with V-belt motor drive, 525 c.f.m.
- 1 Air heater, 10-kw., minimum 34,000 B.t.u./hr.
- 2 Electric unit heaters, 750 watt, with motor drive, each 2500 B.t.u./hr.
- 4 Electric unit heaters, 10-kw., with motor drive, each 1415 c.f.m., 34120 B.t.u./hr.
- 2 Electric unit heaters, 7.5 kw., with motor drive, each 760 c.f.m., 25,590 B.t.u./hr.
- 1 Air conditioning unit, 24,000 B.t.u./hr.
- 1 Propeller fan with motor drive, 200 c.f.m.

DRAWINGS

- W-136842 - General Arrangement Plan - Sheet #1.
- W-135933 - General Arrangement Plan and Sections - Sheet #2.
- W-136037 - General Arrangement Plan and Sections - Sheet #3.
- W-135875 - General Arrangement - Sections - Sheet #4.
- W-135718-A - Flow Diagram - River Water in Pump House.
- W-135718-B - Flow Diagram - Service Water.
- W-135718-D - Flow Diagram - Drainage and Dewatering System.
- W-135719-B - Flow Diagram - Chlorination System.
- W-135719-C - Flow Diagram - Hydraulic Oil System.
- W-135719-D - Flow Diagram - Oil Lubrication System.
- W-135719-E - Flow Diagram - Domestic Water System.
- W-135843 - Floor Plan and Details - Elevation 90'-0".
- W-136179 - Plans at Elevation 76'-0" and 90'-0".
- W-136227 - Plans at Elevation 112'-0" and 126'-0".
- W-136105 - Intake Structure - Plans - Sheet #1.
- W-136044 - Intake Structure - Sections - Sheet #2.

BUILDING #681-3G - WATER PUMP HOUSE

This building was designed as an exact duplicate of Building #681-1G, with the following exceptions:

The intake channel is approximately 1500 ft. long as contrasted with a 1900 ft. channel for Building #681-1G, and does not contain pressure relief wells installed along the center line because artesian pressure beneath this

channel is not sufficiently great to require facilities for its reduction.

Building #681-3G is set approximately 3 ft. lower in the ground than Building #681-1G and its over-all height is approximately 82 ft. of which 55 ft. is below grade - as contrasted to an over-all height of 79 ft. for the #681-1G Pump House, of which 53 ft. is below grade. Each building extends the same height above grade.

One of the factors developed during the site selection investigation concerned the minimum flow of water in the Savannah River. At that time du Pont was advised by the Army Corps of Engineers that the minimum flow of the river would be maintained at 4000 c.f.s. after completion of Clark Hill Dam. Subsequent to the selection of this site, the Corps of Engineers advised that, after the Clark Hill Dam reservoir had been filled to an operating level, the discharge would be so regulated that there would be a minimum rate of flow of 5300 c.f.s. below Augusta in the vicinity of the SRP water pump houses. The elevation of the pumps was therefore established, after allowing for a safety factor, on the basis of the 5300 c.f.s. flow set by the Engineering Corps. Since there was every indication that the reservoir would be full before the #681-3G Water Pump House could be placed in operation, this building was designed to operate simultaneously with Buildings #681-1G and #681-5G at full initial capacity with a minimum river flow of 5300 c.f.s.

However, after design of Building #681-3G was under way, AEC notified Design that the Corps of Engineers was contemplating a reduction in the proposed minimum flow to 3000 c.f.s., and requested Design to investigate the effects of this reduced flow and advise the minimum flow to #681-3G that could be tolerated if 3000 c.f.s. were lower than the acceptable minimum. After a thorough investigation of the water elevation that would result from the lower flow it was determined that if Building #681-3G were lowered 2-1/2 ft. all the pump houses could operate at a flow of 4000 c.f.s. in the river, and under some circumstances of plant demand even 3000 c.f.s. could be tolerated.

It was decided therefore to lower the center line of the Building #681-3G pumps 2-1/2 ft., which required changes in the drawings.

As Building #681-1G and #681-3G are identical except for orientation and the differences listed above, reference is made to the drawings listed under Building #681-1G for details of the structure and the various component systems.

BUILDING #681-4G - WATER PUMP HOUSE

## FUNCTION

This pump house supplies river water to the CMX Building, #679-G.

## PRINCIPAL COMPONENTS

Two vertical submersible five-stage pumps rated at 800 g.p.m. each against a 150 ft. TDH, each powered by a 40 hp. motor, are mounted on a pump platform. Construction of this installation followed drawings prepared by the Construction Division.

BUILDING #681-5G - WATER PUMP HOUSE

## FUNCTION

This facility supplies chlorinated river water to the #400 Area.

## PRINCIPAL COMPONENTS AND PROCESS

Located on the Savannah River, this pump house has a designed capacity of 75,000 g.p.m. It is a rectangular structure, of sheet steel piling, divided into two separate intake chambers above which are mounted six outdoor pumping units. The principal systems and associated equipment comprising this facility are as follows:

River Water Systems

This system incorporates the elements for pumping water between its source in the river and the distribution pipe system designated as Building #901-D.

An excavated earth intake channel, approximately 120 ft. long, conveys water from the river to both intake chambers. From the river entrance the base of this channel narrows to 10 ft. along most of its course, but widens to 37 ft. ahead of the intake chambers. At this point the channel base is of gravel and the sides are faced with stone.

Water entering the intake chambers passes through trash racks and traveling screens installed at the entrance of each chamber. Each traveling screen is 10 ft. wide and the distance between the center lines of the head and foot shafts is 53 feet. The wire mesh screen has 1/2-in. square openings and is cleaned by a water spray. The unit is driven by a 2 hp. totally enclosed motor.

The intake chambers are enclosed by sheet steel piling with each chamber covered by a concrete slab supporting three pumping units. These slabs are placed at the design flood stage elevation (125 ft.). Each of six installed pumping units consists of a vertical turbine pump with a rated capacity of 12,500 g.p.m. against a total head of 105 ft., and a 400 hp. induction motor drive. The motors are cooled by coils supplied with strained water from the service water system.

Each pump takes suction from the chamber over which it is mounted and each discharges through a 20-in. line fitted with a tilting disk check valve, orifice plate and tap for metering, and a gate valve. The discharge lines of each group of three pumping units are connected to a 36-in. steel pipe header which, in turn, is connected to a 60-in. reinforced concrete cylinder pipe through a steel "Y" and a steel-to-concrete pipe adapter. This 60-in. line conveys the water to the #483-D Area Reservoir.

A 6-in. blow-off line to the respective intake chamber is installed in each of the 36-in. steel headers. These lines are controlled by gate valves, and provide for draining the 60-in. delivery line into the intake chambers.

#### Service Water System

Auxiliary services requiring water within this building are supplied from a 6-in. loop header fed by a 6-in. take-off from each pump discharge line. The pump motor cooling coils are supplied with cooling water by 3/4-in. take-offs from the loop header, the cooling water discharge flowing back to the intake chambers.

A 600 g.p.m. screen wash pump driven by a 20 hp. motor takes suction from a 4-in. take-off line from the loop header and discharges screen wash water to the traveling screens through quick opening valves (for spray).

The chlorination system is supplied with water by a 4-in. take-off from the loop header.

Water is piped to the river water pump glands through 1/2-in. lines which take off from each of the 6-in. lines feeding the loop header.

### Chlorination System

Chlorine is injected in the river water to prevent the growth of organic life and the deposition of slime in the pipe lines and other components of the pumping and distribution systems.

Liquid chlorine is stored in eight 1-ton cylinders mounted on cradles inside a storage shed on the operating floor at the rear of the building. These cylinders are manifolded to a common supply header which feeds an evaporator in the chlorine room, also located on the operating floor.

Chlorine gas from the evaporator is fed to a solution feed vacuum chlorinator having a capacity of 6000 lbs./24 hrs. Filtered service water is supplied to the chlorinator from the main service water line to the chlorine room. An injector assembly, supplied with service water under pressure, sucks the liquid chlorine solution from the chlorinator into the service water stream. This solution is fed intermittently to the river water through a solution line, and is applied through a rubber-lined and covered chlorine solution diffuser installed in each intake chamber.

A small compressor supplies compressed air for the operation of the evaporator, chlorinator, and the valves controlling the intermittent feeding of the chlorine solution to the intake chambers.

### Electrical

Two 13.8-kv. feeders, and two 1500-kv.-a., 13.8-kv.-a., 13.8-kv./440-v. outdoor unit substations located on the operating floor provide the power required for operation.

### Miscellaneous

A monorail with trolley and 10-ton overhead electric hoist are installed above each set of three pumping units to facilitate the removal and replacement of equipment.

### BUILDING FLOOR SPACE

|                                        | <u>Approx. Sq. Ft.</u> |
|----------------------------------------|------------------------|
| Operating Floor - Elevation 125'       | 4100                   |
| Operating Floor - El. 73' (coffer dam) | 1600                   |
| Chlorine Room - El. 125'               | 140                    |

## BUILDING DETAILS

This pump house is of Class III construction, irregular in shape, and with maximum rectangular dimensions of approximately 83 ft. by 61 ft. The over-all height is 52 ft. to elevation 125 ft., the operating floor. Height of the structure from the floor of the intake chamber to the monorail is 82 ft.

The dimensions of each intake chamber are approximately 19 ft. wide by 43 ft. long by 50 ft. deep.

The chlorine room measures approximately 14 ft. by 10 ft. by 11 ft. average height.

## CONSTRUCTION DETAILS

Base slab (Elevation 73 ft.) - Reinforced concrete.  
Reinforced concrete footings under steel columns support the structure.  
Floor slab (Elevation 125 ft.) - Reinforced concrete.  
Coffer dam - Steel sheet piling.  
Stairs - Steel.  
Windows - Steel.  
Doors - Steel.  
Handrails, toe-plates, gratings, ladders with cages, and all other necessary safety installations were provided.

### Chlorine Room

Foundation - Operating floor slab (Elevation - 125'-6").  
Frame - Steel.  
Roof - Beam and girder (peaked).  
Roof covering - Corrugated steel.

### Chlorine Cylinder Shed

Foundation - Operating floor slab - Elevation 125'.  
Frame - Steel.  
Roof - Beam and girder (sloped).  
Siding - Corrugated steel.  
Roof covering - Corrugated steel.

The fixed lighting was supplemented by the installation of two incandescent searchlights with an illumination range to cover the river front on a normal beam projection of 500 ft.

The chlorine room was equipped with a propeller-type exhaust fan for the removal of chemical fumes, and a roof

mounted ventilator and louvers in the doors provide general ventilation. A unit heater also was installed in this room.

## EQUIPMENT

### Mechanical

- 6 Vertical turbine pumps, each rated at 12,500 g.p.m., with 400 hp. induction motor drives and pushbutton stations.
  - 2 10 ft. wide Traveling screens with a.c. magnetic starters and 100-v. pushbutton service.
  - 2 Trash racks.
  - 2 Electric chain hoists with motor drives, each 10 tons.
  - 1 Chlorinating unit, 6000 lbs./24 hrs.
  - 1 Screen wash water pump with motor drive, 600 g.p.m.
- All necessary piping, valves and fittings were obtained by field procurement.

### Electrical

- 2 1500-kv.-a. 13.8-kv./440-v. Outdoor unit substations.
- 1 15-kv.-a. Transformer for lighting and misc. power.
- 1 Lighting panel.
- 2 500-watt Floodlight projectors.
- 1 24-v. D.c. howler.

### Heating and Ventilating

- 1 6.1-kw. Electric unit heater with combination starter and motor drive, 20,810 B.t.u./hr.
- 1 16 in. Propeller type exhaust fan with motor watchman starter and motor drive, 2000 c.f.m.

## DRAWINGS

- W-138244-A - Flow Diagram - River Water in Pump House.
- W-138244-B - Flow Diagram - Service Water.
- W-138244-C - Flow Diagram - Chlorine Control System.
- W-135010 - Piping - Plans and Sections.
- W-135011 - Plot Plan and Profile.
- W-135014 - Piling and Framing - Steel.
- W-135016 - Sections - Steel.
- W-135017 - Plans and Sections - Concrete.
- W-135103 - Foundation Plan - Concrete.

## BUILDING #901-G - WATER LINES

### FUNCTION

These water lines deliver raw river water from the River Pump Houses #681-1G and #681-3G to the five #100 Areas, and from Pump House #681-5G to the #400 Area.

Lines in the #100 Areas other than the main river water supply line are identified as Buildings #901-R, #901-P, #901-L, etc. The main river water supply line within the #100 Areas is designated Building #901-G.

### PRINCIPAL COMPONENTS

The river water supply system consists of approximately 48 miles of lock-joint reinforced concrete pipe ranging in size from 48 in. to 84 in.

One line runs from #681-5G to the #400 Area and is entirely independent of the remainder of the system.

Two lines each run from #681-1G and #681-3G to the Ellenton header located about one mile away and, from the Ellenton header, a supply line runs to each of the #100 Areas.

Shut-off valves are located in each of the main supply lines near the Ellenton header, in the Ellenton header itself, and in the cross connection between the lines and the header. These are cast steel gate valves manually operated and ranging in size from 48 in. to 66 in. Motorized cast steel gate valves ranging in size from 54 in. to 60 in., which act as shut-off valves at the ends of the lines, are located in each of the #100 Areas. (These motorized valves are within the fenced areas, except those for the #100-R Area where they are located immediately outside the fence.)

Butterfly and Dow pivot valves are located at the delivery points within the fenced areas at the ends of the lines.

Blow-offs, access manholes, air releases valves, air inlet valves and special air inlet valves are built into the lines.

A venturi meter is located in each of the lines adjacent to Pump Houses #681-1G and #681-3G.



Two venturi meters also are installed in the #100-R Area only, since there is no Building #183-1 in any of the other #100 Areas, in both the normal and the emergency supply lines to pace the chemical feed to Building #183-1R. The flow meters at the Pump Houses are used to determine the total amount of river water being delivered to the system.

The gate valves are housed in covered concrete pits extending slightly above established grade.

The manually operated gate valves around the Ellenton header are equipped for air-wrench operation, with a mobile air compressor being provided for this purpose. This mobile unit is radio-equipped to receive project-wide instructions and security warning signals.

A 2 ft. minimum cover was provided for all pipe outside the fenced areas and a 3 ft. minimum cover was provided for installations within the areas.

Retention basins with riprap are constructed adjacent to each special air valve installation to prevent erosion when the valves discharge. All necessary piping and ditching are provided to drain these basins.

The special and regular air inlet valves are covered by housings, and simple wooden box structures are provided around each of the air release valve installations.

Automatic gas heating is provided to maintain the temperature of the Pelton valves above freezing.

Concrete pipe anchors are provided at all tees and bends as required.

Concrete cradles are placed under the pipe at points where excessive back-load pressures were expected, or where the soil bearing value was too low.

Approximately 180 manholes were required, and four markers are installed at each manhole location.

#### BUILDING (HOUSING) FLOOR SPACE

|                                                    | <u>Approx. Sq. Ft.</u> |
|----------------------------------------------------|------------------------|
| 3 Housings for 6 special air inlet valves,<br>each | 280                    |
| 1 Housing for 5 special air inlet valves           | 266                    |
| 4 Housings for 3 special air inlet valves,<br>each | 192                    |

|     |                                                                  |     |
|-----|------------------------------------------------------------------|-----|
| 8   | Housings for 2 special air inlet valves, each                    | 165 |
| 8   | Housings for 2 regular air inlet valves with 10 in. flange, each | 142 |
| 117 | Valve boxes for 4 in. air valves, each                           | 6   |

## BUILDING DETAILS

The valve housings along this line are of Class III construction, and rectangular in shape.

## CONSTRUCTION DETAILS

### Housings for Special Air Inlet Valves

Height - 11 ft.

Foundation - Creosoted wood sills.

Frame - Wood.

Siding and Roof Covering - Corrugated asbestos.

The bases of all these buildings are set about 3 ft. below grade with the floor elevation at the same level as the top of the pipe.

### 117 Valve Boxes

Height - Dependent on depth of pipe - to Grade in all cases.

Material - Creosoted timber.

Access - Hinged trap door.

### Manholes (Buried)

Material - Cast steel.

4 Location markers were provided at each manhole, so that they may be located easily.

## EQUIPMENT

All piping of reinforced concrete ranging in diameter from 48 in. to 84 in.

|     |                                                            |
|-----|------------------------------------------------------------|
| 24  | Line valves, 48 in. to 66 in. gate valves.                 |
| 117 | Air release valves.                                        |
| 85  | Blow-off gate valves, ranging in size from 6 in. to 12 in. |
| 14  | Valve operating air motors.                                |
| 67  | Air inlet shut-off valves, 6 in. and 8 in. gate valves.    |
| 4   | 72 in. Venturi meter tubes.                                |
| 48  | Companion flanges, 48 in. to 66 in.                        |

- 16 Air inlet valves, 6 in.
  - 51 Special slow-closing air inlet valves, 8 in.
  - 2 Air compressors, skid-mounted, 160 c.f.m. for use with running gear.
  - 12 Recording pressure gauges
- All necessary blow-off piping, valve boxes, frames and covers, air valve piping and miscellaneous steel piping and fittings were obtained by field procurement.

## DRAWINGS

### Hydro

- W-135011 - Plot Plan and Profile.
- W-136128 - General Arrangement.

#### #681-1G to Header (North Line)

- W-135790 - General Plan.

#### #681-1G to Header (South Line)

- W-135778 - General Plan.

#### #681-3G to Header (North Line)

- W-136480 - General Plan.

#### #681-3G to Header (South Line)

- W-137752 - General Plan.

#### Ellenton Header and Cross Connections

- W-135720 - General Plan.

#### Header to #100-R Area

- W-135788 - General Plan.

#### Header to #100-P Area

- W-137846 - General Plan.

#### Header to #100-L Area

- W-137809 - General Plan.

#### Header to #100-K Area

- W-137824 - General Plan.

Header to #100-C Area

W-137859 - General Plan.

Intersection #100-R-P Area

W-137756 - General Plan.

Emergency Connection to #100-R Area

PF-4749 - Profile Station 0+00 to 10+72.25.

Emergency Connection to #100-P Area

PF-4705 - Profile Station 0+00 to 7+83.00.

Emergency Connection to #100-L Area

PF-4718 - Profile Station 0+00 to 6+35.07.

Emergency Connection to #100-K Area

PF-4737 - Profile Station 0+00 to 17+34.13.

Emergency Connection to #100-C Area

PF-4735 - Profile Station 0+00 to 18+06.67.

BUILDING #905-G - WELLS AND PUMPS

## FUNCTION

This facility supplies domestic water requirements to the Locomotive Shop Building #618-G, the River Pump Houses Building #681-1G and 3G, and to the Gate Houses.

## PRINCIPAL COMPONENTS

#905-26G

A deep well and a 75 g.p.m. pump at 370 ft. TDH with a 10-hp. motor are installed adjacent to Building #618-G Locomotive Shop.

#905-2 & 3G

These wells which were drilled originally for construction purposes, are provided to supply domestic water requirements to Building #681-1G Pump House. They comprise only

the well with risers and required air release valves and manholes. The pumps servicing these deep wells are a part of the #681-1G installation. The 750-gallon tank provided for this facility also was obtained as a part of the #681-1G procurement. Provisions are made to install deep well pumps in the future, if required.

#### #905-4G

Initially, it was planned to utilize two of the pressure relief wells drilled for construction purposes at Bldg. #681-3G for domestic water supply for Bldg. #681-3G. It was decided subsequently to drill a new well for this water supply. This is serviced by pumps installed as a part of the equipment in Building #681-3G. The 750-gallon tank provided for this facility also was obtained as a part of the #681-3G procurement.

#### #905-6, 7, 8, 9, and 10G

A 5-g.p.m. turbine pump with motor drive, a chlorinator and a pressure tank were obtained by field procurement for each of these wells which supply domestic water to the following perimeter Gate Houses:

| <u>Well</u> |     | <u>Gate House</u> |
|-------------|-----|-------------------|
| #905-6G     | for | #701-2G           |
| #905-7G     | for | #701-3G           |
| #905-8G     | for | #701-4G           |
| #905-9G     | for | #701-5G           |
| #901-10G    | for | #701-6G           |

An enclosed building was constructed at each location.

#### #905-11G

A 15 g.p.m. turbine pump with motor drive, chlorinator, and a pressure tank were obtained by field procurement for this well which supplies domestic water for the Patrol Training Headquarters, Bldg. #661-G.

#### BUILDING FLOOR SPACE AND DETAILS

The six Class III structures - one each at 6G, 7G, 8G, 9G, 10G and 11G - each have 49 square feet, being approximately 7 ft. by 7 ft. by 8 ft. high.

## CONSTRUCTION DETAILS

The installation at 1G was made on a concrete slab. For the structures at 6G through 11G the foundation is reinforced concrete and the frame is wood. Roof and siding are wood and with corrugated asbestos covering. A 1-1/2 kw. electric wall heater and thermostat are installed in each of the structures at #905-6G and through 11G.

## EQUIPMENT

#905-1G

- 1 20 Stage turbine deep well pump with 10 hp. motor drive (75 g.p.m.).

#905-2G

The pumps servicing this well were procured as part of equipment for Building #681-1G.

#905-3G

The pumps servicing this well were procured as part of equipment for Building #681-1G.

#905-4G

The pumps servicing this well were procured as part of equipment for Building #681-3G.

#905-5G

The pumps servicing this well were procured as part of equipment for Building #681-3G.

#905-6G, 7G, 8G, 9G, 10G & 11G (Each)

- 1 1-1/2 kw. Electric wall heater.
- 1 Thermostat.
- 1 8-circuit Lighting panel.
- 4 Lighting fixtures.

The turbine deep well pump with motor drive, the chlorinator, pressure tank, receptacles and switches were all obtained by field procurement.

## DRAWINGS

- W-136424 - Underground Service to Building #618-G.
- W-138810 - Well Pump Houses - 6G through 10G.

- W-138520 - Domestic Water Piping - Plans and Sections (Bldg. #681-1G.).
- W-137267 - Domestic Water Piping - Plans and Sections (Bldg. #681-3G.).

#### AREA #700-A

#### BUILDING #782-A - RESERVOIR (GROUND TANK)

##### FUNCTION

This structure is a back-up storage facility for the domestic, fire, and service water systems supplying the #300/700 Area from three deep wells. (See Building #905-M in #300 Area.)

##### PRINCIPAL COMPONENTS

The basic structure consists of two vertical steel tanks, one centered within the other. The inner tank, 27 ft. in diameter, stores domestic water - 150,000 gal. capacity; the outer tank, 50 ft. in diameter, stores both fire and service water - 350,000 gal. capacity, 100,000 of which is reserved for fire water exclusively. Over-all height of this ground tank is approximately 37 ft. and the total capacity is 500,000 gal.

A supply line from the wells discharges into the inner tank which remains filled at all times and overflows into the surrounding tank. However, the outer tank can be filled directly from the supply line by means of manually-operated valves diverting the flow from the inner to the outer tank.

Flow is normally controlled by a float valve actuated by the water level of the outer tank. An overflow nozzle is located at the maximum water level in the outer tank which is slightly below the water level of the inner tank. A by-pass line enables the flow to be diverted around the tank when desired.

Chlorine solution is fed into the tank inlet line through a hose and, when necessary, can be fed into the by-pass line. Lime also is fed into the inlet line for pH correction.

All service, fire and domestic water distribution pumps are located in Building #784-A - Power House. Water from the Reservoir flows to the service water pumps from the outer tank by way of a 16-in pipe line which connects with a nozzle located 10 ft. above the tank bottom. The fire water pumps are supplied in the same fashion, the nozzle, however, being located approximately 6-in. above the tank bottom. The domestic water pumps are supplied through a pipe line which connects with the inner tank. The domestic water discharge nozzle is located 6 in. above the bottom of the inner tank.

This arrangement permits the retention of an emergency supply of fire water, since service water, although not physically separated from fire water, cannot be withdrawn below the 10 ft. level of the tank - the bottom 10 ft. being reserved for fire water.

Two floor drains are located on the bottom of the tank - one each in both inner and outer sections. Water drains through these into a sump and from there to the sewer.

A Bell telephone station is installed adjacent to the Reservoir.

The general outdoor safety alarm system serves this facility.

#### CONSTRUCTION DETAILS

These two concentric tanks are erected on a crushed stone foundation on grade. The roof, or top, is accessible by means of a caged ladder and is provided with a valve operating platform and roof hatches for interior maintenance.

#### EQUIPMENT

- 1 Ground storage tank, 500,000 gal. capacity (150,000 gal. inner capacity - 350,000 gal. outer capacity).
  - 3 Automatic tank gauges.
  - 1 6-in. Float control valve.
  - 1 pH Cell.
- All necessary pipe, nozzles, reducers, valves, and hose.

#### DRAWINGS

- W-136172 - Ground Storage Tank - Plan Section and Arrangement.
- W-136024 - Foundations.



BUILDING #784-A - BOILER HOUSE

## FUNCTION

The primary function of this facility is to supply the process and heating steam required in the #300/700 Area. No electric power is generated in this building.

## PRINCIPAL COMPONENTS

Steam Generating Units

Steam is generated by two 60,000 lbs./hr. stoker fired, Combustion Engineering - Superheater, Inc., boiler units producing saturated steam at an operating pressure of 325 p.s.i.g. Each unit includes the following components: a traveling grate spreader stoker with dual drive feeders; pressure parts; casing; soot hoppers; cinder return system; overfire-air system; air heater; dust collector; windbox; duct from air heater to windbox; flue to air heater; flue to dust collector; two sets of ducts and breeching including flue from dust collector to I.D. fan, breeching, and F.D. duct from fan to air heater.

Two turbine-driven F.D. and I.D. fans are mounted on a common shaft. The F.D. fans are designed for 19,500 c.f.m. 100°F., at a pressure of 4.75 in. W.G. The I.D. fans are designed to expel products of combustion at 38,500 c.f.m., 460°F., at a draft of 9.5 in. W.G. These units are regulated by the combustion control system. Provision was made for the future installation of a motor drive on fans, if desired.

A single stack, 75 ft. high by 6 ft. top diameter, serves both boilers.

Coal Handling System

The coal handling equipment consists of a car puller for placing coal cars, a double track hopper, reciprocating feeder, belt conveyor, weightometer, a magnetic pulley for tramp iron removal, a crusher, bucket elevator, stocking-out chute, and screw conveyor across the coal bunkers.

Ash Handling System

A pneumatic-type ash removal system was provided. This includes the following components: boiler ash hopper gates; ash piping; dust collector outlet valves; dust piping and fittings; steam vacuum producer; primary and secondary separators; air washer; and controls.

All ash removed from the steam generating units is discharged into an overhead concrete ash silo. A rotary unloader was installed to control the feeding rate of ashes and to eliminate dust when emptying ashes into cars or trucks from the silo. A reinjection system is included to permit the re-burning of large particles of fly ash collected in the primary stage of the dust collectors. The conveyor system has an operating capacity of 30 tons per hr. and the fly ash system has an operating capacity of 12 tons per hr.

### Pumping Station

The west section of the Boiler House is utilized as a pumping station for water distribution within the #300/700 Area. The following pumps were installed here: four centrifugal service water pumps, three with motor drives and one with turbine drive; three domestic water pumps, two with motor drives and one with turbine drive; three boiler feed pumps, two with turbine drives and one with motor drive; and two fire pumps, one turbine-driven, the other motor-driven.

### Feedwater System

A deaerator with all necessary valves, float box, alarm switch, vent condenser, control storage tank and other components was installed on the roof over the pump room. This unit was designed for an outlet capacity of 123,000 lbs./hr. The deaerator is mounted on a 500 cu. ft. horizontal storage tank from which water flows to a boiler feed pump suction header.

Internal boiler feedwater treatment equipment consists of storage, dissolving, mixing and feeding tanks, portable mixers, and pumps. This equipment is located in the chemical room and on the operating floor above the locker rooms. Provisions were made for testing the feed water at specified intervals.

### Combustion Control System

Combustion control equipment was installed to control steam pressure, steam flow, air flow, fuel feed, and furnace draft. The control panel board is located on the operating floor. Manual control devices also were provided with the combustion control system. Annunciator alarms are located on the panel board.

### Compressed Air Facilities

Two 7 in. x 7 in. vertical, single-stage, double acting, water cooled, dual-chambered air compressors, with an air

receiver, instrument air dryer, after-coolers, valves and accessories, were provided to furnish the required instrument air. One air compressor suffices for normal operations, the other serving as a standby. A steam-driven air compressor was also installed for use in case of electric power failure.

### Miscellaneous

A 440-v. unit load-center was provided to feed all motor-driven pumps, coal and ash handling systems, and all other electrically operated equipment.

The operating floor, 10 ft. above grade, supports the main steam header and valve system. The motor control centers are installed at grade level.

### BUILDING FLOOR SPACE

|                                        | <u>Approx. Sq. Ft.</u> |
|----------------------------------------|------------------------|
| Ground Floor                           | 3800                   |
| Operating Floor                        | 1600                   |
| Chemical Room                          | 350                    |
| Toilet Room #1                         | 125                    |
| Locker Room #1                         | 100                    |
| Toilet Room #2                         | 60                     |
| Locker Room #2                         | 170                    |
| Results Engineer's and Clerical Office | 170                    |
| Area Engineer's Office                 | 130                    |
| Foreman's Office                       | 130                    |

### BUILDING DETAILS

This building, of Class III construction, is irregular in shape with over-all dimensions, including irregularities, of 67 ft. by 62 ft. There are three primary floors of operation: the ground floor at Elevation 378'-8"; the operating floor at Elevation 378'-8"; and the Chemical Room at Elevation 398'-8". The Crusher House platform, 12 ft.-6 in. above grade, is located south of the Boiler House and is 12 ft. x 15 ft. - an area of 180 sq. ft.

|                              |                 |
|------------------------------|-----------------|
| Over-all area                | 3,795 sq. ft.   |
| Volume of enclosed structure | 130,195 cu. ft. |
| Volume of open structure     | 72,240 cu. ft.  |

## CONSTRUCTION DETAILS

### Boiler House

Foundation - Reinforced concrete spread footings and grade beams.

Frame - Steel.

Roof - Standard girder beam.

Roof covering - Built-up roofing over concrete slab.

Wall siding - Flat asbestos.

Partitioning material - Steel stud, cement asbestos board, with Keene's cement plaster wainscot 5 ft.-6 in. high in toilet rooms.

Flooring - Concrete Class I finish with asphalt tile in certain spaces.

Stairs - Steel.

Windows - Commercial projected steel sash.

Doors - Hollow metal, steel roll-up, and metal-clad slidings.

### Heating and Ventilating

One 36 in. ventilator for general building ventilation and one 18 in. ventilator for office, toilet, and locker area ventilation are mounted on the roof. Both are power driven. Adjustable louvers on the west side of the operating floor and two large doors, open at all times, provide ventilation around the boilers. One large door and louvers are installed in the Chemical Room to disperse fumes.

Two unit heaters supply heat for the Pump Room area and a third is installed in the Chemical Feed Room. The office, toilet, and locker areas are heated by radiators. A hot water storage tank and heater are installed for domestic purposes.

### Lighting

The illumination design was prepared with special emphasis upon lighting around the control board and other control devices. All lighting is regulated by the black-out control system.

### Communication and Alarm Systems

Safety, fire alarm, and sound-powered systems were provided. Five common-talking, common-signaling stations were installed and a separately mounted howler was provided. One of these stations is equipped with a sound deadening telephone booth. A safety alarm amplifier system with eight loudspeakers was installed.

Bell telephone instruments are installed in the Area Supervisor's, Foreman's, and Results Engineers' offices with another located near the control board.

## EQUIPMENT

### Mechanical

- 2 60,000 lbs./hr. Steam generating units.
- 1 Stack.
- 2 Forced draft fans, duplex mounted; with reduction gears and turbine drive.
- 2 Induced draft fans, duplex mounted; with reduction gears and turbine drive.
- 1 Ash handling system.
- 2 Boiler non-return valves.
- 1 Combustion control system for both boilers with control panel including:
  - 2 Sets of Boiler draft gauges.
  - 2 Boiler meters.
  - 2 Feedwater meters.
  - 2 Boiler temperature recorders.
  - 2 Boiler feedwater regulators.
- 2 Sets of Coal bunker gates, coal meters, and distributors to stoker hoppers.
- 1 Coal handling system.
- 1 Vertical track hopper sump pump with motor drive.
- 1 Deaerating heater, including overflow controls, level gauge, steam and water thermometers, safety and vent valves, and water inlet control valve.
- 3 Four-stage 170 g.p.m. boiler feed pumps, including all necessary couplings and three boiler feed pump recirculating controls. Two of the pumps are turbine-driven and one is motor-driven.
- 1 Continuous blow-down and blow-off system for both boilers, including sample coolers, flow control valves, flash tank with level gauge alarms, safety valve, and heat exchanger.
- 1 Chemical feed system, including:
  - 4 Chemical feed pumps with motor drives, 8.7 g.p.h.
  - 1 Caustic unloading pump with motor drive, 10 g.p.m.
- 2 Air compressors with motor drives, 105 c.f.m.
- 1 Steam-driven air compressor, 97 c.f.m.
- 3 Domestic water pumps, two motor-driven and one turbine-driven, each 350 g.p.m.
- 2 Fire water pumps, one motor-driven and one turbine-driven, each 1000 g.p.m.
- 4 Service water pumps, three motor-driven and one turbine-driven, each 500 g.p.m.
- 1 Instrument air dryer, 100 c.f.m.

- 1 Reinforced concrete ash silo, 16 ft. I.D. x 25 ft. high, approximate capacity 500 cu. ft.
- 1 Electric hoist with motor drive, 1000-lb. lift.
- 1 Set of water laboratory equipment and chemicals.
- 1 Car puller with motor drive, capacity 3 loaded cars at 45 f.p.m.
- 1 Blow-off tank, 48 in. O.D. x 7 ft.-9 in. high, approximate capacity 90 cu. ft.
- 1 Steam pressure reducing valve, steam to 125 p.s.i.g. maximum capacity 11,000 lbs./hr.
- 1 Water pressure reducing valve, emergency water line from fire pump, maximum capacity 300 g.p.m.
- 1 Steam pressure reducing valve, steam to deaerator, maximum capacity 9000 lbs./hr.
- 1 Water pressure reducing valve, by-pass from blowdown heat exchanger, maximum capacity 210 g.p.m.
- 1 Well water meter.
- 1 Domestic water meter.
- 1 Service water meter.
- 1 Bulldozer for coal handling, obtained by field procurement.

Steam separators for all turbine drivers.

All necessary exhaust line pressure relief valves for boiler feed turbines, chemical feed pumps, compressors, domestic and service water pump turbines; also safety valves on 135 p.s.i.g. steam line to ash silo and air dryer, and exhaust steam header.

All necessary steam gauges for boiler feed, service water, domestic water, fire water, chemical feed, turbine drivers and stoker.

### Electrical

- 1 1500-kv.-a., 440-v. Unit load center substation
- 2 45-kv.-a., 480/208Y-120-v. Lighting transformers.
- 5 Motor control centers.
- 1 Miscellaneous control switchboard.
- 1 D.c Control power distribution cabinet.
- 1 A.c. Power distribution cabinet, miscellaneous power.
- 1 D.c. 100 amp. Transfer Switch.
- 1 Blackout control cabinet.
- 1 Current relay, magnetic pulley circuit.-
- 1 A.c. 4/C Cabinet - 208-120-v.
- 2 9-kv.-a., 3-phase 480/208Y-120-v. Transformers.
- 1 Lighting panel, blackout.
- 2 30-amp., 120-v. Automatic transformer switches.
- 2 Lighting panels.
- 1 18/C Lighting panel.
- 1 Indoor telephone, load dispatcher's circuit.
- 1 Assembly for intercom system.

- 1 Noise reducing telephone booth.
  - 4 Splash proof assemblies for intercom system.
  - 1 Contactor, size - 00.
  - 2 Terminal blocks and mounting brackets, AH-CH Load center.
  - 1 100-watt Single rack cabinet.
  - 6 Loudspeaker assemblies.
  - 2 Horn type loudspeaker assemblies and transformers.
- Approximately 320 lighting fixtures with necessary brackets and stanchions.
- Necessary conduit, conduit fittings, pull and junction boxes, receptacles, switches and hardware were obtained by field procurement.

All necessary grounding material and hardware, including bare copper ground cable, lugs, ground rods, tile pipe, connectors, together with the required supporting steel, splicing material, and terminals were also obtained by field procurement.

#### Heating and Ventilating

- 1 18 in. Roof ventilator, 1040 c.f.m.
- 1 36 in. Roof ventilator, 9800 c.f.m.
- 2 Unit heaters with motor drive, each 722 c.f.m., 38,500 B.t.u./hr.
- 1 Unit heater with motor drive, 587 c.f.m., 44,000 B.t.u./hr.

#### Architectural

- 1 Hot water storage tank and heater, 24 in. diameter x 84 in. high, 200 g.p.h.
- 2 Electric water coolers, 10 g.p.h. each.

### PLANT OPERATION

#### Boiler Feedwater Flow

Approximately 80 per cent of the required boiler feedwater is make-up. This flows by gravity from the outer section of the #782-A Ground Tank to the Power House where it is pumped by the service water pumps through the blowdown heat exchanger to the deaerator.

The remaining 20 per cent of the boiler feedwater is supplied to the deaerator as exhaust steam from the auxiliaries and as steam from the continuous blowdown flash tank. The water in the storage tank on which the deaerator is mounted flows to the main boiler feed pump suction header.

From here the feedwater is pumped by the boiler feed pumps through the main or auxiliary boiler feed headers to the boilers at a pressure somewhat in excess of the 325 p.s.i.g. drum pressure, and at a temperature of approximately 240°F.

### Steam Generation and Flow

Each steam generator is fired by a continuous ash discharge spreader stoker feeding a mixture of nut and slack Eastern bituminous coal at a rate of 5200 lb. per hr. when the boiler is operating at 60,000 lb. of steam per hr. Each stoker is fed by a 3000 lbs. capacity hopper which supplies coal to three dual drive feed units. These are normally turbine driven, but motor drives are also provided. The grate has a continuous forward motion and also operates on dual drive.

Combustion air is supplied to each boiler through an air preheater by a single F.D. fan at 290°F. Air is admitted to the stoker in three zones arranged across the furnace under the grate. These underfire air intake zones are regulated by dampers located at the side of the boiler. The products of combustion are removed from each boiler by one double inlet I.D. fan.

The over-all boiler efficiency at the 60,000 lbs./hr. firing rate is 82.5 per cent.

An automatic-manual type combustion control system regulates the supply of fuel and air to each boiler in proportion to its steam load, maintaining constant steam pressure and optimum combustion efficiency. Normally, the automatic control is in continuous use, the manual control being used during emergencies or special conditions such as very low loads.

Steam is generated at 325 p.s.i.g., saturated, at drum outlet and flows to the steam header. The export line from the steam header supplies the heating and process steam required throughout the #300/700 Area. One hundred per cent make-up water is required to compensate for the steam exported for heating and process, as there is no condensate return.

Within the Power House the following turbine drives are supplied directly from the steam header: boiler feed-water pump driver; combined F.D. and I.D. fan driver; fire pump driver; stoker and feeder drivers; service water pump driver; and domestic water pump driver. All plant accessories requiring steam are also supplied directly from the steam header.



### Boiler Feedwater Treatment

The well water to the #782-A ground storage tank, from which the make-up water is taken, is characterized as being low in hardness and total solids. As a result, internal boiler treatment only is required. This is accomplished through a chemical feed system which includes mixing and feed tanks and solution pumps. By means of this system a solution of trisodium phosphate is prepared and fed directly into the drum. Sulfite is fed into the suction header of the boiler feedwater pumps. The phosphate solution is added to reduce scale formation, while the sulfite solution is added as a corrosion inhibitor.

Exhaust steam from the various auxiliary drive turbines is exhausted into a low pressure system which leads to the deaerator. The make-up water enters the deaerator through a vent condenser and is heated by the exhaust steam to a temperature of approximately 240°F. The deaerator operates at a pressure of 15 p.s.i.g. and has an outlet capacity of 123,000 lb. of effluent per hour. It delivers boiler feedwater containing not more than .005 ml. of dissolved oxygen per liter. Undissolved gases are vented off through the vent condenser.

### Continuous Blowdown

To limit the solids in the concentrated boiler feedwater to a maximum of 3000 p.p.m., a continuous boiler blowdown is maintained. This blowdown is discharged into the continuous blowdown flash tank at 20 p.s.i.g. The flashed steam enters the low pressure system and flows to the deaerator. The drain from the flash tank discharges through the tubes of a blowdown heat exchanger for further removal of useful heat into the make-up feedwater ahead of the deaerator. Following the heat exchanger the blowdown water is discharged to the sewer.

### Coal Handling System

On the basis of two boilers generating 60,000 lbs./hr. continuously, this plant required 130 tons of coal per day.

Coal is emptied into a double track hopper (2-12 ft. x 12 ft.) which connects to a reciprocating feeder. It then is passed to a coal crusher by a belt-conveyor. The crusher can be by-passed when not required. Both the crusher and by-pass are located at the base of a bucket elevator which raises the crushed coal to a screw conveyor for distribution to the boiler coal bunkers. Coal from the bunkers is then delivered to the stoker hoppers through a non-segregating-type distributor chute.

Coal can also be chuted to the stock-out pile from the top of the bucket elevator.

#### Ash, Cinder and Dust Handling System

Furnace ash is discharged into a hopper directly in front of the boiler, the hopper being designed for an eight hour capacity, assuming 15 per cent ash. Ash from the hopper and from underneath the furnace grate, and fly ash from the dust collectors and stack, is pneumatically transported into an overhead ash silo by means of a vacuum handling system. Fly ash from under the boiler section and from the primary hoppers of the dust collectors is reinjected into the furnace to reduce unburned carbon losses.

#### DRAWINGS

##### Mechanical

- W-135178 - General Arrangement - Plan and Elevation.
- W-135851 - Power Block - Plot Plan - #300/700 Area.
- W-135741 - Flow Diagram - Sheet 1.
- W-135158 - Flow Diagram - Sheet 2.
- W-135629 - Flow Diagram - Sheet 3.
- W-135148 - Coal Handling System.
- W-137922 - Ash Disposal System.

##### Electrical

- W-142327 - Blue Print File Reference List - Electrical Equipment #300/700 Area.

##### Structural

- W-135740 - Foundation Plan and Sections.

##### Architectural

- W-135741 - Floor Plans - Elevations 378'-8" and 388'-8".
- W-135799 - Floor Plans - Elevations 398'-8" and 406'-3-1/4".
- W-135849 - Floor Plans - Elevations 417'-9-1/4" and Roof Plan.
- W-135910 - Elevations and Details.

BUILDING #785-A - COOLING TOWER-AND CHLORINE BUILDING

## FUNCTION

This facility provides cooled and chlorinated water for the condensers installed in the #789-A Refrigeration Building.

## PRINCIPAL COMPONENTS

Cooling Tower

This is a three-cell, double flow, induced draft cooling tower erected on a concrete foundation which also acts as the cooling water basin. The installation receives water from the condensers in Bldg. #789-A at 91°F. and returns it at 85°F., based on 78° wet bulb temperature, at a maximum flow of 22,000 g.p.m. It operates on the principal of subjecting water dropping through the cells of the tower to currents of cooling air induced through the louvered sides of the tower by three roof-mounted motor-driven fans.

Four condenser water circulating pumps, three turbine-driven and one motor-driven, are installed over the sump at the west end of the cooling water basin. This sump has removable screens to filter out foreign matter as protection for the pump impellers.

Chlorine Building

This structure houses a semi-automatic, volumetric, solution feed, vacuum-type chlorinator and an evaporator. The chlorinator is fed from one-ton chlorine cylinders. Space was provided for three of these cylinders, which are handled by a monorail hoist installed for this purpose. Chlorine is added to the condenser cooling water to control algae growth in the Cooling Tower basin.

Barometric Condenser

A barometric condenser is provided to condense a maximum of 15,000 lbs./hr. of exhaust steam from the turbine-driven pumps. This installation, in addition to the condenser, includes a hotwell, condensate return pump, steam-type air ejector, controls, and all necessary accessories. The unit is installed adjacent to the northwest corner of the Cooling Tower. It requires condensing water at a rate of 300 g.p.m. and a temperature of 85°F., and operates at a condensing pressure of 15 in. Hg absolute.

The condensate return pump is attached to the base of the condenser and discharges into the Cooling Tower return water line, allowing the condensed steam to return to the system.

### Circulating System

Two 36-in underground supply and return lines from the circulating system between the Cooling Tower and the condenser in the #789-A Refrigeration Building. The flow is measured in the 36-in supply line.

### Electrical

Electrical power to operate the motor for the circulating water pump and the Cooling Tower fans is fed respectively from the 2400-v. and 440-v. switchgear located in the #789-A Refrigeration Building. The barometric condenser return water pump, the Chlorine Building auxiliaries, air compressor, heater and ventilation fans, are fed from the 440-v. motor control center. An electrical distribution unit, including the lighting panel, three combination starters and switches, is installed outside the Chlorine Building. The chlorine program feed control panel, with alarm horn and solenoid valve, is installed inside the building.

### BUILDING DETAILS

Cooling Tower and the Chlorine Building are both Class III construction.

The Cooling Tower is rectangular in shape and approximately 91 ft. by 53 ft. by 27 ft. high.

The Circulating Water Pit and Pump Well is rectangular in shape and approximately 106 ft. by 53 ft., with a depth varying from 7 ft. to 14 ft.

The Chlorine Building is rectangular in shape and is 26 ft. by 16 ft.

|        | <u>Cooling Tower<br/>(Structure)</u> | <u>Cooling Tower<br/>(Circulating<br/>Water Pit and<br/>Pump Well)</u> | <u>Chlorine<br/>Building</u> |
|--------|--------------------------------------|------------------------------------------------------------------------|------------------------------|
| Area   | 4823 sq. ft.                         | 5600 sq. ft.                                                           | 416 sq. ft.                  |
| Volume | 130,221 cu. ft.                      | 46,300 cu. ft.                                                         | 5200 cu. ft.                 |

## CONSTRUCTION DETAILS

### Foundations

The Cooling Tower has a reinforced concrete foundation which also serves as the Circulating Water Pit and Pump Well.

The Chlorine Building foundation consists of concrete piers on footings with connecting grade beams.

### Superstructures

The Cooling Tower framework, casing, drift eliminators and fan deck are constructed of California redwood. The Chlorine Building is a steel frame structure with concrete slab floor and a peaked, beam and purlin roof. The wall siding is flat asbestos cement board and the roof covering is corrugated asbestos cement board.

### Intercommunication

A common-talking, common-signaling sound-powered telephone station with a separately mounted howler is installed for intercommunication between this facility and the #789-A Building. An extension to the Bell telephone station in #789-A was installed at the Chlorine Building. The general outdoor safety alarm loudspeaker system is sufficient coverage for this facility.

### Lighting

The lighting was designed to penetrate the steam vapors, with vapor-proof incandescent fixtures being provided. All lighting is regulated by the blackout control system.

### Heating and Ventilating

Two ceiling-mounted unit heaters and three ventilation fans were installed in the Chlorine Building. A door and adjustable louvers were provided to disperse chlorine fumes.

## EQUIPMENT

### Mechanical

- 1 Cooling tower with motor drive, 22,000 g.p.m.
- 4 Circulating pumps, 1 motor-driven and 3 turbine-driven, each 7700 g.p.m.
- 1 Cooling tower make-up control valve and level control.
- 1 Lot chlorination equipment, 2000 lbs./24 hrs.

- 1 Low level barometric-type steam condenser, 15,000 lb./hr.
- 1 Condensate return-pump with motor drive, 320 g.p.m.
- 1 Chain hoist, hand operated, 4000 lb.
- 1 Orifice plate.
- 1 Lifting clamp for chlorine cylinder.

All necessary pressure gauges, pressure switches and alarms, steam separators, steam separator air ejector, safety valves and expansion joints.

### Electrical

- 1 Transformer, 3 kv-a.
- 1 Weather-proof 4-wire lighting panel.
- 1 Lighting panel, 8-circuit.
- 1 Blackout control cabinet.
- 3 4-unit Stop-start pushbutton stations - NEMA IV.
- 7 Momentary contact start-stop pushbutton stations - NEMA IV.
- 3 Maintained contact start-stop pushbutton stations - NEMA IV.
- 3 Manual motor starters - NEMA IV.
- 3 Combination motor starters - NEMA IV.
- 1 Assembly for intercommunication system.

All necessary conduit, conduit fittings, pull - and junction boxes, receptacles, switches and hardware were obtained by field procurement.

### Heating and Ventilating - (Chlorine Building)

- 2 10-kw. Electric unit heaters with motor drives and thermostats, 134,150 B.t.u./hr.
- 1 16-in. Ventilation fan with motor drive and back-draft damper, 2300 c.f.m.

### DRAWINGS

- W-139923 - Chlorine Building - Plans, Sections and Arrangements.
- W-136295 - General Arrangement - Plan and Section.
- W-138799 - Chemical Building - Plan, Elevation and Details.

BUILDING #769-A - REFRIGERATION BUILDING

## FUNCTION

This centralized refrigeration facility supplies chilled water to Buildings #703-A, #708-A, #719-A, #720-A, #735-A, #736-A, and #773-A for air conditioning purposes.

## PRINCIPAL COMPONENTS AND PLANT OPERATION

Refrigeration Units

The design capacity of this equipment is 3300 tons of refrigeration. Four refrigeration units are installed - three centrifugal water-cooled units of 1350-ton capacity each and one 305-ton booster unit of the same type. One of the 1350-ton units is a spare which is partially loaded during periods of peak demand.

The three 1350-ton units, transferred from the Hanford Engineer Works, are each driven by a 200-hp. motor and include compressors, refrigerant condensers, and chilled water coolers (evaporators). This equipment was reconditioned and adjusted to cool recycled water from approximately 54°F. to 45°F. at a rate of 3600 g.p.m. The units discharge into a common header from which chilled water is piped to each of the seven #700 Area buildings noted above for comfort air conditioning.

The 305-ton booster unit chills water from 45°F. to 39.5°F. at a rate of 1330 g.p.m. It is driven by a 400-hp. motor, taking suction off the main header. This 39.5°F. water is piped to Buildings No. #736-A, #735-A, and #773-A where certain instrument areas of these structures require closely controlled conditions of temperature and humidity.

All four of these refrigeration units use Freon-114 refrigerant.

Chilled Water Circulating Pumps

Four 3750 g.p.m. motor-driven chilled water pumps, also transferred from Hanford, circulate water through the coolers and supply the distribution systems to the point of use in the various buildings serviced by this facility. These pumps and associated equipment are installed outside of the building.

### Auxiliaries

Auxiliaries to this facility include 13.8-kv., 2400-v., and 440-v. switchgear cubicles with all necessary motor generators, batteries, charging sets, motor control center and panels; refrigerant pump-out and charging units; compressed air supply; and a pneumatically operated control system.

### BUILDING FLOOR SPACE

|                        | <u>Approx. Sq. Ft.</u> |
|------------------------|------------------------|
| Building Proper        | 6000                   |
| Battery Room           | 90                     |
| Toilet and Locker Room | 150                    |

### BUILDING DETAILS

This is a Class III, single-story building approx. 50 ft. wide by 121 ft. long by 23 ft. average height.

|        |                 |
|--------|-----------------|
| Area   | 6000 sq. ft.    |
| Volume | 138,000 cu. ft. |

### CONSTRUCTION DETAILS

Foundation - Concrete piers on square footings under columns, with connecting grade beams.

Superstructure - Frame - structural steel.

Roof - Truss - peaked.

Roof Covering - Corrugated asbestos - cement.

Wall siding - flat asbestos - cement.

Doors - Hollow metal.

Flooring - Concrete slab.

Partitioning Material - Steel studs and flat asbestos cement board.

Ceiling - 1/4 in. Asbestos cement board.

Special concrete foundations were provided for heavy equipment.

Two concrete trenches were constructed, one for refrigeration piping and the other for electrical cables.



A steel frame structure was provided to support the elevated chilled and condenser water piping.

Heating and Ventilating - Six unit heaters, four at 164,000 B.t.u./hr. each, were installed in the general plant space - one at 19,500 B.t.u./hr. in the Toilet and Locker Area and one at 10,000 B.t.u./hr. located in the Battery Room.

Four roof ventilators, each rated at 20,000 c.f.m., one toilet exhaust fan and adjustable louvers were provided for ventilation. One exhaust fan was provided for the Battery Room.

Plumbing - All necessary sanitary provisions were made, including an electric water heater to supply domestic hot water and an electric water cooler for drinking water.

Lighting - The lighting provisions here were of the standard type for a facility of this character. A d.c. source of power was provided for lighting in the event of power failure. All lighting is regulated by the black-out control system.

Intercommunication and Safety Alarm - A safety alarm loud-speaker, a sound-powered telephone and a Bell telephone station were provided to supply safety warning signals, intercommunication between this building and the #785-A Cooling Tower and outside communication, respectively.

## EQUIPMENT

### Power

- 3 Complete refrigeration units #1 - 2 - 3 - reconditioned and transferred from Hanford Works, each 1350 tons.
- 3 2000-hp. Motors.
- 1 15-hp. Motor with controls.
- 3 Gears.
- 3 Condensers.
- 1 Pumpout unit condenser.
- 3 Float chambers.
- 3 Water coolers.
- 3 Purge units.
- 3 Gauge and safety control boards.
- 2 Freon receivers.
- 1 Pumpout compressor.
- 1 Manual vane control.
- 4 Weather-proof covers for pumpout units.

- 4 Chilled water pumps - transferred from Hanford, each 3750 g.p.m.
- 4 75-hp. Motors.
- 1 Centrifugal water cooling unit, refrigeration unit #4 and accessories, 305 tons.
- 1 Instrument air compressor, V-belt motor drive and accessories, 55 c.f.m.
- 1 Complete standard building.
- 16 Pressure gauges.
- 34 Thermometers and wells.
- 1 Vertical expansion tank, 72 in. diameter x 96 in. high, approximately 220 cu. ft.
- 1 Make-up water control valve.
- 1 Leveltrol.
- 4 Alarms and pressure switches.
- 1 Pressure switch.
- 2 Refrigeration stop valves.
- 4 Refrigeration relief valves.
- 4 Refrigeration bursting disks.
- 2 Pressure gauges.
- 3 Air regulating valves.
- 4 Safety valves.
- 4 Flow meters, chilled water.
- 1 Flow meter and accessories, condenser water.

#### Heating and Ventilating

- 4 Unit heaters with motor drives, each 175,000 B.t.u./hr. with two thermostats.
- 1 Pressure reducing valve, 700 lb./hr. saturated steam.
- 4 48-in. Roof ventilators with motor drives, each 20,750 c.f.m.
- 1 Toilet exhaust fan with motor drive, 950 c.f.m.
- 2 Unit heaters with thermostats and motor drives, each 25,000 B.t.u./hr.
- 1 Battery room exhaust fan with automatic damper and motor drive.

#### Electrical

- 1 24-kv. Metal clad switchgear.
- 1 440-v. Unit load center substation.
- 2 1500-kv.-a., 3 phase, 60 cycle Outdoor transformers.
- 1 440-v. Motor control load center.
- 1 13.8-kv. Indoor substation metal clad switchgear, oil circuit breakers.
- 1 45-kv.-a., 3 phase, 60 cycle Transformer.
- 2 Combination motor starters.
- 4 600-v. 3-phase Motor starters.
- 63 Cable trays and associated material including Unistrut fittings.
- 1 30-amp. Automatic switch.

- 1 Station control power battery with 3-kv. battery charging MG set.
- 2 MG sets.
- 2 MG set equilizer panels.
- 2 100-amp. Circuit breakers.
- 1 50-amp. Circuit breaker.
- 1 Lighting panel and NEMA I cabinet.
- 1 Blackout control cabinet.
- 1 Annunciator and relay cabinet.
- 3 2000-hp. Motor control panels.
- 1 Control panel for 400-hp. motor, - for refrigeration unit #4.
- 3 2000-hp. Motor field rheostats.
- 3 Exciter cubicles.
- 1 12-circuit 208/120-v. a.c. Deion distribution panel, indoor.
- 1 12-circuit 125-v. d.c. Deion panel, indoor.
- 1 10-circuit 600-v. Deion panel, indoor.
- 1 Regular and emergency lighting panel.
- 9 Momentary contact pushbutton stations.
- 1 Momentary contact pushbutton station, 4 unit, Red - Green - Start - Stop.
- 2 Start - Stop contact pushbutton stations.
- 3 Surge protection units.
- 2 Welding receptacles.
- 2 Loudspeaker assemblies, type TC.
- 2 Horn type loudspeaker assemblies.

All necessary conduit, conduit fittings, junction and pull boxes, splicing material, lugs and terminals, safety switches and hardware were obtained by field procurement.

#### Plumbing

- 1 Electric water cooler, 10 g.p.m.
- 1 Electric water cooler, 80 g.p.m.

#### DRAWINGS

##### Mechanical

W-136366 - General Arrangement.

##### Architectural

D-117638 - Toilet and Locker Areas and Battery Room.

##### Structural

W-137941 - Foundation Plan - Concrete.

## BUILDING #801-A - PIPE SUPPORTS

### FUNCTION

This facility supports the overhead steam lines from Building #784-A, the Boiler House, to various buildings within the #700-A Area.

### PRINCIPAL COMPONENTS

The lines are supported on creosoted wood poles with cross-arms.

### EQUIPMENT

All required equipment and material for this facility were obtained by field procurement.

### DRAWINGS (#801 & #802-A)

Map 3313 - Sheet #1123 - Location.  
PF 4514 through 4545 - Overhead Piping and Supports -  
Plans, Sections and Details.  
PF 4527 and 4528 - Overhead Piping and Supports -  
Plans, Sections and Details.  
PF 4530 and 4531 - Overhead Piping and Supports -  
Plans, Sections and Details.  
PF 4533 and 4535 - Overhead Piping and Supports.

## BUILDING #802-A - STEAM LINES

### FUNCTION

This facility consists of overhead piping for steam distribution from Building #784-A, Boiler House, to various buildings within the #700 Area.

### PRINCIPAL COMPONENTS

Pipe sizes ranging from 3 to 10 inches were required for steam lines in the area. The design included all necessary valves, drip pockets and traps. A minimum height of 7 feet is maintained over the yard area, 17 feet over roads, and 22 feet over railroads.

## EQUIPMENT

All piping and accessories were obtained by field procurement.

## DRAWINGS

See tabulation under Building #801-A.

BUILDING #901-A - WATER LINES

## FUNCTION

This system distributes water to all points of use in the #700 Area.

## PRINCIPAL COMPONENTS

All water used in the area originates in a three-well system which discharges into the Ground Storage Tank, Building #782-A.

Domestic water lines include the 12-inch suction line from Bldg. #782-A to a point adjacent to Bldg. #784-A, Power House, and the 12-inch domestic water header from that point. Depending upon uses and quantities required, the system piping ranges in size from 1 to 12 inches.

The entirely separate service water system also originates at Bldg. #782-A. A 14-inch header continues to a point near Bldg. #784-A and from there branches out in 3 to 14-inch piping to supply laboratory and process users and the cooling tower basin make-up in Bldg. #785-A.

Condenser water for the Refrigeration Building, #789-A, is pumped from the basin of the cooling tower to the condensers. Return water is sent to the top of the cooling towers. Service water is added automatically for condenser water make-up.

Chilled water from Bldg. #789-A is distributed through a closed system to the various buildings. Pumps at these buildings return the water to the chilled water pumps by way of an expansion tank at Bldg. #789-A.

With one exception the service and domestic water piping 3 inches in diameter and larger is cast iron, centrifugally cast, of the mechanical joint type. The smaller domestic piping is soft copper tubing. The 3-inch supply line to the Chlorine Building, #905-A, branching from the 12-inch main supply west of Bldg. #784-A, is seamless carbon steel.

#### EQUIPMENT

All piping, fittings and accessories were obtained by field procurement.

#### DRAWINGS

Map 3314 - Sheet #1123 - Location.  
Map 3314 - Sheet #1153 - Location.  
W-136195 - Details - Underground Piping.  
W-138675 - Chilled Water Lines - Piping Details.

#### BUILDING #902-A - FIRE LINES

#### FUNCTION

Water for fire protection in the #700 Area is distributed through these lines from the area reservoir, Building #782-A.

#### PRINCIPAL COMPONENTS

The installation consists of cast iron, mechanical joint, underground piping in sizes from 3 to 16 inches, together with the necessary hydrants, post indicator valves and auxiliary equipment.

#### EQUIPMENT

All piping, hydrants and accessories required for complete fire protection in the area were obtained by field procurement.

## DRAWINGS

Map 3312 - Sheet 1123 - Location.  
 Map 3312 - Sheet 1153 - Location.

BUILDING #905-A - WELLS AND PUMPS (INCLUDING CHEMICAL BUILDING)

## FUNCTION

All #300/700 Area water requirements, including domestic service and fire protection are furnished and treated by components of this facility.

## PRINCIPAL COMPONENTS

## Well Specifications:

| <u>Well No.</u> | <u>Capacity</u> | <u>Pump</u><br><u>Rating</u> | <u>Column</u><br><u>Depth</u> | <u>Pipe</u><br><u>Size</u> | <u>No. of</u><br><u>Pump Stages</u> |
|-----------------|-----------------|------------------------------|-------------------------------|----------------------------|-------------------------------------|
| #905-A-15       | 450 g.p.m.      | 60 hp.                       | 220'                          | 6"                         | 8                                   |
| #905-A-20       | 1000 g.p.m.     | 150 hp.                      | 290'                          | 8"                         | 7                                   |
| #905-A-31       | 1000 g.p.m.     | 150 hp.                      | 250'                          | 8"                         | 7                                   |

Chlorine and lime solutions are injected in the water before it is stored in the 500,000-gallon reservoir, Building #782-A. A Chemical Building is provided for this process.

## BUILDING DETAILS

The Chemical Building is a one-story, Class III, 15 ft. by 16 ft. structure with a peaked roof. It has an area of 240 square feet and a volume of 3000 cubic feet.

## CONSTRUCTION DETAILS

Building foundations are reinforced concrete with spread footings. The structural steel frame has flat cement asbestos board siding and corrugated asbestos roofing. The floor is a concrete slab. The building is heated by a 15-kw. electric heater circulation-vented through an exhaust fan installed at a backdraft damper.

The vertical turbine type deep well pumps are located out-of-doors on concrete pads. Reinforced concrete pads 10 ft. square are installed also at each well location.

## EQUIPMENT

### Mechanical

- 1 Electric motor-driven deep well pump, 450 g.p.m., 60 hp.
- 2 Electric motor-driven deep well pumps, 1000 g.p.m. 150-hp.
- 2 Chlorinators, 75 lbs./day capacity.
- 1 Lime feeder, 60 lbs./hr. capacity.
- 1 pH Recorder with alarm and signaling equipment.
- 1 Electric heater, 15-kw.
- 1 Propeller fan.

The test orifices were transferred from equipment purchased for the boiler.

### Electrical

- 1 3-kv.-a. Transformer, lighting, 480/120-v.
- 1 Blackout contactor and relay cabinet.
- 1 Lighting panel, 8-circuit.

All necessary conduits and fittings, racks, grounding cable, rods and similar accessories were obtained by field procurement.

## DRAWINGS

- D-117599 - Chemical Building, Architectural - Plan, Elevation and Details.
- W-137995 - Chemical Building and Deep Well Pumps - Piping.



PART II

ELECTRICAL FACILITIES

SAVANNAH RIVER PLANT  
ENGINEERING AND DESIGN HISTORY

PART II - ELECTRICAL FACILITIES

I - INTRODUCTION

In 1950, the initial outline of contemplated facilities for the Savannah River Plant indicated that numerous and unusual electrical engineering problems would be encountered. The history of the solution of many of these problems is covered in this volume, while others are discussed in the histories of the individual areas.

Early surveys had shown that a serious shortage of available power existed in the area of the selected site and that the age and type of systems then in use cast doubt upon their quality and reliability as suitable sources of power for the type of production being planned. Recorded in chronological sequence are the alternative evaluations and exhaustive negotiations conducted with public utilities, governmental authorities and operating groups. These led to ultimate decisions to provide "on-site" power generation coupled with public utility power for added flexibility, standby power, and means for future plant expansion if required.

The development of the resulting electrical transmission and distribution system presented many complex problems including considerations of capability, flexibility, dispersal, stability, and protection against blast damage, sabotage and lightning. It will be noted that time was a critical factor in the early stages, first to meet temporary construction requirements and later to provide production power in the quantities demanded by the sequencing of power facilities.

As described under appropriate headings, other systems included in the over-all design and development of electrical facilities incorporated many special features. Among these were supervisory control, telemetering, pilot wire relaying, and emergency power supplies of varied and unique characteristics. Blackout lighting was provided as well as communication systems to perform a multiplicity of functions including radio and telephone dispatching, radio train control, policing and safety alarm for production and military protection.

## SECTION II —

DEVELOPMENT OF POWER SUPPLY PLAN

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## II - DEVELOPMENT OF POWER SUPPLY PLAN

During the site survey period, preliminary contacts had been made with the Department of Interior and South Carolina Electric & Gas Company to determine the availability of power suitable for use at the Savannah River Plant. These preliminary investigations resulted in the following statement in the site selection report: "In common with other sites, electric power is not adequate to supply the plant, and evaluations have been based upon the generation of electric power on the site". Nevertheless, a policy was established which required a complete, detailed investigation of all possible suppliers of electric power for the Savannah River Plant to determine the availability, cost, and reliability of electric power. These early discussions and negotiations with power suppliers were based on supplying 125,000 kw. with three points of delivery at the plant site. Because of their locations, the following three power producers were considered the most likely primary sources:

1. South Carolina Electric & Gas Company (SCE&G Company);
2. South Carolina Public Service Authority (Santee Cooper); and
3. South Eastern Power Administration - Department of Interior Agency (SEPA).

Certain other major utility companies which, by virtue of their direct or indirect transmission system ties with SCE&G Company, could become involved in a possible power pool included the Carolina Power and Light Company, Georgia Power Company and Duke Power Company. Although there were no formal power-pooling agreements between SCE&G and these adjoining utilities, the latter had expressed a willingness to help. Therefore, data were obtained on their generating capabilities and system loads to determine the possible extent of their potential contributions to the Savannah River Plant power requirements. The initial round of negotiations with these utility companies for the supply of purchased power on the aforementioned load basis developed the following proposals and information.

### **SOUTH CAROLINA ELECTRIC & GAS COMPANY**

From the beginning, the SCE&G officers had expressed a willingness to provide all or any portion of the SRP power requirements. They noted that the plant site lay within the SCE&G service area; that their system was interconnected

with several neighboring systems; and that a new SCE&G transmission line section under construction passed through the plant site. SCE&G also had a new steam-operated generating unit under construction which it was estimated would be in operation by the late summer of 1951. SCE&G was willing also to reinforce its existing transmission facilities and to construct new facilities for "wheeling" power from SEPA's Clark Hill Dam and the Santee Cooper system. In its formal proposal, this firm offered to supply the 125,000 kw. and to deliver it at three separate points in the plant area, this power to be furnished from a new steam plant of two 75,000 kw. turbo-generators which would be located on the Savannah River. For back-up protection against interruptions of this service, SCE&G proposed to depend upon its ties with neighboring transmission systems. Tentative energy charge rates, based on this proposal, for both a 25-year contract and a 10-year contract were submitted. Information also was furnished on the present facilities, the forecast system capability and loads based upon the proposed expansion of facilities, and the total energy output for the years 1949 and 1950.

This information brought out certain pertinent facts. The installed generating capacity of this utility was approximately 315,000 kw. divided nearly equally between hydro and steam units, both of which types were relatively old. With the exception of the modern steam station at Hagood, no major new generating facilities had been added to the SCE&G system since 1929. Assuming the firm power requirement which had been increased from 125,000 kw. to 200,000 kw. by the plan of February, 1951, and with operation at an average load of 90% of this figure, the total energy output of SCE&G Company would have to be increased approximately 60% over its 1950 output in order to accommodate the project's total load. Based on a preliminary calculating board study of its system, the utility's engineers expressed the opinion that the average amount of power which could be delivered to the plant site over the new transmission line section then under construction was 10,000 kw. It was estimated also that, by building another transmission line section of approximately 63 miles from their Saluda Dam switchyard to the site, 50,000 kw. of additional capacity could be made available. The utility had announced its plan for construction of a new steam station, had a firm commitment for the delivery of one 75,000 kw. steam turbo-generator unit, and was negotiating for delivery of the second. The utility estimated a reserve capacity of 46,700 kw. in 1951, 120,900 kw. in 1952, and 182,900 kw. in 1953. The 1953 reserve capacity figure was predicated upon completion of the new steam generating station.

## SOUTH EASTERN POWER ADMINISTRATION

At the time of these power supply negotiations, the SEPA was a new federal power agency of the Department of the Interior. It had no generating capacity of its own - its legal function being to distribute power generated at Clark Hill Dam and other existing or proposed dams in the southeast. Although the prime concern was to supply electric co-operatives, the administrators of the authority were interested in supplying blocks of power to the new AEC installation. Their ability to do so was contingent upon several factors: (1) completion of the construction of Clark Hill Dam; (2) installation of suitable generating units; (3) construction of necessary transmission lines; (4) the filling rate of the reservoir at Clark Hill; and (5) the availability of suitable steam generation facilities to firm up the hydro supply.

Most of these factors were dependent in some degree on congressional approval and appropriations. SEPA indicated that the first of seven proposed 40,000 kw. hydro units would be placed in service by the Corps of Engineers in October, 1952. The energy available from Clark Hill Dam during the succeeding four-year period, according to advice received from the authority, would correspond to about 22% of the Savannah River Plant's total estimated energy requirement.

## SOUTH CAROLINA PUBLIC SERVICE AUTHORITY

This hydro-electric power project had a total nameplate capacity rating for all units of approximately 150,000 kv.-a. During an adverse water year, however, the firm capacity of the system was indicated to be only 52,000 kw. at 100% load factor. The only way the authority could make any appreciable amount of power available would be to cancel contracts with some of its large power users, such as Carolina Power & Light Company, which had a contract for the firm supply of 27,000 kw. Therefore, the Santee Cooper project had little, if any, surplus firm power available.

## PLAN OF FEBRUARY, 1951

A general review of the other interconnected utilities revealed that surplus power in the region was very limited and would continue to be so in the immediate future. The plans of the several utilities for the expansion of their facilities were quite impressive. However, as the survey continued, it became evident that the availability of firm power in this region was not adequate to cover the scheduled needs of the Savannah River Plant. The negative results of

the survey and the pessimistic outlook for the immediate future were further confirmed at a conference with the Power Supply Division of the Department of Interior which revealed that power would be in tight supply in the southeastern area during 1951, 1952 and part of 1953.

In the meantime, the power supply requirements became more stringent. The inclusion of a heavy water production plant (the #400 Area) boosted the total plant power requirement from 125,000 kw. to 175,000 kw. or possibly 200,000 kw., depending upon the over-all site load factor. The required start-up date for this additional area also reduced the time available to obtain a firm supply for the first block of power.

A meeting was held in late February, 1951, to review with Engineering Department Management the information developed by the survey and to formulate an engineering recommendation as to the amounts and sources of power to be supplied to the various areas of the Savannah River Plant.

The forecasted load requirements and their scheduling were weighed against the results of the purchased power survey to that date. Consequently, it was the consensus that, in order to be certain of the availability of power for the start-up and operation of the manufacturing facilities in the new #400 Area, the Engineering Department should recommend the construction in that area of a steam-generating station housing three 17,500 kw. turbines. Because of the large quantities of steam required for the manufacturing processes in the #400 Area, the incremental cost of generation using by-product steam was justified as compared with the cost of the proposed use of purchased power.

A second recommendation was made to continue negotiations with the Southeastern Power Administration on the basis of contracting for 40,000 kw. of firm capacity with an understanding that capacity up to 125,000 kw. be made available for short periods to the Savannah River Plant.

A developing awareness of the power supply characteristics of quality and continuity requisite for the sensitive reactor operations in the #100 Areas dictated a third recommendation that electric power required in these areas should be generated on the site by means of separate generating stations in each of the #100 Areas.

Any permanent power capacity not otherwise provided for would either be purchased from South Carolina Electric & Gas Company or would be generated on the site. The amount of such power appeared to be approximately 30,000 kw.

## ADVANCED NEGOTIATIONS WITH SEPA

To implement the second recommendation above, negotiations with and investigations of SEPA were continued on a more detailed basis. The investigations involved a discussion in Washington with the Defense Electric Power Administration. This organization was concerned with the allocation of copper, aluminum and other critical materials to provide the maximum strategic utilization of the nation's power facilities. The officials of this administration agreed that the power supply in the southeastern area was tight, but they anticipated that starting in 1953 or 1954 power supply would be more than adequate for the area's needs. They mentioned that possibly only five of the proposed seven units would be installed at the Clark-Hill Project. The representatives of SEPA suggested that to derive the greatest good from the Clark-Hill Project it should be used to provide peaking capacity rather than firm base supply.

A conference then was held with representatives from the Corps of Engineers concerned with the Clark-Hill Project. From them it was learned that the prime continuous power, which is the 100% load factor power guaranteed under conditions of lowest stream flow, was estimated to be 54,200 kw. This was based upon the low stream flow conditions which existed from May through December, 1925. The water level in the Clark-Hill reservoir that would have existed at the end of December, 1925, would have been at elevation 305 ft., at which level the maximum capacity of the power plant would have been 235,000 kw. Therefore, the annual load factor on which the Clark-Hill Plant would be able to operate during a dry year was 23.1%. During periods when actual water flow is more than required to produce this amount of prime power, the excess could be used to generate secondary power for non-preferential customers. The estimated average energy capability of Clark-Hill was set at 698,000,000 kw.-hours per year, based upon reservoir levels calculated from data on stream flow conditions accumulated from 1925 through 1946.

In response to a request from du Pont, the Southeastern Power Administration submitted a tentative contract, dated March 15, 1951, which proposed a basic supply of 40,000 kw. for normal use and 125,000 kw. for both normal and standby use. This power would be delivered to the project site over two direct transmission lines and a third indirect transmission line at a power factor of not less than 85% lagging. The proposal limited the supply of the 40,000 kw. of normal power to the extent that the total energy consumption should not exceed 30,000,000 kw.-hours per month or 315,000,000 kw.-hours per year. Furthermore, SEPA reserved the right to



reduce the normal service by half after the first three years of the contract. The proposal also limited the use of the "contract demand", considered to be 125,000 kw. to the extent that the total energy available for standby usage would now exceed 35,000,000 kw.-hours per fiscal year. The rate proposed for this service was \$.90/kw./month for the actual 30-minute power demand as metered or the contract demand, whichever was higher, plus 4 mills per kw.-hour of energy consumed. The effect of this billing formula would be such that if du Pont contracted for 125,000 kw. demand in order to be able to obtain 85,000 kw. of standby service, the annual charge for the standby capacity would be equal to approximately \$918,000 per year, exclusive of any energy charge.

It was suggested to the SEPA representatives that the rate for demand charges should be re-examined in view of the apparent inequitable charges for standby capacity. The cost of normal power usage figured at \$.90 per kw. per month of demand plus 4 mills per kw.-hour of consumption, based upon 40,000 kw. at 90% load factor (the maximum allowable) was calculated to be \$1,692,000 per year. SEPA's ability to fulfill the proposed contract was conditioned upon the completion of Clark Hill Dam and Power House and the appropriation of funds by Congress for construction of a transmission system. In addition, there were other factors which, while not specifically mentioned in the proposed contract, were recognized as having potentially important influence upon the consummation of a satisfactory arrangement for the supply of power from SEPA. Among these factors were the new priority agencies, the National Production Administration and the Defense Electric Power Administration. SEPA officials already had indicated their opposition to any arrangements which called for large blocks of firm power to be supplied from Clark-Hill. Another factor which would require careful consideration was the lack of a transmission system operating organization within SEPA.

In response to du Pont's suggestion that it re-examine its computation of the demand charge, SEPA offered to change its definition of billing demand so that the \$.90 per kw. per month demand charge would be applied to the highest of the following quantities:

1. The measure demand;
2. 75% of the highest measured demand occurring during the preceding 11 months; and
3. 75% of the contract demand.

Du Pont then proposed an alternate basis for the contract. Instead of calling for 40,000 kw. base load and

a total demand of 125,000 kw., the alternate proposal called for 30,000 or 40,000 kw. normal base load with a total availability of 70,000 or 80,000 kw., without changing the yearly base load or emergency load energy limits. The effect of the alternate plan was to tie up less capacity in standby power, at the same time making standby power available for more hours during the year than would have been possible under the original plan. After some deliberation, SEPA indicated a willingness to enter into a contract on this alternate basis.

#### ADVANCED NEGOTIATIONS WITH SCE&G CO.

During the two-month period that du Pont was negotiating with SEPA over a contract for the delivery of 40,000 kw. firm power, negotiations also were being continued with South Carolina Electric & Gas Company concerning the supply of 30,000 kw. of permanent power. The first proposal covered the supply of 30,000 kw. at approximately 90% load factor during a contract period of 10 years. SCE&G proposed the construction of a new transmission line from Saluda to the plant site, which it estimated could be placed in service in time to meet the plant's requirements, providing the necessary priorities were obtained for the material and equipment.

The basic charges given in the proposal were \$2 per kw. per month demand charge plus 4-1/4 mills per kw.-hour of consumption. For billing purposes, the monthly demand was considered to be the contract of 30,000 kw. The proposal included a penalty clause applying to average monthly power factors below 90% and an escalation clause covering fluctuations in fuel cost above or below a \$6 per ton base price for coal. The tentative rates proposed were based upon federal approval of accelerated amortization of the cost of the new transmission line. The energy charge also included a South Carolina generation tax estimated to be about .54 mill per kw.-hour. (There was reason to believe that this state tax might be waived.)

This proposal was just one of a series requested by du Pont. Negotiations were begun on the basis of 125,000 kw.; were raised to 175,000 kw. and 200,000 kw. following the inclusion of the #400 Area; reduced to 30,000 kw. following the February Planning Conference; bracketed by 20,000 kw. and 60,000 kw. for firm power and finally shifted to cover standby power in the range between 30,000 kw. and 60,000 kw. Reference is made to the table on page 469 for a summary of the pertinent features of these proposals.

To supply contract demands of 60,000 kw. or more, construction and installation of new steam generating facilities would be required. As noted, South Carolina Electric & Gas Company had announced plans for the construction of a new steam generating plant and had placed orders for the large components. It was learned from SCE&G Co. that the first 75,000 kw. turbo-generator unit had been ordered in July, 1950, and was scheduled for delivery in August, 1952. The boiler equipment was scheduled for delivery in January, 1952, but fabricated steel members for the power house were not scheduled for delivery until the second quarter of 1952. The utility's planning schedule called for the first generator to be "on the line" in December, 1952. In mid-April, 1951, SCE&G presented the following figures to indicate its generating reserve situation forecasted for the end of 1951:

1. Forecasted system load in 1951 - 318,600 kw.;
2. Installed generating capacity - 365,000 kw.; and
3. Indicated reserve - 47,000 kw.

**SUMMARY OF TENTATIVE PURCHASED POWER COSTS\***  
**BASED ON PRELIMINARY PROPOSALS SUBMITTED BY SOUTH CAROLINA ELECTRIC & GAS CO.**

| Case | Capacity             | L.F.<br>% | P.F.<br>% | Facilities to be<br>Provided                                                  | Type of<br>Service                                         | Contract<br>Term | Unit Pwr. Costs<br>Mills/kw.-hr.                                                                                                | Remarks                                                                                   |
|------|----------------------|-----------|-----------|-------------------------------------------------------------------------------|------------------------------------------------------------|------------------|---------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| A    | 20,000 kv.           | 90        | 85        | Letter not specific as to whether new line would be built                     | Standard Comm'l Service                                    | 10 yrs.          | 8.27 (est.)<br>7.72 (est.)                                                                                                      | Incl. 0.5 mills/kw.hr. S.C. generating tax<br>Excl. 0.5 mills/kw.hr S.C. generating tax   |
| B    | 30,000 kv.           | 90        | 85        | New 70 mile line from Saluda to Ellenton to tie-in with existing 115 kv. line | Standard Comm'l Service                                    | 10 yrs.          | 8.27 (tenta.)<br>7.72 (tenta.)                                                                                                  | Incl. 0.5 mills/kw.hr. S.C. generating tax<br>Excl. 0.5 mills/kw.hr. S.C. generating tax  |
| C    | 60,000 kv.           | 90        | 90        | Letter of 3/28/51 not specific as to size of steam plant to be built          | Firm Service                                               | 25 yrs.          | 6.88 incl. S.C. gen. tax.<br>6.33 excl. S.C. gen. tax.                                                                          | Utility's 3/28/51 letter* implies that a steam plant would be built near site             |
| D    | 125,000 kv.          | 90        | 90        | Steam station near site, 2- 75,000 kw. gen. units plus tie lines to system    | Firm Service High Degree of Continuity                     | 25 yrs.          | 6.13<br>5.58                                                                                                                    | Incl. 0.5 mills/kw.hr. S.C. generating tax<br>Excl. 0.5 mills/kw.hr. S.C. generating tax. |
| E    | 175,000 kv.          | 90        | 90        | Same as in "D" plus installation of add'l generating units                    | Firm Service High Degree of Continuity                     | 25 yrs.          | 6.13 (with S.C. tax)<br>5.58 (excl. S.C. tax)                                                                                   | Utility believes same unit rate would apply as for 125,000 kv.                            |
| F    | 200,000 kv.          | 90        | 90        | Same as in "D" plus installation of add'l generating units                    | Firm Service High Degree of Continuity                     | 25 yrs.          | 6.13 (with S.C. tax)<br>5.58 (excl. S.C. tax)                                                                                   | Utility believes same unit rate would apply as for 125,000 kv.                            |
| G    | 30,000 to 60,000 kv. | -         | -         | (To be determined)                                                            | Standby Service for emergency or overhaul of units on site | -                | No specific rates quoted by S.C.E.&G. Company - requires more specific data concerning use before it can quote a rate for same. |                                                                                           |

\* Additional rate escalations over "D" would be applicable due to smaller demand involved.

## PLAN OF APRIL, 1951

In mid-April, 1951, another meeting was held within the Engineering Department to review and evaluate the developments in the power supply program to that date. Following a detailed presentation of the steam and electric generation plan for the #400 Area and the anticipated requirements for the ultimate needs of the plant, the following conclusions were reached.

1. The #400 Area power plant, consisting of three 325,000 lb./hr. boilers and three groups of 7,500 kw. and 10,000 kw. turbines, was considered to be an integrated power unit which would meet the immediate requirements of that area.
2. The ultimate demands of the #400 Area might require additional steam generation which, together with the necessity for standby boiler capacity, indicated economic and engineering justification for an additional boiler of 325,000 lb./hr. capacity.
3. The use of an additional boiler in the #400 Area power house would justify the installation of additional generation equipment - perhaps one 7,500 kw. high pressure, non-condensing unit and one or two 10,000 kw. condensing units - thus providing additional capacity for use in all plant areas.
4. The minimum requirements for generation in each #100 Area could be met logically and expeditiously by the installation of two 11,500 kw. generators in each area.
5. The combined generation in the five #100 Areas would consist of at least ten 11,500 kw. units with spinning reserve to be obtained from the #400 Area power house, from outside sources, or from additional generating units on the site.
6. The over-all power requirement for the entire plant was estimated at 220,000 kw. plus or minus 10%, of which 185,000 kw. could be site-generated and the remaining 35,000 kw. obtained from outside sources or additional generation as economics dictated.
7. The incremental cost for electric generation over and above the operating cost for steam generation alone was estimated to be 2.6 mills per kw. in the #400 Area and 5 mills per kw. in the #100 Areas. These figures did not include taxes or amortization.

8. The #400 Area manufacturing operations were expected to continue at full production rate until after 1955, and at 2/3 full production rate thereafter. For this reason the planning could not consider the utilization of any excess #400 Area generation until after that period.

These conclusions formed the basis for revisions to the power supply plan formulated in February, 1951. The revised plan contained the following tentative recommendations:

1. Install an additional boiler and associated generating capacity in the #400 Area to increase power to 70,000 kw.;
2. Install generating capacities in all five #100 Areas to provide a total capacity of 115,000 kw.; and
3. Obtain firm proposals to purchase 60,000 kw. total from the two available sources of power: (a) SEPA, and (b) SCE&G.

These studies, conclusions and recommendations were reviewed with the Atomic Energy Division of the Explosives Department, and at meetings on May 21 and 22, 1951, the du Pont Company presented the following specific recommendations to the Atomic Energy Commission.

1. The bulk of the electric power should be generated on the site in a number of small, dispersed stations.
2. An additional boiler, #4, should be ordered for the #400 Area.
3. An additional 10,000 kw. extraction turbine generator, #4, should be ordered for the #400 Area.
4. A total of six 11,500 kw. turbine generators and associated equipment, two for each area, should be ordered for the first three #100 Areas (R, P & L).
5. Contract negotiations for purchasing 63,000 kw. of firm electricity, which could be divided between SCE&G and SEPA, should be initiated.
6. When definite information pertaining to purchased electricity became available, the situation relative to purchased power versus power generated on the site for the fourth and fifth #100 Areas (K & C) should be reviewed.

By letter of May 23, 1951, the Atomic Energy Commission approved these recommendations and basic design proceeded accordingly. Reference is made to Engineering Report ED-203, entitled "Electric Power Plan - Report of Studies and Investigations Made Prior to May 22, 1951", for more details on schedule requirements, economic comparisons, and continuity of service comparisons presented as justification for the above recommendations.

#### NEGOTIATIONS FOR 63,000 OR 50,000 KW.

In accordance with the above plan, negotiations with SEPA and SCE&G were continued to establish a supply of 63,000 kw. As stated in an earlier contract proposal from SEPA, its ability to deliver any energy to SRP was dependent upon the appropriation of funds by Congress for the construction of the transmission line. During this phase of the negotiations, a congressional committee was holding hearings and considering a request for funds for the construction of other SEPA transmission lines. When the committee denied the request, the du Pont Company Engineering Department contacted the SEPA to express its concern regarding that administration's ability to obtain funds for the construction of transmission lines to deliver power from the Clark-Hill Dam to the Savannah River Plant as outlined in several proposal letters. While seeking assurances of SEPA's ability to deliver energy to SRP, du Pont suggested that if such were not forthcoming, a tripartite agreement might be made for the "wheeling" of Clark-Hill energy over SCE&G's electric transmission lines.

In his reply of July 9, 1951, the acting administrator of SEPA stated that, to the extent of his knowledge, no federal agency had failed to fulfill contractual obligations to deliver power to a defense establishment. He observed that SEPA could not give positive assurances as to what action the Congress might take on a request for funds. But, in answer to du Pont's reference to congressional denial for funds for similar transmission lines, SEPA considered that situation by no means analogous to that involving service to the Savannah River Plant. It was noted that the House Committee on Appropriations had acted favorably on the request for these funds but that they had been eliminated by an amendment to the Bill when it was reported out of the committee. The administrator expressed the thought that there could be no doubt that if the Atomic Energy Commission desired Clark-Hill power for the Savannah River Plant and was willing to contract directly, or through du Pont as its agent, for such power and was willing to support such appropriations, Congress would appropriate the funds.

In discussing du Pont's suggestion for a "wheeling" arrangement involving SCE&G Co., SEPA stated that it could not contract with SCE&G for the delivery and resale of Clark-Hill power at the Savannah River Plant. Such a contract would have to be made between SEPA and the user. A separate agreement then would be needed between SEPA and SCE&G Co. for the "wheeling" of this energy over the latter's lines. SEPA noted that a satisfactory basis for such a "wheeling" arrangement had not yet been proposed.

These answers left the status of the SEPA as a supplier of firm power to the Savannah River Plant still unresolved. Furthermore, its offer to supply firm power was limited to 40,000 kw. for three years and 20,000 kw. thereafter.

In the meantime, the SCE&G Co., in response to du Pont's request, furnished a proposal for the supply of all of the outside power requirements of the Savannah River Plant, based upon the following conditions.

1. Contract demand of 63,000 kw.
2. Contract period of 25 years, starting from date of initial delivery of power, but with cancellation privilege with one year's notice.
3. Delivery of power to be made from 110 kv. bus at a new steam plant to be located near the project on the Savannah River.
4. Delivery of power to start in 1953.
5. Delivery of power to be made over two 110 kv. lines to be constructed by the company from steam plant bus to two points in the project area with sufficient capacity in each line to handle contract demand.
6. Power to be metered at 110 kv. with the meter located at the steam plant end of the line.
7. AEC to furnish all facilities for terminating 110 kv. lines on the project end of these lines and furnish, without cost to the company, the necessary transmission right-of-way across the project area.
8. Steam plant to be operated in parallel with other plants of the company and its neighboring facilities if the company chose to do so.
9. SRP to be responsible for the regulation of its instantaneous demands to conform with the contract.



The base rate demand charge stated in the proposal was to be \$19.00 per kw.-year for delivery at the steam plant bus and subject to certain adjustments reflecting changes in the estimated base cost factors, such as plant cost, working capital, taxes, interest, labor and overhead. An additional demand charge of \$1.00 per kw.-year was set for providing the necessary transmission lines from the company plant to the project. This charge was also subject to certain base cost factor adjustments. The base rate for energy was set at 2.25 mills per kw.-hour, subject to adjustments reflecting changes in fuel costs, steam plant heat rate, maintenance and miscellaneous supply expenses. The proposal stated the willingness of SCE&G Co. to reduce the contractual demand by as much as 20,000 kw. in order to allow the SRP to substitute that amount of power from Clark-Hill project.

With information at hand on the cost of purchasing power to complete the project's requirements, the Engineering Department's next task was an economic analysis comparing purchased power with on-the-site generation in #100-K and #100-C Areas. This analysis required estimates of permanent investments for the following facilities: (1) SCE&G Company's 150,000 kw. station; (2) Project's 23,000 kw. station; and (3) Project's 70,000 lb./hr. boiler houses without generation.

It was also necessary to estimate the effect of each of these schemes on the cost of electrical substation equipment for #100-K and #100-C Areas. To make a quick check on the first of these items, the du Pont Company Engineering Department made inquiries into the cost of similar new generating stations and concluded that the utility's estimate of \$23,000,000 was realistic. A factor which could have seriously upset this estimate, by increasing the construction cost for the generating station, was the coincidence and nearness of its construction to that of the SRP. Estimates for facilities, Items (2) and (3), were prepared by Gibbs & Hill, Inc. (a design subcontractor for du Pont).

With these estimates as a basis, an economic analysis was made, and on August 10, 1951, a meeting was held with the operating department to review the desirability of installing electric generating equipment in #100-K and #100-C Areas. It was agreed that the electric power required beyond that obtainable from the plant generating equipment authorized to that date should be purchased from the SCE&G Company. The nameplate capacity of the then authorized generating units totaled 131,500 kw. Deducting the auxiliary power required for these generating installations, a net availability of 115,000 kw. was indicated. This left 63,000 kw. to be supplied from outside sources to meet a net demand of 158,000 kw. plus 20,000 kw. for reserve and standby.

However, further development of detailed design indicated that the net capability of these authorized generating units totaled 128,500 kw. Using this net capability instead of the 115,000 kw. net capacity, the requirements for additional power were reduced from 63,000 kw. to 49,500 kw. The need for purchased power could be eliminated entirely by the installation of generation in Areas "C" and "K" if advantage was taken of the increased capability and if slightly larger generators, 12,500 kw. instead of 11,500 kw., were installed in Areas P, L, K and C. No other design or equipment changes would be involved. This installation would result in a net operating capability on the site of 183,000 kw., 5,000 kw. more than the estimated requirements.

Incremental investment for these facilities was estimated at \$12,600,000, resulting in a saving in operating cost of about \$900,000 per year. On this basis, therefore, it would require approximately fourteen years to pay out the additional investment. Several variables were estimated for these calculations, but it was considered unlikely that the payout time could be reduced to twelve years, and it might be as long as sixteen years. From an economic standpoint, the additional investment for increased generating capacity was not considered justified. The proposal from SEPA was, as noted, limited to 40,000 kw. of firm power for three years, after which only 20,000 kw. would be available. There was also the reasonable doubt that SEPA could obtain the necessary congressional appropriations required for the construction of transmission lines from Clark-Hill to the plant site. For these reasons, it was decided to defer further negotiations with SEPA and plan on getting the additional power directly from the SCE&G Co.

Although the decision in favor of purchased power versus increased on-the-site generating capacity was based primarily upon economic considerations, other factors were also considered. An equally important factor was the quality and reliability of service required. It was the consensus that off-the-site generated power would not be as reliable as on-the-site generated power. However, it was felt that with SCE&G Company's new steam generating station located close to the site boundary and with two direct transmission tie lines, the utility would be in a position to supply reliable service on an acceptable preferential basis. The greater flexibility for adjusting to increases or decreases in the power supply requirements to be derived from the tie with the power company was a recognized advantage.

The Engineering Department then drafted a letter to SCE&G Company announcing its intent to purchase 50,000 kw. of electric power. The draft of this letter of intent was

reviewed with SCE&G Co. in a conference held in late August of 1951. The first provision called for preferential electric service from the new station, to the extent that one generator would serve the Savannah River Plant to the exclusion of any other circuit at such times as the other circuits are causing operation at frequencies below 59 or in excess of 61 cycles per second respectively and/or at voltages 10 per cent below or above 114 kv. The circuits causing the unfavorable operating conditions were to be unloaded from the generator in question by the fastest commercially available relays and circuit breakers.

The utility representatives stated that they would have to explore the engineering and rate implications involved in the provision for preferential service. They advised that all of the utility's rate proposals, including that of June 15, 1951, had been predicated on the utility's supplying good commercial grade service with no specific generator being devoted to the Savannah River Project service. The utility spokesmen felt that unless they had full access to the use of all units at the new station, they would have to incorporate an additional charge to compensate for the loss of capacity and energy during such periods as the full output of any unit might not be available to serve their system.

A few days after this conference, the president of the SCE&G Co. advised that the utility was reluctant to enter into a contract which required preferential service as defined in du Pont's letter of intent; but if it did, the basic "kw." demand charge would be increased by about \$9.00. He stated that his engineers were preparing an alternate to the preferential generator unloading scheme contained in du Pont's preferential service clause which he would like to discuss with du Pont's engineering personnel.

During the next few weeks, several conferences were held with SCE&G Co. in an effort to reach an agreement on preferential service. Although the utility offered to improve the over-all reliability of its system by the installation of high speed circuit breakers at key points, and proposed also to sectionalize parts of their system during storms, it did not remove the limitations it felt compelled to place on preferential service to SRP. The final meeting was held with the utility's officials on October 1, 1951, in an effort to obtain the preferential service considered necessary by du Pont to meet the unique requirements of SRP for power supply reliability. This effort was not successful and du Pont was forced to reconsider its plan to purchase a large block of power to fulfill the SRP's requirements.

# CONTRACT WITH SCE&G CO. FOR 30,000 KW.

By letter of October 3, 1951, the du Pont Company recommended to the Atomic Energy Commission that electric generating facilities should be installed in the #100-K Area and negotiations with the SCE&G Co. continued for the purchase of 30,000 kw. instead of 50,000. The recommendation was approved by AEC by letter of October 25, 1951.

Du Pont issued a revised draft of its letter of intent covering the proposed purchase of 30,000 kw. of electric power from the SCE&G Co. In addition to reducing the quantity of power required, the revision also reduced the type of service from preferential to high-grade commercial by permitting full availability of the maximum capacity of the new generating station to the utility's system and by calling for system changes and improvements as had been proposed by the utility. In view of the reduction in the project's purchased power requirements, only one transmission line between the new generating station and a terminal point on the project site was required.

After several reviews and modifications, a letter-contract, dated January 11, 1952, was approved by the du Pont Engineering Department and Legal Department prior to its actual issuance by the Explosives Department. This letter was accepted on January 23, 1951, by SCE&G Co. and by the South Carolina Generating Company (a separate company established and wholly owned by the SCE&G Co. to operate the new steam generating plant). The Savannah River Operations Office of the Atomic Energy Commission approved the letter on February 7, 1952.

Formal execution of the letter-contract cleared the way for several conferences required to settle the technical details involved in tying the SRP power system and the SCE&G Co. system together through the tie-line between the latter's new generating station, known as Urquhart Station, and one of the switching stations at SRP. Some of these details are noted in subsequent sections of this account of the design development of electrical facilities. In general, the details of the tie-line to be constructed and owned by SCE&G Co. were critically reviewed by the du Pont Engineering Department and its subcontractor, Gibbs & Hill, Inc. Du Pont also studied the design features and followed the construction of the Urquhart Station, since the final cost of this station would be an important factor in the cost of power purchased from it. The formal, definitive power contract between du Pont and the SCE&G Co. and South Carolina Generating Company required considerable time for drafting, reviewing and revising before it was finally executed and approved. The final execution of this contract was accomplished on March 9, 1954.

## SUMMARY OF POWER SUPPLY DEVELOPMENT

It appears advisable at this point to summarize briefly the final power supply plan for the Savannah River Plant and its development. To reduce the total investment in the Savannah River Plant, du Pont endeavored to develop adequate reliable sources of electricity off the plant site. However, no existing sources of power, either individually or by pooling, could have supplied the required large blocks of power in time to meet the construction schedule. This was especially true in the case of the first block of power for the #400 Area. To meet the requirements of this area, du Pont resorted to accelerated design and the use of small boiler and turbo-generator units. Three 7500 kw. high-pressure units and three 10,000 kw. low-pressure units were procured for the #400 Area power house. Economic considerations later justified the addition of another 10,000 kw. unit.

In developing a power supply plan for the critical #100 Areas, prime consideration had to be given to the quality and reliability of service. In order to assure the availability of reliable power for the start-up of the first three #100 Areas, two 11,500 kw. turbo-generators were procured for power house installation in each of these areas. The schedules for #100-K and #100-C Areas permitted further negotiations for reliable power supply for these areas.

Negotiations with SEPA for the supply of this power failed because of the limit placed by SEPA on the firm power availability from Clark-Hill and because assurances could not be obtained that SEPA could deliver the power to the site. Negotiations with SCE&G Co. for the purchase of 50,000 kw. firm power developed to the point of drafting a letter-of-intent contract before a major obstacle was encountered. The utility was unwilling to provide the degree of preferential service, which the du Pont Company felt was required for adequate reliability, without a substantial increase in the power rate. It was then decided to install generation equipment in the #100-K Area. To take full advantage of the maximum capability of the boilers and turbines, 12,500 kw. generators were ordered. Negotiations with SCE&G Co. then were successfully completed for the purchase of 30,000 kw. from the utility's proposed new generating station near the plant site. This service was to be high-grade commercial rather than preferential and was to be used primarily as reserve power.

The nameplate capacity of the SRP generating units totaled 156.5 megawatts. The estimated capabilities of these machines plus the 30,000 kilowatts of purchased power approximated 200 megawatts. This total capability provided

a margin of power availability over the then predicted gross load peak of 176 megawatts. The margin was far from being excessive but it did permit the outage of the largest plant generating unit or an outage of short duration of the purchased power supply. This margin existed, at the time, only on paper and was dependent upon the accuracy of certain assumptions used in estimating the project's peak power load. The decision was made not to install generating equipment in the #100-C Area because the tie with the utility system represented a means of covering emergency periods of abnormal outages in the project's generating facilities and also providing the necessary flexibility of purchasing additional amounts of power when present load warranted.

The tie to the utility system, together with the possibility of additional ties at geographically separated points, provides a means for accommodating plant expansion and increased power requirements without the necessity of immediate high investment and operating costs.

Obviously, a controlling factor in the development of the power supply plan was the estimate of the power supply requirement for the project. A discussion of development and interpretation of the data that resulted in the load forecast follows.

SECTION III —  
ELECTRIC LOAD ESTIMATING

### III - ELECTRIC LOAD ESTIMATING

One of the first problems to be encountered by the electrical design group at the start of any project is the determination of electric load data. The electric load or power demand for each piece of equipment utilizing electricity must be determined. The individual demands must be properly totaled by load groups, buildings, areas and, finally, the entire plant, making proper allowance in the summation of demands for diversity among the load units or groups. Faced with long delivery time on major electrical equipment such as transformers, switchgear, and motors, and also faced with a tight schedule to meet construction target dates, the electrical design engineer must accumulate the load data as soon as possible.

However, the engineer often is forced to make preliminary load estimates before individual pieces of equipment are selected or sized. In the case of the more familiar facilities such as power houses, office buildings and laboratories, the preliminary estimate may not be too difficult to make. In the case of manufacturing or process facilities, data accumulated during laboratory prototype or pilot plant operation would be helpful for preliminary load estimating; but in the case of a new process, preliminary estimates are obviously more difficult to make. A preliminary estimate of the total SRP power requirement was needed at an early date for the power supply survey.

The estimate of 125,000 kw. made in December, 1950, was based on the broad concepts of the processes and the rough data available at the time. It was known, for instance, that tremendous quantities of heat would be generated in the production reactors and that a large proportion of the total power requirement would be involved in pumping capacity to supply the necessary cooling, the average daily water requirement being expected to approximate that of the City of Philadelphia. An estimate made in January, 1951, indicated that the anticipated normal load of one of the five #100 Areas would be approximately 20,000 kw. Of this total, it was expected that 17,500 kw. would be required for pumping facilities. To supply the large volume of water, it was estimated that the normal pumping load at the river pump houses would total 42,300 kw. The estimate of electric loads for the #400 Area was based upon known electric power loading at the Dana Plant. Reasonable bases existed for the estimated over-all power requirement for the project. There was, however, much less surety in estimating smaller area blocks of power required for sizing transformers, switchgear and cable. To obtain the required refinement in the area estimates, it was necessary to tabulate the electric power



loads by individual buildings for lighting, heating and ventilating, and process. In many cases, the preliminary pre-design estimates were derived empirically from basic elements such as floor area, volume of the building, number of personnel in attendance and available preliminary process information. As the detailed architectural, process, and power designs progressed, it became possible to insert into the load tabulation the actual ratings of the utilization equipment.

Recognizing that an individual unit or group of like units seldom operate continuously at rated power, it was necessary to estimate a demand factor to derive the maximum individual load or demand. Then, after making a summation of the actual individual demands within an area, an area diversity factor was applied to obtain maximum area demand, as it was recognized that these individual peaks would not occur during the same period of time. The area diversity factors were estimated on the basis of general industrial power experience and the knowledge of anticipated operating cycles for the major users of power. Considering the #100 Areas, for example, where groups of large pumps were expected to operate continuously for months at a time, it was reasoned that the diversity among the minor loads of those areas would have little effect upon the total area maximum demand. To obtain the maximum demand for the entire plant, it was necessary to total the maximum demands of the several areas and again apply a diversity factor.

One of the earliest tabulations of electric loads by areas, completed in April, 1951, showed a total plant load of 220,000 kw. This total did not reflect inter-area diversity. Design progress during the spring and summer, however, permitted greater accuracy and refinement in these tabulations of area loads. During this period, an appreciable reduction in the cooling water requirements resulted in a decrease of about 20,000 kw. in the power demand of the river pump houses. A tabulation prepared in October, 1951, from the more accurate data then available, indicated the summation of area loads equaled 195,400 kw. This figure included allowances for electrical losses in the transmission and distribution system. The expected maximum demand for the entire plant, allowing for diversity among the area demands, was 182,000 kw. This tabulation was based on five "on-site" steam electric plants, and the demand figures included the power required to operate them.

In order to formulate a plan for the supply of power to the Savannah River Plant, it was necessary to determine the schedule of load increases reflecting the start-up of the operating facilities. One of the earliest load growth studies was completed early in 1951 and was included as a

chart in Engineering Department Report ED-2203. This revealed that load growth was expected to begin about April, 1952, continue at a uniform rate as production units in the #400 Area were started, and reach approximately 35,000 kw. during August, 1952. The demand was expected to become twice that amount within a few months as a result of operations in the #100-R Area, and to remain at that level until the beginning of 1953, when the #200-F and #100-P Areas were expected to begin operations, thereby increasing the demand to approximately 100,000 kw. Further major load increases were expected in the middle of 1953, and in February and August of 1954 as the last three #100 Areas were put into operation. This early chart of load growth showed an expected maximum of 158,000 kw. to be reached by September of 1954. Subsequent studies and load growth charts reflected changes in load estimates and schedules but followed the same pattern - load increases beginning in the spring of 1952 and reaching a maximum by the end of 1954.

The electrical load estimate tabulation of October, 1951, was revised in April, 1952, and again in October of that year. The April tabulation showed a total connected load equal to 250,648 kw., a summation of area demands and losses equal to 196,600 kw., and a total expected plant demand equal to 182,800 kw. The October, 1952, tabulation (see page 486) showed corresponding figures of 253,918 kw., 197,100 kw., and 178,500 kw. This estimate was used until sufficient load and generation were in operation to estimate from actual operating conditions.

PROJECT 8980  
SAVANNAH RIVER PLANT - ELECTRIC LOAD ESTIMATE

Based on Five On-Site Steam-Electric Plants

| AREA    | CONNECTED<br>(KW) | SUM OF<br>INDIVIDUAL<br>DEMANDS<br>(KW) | AREA<br>DIVERSITY<br>FACTOR | AREA<br>DEMAND<br>(KW) | AREA<br>LOSS<br>FACTOR | AREA<br>LOSS | SUM OF AREA<br>DEMAND AND<br>AREA LOSS<br>(KW) |
|---------|-------------------|-----------------------------------------|-----------------------------|------------------------|------------------------|--------------|------------------------------------------------|
| 100-R   | 24,695            | 20,386                                  | 1/.98                       | 20,000                 | .02                    | 400          | 20,400                                         |
| 100-P   | 24,466            | 20,219                                  | 1/.98                       | 19,900                 | .02                    | 400          | 20,300                                         |
| 100-L   | 24,466            | 20,219                                  | 1/.98                       | 19,900                 | .02                    | 400          | 20,300                                         |
| 100-K   | 24,466            | 20,219                                  | 1/.98                       | 19,900                 | .02                    | 400          | 20,300                                         |
| 100-C   | 23,066            | 19,207                                  | 1/.98                       | 18,800                 | .02                    | 400          | 19,200                                         |
| 200-F   | 10,852            | 7,964                                   | 1/.8                        | 6,500                  | .035                   | 200          | 6,700                                          |
| 200-H   | 6,054             | 4,466                                   | 1/.9                        | 4,000                  | .035                   | 100          | 4,100                                          |
| 300/700 | 18,171            | 11,414                                  | 1/.7                        | 8,000                  | .035                   | 300          | 8,300                                          |
| 400-D   | 55,729            | 47,275                                  | 1/.95                       | 45,000                 | .035                   | 1,600        | 46,600                                         |
| 500-G   | 200               | 150                                     | 1/.5                        | 100                    | .01 x total            | 1,900        | 2,000                                          |
| 600-G   | 38,716            | 29,230                                  | 1/.95                       | 27,800                 | .035                   | 1,000        | 28,800                                         |
| 900     | <u>237</u>        | <u>204</u>                              | 1/.5                        | <u>100</u>             | .035                   | 0            | <u>100</u>                                     |
| Totals  | 253,918           | 200,953                                 |                             | 190,000                |                        |              | 197,100 *                                      |

\* 197,100 kw. x 90.5% Diversity = 178,500 kw. Expected Demand

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CONSTRUCTION POWER SUPPLY

SECTION IV

#### IV - CONSTRUCTION POWER SUPPLY

Before proceeding into the design development of the permanent electrical facilities for the Savannah River Plant, it is advisable to discuss the development of the power supply and distribution system to meet construction requirements. Obtaining electric power for construction activities is, of course, primarily the responsibility of the Construction Division. However, the Design Division and other groups provided assistance to Construction in negotiations with the utilities, and during the early stages of planning and designing a supply system and procuring critical equipment.

Mention was made previously that the SCE&G Co. had under construction at the opening of this project a new transmission line section which traversed the selected site, running north and south through its center. Negotiations with the utility were started at once to establish an agreement providing construction power from a number of tap points on this new transmission line. SCE&G Co. quickly indicated its desire to serve the project and its willingness to provide service at as many tap points on the 115-kv. transmission line as were desired. During a visit to the offices of the utility on January 5, 1951, by two members of the Electrical Design Group it was learned that the high tension line then under construction had more than sufficient designed capacity for carrying the construction load. Line voltage regulation was being studied on a system calculating board. No transformers for construction power were available immediately from the SCE&G Co., but a willingness to conduct a survey among the neighboring utilities for suitable transformers was indicated. After completing a study of their system, the SCE&G Co. engineers advised that they could supply 10,000 kw. at 80% power factor or 20,000 kw. at 90% power factor, with higher peak loads permitted.

In the middle of December, 1950, the Construction Division reported estimated power loads for construction totaling 10,500 kw. This estimate was revised during the following month after the addition of the #400 Area to the project and following discussions with the firm of engineers in Augusta, Georgia retained by the Construction Division to design the TC Administration Area buildings and the temporary offices and shop buildings for the individual areas. It was decided to base procurement for the temporary construction power substations upon a total transformer capacity of 15,000 kv.-a.

A plan for supplying power for construction activities developed rapidly. The SCE&G Co. was willing and able to supply sufficient quantities of construction power, and contract negotiations with the utility were underway. There was a convenient transmission line in the final stages of construction from which lateral feeders could be tapped to supply temporary substations located strategically throughout the project. The main obstacle to the successful implementation of this plan was the procurement of adequate transformer substation equipment. When in mid-January, 1951, it was decided to provide construction power transformers totaling 15,000 kv.-a. capacity, the General Electric Company and Westinghouse Electric Corporation were consulted to determine the relative availability of coordinated substation equipment using transformer combinations as follows: two 7500-kv.-a. transformers, three 5000-kv.-a. transformers or a combination of one 5000-kv.-a. and one 10,000-kv.-a. transformers. On the basis of this consultation, a verbal order was placed on January 26, 1951, for one 5000-kv.-a. unit substation.

An intensive search was made of used-equipment dealers as well as public and private utilities for power transformers and associated electrical equipment suitable for use in supplying construction power. The offices of the AEC and Gibbs & Hill, Inc., aided in the search, but it was not successful. The SCE&G Co. offered to make available by March 1, 1951, a portable 2500-kw. unit substation which could be supplied at 44-kv. from the 115-kv. transmission line operated temporarily at the lower voltage.

After the unsuccessful search for used electrical equipment, du Pont recommended to the AEC that the NPA be requested to issue a directive improving the scheduled delivery of the first 5000-kv.-a. new unit substation. This was done. An order for the other two 5000-kv.-a. units was placed on March 2, 1951, and the assistance of a directive was also requested for this order. At a later date, the Construction Division was able to locate two additional sets of substation equipment, each containing three 1000-kv.-a. transformers, making a total of five temporary substations eventually connected to the SCE&G Co. lines.

Although the contract with SCE&G Co. was not formally executed and approved until the spring of 1953, initial delivery of construction power commenced on May 15, 1951. A peak demand of 12,168 kw. on construction service was reached in January, 1953. Thereafter, construction power demand gradually decreased to about 5268 kw. in February, 1954. After this date, all remaining construction power was supplied from SRP's own internal transmission network and the lateral supply lines to the utility's original 115-kv. line through the site were disconnected and the utilities construction power meters were removed.

## SECTION V

DEVELOPMENT OF ELECTRICAL SYSTEMS

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## V - DEVELOPMENT OF ELECTRICAL SYSTEMS

### INTRODUCTION

The development of the electrical systems of the Savannah River Plant required the coordinated contributions of many individuals and groups - design engineers, field personnel, large manufacturers, small specialty shops, draftsmen and management.

One of the early pieces of information available was a topographic map of the project area with the general locations of the several process and auxiliary areas marked. To provide these areas with power, light, communications and certain special aids to safety and security, several differing types of electrical systems were required. These integrated electrical systems required: (1) transmission at high voltage, (2) distribution at medium and low voltages, (3) fence and road lighting, (4) fire alarm, (5) safety alarm, and (6) communications. They included approximately 90 miles of transmission lines requiring 65 miles of cable for its supervisory control; 32 miles of underground circuits and 62 miles of overhead pole line circuits for the 13.8 kv. distribution; 2000 circuit miles of telephone cable servicing about 2200 telephone instruments on the Bell System; 500 sound-powered telephones for special communication circuits; 36 circuit miles for road and fence lighting within individual areas; and 55 circuit miles involved in the safety alarm systems within the areas. The greater portion of these facilities are outside the buildings.

Electrical design work for facilities within buildings involves the specification of electrical equipment and controls for the performance of many functions; the location and arrangement of electrical equipment; the layout of electrical conduit, electrical cable trays and ducts; and the design of intra-building communication and lighting systems. Electrical design work, particularly that involving facilities within buildings, required the careful coordination of data and details with virtually every other design group. Accounts of the design development of the electrical facilities within the process buildings are included in those sections of this history devoted to the design development of the specific buildings.

The Senior Electrical Engineer in charge of electrical design for the project delegated large measures of responsibility and authority to his supporting engineers. The division of work was made, in general, on an area basis, considering the open territory around the fenced areas as

the General Area. The bulk of the design work for the Savannah River Plant was divided by du Pont among several subcontracting companies and itself along area lines. The reader will find elsewhere in the du Pont history of Project 8980 discussions on the selections and responsibilities of these several subcontracting organizations. One of these concerns, Gibbs & Hill, Inc. of New York City, will be referred to most frequently in the following accounts of the development of design for the various electrical systems. Gibbs & Hill was awarded a contract, AXC-5-1/2, for the design of certain general facilities involving steam, water, and electricity. In addition to the electrical facilities within the so-called power buildings and the inter-area transmission system, the intra-area distribution, fence and road lighting, and communications and signal systems were designed at Gibbs & Hill, except those portions for the #200 Areas designed at the Blaw-Knox Company.

In addition to the services of the du Pont electrical design engineers, (several of whom had participated in the design, construction and operation of the Hanford Engineer Works), and those of the subcontractors, experts employed by the various electrical manufacturers, utilities and others were consulted.

#### TRANSMISSION AND DISTRIBUTION SYSTEMS - GENERAL

"Modern alternating current power systems usually consist of the following elements: (1) generating stations; (2) step-up transformer stations; (3) transmission lines; (4) switching stations; (5) step-down transformer stations; (6) primary distribution lines or networks; (7) service transformer banks; and (8) secondary lines or networks. Essentially, Elements 2, 3, 4 and 5 are the transmission system and Elements 6, 7 and 8 are the distribution system.

"The difference between transmission and distribution systems depends upon the function. The function of the transmission system is the transmission of bulk power to load centers and large industrial users beyond the economical service range of the regular primary distribution lines. The function of the distribution system is to deliver power from generating stations or transmission substations to the various consumers."

The above extract from the seventh edition of Standard Handbook For Electrical Engineers orients the reader in his consideration of the following account of the design development of the Savannah River Plant transmission and distribution systems. The system elements and functions given above are generally applicable to the SRP systems.

## TRANSMISSION SYSTEM

### CRITERIA

A transmission system interconnecting the various areas of the project was recognized almost immediately as a major part of the scope of work for the design of electrical facilities. It would have been possible to supply power to each area independently, either by generation within each area or by separate lines from outside sources. But the need for a transmission system appeared immediately when the decision was made that all energy, regardless of source, should be "pooled" for the following reasons: (1) to provide maximum reliability and flexibility to meet necessary curtailment of any source of energy; (2) to forestall complete shutdown of a vital area due to an isolated power supply failure to one of its auxiliary operations (such as the shutdown of a #100 Area, otherwise able to operate at full capacity, because of the failure of power supply to a pumping station), and (3) to minimize investment in spare capacity required to protect the supply (because of "pooling", one spare unit may be made available to all power zones).

To minimize the effect of possible sabotage or enemy action, the following criteria were established for the arrangement of transmission system facilities: (1) any two vital facilities (switching stations, delivery substations, or generating plants) which are not parts of the same operating area should not be located less than 2.5 miles apart; (2) no transmission line should be closer than 2.5 miles to a critical area other than the one being directly served; and (3) the transmission substations at each area should be able to import or export the required amount of energy over either of two independent lines, arranged to be as little susceptible to simultaneous outage as possible.

### SCHEMES

During the initial study of possible transmission system arrangements, the sources of energy were not known. Therefore, all such arrangements had to be suitable, with minor modifications, for distributing the required electrical energy whether purchased entirely from outside the project area, generated within the area, or a combination of the two types of supply. The primary consideration, however, in selecting the best system arrangement was operating reliability. Several different schemes for the transmission system were developed and estimates were made

to indicate differences in cost. In seeking the best system arrangement, the variations developed and studied included different geographical locations and routings as well as alternate electrical bus and switching arrangements. The two basic arrangements studied, with several variations of each, were the multi-loop network and the ring bus with radial feeder arrangements.

The first of the loop network schemes, known as Scheme I, (see diagram, page 497) provided three separated, single-circuit, transmission lines running longitudinally through the heart of the project area and converging at north and south switching stations. This arrangement of lines and tie stations provided the means for interconnecting the five #100 Areas and for providing service to each #100 Area from opposite directions. Two of the transmission lines looped through two #100 Areas each, while the third line looped through the fifth #100 Area and provided a logical location for the insertion of any future #100 Area.

The north and south switching stations were interconnected further by two lines circling to the west of the process areas and passing through two additional high-tension switching stations. These switching stations provided interconnection and dual feed to each of the main river pump houses and to the #400 Area power station. Thus the #100 Area processes and their vital water supply facilities were interconnected by a network of transmission loops. It was proposed that the service and auxiliary areas would be supplied by short transmission loops leaving and returning to the nearest switching station.

This scheme provided a high tension bus at each of the #100 Area loop transmission substations by using two incoming-line circuit breakers and a primary circuit breaker feeding each of two transformers. As would be expected normally for a scheme such as this, each of the two transformers was rated to carry half of the total area load. This scheme was considered to be workable and dependable and could be satisfactorily relayed, but it involved a relatively large number of expensive high-tension circuit breakers, and the use of firm transformer capacity for only half of the area load was questioned. Scheme I was based principally upon generation of energy within the plant site.

Scheme II was developed primarily for the transmission of purchased energy. This scheme (see diagram, page 499) had substantially the same geographic layout of lines as Scheme I, but modifications were made to the high-tension switching arrangement at each transmission substation. Because it was assumed for this scheme that there would be

SAVANNAH RIVER PLANT  
 DU PONT PROJECT 8980  
 G. & H. JOB NO. 835  
115-KV TRANSMISSION SYSTEM  
SCHEME 2  
 GIBBS & HILL, Inc.  
 CONSULTING ENGINEERS

little or no local area generation, it was considered necessary for reliability to have each transformer capable, under an emergency rating, of carrying the entire area load. Under these conditions, it would not be necessary to have a high-tension bus with its two line breakers and two transformer primary breakers. Instead, each transformer could be tied directly to the high-tension line section through a disconnect switch. One high-tension circuit breaker only would be required in the line between the two transformer connection points to provide high-speed sectionalizing of the transmission circuit. The number of high-tension circuit breakers at each substation was reduced from four (in Scheme I) to just one. Each transformer could be considered as a part of a transmission line section and could be switched out of service in case of a fault. The remaining transformer and the transmission line section feeding it would continue to carry the area.

Further reductions in the quantity of high-tension breakers required was effected in Scheme II by eliminating the switching stations on the west side of the area feeding the main river pump house. The high-tension switching arrangement proposed in this scheme for the river pump houses was similar to that for the transmission substations at the process area. Two high-tension, sectionalizing circuit breakers were inserted in each of the western transmission loop circuits and a tap connection was made on each side of each line breaker for feeding a transformer at a pump house.

At the time of these studies, three large river pump houses were proposed to supply water to the #100 Areas, and one smaller river pump house to supply water to the #400 Area. The protective relaying requirements of Scheme II would be almost identical to that of Scheme I for those transmission lines passing through the process zone of the project. In the pump house area, the distances between the high-tension switching points in the transmission system and the step-down transformers at the pump houses would introduce a relay complication. Otherwise, Scheme II was considered satisfactory and less costly than Scheme I.

Scheme III represented a different approach to the development of a transmission system arrangement. In this scheme, two transmission loops would completely encircle the process areas (possible future areas, as well as those then authorized). The two loops could be operated as independent ring buses or could be tied together at either or both of two high-tension switching stations - one on the east side and one on the west side. These two switching stations would also be provided with circuit breakers for sectionalizing the two rings. High-tension line circuit

breakers located at two other switching points, one north and one south, would provide additional means for sectionalizing the two loops. Each ring then could be sectionalized into approximately equal quarter segments to quickly isolate faulted sections.

For a reliable supply to each of the load areas, two radial transmission feeders would be required, one from each of the high-tension ring buses. For the supply to the river pump houses, two short loops leaving and returning to the west side switching station would be required. Each of these loops would have sectionalizing circuit breakers and radial feeders to the pump house substations. The system arrangement of Scheme III would use approximately 30% more miles of open transmission line than either Schemes I or II. It would be more difficult to maintain the desired physical spacing between vital electrical facilities and there would also be a relatively large number of unavoidable line crossings.

Scheme IV was developed for comparison purposes to show an arrangement eliminating to some extent the number of parallel lines and switching stations. The basic pattern consisted of a single-circuit loop routed from area to area around the project. One rather large switching station was shown from which duplicate radial feeders could be routed to the pump houses. To augment the transmission line tie between the river pumping stations and at least some of the #100 Area substations, a parallel transmission circuit would be routed from the pump house switching station southward around the process areas to a small high-tension switching station on the east side of the project, passing through three #100 Area substations enroute. Additional switching facilities would be required to receive purchased energy into the system. Careful study of Scheme IV indicated that the estimated savings in transmission line mileage and high-tension circuit breakers would not justify the reduction in reliability and flexibility resulting from what was basically a single-loop system.

By the end of January, 1951, the Engineering Department's power supply survey had developed to a point which indicated that a large block of power generation was required in the #400 Area and that some generation was probable in at least the earlier #100 Areas. Process area locations also were established. With this additional information available, transmission Scheme V was developed combining features of Schemes I and II. The feature of three transmission lines traversing the central process zone of the project and converging at switching stations to the south and north was retained. The northern switching station, however, was to be located north of the #200 Area



auxiliary process facilities in order to keep it 2.5 miles from all other target areas. This arrangement prompted the location of one #200 Area, in addition to two #100 Areas, in each of the single circuit lines. The five #100 Areas and two #200 Areas then authorized had relative locations which indicated that the middle of the three process zone transmission lines would serve only one #100 Area and would pass through a region which was considered a likely location for any future #100 Area. However, this arrangement later was changed. The middle line was re-routed through one of the #200 Areas, leaving the easterly line as the one most likely to serve any future areas. The high-tension switching arrangement recommended in Scheme V for the transmission loop substation was that developed in Scheme II.

A modification of the Scheme I arrangement for the pump house supply was incorporated in Scheme V, (see diagram, page 505) the modification effecting a reduction in the number of line-crossings involving radial feeders to the pump house substations. This was accomplished by routing the feeder lines to the southern and northern main river pump houses (two lines for each) from the nearest high-tension switching station. For the middle pump house, one transmission feeder line was run from each of the two west-side high-tension switching stations. As in Schemes I and II, duplicate lines were provided for interconnecting the process zone network switching stations (north and south) and the river pump house switching stations (west side). This arrangement provided a reliable power link between the tremendous heat-generating processes and the vital cooling water supply facilities. One of these western loop circuits was routed through the transmission substation feeding power to the #300/700 Areas. The layout of the process zone network was in practical agreement with the 2.5-mile spacing criterion. However, because of the short distances between adjacent main river pump houses, it was impossible to meet this condition for the routing of feeder lines in the pump house zone. Studies of the use of high-tension, underground cables as part of the pump house supply system were begun, but the deletion of the center pump house from the scope of work removed the need for further consideration of an underground cable supply.

Three variations of Scheme V were prepared, showing the minor modifications necessary to the basic scheme to make it most suitable for the transmission of either site-generated or purchased power or a combination of the two. The line layout of Scheme V changed very little whether energy was purchased or generated. However, the purchase of substantial quantities of energy, along with such factors as points of delivery and delivery voltage would affect the

operating voltage level selected for the SRP system, the use of voltage control equipment at transmission substation transformers, and the duties of the SRP system supervisor. In February of 1951, the first block of on-site generation was authorized and it became evident that the most suitable arrangement would be Scheme V-C, developed for a combination of generation and purchased power.

An important part of transmission system design is the application of protective relays to the system. Relays are the "watchdogs" of the electrical system, their functions being: (1) to sense unusual conditions such as short-circuiting faults, unbalanced current flow, overload and overtemperature, and voltage variations; and (2) to initiate the action of circuit-opening equipment. It is essential that fast protective relays be provided to isolate and limit fault damage and to protect the remainder of the system from disturbances due to the fault. Investigations of various types of relaying and a discussion of the features of the selected system are covered in a later section of this volume.

In Scheme V, the system can be operated in such a way that a section of line between transmission substations, including the transformers on either end, can be removed from service to isolate a fault without disrupting the flow of energy to the area load. After interrupting the short circuit by circuit breaker operation, the faulted part (line or transformer) can be isolated by means of disconnecting switches and the unfaulted portions of the affected section can be returned to service within a few minutes.

In order to provide for proper system protection and control, a system supervisor (also known as a load dispatcher) should at all times have an immediate and accurate knowledge of system connections, automatic operations and general conditions in addition to operation control of the principal devices of the transmission system.

By early March, 1951, Gibbs & Hill and the Design Division had selected Scheme V-C as the one most suitable for the SRP. At a meeting on March 8, 1951, this scheme was recommended to the Engineering Department and received favorable reaction but final approval was delayed because of the many studies and problems relating to the transmission system that were still under consideration. Related subjects included the development of suitable sources of power supply; the type of drive and power supply for the #100 Area process and cooling water pumps; and the development of load data by area. In addition to these, it was desirable to make more detailed studies of the proposed system including its operating and short circuit

SAVANNAH RIVER PLANT  
 DUPONT PROJECT 8980  
 G. & H. JOB NO. 835  
115-KV TRANSMISSION SYSTEM  
SCHEME 5  
 GIBBS & HILL, INC.  
 CONSULTING ENGINEERS

characteristics, and its relaying and supervisory control requirements. In the meantime, however, some design work was underway at Gibbs & Hill. Detailed design for an "H"-frame type of wood structure was being developed in addition to a bill-of-materials covering poles, anchors and cross arms.

During the remaining weeks of March and the first week of April, 1951, detailed consideration was given to the problem of selecting the type of #100 Area pump drive and supply system. One system considered was all-electric; the other was all-hydraulic. The former was selected. Details of the selection and design development of the drive and supply system are covered in a later section. This decision permitted further review of the transmission system within the Engineering Department, with the Operating Division and outside consultants.

One of the latter was Phillip Sporn, of the American Gas & Electric Company, and a well-known authority on integrated power systems. Notes taken during the meeting with Mr. Sporn on April 10, 1951, report his comments and suggestions on the transmission system as follows:

1. The 115 kv. grid system was endorsed as were wood "H" frame transmission line structures having two aerial ground wires.
2. Oil circuit breakers having an interrupting-time rating of 5 cycles should be used on the 115 kv. system.
3. The basic idea of employing pilot wire relaying on the 115 kv. transmission system was endorsed. The necessity of preserving the integrity of pilot wire circuits was discussed and it was stated specifically that commercial telephone cables should not be used to carry pilot relay circuits.
4. Particular care was recommended in the preparation of transformer specifications, especially to be sure that adequate surge protection would be provided.
5. It was recommended that each of the two 115 kv. transformers in a #100 Area transmission sub-station should have a rating at least sufficient to carry the entire load of Building #105 (the reactor building) and the total rating of the two transformers should be at least great enough to export the entire generating capacity of the local power house.

6. The policy of preparing for sabotage or other enemy action that might damage the 115 kv. substations by storing transformers, oil circuit breakers, wood poles and other components at isolated locations was endorsed.
7. The #100 Area 13.8 kv. ring-bus arrangement with dual tie breakers was endorsed.
8. From the standpoint of reliability, preference was expressed for oil or askarel-filled transformers.
9. The operation of all the sources contributing to the supply of power as an integrated and interconnected system was recommended. It was recognized that technical problems of system control and load dispatching would develop, but Mr. Sporn was confident that with the cooperation of all contributing agencies, satisfactory solutions could be reached.
10. It was recommended that connections of purchased power sources to the 115 kv. transmission grid be separated geographically as much as possible.

In May, 1951, the proposed electrical transmission system was formally presented to the Atomic Energy Division of the du Pont Explosives Department and to the Atomic Energy Commission, along with the recommendations for on-site generation in the first three #100 Areas. The system was again discussed with the Operating Division's management at a meeting on June 13, 1951, and a letter of that date affirmed the following decisions:

1. The schematic arrangement prepared by the Engineering Department showing three transmission lines through the main plant area was agreed upon, and it was recommended that the most easterly line should be laid out to favor passing through the future #100 Area rather than favoring the #200 Area.
2. The system would include three collective points and purchased power would be fed into the system at two points to be determined by geography, economics and further development of the sources of purchased power.
3. The locations selected for the collecting points were acceptable with the provision that the one located at coordinate North 88000 and East 54000 would be re-appraised when the location of the road from Aiken into the northern part of the plant site was firm.

4. The Engineering Department would re-examine the system of electrical supply to the river pump house area on the basis of two pump houses approximately two miles apart. The third or center pump house location should be considered as a future installation.

Elimination of the center pump house permitted routing a transmission line feeder to each pump house from each of the two switching stations with but one line-crossing. These lines were routed in a manner providing for the erection of aerial feeders to the center pump house at any time in the future with a minimum of relocation of existing lines. The arrangement of steam, water and electric power facilities is sketched on page 509.

#### TYPE OF CONSTRUCTION

The formal approval in June, 1951, of the recommended transmission system allowed the issuance of final detailed design and the acceleration of procurement. A considerable amount of study and preliminary design and procurement work had been accomplished prior to that date. In one of the earlier studies, comparative costs and the relative merits of wood pole "H"-frame construction versus steel tower construction were developed. The former was chosen because of lower cost, shorter construction time, greater ease in replacing damaged structures and the critical shortage of steel at that time. In another related study comparative costs for transmission lines employing line conductors of various materials were developed. Factors included structure spacing (a function of conductor tensile strength) and structure strength (a function of spacing, conductor weight, and wind resistance) in addition to the cost of the conductor and hardware. The use of aluminum cable, steel-reinforced (ACSR) was indicated for this particular system and the current carrying capacity required.

#### NETWORK ANALYZER STUDY

The load tabulation prepared by the Design Division in April, 1951, provided a great impetus for the completion of preliminary studies, specification writing, and detailed design of the transmission system. On the basis of these estimated area loads, tentative capacities were established for the transmission lines, the generators and the power transformers.

It then was possible to simulate the transmission system on a network analyzer board for detailed system



study. This board study provided a check and extension of previous calculations and assumptions. It predicted load flow under various operating conditions; the short circuit current resulting from three-phase and line-to-ground faults; and established the voltage regulation throughout the system and the range of voltage taps required on power transformers. Information was developed that was useful in studying generator grounding and application of lightning arresters and in making detailed calculations of voltage regulations and fault curves at distribution and utilization voltages. One of the important results of the board study was the preparation of specifications covering the protective relaying, supervisory control and telemetering systems required for the transmission system. The network analyzer study emphasized such characteristics of the transmission system as the short lengths and low impedance of the lines, the many terminals and fault current paths of the network which, together, would present difficulties in the development of a protective relaying system.

#### PROCUREMENT

To establish competitive prices and deliveries from the several manufacturers of large power transformers, a general specification was issued early in March, 1951, covering the total needs of the project power system for this equipment. Where the load information for a particular area was uncertain, several transformer sizes were listed. The load tabulation and subsequent network analyzer study permitted a more accurate specification of transformer sizes, voltage-tap-changing equipment, and internal impedance characteristics. The power transformer general specification was re-issued in parts by areas, and the following orders were placed: #400 Area on June 7, 1951; #600 and #700 Areas on June 21, 1951; #100 Areas on July 25, 1951; and #200 Areas on August 8, 1951. It is interesting to note that these early transformer orders totaled over \$2,900,000.

Another million-dollar order had been placed on April 17, 1951, for the 44 outdoor, 115 kv. circuit breakers required by transmission system Scheme V. Because that scheme had not, as yet, received formal approval, provision was made in the order for increasing or decreasing the total quantity of breakers; but it was not found necessary to change the quantity of 44.

Immediately following the final approval of the transmission network layout, specifications were furnished to the Construction Division covering quantities, material and treatment for poles, anchor logs and cross arms for field procurement. With special concern being directed toward the

expediting of delivery of major equipment, it was disappointing to learn that a "bottle-neck" existed in the procurement of poles and cross arms of the specified quality grade. Accordingly, it became necessary for the Construction Division to accept materials of less than first class grades in order to avoid unacceptable construction delays. Alternate designs were provided for the transmission line structures to cover the addition of "X" braces for the poles and sag braces for the cross arms, where required. Field tests demonstrated the need and effectiveness of sag braces on cross arms, and every tangent structure was so equipped.

### POLE LINE DESIGN

Because of the reliability requirements of the transmission system, considerable interest was directed toward the design of the line structures. Two factors were particularly pertinent - mechanical strength and lightning performance. To assure adequate line strength and stability, all mechanical factors of safety were made equal to or greater than those contained in "Safety Rules for the Installation and Maintenance of Electric Supply and Communication Lines", Section 25, Grade B, of the National Electric Safety Code.

The plant site is located on the border of the NESC medium and light loading districts; therefore, the transmission line was designed to withstand the maximum design loads specified for either district. The medium loading district calls for a maximum load condition of 1/4 inch of ice, 4 lb./sq. ft. wind pressure and 15°F. temperatures; the light loading district calls for no ice, 9 lb./sq. ft. wind pressure and 30°F. temperature. In designing the line to be satisfactory for either district, it was found that the medium loading conditions were controlling for the conductor design while the light loading conditions were controlling for the structure design. As to such loading conditions as those imposed by a hurricane, the constants and formulae accepted by the industry for such calculations were applied and it was determined that the structure designed was adequate to withstand a 100 mile/hr. hurricane wind with a factor of safety of 1.4. This safety factor was considered adequate to cover reasonable pole variations and pole deterioration for this extreme condition.

To gain insight into the importance of providing a transmission system having excellent lightning performance, one should study the isokeraunic charts for the past several years. These charts, which are prepared from U. S. Weather Bureau data, are maps of the United States on which have been plotted lines of equal storm frequencies.

The charts indicate that the average number of thunder-storm-days per year for most of the country east of the Rockies is about 30, while in the area of the Hanford Works the average is about 7. In contrast with these averages, the number of thunder-storm-days per year expected in the vicinity of the Savannah River Plant is 55. While these charts do not indicate the duration or severity of storms, they do provide an indication of the relative needs for lightning protective measures required to minimize the number of lightning outages on a transmission system. Lightning strokes may be kept from overhead lines by placing an intercepting grounded conductor above the line in such a manner that all predictable strokes will strike the grounded conductor rather than the energized conductor. The generally accepted shielding angle of  $30^\circ$  with accepted spacing will give protection against 99.5% of all strokes. For the Savannah River Plant lines two overhead ground wires were necessary to provide adequate shielding for the desired high degree of lightning immunity.

In addition to these shielding measures, it was necessary to design a structure configuration which used the insulation values of the porcelain insulators, the wood cross arms and air in such a way as to provide the desired basic insulation level (BIL). Power equipment rated 115 kv. has a BIL of 550 kv. This means that the equipment can withstand the impulse wave of an impressed voltage which rises to 550 kv. in one and one-half microseconds and decays to half that value at 40 micro-seconds. The impulse insulation level of a transmission line is also a function of the structure grounding resistance. Because grounding conditions at the plant site were uncertain and the design could not wait for surveys and tests to be made, an average structure grounding resistance of 50 ohms was assumed for design purposes. There was little doubt that such a value could be obtained and, if a lower value of grounding resistance were realized, the lightning performance of the transmission line would be improved. Because of the installation, for other reasons, of a continuous, buried ground wire known as a counterpoise, connected to each structure ground, the structure grounding resistance was reduced actually to a very low value. The total effect of the overhead shielding ground wires, the buried counterpoise, and the structure dimensions and configurations was to reduce the probability of lightning outages of the transmission line to almost negligible limits.

In addition to the time required for studies, calculations and detailed design of structures, many more design manhours were required for the layout of line routes and structure locations. To eliminate as much of the surveying and staking work in the field as possible, a fast alternate method was used. Line routes were plotted initially on topographic maps

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in the office, from which profiles were prepared for use as the bases for locating structures. These plan and profile drawings then were checked by a Site Clearance Group for possible interference with other facilities and also were checked in the field for unusual conditions or obstacles. After the right-of-way had been cleared in preparation for construction, the line routes were walked and minor adjustments were made in the location of structures.

By late September, 1951, approximately 50% of these detailed profiles were ready for field checking. Although the detailed design for some of the individual areas had not yet been released, every effort was made to maintain steady and rapid progress in the design of the complete transmission system. This was desirable in order to keep the line construction crews busy once they had started and to have the system ready, if possible, to transmit power for the later stages of construction.

## CONTROL AND PROTECTIVE RELAYING

### GENERAL

Concurrently with the design development of the transmission lines, intensive studies were made of the protective relaying and supervisory control of the system. Available protective and control devices and systems were carefully evaluated in terms of the rigorous requirements for reliability. It was recognized early that the more difficult and unusual problems would be encountered in providing adequate protective relaying systems; whereas satisfactory alternative systems were available for providing supervisory control and telemetering. Therefore, first attention was given to the solution of the relaying problem, following which a compatible control system could be developed along standard lines.

All phases of the protective, operational, and control requirements of the SRP system were discussed frequently with representatives of the General Electric Company and the Westinghouse Electric Corporation, manufacturers of coordinated systems for these functions. When requirements were developed into a specification (issue date - 6/15/51), both companies were familiar with the problems and were able to submit their proposals and the bids the latter part of July, 1951. After careful analysis of these proposals, the Westinghouse Electric Corporation was selected as the supplier of the coordinated protective relaying, supervisory control, telemetering and telephone communication systems equipment.

## PROTECTIVE RELAYING

The function of relays and circuit breakers in the operation of a power system is to prevent or limit damage during faults or overloads and to minimize their effect upon the system. This is accomplished by dividing the system into protective zones separated by circuit breakers. During a fault, the zone which includes the faulted apparatus or line section is de-energized and disconnected from the system. The problem of applying protective relays then consists in selecting for each zone a relay scheme which will recognize the existence of a fault within the zone and initiate circuit breaker operation. Protection zones of a power system, and hence the protective relaying schemes, may be conveniently classified as follows: (1) apparatus protection; (2) bus protection; and (3) line protection.

A different relay scheme may be selected for each of these zones and an important phase of design becomes that of providing coordination between zones to provide selective circuit breaker operation. The application of relays for the protection of power zones in the apparatus and bus classifications was accomplished by conventional methods. However, for some vital zones, additional protection was provided.

The selection and development of a protective relay scheme for the transmission line zones involved complex problems with few promising solutions. Studies to determine the most suitable relaying arrangement proceeded for a number of months during the first part of 1951. The 115 kv. transmission system is characterized by sequences of short line sections and multiple parallel paths between switching points which combine to create a situation responsible for most of the problems. The short line distances and low line impedances of the system eliminated the use of relay schemes involving impedance-measuring (or "distance-measuring") relays. The need for high-speed circuit breaker operation eliminated the use of induction type relays for first-line protection.

Of the high speed relay schemes available, two appeared applicable. One of these, known as carrier-current relaying, gained general acceptance around 1935. It operates on the principle of quickly tripping all terminals through which power flows into a line, provided fault power does not flow out at any other terminal. If fault power flows out at any other terminal, that terminal continues to transmit, over the power line, a straight telegraphic carrier signal which is picked up by all other terminals on that particular line and prevents tripping. A carrier-current scheme is generally built around a high-speed distance type relay.

The other high-speed relay scheme, known as pilot-wire relaying, was developed a few years after the carrier-current type. This scheme employs a relay which operates on the principle that a fault current may be represented by three symmetrical components. These component currents are known as the negative-sequence, positive-sequence and zero-sequence currents. At each end of the line section, voltage is developed during a fault which is proportional to the positive-sequence current and a constant multiplied by the zero-sequence current. Each relay contains a filter for segregating these two components and combining the right amount of each into a single relaying quantity. Thus tripping is obtained at any desired ground-fault current and phase-fault current. The reduction to a single differentiating quantity makes comparison over only two pilot wires possible.

Pilot-wire relaying is to the short transmission line what carrier-current protection is to the long one. It provides uniform, simultaneous tripping of the circuit breakers at both ends of a section, with all that such operation implies in the way of increased stability, lessened shock and damage to the system, and simplified coordination with other relay protection.

The cost of pilot-wire circuits increases directly with the length of line, whereas the cost of carrier-current protection is practically unaffected by the length of the line. However, the terminal equipment required for the carrier-current is considerably more expensive than the terminal equipment required with pilot-wire protection. Consequently, there is an economic break point between the two schemes; this point varies widely, depending upon the cost of the pilot-wire cable and the allocation of that cost against the relay protection scheme. This latter function depends upon the number of other pilot-wire services, such as supervisory control, telemetering and communications with which the cost of the pilot cable can be shared. The fact that the line sections of the Savannah River Plant transmission system were short contributed to the economic feasibility of pilot-wire protection. Its high speed of operation, inherent selectivity, the simplicity of its terminal equipment and its reliability, all combined with the characteristics of short line sections and many terminals of the system, indicated pilot-wire relaying as the best choice for first-line protection.

The following are some of the design factors involved in the development of a high quality pilot-wire relaying system.

1. Provide operation at high speed.



2. Use a minimum number of pilot wires.
3. Provide supervision for the pilot wire.
4. Provide complete phase and ground protection with the simplest relay arrangement at each terminal.
5. Provide allowance for variations in current transformer performance.
6. Avoid incorrect operation when the system is out of synchronism.
7. Provide adequate insulation between the pilot wires and the terminal equipment.
8. Provide for dealing readily with induced voltages in the pilot circuits or with differences in station-ground potential.

Some of these items required calculating board analysis, field testing, and extensive study. In particular, the last two items will be discussed briefly because of the measures required to meet those provisions.

The principal concern of Items 7 and 8 above is with transient overvoltage stresses in the cable and provisions for adequate protection against such overvoltages for personnel and terminal apparatus as well as the cable itself. Voltage stresses on the cable result from two distinct effects. The first is a component of the voltage induced directly by the overhead transmission line, running parallel to the cable, and second, a transient component resulting from a difference in ground potential between adjacent stations produced by the flow of ground-fault current. Tests made in the field indicated that appreciable differences would exist in station-ground potentials. Using the preliminary data developed, the Westinghouse Electric Corporation set up its analyzer calculating board to study the cable overvoltage problem. This indicated that voltage stresses up to 7 kv. could occur and that corrective measures were necessary to permit the application of terminal protective devices. The following over-all program was established at a conference in early October, 1951.

1. Provide a continuous counterpoise under the transmission line, comprised of a single 2/0 (AWG) copper cable connected to each structure ground for the purposes of reducing potential differences among substation ground grids and of partially shielding the supervisory cable.

2. Ground all spare cable pairs, considering two pairs so grounded as the acceptable minimum in any cable section.
3. Apply protector-tubes at each end of any pair used for supervisory control, telemetering and telephone.
4. Apply neutralizing reactors at each end of each pair used for pilot-wire relaying. (Each such transformer will neutralize 4000 volts.) The use of protector-tubes is not feasible on relaying circuits of this system, using d.c. supervision relays for remote trip functions, because the tubes might ground the circuits at the very moment that protective relays should be operative for clearing the fault.
5. Provide a substantial steel cabinet at each cable termination in which all protective devices would be installed, each cabinet to be divided into two compartments. One would be marked and treated as an energized high-voltage cubicle and would contain the neutralizing reactors where all cable circuits would actually be terminated on blocks connected to protective devices and cross-connected as required. The second compartment would contain the protector-tubes, low voltage fuses and terminal blocks for circuits to be carried to the station control board. This second compartment could be considered as containing only low-voltage circuits.

A restudy of the problem, taking into account the effect of these corrective measures, indicated that the maximum supervisory cable overvoltage stress would be 2800 volts.

Another outstanding relaying problem which developed during those months of study early in 1951, pertained to providing a suitable system of back-up relay protection that would function reliably in the event a pilot-wire circuit or a circuit breaker failed to operate. The conventional application of either impedance-measuring relays or over-current relays for back-up protection was not feasible - the former because of the lack of selectivity on short lines and the latter because of lack of coordination for all possible system fault conditions.

The necessarily unique solution to the problem was provided by the application of a second, independent set of pilot-wire relays for each line section. The pilot wires for the first set of relays follow the path of the protected line. The pilot wires for the second set of relays loop around through other stations so that they do not have a

common right-of-way with the first set; also the two sets of relays are energized from separate current transformers. In this manner the two sets of relays are made independent; each set can serve as first-line protection and each set serves as back-up for the other for all faults on the transmission line.

The implementation of this duplicate pilot-wire relay protection scheme presented some unusual engineering problems. For clarity of discussion, the two pilot wires following the short, direct route between line section terminals are designated the "direct pair", while the two wires following the longer, loop route between the same two terminals are designated the "looped pair". The application of relays to the direct pair was considered routine. For the looped pair, approaching 30 miles in length in some cases, the application of pilot-wire relays required special measures. Avoiding the detailed technical complications, the problem may be stated as that of providing sufficiently low circuit resistance and shunt capacities to insure proper operation of the pilot-wire relays over the looped pair circuit.

Westinghouse Electric Corporation established upper limits for these circuit parameters to insure proper relay operation. Discussions with cable manufacturers indicated that available cables of conventional construction could not be employed within these limits and a new cable design would have to be developed, without complete assurance of success. But further delay in ordering the relay equipment could not be tolerated and a purchase order, executed with Westinghouse Electric Corporation on August 24, 1951, initiated the design and fabrication of the pilot-wire relay equipment. The decision to proceed with the relay order in the face of the uncertainties was based upon the possibility of taking special measures to bring circuit parameters within limits. One of these measures would be the use of inductive shunt reactors to compensate for excess cable capacitance. A last resort measure would be the re-routing of some of the pilot-wire cable to shorten the longer loop circuits. It was not until April, 1952, that tests could be made on sample lengths of the special cable that was developed by the Anaconda Wire and Cable Company. Anaconda had been selected because of its proposal to use polyethylene for the insulation of the individual wires with a vinyl-resin compound outer jacket. This insulating material appeared to offer the best chance of meeting the low capacitance requirements. These early sample tests indicated that the cable design was successful; however, there was some reason to believe that the use of a few compensating reactors might be desirable, and these were ordered. As early as possible, field tests were made with actual relays installed to check their calibration with

and without compensating reactors. These tests demonstrated the advantages of installing reactors in some of the longer pilot-wire circuits.

The use of two independent sets of pilot-wire relays, as described, provided back-up relay protection which assured relay operation for faults occurring on all 115 kv. line sections except the dead-end, radial lines to the river pump houses. For these radial lines, single line feeds without multiple parallel paths, it was possible to apply and coordinate separate overcurrent relays for line-to-line faults and for line-to-ground faults.

To achieve complete back-up protection, it was necessary to provide means for tripping other breakers if the breaker associated with the faulted line section failed to open. To accomplish this, the pilot-wire tripping signal is transferred on to the next breaker, so that if the first breaker fails to open within five-tenths second, the adjacent breaker or breakers will be tripped.

The last phase in the development of the transmission line protective relaying system involved the purchased-power line, between the Urquhart Station of the South Carolina Electric & Gas Company and the north switching station on the project site. Detailed consideration was given to protective relaying for this line long after the fundamental relay system for the plant was developed. At a conference in June, 1952, engineers of Gibbs & Hill, du Pont, and South Carolina Electric & Gas Company agreed, since (1) the line would be long for pilot-wire protection, (2) General Electric Company's carrier-relaying equipment had been adopted by the utility as standard equipment and (3) SCE&G Company would maintain the line, that power-line carrier with conventional relays with distance-measuring relays for back-up protection would be used. In addition to fault protection relays, under-frequency-directional tripping relays were provided to prevent operating difficulties on the SCE&G Company's system from jeopardizing the reliability of the Savannah River Plant system. Reverse power flow in conjunction with an under-frequency condition initiates tripping of the tie line. Page 523 presents a one-line diagram of the relaying system.

Before leaving the subject of protective relaying, recognition should be given to the preparation of Specification No. 3241, "Protective Relay Settings for Electric Transmission & Distribution Systems". This specification tabulates for supply points the settings for protective relays and circuit breaker tripping devices in all areas and also in some buildings. It includes, in addition to the tabulated settings, the setting criteria,

coordination tables and curves, test values and testing information where required.

## SUPERVISORY CONTROL AND TELEMETERING

The decision to interconnect all electric sources and loads by means of a transmission system, forming an integrated power system, led logically to the decision to provide a point of centralized control of the interconnected system. From this central point, a load dispatcher can coordinate and control the operation of the primary switching elements of the electrical supply system. Electric power information transmitted to instruments in his office by the telemetering system provides data enabling the load dispatcher to supervise the balance of the system. The transmission system should normally be operated as a closed network with all loops interconnected by the tie circuit breakers between the "A" and "B" buses at the 115 kv. switching stations. At the discretion of the load supervisor, the "A" and "B" looped systems may be operated separately. This would be an abnormal operating condition but a condition that could occur during a start-up period or while getting into operation after an outage. Synchronizing devices were provided for bringing separate portions into synchronism before tying together.

The #700 Area was selected as the site for the location of the central supervisory control point - the Load Dispatcher's Office, sketched on page 525. This location for the "nerve-center" of the electric power supply system removed it from proximity to other primary target areas. The supervisory equipment was housed in a blast-proof extension of the #700 Area transmission substation control house to permit direct operation of that substation by the dispatcher.

As indicated, the supervisory control and telemetering requirements for the power system were included in the same specification with the protective relaying requirements. These several interrelated systems were combined within one specification to assure the development of these systems on a compatible and coordinated basis, with one vendor having primary responsibility for the equipment and its design. The Westinghouse Electric Corporation proposed the use of "Visicode" supervisory control equipment designed to operate over one pair of telephone-type line wires carried in the same cable with the pilot wires for the protective relaying system. As indicated by its trade name, this remote control equipment employs the transmission of coded impulses over the wire pair to initiate the operation of the selected device. Control-function codes are initiated by the load dispatcher at his control panel; supervision-function codes are initiated at a transmission system station by a change in the position of a switch or circuit breaker or by some other supervised local occurrence.

1. PRESS TRIP IN @ 1 (RELAY)  
2. PRESS TRIP IN @ 2 (RELAY)

### LEGEND

- (1) OVERCURRENT RELAY
- (2) OVERCURRENT AND RELAY
- (3) PILOT WIRE RELAY
- (4) DIFFERENTIAL RELAY
- (5) DIFFERENTIAL RELAY
- (6) DIFFERENTIAL RELAY
- (7) DIFFERENTIAL RELAY
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- (100) DIFFERENTIAL RELAY

### INSTRUMENTS:

- V - VOLTMETER
- A - AMPERE
- K - KWH METER
- W - WATT METER
- S - VOLTAGE FOR MANUAL SYNC.
- AS - VOLTAGE FOR AUTOMATIC SYNC.
- T - TELEMETRYING - W. V. R. V. S.

### GENERAL NOTES:

1. All 115KV OCBs will be General Electric FR-439-3500 with following NEMA standard services:  
Quenching Current - 35000 A - 35 Type BR, 1000/5, Multiratio.
2. All Bus Capacitance Potential Devices will be NEMA standard GE Type KA-119 for 115 and 66 kV sec. volts.
3. Generator rating and synchro instrument transformer ratio summary:

| Station | C.B. 200 MVA | Voltage | Instrument Transformer Ratio |
|---------|--------------|---------|------------------------------|
| 151-R   | 115KV        | 115KV   | 115KV/5                      |
| 151-L   | 115KV        | 115KV   | 115KV/5                      |
| 151-D   | 115KV        | 115KV   | 115KV/5                      |
| 151-K   | 115KV        | 115KV   | 115KV/5                      |

4. Power transformer rating and associated instrument transformer ratio summary

| Station | Power Transformer Rating | Instrument Transformer Ratio |
|---------|--------------------------|------------------------------|
| 151-R   | 115KV/115KV              | 115KV/5                      |
| 151-L   | 115KV/115KV              | 115KV/5                      |
| 151-D   | 115KV/115KV              | 115KV/5                      |
| 151-K   | 115KV/115KV              | 115KV/5                      |

### SAVANNAH RIVER PLANT 115KV TRANSMISSION LINE - 503G RELAYING ONE-LINE DIAGRAM

GIBBS & HILL, INC.  
CONSTRUCTORS  
SAVANNAH, GA.  
JOB NO. 523

| REVISION | DATE     | BY      | CHKD. | REVISION | DATE     | BY      | CHKD. |
|----------|----------|---------|-------|----------|----------|---------|-------|
| 1        | 11/15/57 | N/15557 |       | 1        | 11/15/57 | N/15557 |       |
| 2        | 11/15/57 | N/15557 |       | 2        | 11/15/57 | N/15557 |       |
| 3        | 11/15/57 | N/15557 |       | 3        | 11/15/57 | N/15557 |       |
| 4        | 11/15/57 | N/15557 |       | 4        | 11/15/57 | N/15557 |       |
| 5        | 11/15/57 | N/15557 |       | 5        | 11/15/57 | N/15557 |       |
| 6        | 11/15/57 | N/15557 |       | 6        | 11/15/57 | N/15557 |       |
| 7        | 11/15/57 | N/15557 |       | 7        | 11/15/57 | N/15557 |       |
| 8        | 11/15/57 | N/15557 |       | 8        | 11/15/57 | N/15557 |       |
| 9        | 11/15/57 | N/15557 |       | 9        | 11/15/57 | N/15557 |       |
| 10       | 11/15/57 | N/15557 |       | 10       | 11/15/57 | N/15557 |       |

W136138

Nº 751A. LOAD DESPATCHER OFFICE & SUPERVISORY CONTROL BOARD.

Lybbs & Hill Inc. - Engineers - Constructors - New York - Los Angeles



Each station device for which control or supervision is provided is given a point-assignment-number which determines the selection code by which a circuit is established between the selected device and the load dispatcher's control point. The scope of this extensive supervisory control system (see diagram page 529) is indicated by a tabulation of the devices and functions and the number of point assignments involved, as follows:

| <u>DEVICE OR FUNCTION</u>                                          | <u>POINTS PROVIDED</u> |
|--------------------------------------------------------------------|------------------------|
| <u>Control &amp; Supervision</u>                                   |                        |
| Circuit Breakers, 115 kv., with automatic synchronizing            | 36 points              |
| Circuit Breakers, 115 kv., without automatic synchronizing         | 4 points               |
| Future Breakers without synchronizers                              | 2 points               |
| Horn Gap Switches, 115 kv.                                         | 27 points              |
| Circuit Breakers, 13.8 kv., with automatic synchronizing           | 18 points              |
| Selective Telemetering of electrical quantities from remote points | 46 points              |
| Telephone Instruments                                              | 12 points              |
| Spares, complete except for escutcheons                            | 8 points               |
| <u>Supervision Only</u>                                            |                        |
| Circuit Breakers, 115 kv.                                          | 5 points               |
| Local-remote transfer switches                                     | 12 points              |
| Substation trouble alarm                                           | 12 points              |
| Pilot wire supervision                                             | 32 points              |
| Transformer temperature relays                                     | 14 points              |
| Transformer differential relays                                    | 8 points               |
| Emergency generator starts                                         | 3 points               |
| Spares, complete except for escutcheons                            | 7 points               |

Relatively few changes in the basic plan were found necessary as the design of the supervisory control system progressed to its final development. Changes and additions in the telemetering, automatic synchronizing and communications requirements which affected the supervisory control system were readily accommodated. One development in the supervisory control scheme is particularly worthy of note. It had been planned originally to provide the load dispatcher with a means for switching his remote control functions to a substitute, emergency pair of wires which follow an indirect route in case the normal, direct route should fail. A scheme was developed for the simultaneous transmission of control impulses over both the direct route and the loop route. Since the sections of the loop route are not connected conductively, the impulses following this route are transferred from section to section through repeaters. The interposition of repeaters in the loop circuit results in transmission delay so that, normally, codes first reach their destination by way of the direct circuit. When these first impulses are received, relay action blocks the delayed impulses coming in over the loop circuit. If the direct circuit fails to transmit the impulses, however, the delayed impulses are effective and the desired action is accomplished.

Telemetering requirements contained in the previously mentioned functional specification included the following: (1) simultaneous and instant indication and recording of totalized mw and mvar generation at each power house, (2) continuous indication and recording of the combined totals of generated mw and mvar, and (3) telemetering of the voltage at each 115 kv. and 13.8 kv. bus. This specification incorporated an energy telemetering scheme involving the application of the voltage output from the energy-measuring thermal converters directly to wire circuits for transmission to the load dispatcher's office.

The Westinghouse Electric Corporation, prime vendor of all equipment covered by the specification, took exception to this telemetering arrangement, stating that the scheme was unworkable on such long cable circuits. Two alternative schemes were offered. The first was a slow-speed system using watt-hour meter elements in place of thermal converters at the generating stations. In this system, 20 seconds is the response time for 99 per cent of any change that occurs. The second system was faster. It used one or more thermal-converter sensing units coupled to an electronic transmitter unit whose output frequency is proportional to the output voltage from the thermal converters. This system has a total response time of approximately 2 seconds for a full-scale change and less than 1 second for most changes.

SAVANNAH RIVER PLANT  
V TRANSMISSION SYSTEM 9086  
LINE SYNCHRONIZING DIAGRAM

[illegible]

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The first of these systems had been in use for over 20 years; whereas the second was new - it had been laboratory-tested but no field installations had been made. After careful study and discussion of the three schemes - the originally specified Leeds & Northrup system and the Westinghouse alternatives - the second of the alternative schemes was selected for the following reasons.

1. The variable frequency system is inherently insensitive to signal voltage changes and is therefore independent of the effects of induced voltages and changes in pilot wire characteristics - effects to which the original scheme is subject.
2. The high-speed response would be advantageous, especially should a requirement for automatic load control ever develop.
3. The equipment is very flexible. Totalizing is easily accomplished by connecting thermal converter outputs in series before application to transmitters or by connecting the outputs of receivers in series. Also, reconnection and recalibration in the field is accomplished easily.
4. The first of the alternative schemes involved apparatus thought to be approaching obsolescence.
5. Further study of the original plan for direct transmission of thermal converter outputs indicated that completely satisfactory operation was certainly questionable.

The advantages stated in reason #3 became especially important as additional telemetering requirements were developed. At a meeting held in mid-October, 1951, engineering representatives of the Operating Department, the Design Division, and Gibbs & Hill reviewed the metering, telemetering and supervisory control systems in the light of increased knowledge of the problems of operating the power supply system. It was decided at this meeting to telemeter to the load dispatcher information concerning the power flow through each transmission substation. In the case of the #400 Area and the #100 Areas having local generation, this information would indicate the net contribution of said generation to the transmission system. The presentation of the information on a continuous basis was not considered necessary, so it was decided to provide selective telemetering, selected as required by means of supervisory control. To meet this requirement in the #400 Area, it was necessary to totalize the load on the four-power transformer banks, but as pointed out earlier, the

variable frequency transmitter system has particular advantages for totalizing. The addition of these selective telemetering requirements had its effect upon the supervisory control system, but there were no particular difficulties in providing the selection control.

The next revision to the telemetering set-up was made early in 1953, and was necessitated by a re-examination and subsequent removal of certain interlock circuits between the 115 kv. and 13.8 kv. circuit breakers at the transmission loop substations. Interlocks were considered to prevent the establishment of parallel circuits resulting in heavy circulating currents and to require specified operating sequences to prevent damage to equipment. During various stages of design development, interlocks were incorporated in the system design to prevent the establishment of a bypass circuit around the 115 kv. circuit breaker through the two transformers and 13.8 kv. bus between them. The opening of a 115 kv. breaker to sectionalize a transmission line loop is a necessary part of the system's operating flexibility. An analysis of the system was made to show the effects of transmission line faults when any particular 115 kv. breaker is open. This analysis was summarized by recommending the proper 13.8 kv. circuit breaker position for the various conditions involving an open 115 kv. breaker. In many cases, these recommendations could not be followed because of the bypass interlocks. On the other hand, the elimination of the interlocks could, in some cases, cause an overload condition on the transformers. In April, 1953, at a conference of Design and Operating personnel, it was generally accepted that a system of interlocks to enforce the recommendations was not feasible and that system load dispatchers of high quality are essential to reliable system operation. It was agreed to eliminate the bypass interlocks, leaving an alarm feature to warn the dispatcher of the existence of a bypass circuit.

This decision required the application of automatic synchronizing to additional 13.8 kv. circuit breakers. A second effect required the modification of selective telemetering from the remote loop substations and the local metering at substation #251-A to permit the load dispatcher, by operation of supervisory control or by local switches, to read at will the kilowatts and kilovars through each transformer individually as well as combined. This modification was required because, during the bypass condition, energy flow through the two transformers is in the opposite direction and the original telemetering arrangement was connected to indicate only the algebraic sum of the two and hence would not indicate the transformer overload condition. Here again, the flexibility of the selected telemetering system equipment proved advantageous.

Portions of the telemetering system were placed in service as soon as generating equipment in the #400 and #100-R Area power houses was started. For several weeks these power houses were operated independently, and from each station the telemetering system transmitted to the load dispatcher in Building #751-A the total area generation in megawatts and megavars, and also the total megawatts and megavars passing through the corresponding transmission substation. During this phase of independent power house operation, no significant trouble was experienced with the continuous and selective telemetering systems. The telemetering equipment had not been tested under actual service conditions, but simulated tests conducted prior to operating service had indicated that operation would be satisfactory.

In late May, 1953, the decision was made by the Operating Department to place the two power houses (#484-D and #184-R) in parallel. A final checkout in preparation for parallel operation revealed that the telemetering systems in the two power houses were performing unsatisfactorily. When the Design Division learned of this erratic operation on May 26, 1953, immediate arrangements were made for a Westinghouse equipment design engineer to visit the site, accompanied by an engineer from Gibbs & Hill and one from the du Pont Design Division, to investigate and to attempt to correct the trouble. On June 15, 1953, a meeting was held at the Westinghouse factory in Newark, New Jersey, to review the unsuccessful attempts to remedy the equipment trouble in the field and to outline a program for corrective measures. The report on the field investigations indicated that temperature changes were responsible for an error of approximately 1-1/2% with an additional, greater error the cause of which was not known.

A follow-up meeting was held on June 17, 1953, with some of the top engineering and research personnel of Westinghouse. As a result of this meeting, Westinghouse: (1) accepted the entire responsibility for the trouble and for its correction; (2) recognized the urgency for putting an acceptable telemetering system into operation as quickly as possible; and (3) proposed to form a team of highly qualified engineers from its Electronics, Relay and Research Divisions to develop a solution to the problem.

Three complete sets of telemetering equipment were returned from the Savannah River Plant to the Westinghouse plant at Newark, New Jersey, for reworking by the trouble-shooting team. By June 22, 1953, a series of modifications to the equipment had been decided upon. These modifications were incorporated in one unit and tests indicated that the equipment was functioning within prescribed limits of accuracy. It was decided to operate this unit at least three days to be

sure that no additional difficulties, such as long-term drift, would occur. These modifications were, individually, of a minor nature and represented refinements rather than basic changes to the equipment. The Westinghouse team continued its work of refinement and testing for another week and, at a meeting on July 1, 1953, the results were presented to engineers of Gibbs & Hill and du Pont Design Division. Two members of this team subsequently supervised the installation and field testing of the modified equipment at the Savannah River Plant. Satisfactory results were obtained and the remainder of the telemetering equipment requiring similar modifications was returned to the Westinghouse factory.

#### LOAD DISPATCHER'S TELEPHONE SYSTEM

In the operation of the 115 kv. electrical system, there is a definite requirement for a reliable, easily accessible means of communication between the load dispatcher's office and power house control rooms and, under certain conditions, with the outlying transmission stations. Such communication is necessary in regulating the interchange of active and re-active power between generating areas and the transmission system; in adjusting frequency in generation areas prior to synchronizing; and in coordinating any local substation operation that may be necessary during emergency or maintenance periods. The requirements of reliability and accessibility were sufficient to warrant an independent telephone system for the exclusive use of the load dispatcher. Therefore, telephone facilities were included in the same functional specification with the protective relaying, supervisory control and telemetering systems, and the necessary circuits were provided in the supervisory cable system.

The two cable pairs assigned to the telephone system leave the load dispatcher's office by two routes and are broken electrically at about the half-way point in the two loops. The telephone switching scheme developed for this system also breaks the two telephone circuit loops at the dispatcher's office and thus provides four independent circuits, two each way. This arrangement permits several simultaneous, independent conversations among the primary transmission stations. All ringing and signaling are accomplished by means of supervisory control and the necessary talking-circuit switching is accomplished by the load dispatcher, giving him complete control over the system. This system was extended as the need became evident so that finally it reached all substations and all power house or boiler house control rooms.



After the telephone system had been installed and put into operation, it was noted that apparently excessive line losses on the longest cable circuits were making conversation between certain points very difficult. A study of this problem was begun in May, 1953. First consideration was given to the use of loading coils which are commonly applied under such conditions. Effective application of loading coils would require cutting into the cable at relatively short intervals and thus jeopardize the reliability of other cable circuits. Very little improvement was possible through the re-arrangement of circuit groups. Therefore, the study turned to determining the most suitable type and arrangement of repeaters. Measurements were taken during July, 1953, to determine the actual circuit losses between the load dispatcher's office and the transmission stations. This information was given to the North Electric Company which, as subcontractor to the Westinghouse Electric Corporation, had developed the telephone system. A survey of available standard telephone repeaters, fixed gain devices for fixed circuit lengths developed for long time requirements, indicated that no standard repeaters were suitable for this application. In July, 1953, the North Electric Company began the accelerated development of special repeaters suitable for this application. These units were to incorporate wide-range, automatic gain control to meet automatically the changing gain requirements encountered in the wide range of circuit lengths. Installation and testing of the repeaters were accomplished during March, 1954, with satisfactory operation resulting.

#### SUPERVISORY CABLE SYSTEM

Having reviewed the design development of the protective relaying, supervisory control, telemetering and telephone systems, the importance of the cable system in the development and operating reliability of these several systems can be appreciated. The effects of the cable characteristics upon the design and operability of the relaying system was especially significant. The purchase order for this cable was awarded to the Anaconda Cable Corporation which had offered polyethylene insulation and a synthetic cable jacket. This order was placed in June, 1951, even before full knowledge of the required electrical characteristics had been developed, so that the vendor could place it in his manufacturing schedule and also participate in the development of the required characteristics. The following cable requirements were finally established.

### Physical

1. Suitable for installation by direct burial in ducts, conduits, and cable trays or lashed to overhead messenger.
2. Must withstand total immersion in water for prolonged periods without deleterious effects.
3. Equipped with a light armor, serving also as a shield, and equipped with a suitable outer jacket.

### Electrical

1. Number 16 AWG conductors for adequate conductivity.
2. Maximum shunt capacity of 0.12 MFD/mile.
3. Conductor insulation capable of withstanding 3000 volts between adjacent pairs and 5000 volts between the outer pairs and the surrounding armor.

The original order in December, 1951, was for 100,000 feet of 31-pair cable and 250,000 feet of 41-pair cable. To meet design progress, the order was modified later to call for approximately 80,000 feet of 31-pair and 260,000 feet of 41-pair cable, at a total cost of \$460,000.

The make-up of the two sizes of cable was similar, other than the number of pairs. Each solid copper conductor was insulated with 25 mils of natural polyethylene; pairs were twisted, bundled and covered overall with a polyethylene binder; and two 13-mil aluminum shielding tapes and a 6/64-inch vinyl-resin compound outer jacket were applied.

Easy and positive identification of any particular pair in the bundle of the cable was desirable, but only rudimentary color coding could be employed because of the possible adverse effects of the pigments upon dielectric strength. By agreement with the Construction Division and the Operating Department, one pair of conductors in each layer of the bundle was color coded and the other pairs in each layer were then identified by counting from the coded pair.

Considerable study and experimentation were required in the development of a reliable, moisture-proof splice which would not require a long course of training for the splicers. The splice design finally adopted involved a compression connector and polyethylene insulating sleeve for each conductor; a specific method of taping; carrying the aluminum shielding tapes across the splice; applying an outer layer

of tape; housing the whole splice in an outer protective Micarta sleeve; and, finally, pouring a micro-crystalline wax to fill all voids within the sleeve. Although polyethylene is practically impervious to water, the polyethylene sleeve over the connectors used in the splice could not be securely bonded to the wire insulation. At this location, water could provide a path under the sleeve that might not resist the induced voltages. It was decided to place all splices above the ground and special concrete pedestals with concrete cast covers were designed as supporting housings for the splices.

The major portions of the cable runs were plowed directly into the ground at a depth of 30 inches. A suitable cable plow was obtained from the American Telephone and Telegraph Company for this purpose and the installation was accomplished with little trouble. However, where streams or marshes were encountered, the cable was run overhead rather than subject it to long periods of immersion. In this installation it was lashed by wire spinning to a pole-line-supported messenger.

After sections of cable had been installed, it was necessary to insure that splices had been made correctly and all circuits were continuous and serviceable, and to determine and record the electrical characteristics of each circuit to insure the use of the best circuits for the most critical functions. A test program was developed to cover both an initial test and subsequent periodic tests and was published as Specification 3204. The repeated, periodic tests were recommended for the purpose of detecting progressive changes in cable characteristics. This specification also included recommended procedures and instruments based upon studies of various methods for fault location.

Underground, water-sensitive cable runs are often supervised by inert gas pressure to detect breaks in the cable sheath and to impede the entrance of water through small leaks. Although unusual precautions had been taken in the selection of cable material, the design and support of the splices, and the use of overhead runs across wet ground to minimize the possibilities of water entry, field tests were made in April, 1953, to determine the feasibility of inert gas supervision of the cable sections. Because of the very slow propagation of the pressure changes through the length of the cable and because of the substantial range of pressure change resulting from temperature changes in aerial sections, gas supervision was abandoned as unpromising.

## TRANSMISSION SWITCHING STATIONS AND SUBSTATIONS

The specific detailed design of the transmission substation in each area was developed in relation to and as a part of each area involved, and a more complete coverage of those facilities will be found in other sections of this history devoted to the electrical facilities of individual areas. There are, however, certain general, project-wide considerations pertaining to the high-voltage portions of the substations which will be presented here as a part of the design development of the transmission system.

The basic electrical arrangement of the 115 kv. system switching stations and substations was determined during the development of the approved transmission scheme during the first quarter of 1951. The recommended arrangement, previously outlined as Scheme V, required three switching stations located outside the production zone in such a manner that transmission lines running generally north and south could serve the process areas enroute as loop feeders. A fourth 115 kv. switching point was provided as a part of the #400 Area substation. The transmission system's schematics required that each switching station consist of two isolated 115 kv. buses, "A" and "B", connected through a bus-tie breaker. This arrangement permitted sectionalizing the normally-closed, multi-looped system into two independent ring systems or portions thereof, as may be required by system trouble and/or maintenance. No attempt was made to provide means for switching any given transmission line from one bus to the other because of the complications attending the relaying, controlling and metering of the lines, the materially increased cost of each switching station, and the more complicated, less reliable operational set-up. The electrical arrangement of the 115 kv. equipment at the transmission loop substations in the process areas was also very simple. It included a line-sectionalizing circuit breaker and the necessary horn-gap disconnecting switches for connecting the transformers to the 115 kv. loop.

The general physical arrangement of all switching stations was considered and decided during the design of the #400 Area substation, the first to receive attention, early in March, 1951. The adopted design (see page 539) was based on what is termed the "on-the ground" arrangement in which bus A and bus B are located at extreme opposite sides of the substation yard, supported by relatively small steel structures; while circuit breaker isolating switches are located on pedestals adjacent to the circuit breakers. A higher center steel structure is provided to receive the incoming and outgoing lines with taps to either bus through the circuit breakers as required. The adaptability and dependability of this arrangement had been proven by extensive use throughout the country.

Bldg. 451 U. S. 115 KV sub station

Gibbs & Hill Inc. - Engineers - Constructors - New York - Los Angeles.

As it was for all vital facilities, consideration was given to the effect of damage by bomb blast in the design of the transmission substations. Experience during wartime indicated the open nature of substations plus the inherent rigidity of the equipment resulted in good resistance to blast. The economic and physical impracticality of protecting walls, entitled them to only passing consideration. A better line of defense was inaugurated, the policy of being prepared for damage by stock-piling spare equipment which could be moved quickly into position and placed in service. This decision led to a related decision to move spare transformers when needed over the plant highway system on a tractor-lowbed-trailer truck. A suitable tractor-trailer, purchased by construction for their general use was turned over to the operating group. The transformers were bought with flanged wheels and their foundations were designed to permit easy transfer between foundations and the lowbed trailer. It was also necessary, of course, to provide suitable access roads into the substations, to study the routes of movement of transformers along the highways, to check bridge capacities and overhead clearances, and to provide a suitable location for storage of the spare equipment.

For each of the switching stations and the substations in the process areas, a small blast-proof building was provided to house the supervisory control switchboard, the local control switchboard, the station battery, and the process area supply switchgear. In the case of the substation in the #700 Area, the load dispatcher's room was of blast-proof construction, but the local substation control house portion was not made blast-proof because the expense was not justified in view of the lower service reliability requirements in that area.

The importance of providing effective grounding to earth at each of the 115 kv. substations has already been mentioned in reference to the development of the relay system and supervisory cable system. There were also other reasons for requiring effective grounds at each station. One of these involved the application of effective lightning protection equipment. Because of the grounding problems (resistivity of the earth) known to exist as evidenced by the South Carolina Electric & Gas Company's experience in the region, the uncertainty of the excellence of solution and the pressing time schedule the proper procedure for insuring adequate equipment to meet the unpredictable grounding situation was to specify transformers having full-voltage insulation and lightning arresters suitable for rated line-to-line voltage application.

The original substation grounding mat design called for a grid of 4/0 cable buried 3 feet deep, 30 feet apart each way, with 20-foot ground rods driven at the intersecting points and connected to the cables. Ground resistance readings were taken by the Construction forces at the several transmission stations during the summer of 1952. The measurements indicated the need for additional ground rods in some areas -- one area required additional rods driven to depths of 150, 200 and 350 feet before mat resistance was lowered sufficiently. The resistances-to-ground of the grounding mats of all switching stations and substations were finally reduced to grounding resistances less than 3 ohms and, because these ground mats were, in turn, all connected together by the buried counterpoise, an excellent ground system was obtained.

As a result of the low system ground resistance finally established, the lightning arrester application was reconsidered and the decision was made to reconnect the arrester units for 97-kv. operation. Application at the voltage was possible because the 115-kv. transformers had been provided with a solidly grounded neutral for the high-voltage windings. The lower lightning arrester voltage value gave an added margin of protection, and therefore increased the overall reliability of the system.

#### LOW VOLTAGE SYSTEMS

General policies pertinent to the design of low voltage electrical systems were established during the first quarter of 1951.

1. Systems were to be simplified and standardized on a project wide basis insofar as possible, consistent with meeting load requirements.
2. Standard apparatus was to be employed wherever possible to minimize cost and delivery time.
3. Power feeders and signal circuits to Class I (blast-proof) buildings were to be underground cables. Where the #100 Area process unit auxiliaries were concerned, supply dependability was paramount and any other considerations were secondary.
4. For circuits other than those in Class I buildings, conventional overhead construction was to be employed.

5. To minimize the number of poles, wire crossings and conflicts, joint-use construction of pole-lines was to be employed for general power distribution and other overhead facilities, such as fence and road lighting circuits and luminaries and various communications and alarm circuits.

## DISTRIBUTION SYSTEMS - GENERAL

The individual area power distribution system serves as the vital link between the inter-area transmission system, and the utilization and generation equipment within the area. Consequently, design of the distribution systems was closely related to the transmission system requirements and the area use requirements. In several areas, these latter requirements involved special considerations and factors which will be discussed, by areas, later in this section. There were some general design considerations common to all areas and these will be discussed briefly at this point before proceeding with the design development of the distribution system in each area.

### VOLTAGE LEVELS

One of the first essentials was to establish, at the earliest practical date, the distribution voltage levels that would best meet all requirements, in order to progress with the design and procurement program involving critical, long-delivery time apparatus such as power transformers and switchgear. Studies and evaluations of the several standard distribution voltages commonly used proceeded rapidly following the release of preliminary load tabulations and the authorization of generation equipment in the #400 Area and the indication of probable generation in some of the #100 Areas.

The basic distribution voltages in those areas having generation and also large process electrical loads was set at 13,800 volts as the logical standard voltage level. The use of this voltage rather than some lower standard voltage was desirable from the economic and copper conservation considerations involving the underground process feeder cables. Moreover, where short circuit capacity is as high as was expected in the #100 Area systems, switchgear can be applied most economically at 13,800 volts. Generation at 13,800 volts in preference to lower standard voltages, such as 6900 volts and 4160 volts, has become almost universal utility practice, and apparatus of this voltage rating is more generally available. Standardization, as far as possible, on 13,800 volts for primary substation low-tension



buses would increase the possibilities of interchanging apparatus in case of emergencies and permit a reduction in the number of major equipment items held as spares. The use of 13,800 volts for general overhead distribution was most economical in view of the estimated circuit mileage and load magnitudes. As in the case of underground cable, a significant amount of copper could be conserved in overhead distribution, at the same time maintaining voltage-drop and line-losses within acceptable limits. Consideration of the cost of large motors for the pumping facilities in the #600 Area indicated an economic advantage in the use of a voltage lower than 13,800 volts. There the distribution system was short and, outside of a small amount of auxiliary power, its only purpose was to serve the river pump motors. In the case of the #100 Areas, the overall economic advantage lay in 13,800 volt distribution.

The studies mentioned thus far were developed at Gibbs & Hill. Independently, the Blaw-Knox Company had fixed the voltage for the distribution system within the #200 Areas at 13,800 volts also. Preliminary studies of a distribution system for the #300/700 Areas were begun at Voorhees, Walker, Foley & Smith (this responsibility was later transferred to Gibbs & Hill) and the use of 13,800 volts was indicated. The use of 13,800 volts for distribution systems was established for all areas with the exception of the river pump houses -- #681-1G and #681-3G -- where the cost of the motors governed the selection of 4160 volt service.

For a project of this nature, the most commonly utilized voltage for miscellaneous building supplies would be 480 volts. General use was made of the normal practice of distributing power at 13,800 volts to unit substations placed close to centers of load where voltage was stepped down to 480 volts. Requirements for 208/120 volts and 240/120 volts for lighting and miscellaneous small loads were satisfied, as a general rule, by providing dry-type transformers, supplied at 480 volts, located within buildings. This general distribution scheme is conventional and economical and a wide range of standardized equipment is available.

## GROUNDING

Primary substation step-down transformers were specified as 115-kv. wye-connected, high voltage and 13.8-kv. delta-connected, low-voltage windings. As mentioned previously, the neutral of the high-voltage winding is effectively grounded. The desirability of grounding at the substation on the low-voltage side of the transformers depends upon a number of factors. Two of these relate to the protection of

rotating equipment directly connected to the 13.8-kv. system. To minimize the overvoltage stress applied to the windings of a large motor being supplied directly from the distribution system, it is desirable to operate that system grounded -- the more effectively grounded, the better. On the other hand, the presence of a solid ground for the system permits larger ground fault currents to flow through the windings of generators directly supplying the system. These factors were of greatest concern in the #100 Areas where both motors and generators were planned for operation at 13,800 volts. The conflict inherent in these two factors was resolved for these areas by grounding the neutrals of the generator windings through grounding resistors. These resistors were selected to limit the ground fault current flowing through the generator windings to a value not exceeding 150% of the full-load current rating of the generators.

The same criterion was applied also to the grounding of the generators in the #400 Area. Since there were neither generators nor motors directly connected to the distribution system of the #200 Areas and #300/700 Areas (originally), these systems remained ungrounded. When three 2000 hp. 13.8-kv. compressor-drive motors were added in the #700 Area, the desirability of grounding the distribution system of that area was re-examined. It was felt that in this particular case the surge protection equipment connected at the motor terminals provided sufficiently reliable protection against over-voltage stresses, and the system was left ungrounded.

When the time came for the detailed design development of the distribution system for the #100-C Area, where large motors but no generators would be directly connected, effective grounding for the protection of the motors was accomplished on the secondary side of the main power transformers by the installation of auxiliary, zig-zag transformers to establish a neutral point for the delta system.

All other low voltage circuits were designed as grounded circuits in accordance with du Pont standard practice. Corner-of-the-delta grounding is employed for the 480-volt delta circuits and neutral grounding is used for 208/120-volt wye circuits. This grounding practice is followed primarily out of consideration for the maximum safety of the operating personnel.

#### LIGHTNING PROTECTION

In addition to the operating voltage level and the grounding of the distribution system, considerable time was

devoted also to the general problem of lightning protection for the 13.8-kv. overhead lines. In general, lightning arresters were provided at every transition point, from overhead wire to underground cable construction, for protection of outdoor secondary substation apparatus and at building entrances of overhead services. The effectiveness of lightning protection at these points is largely a matter of effective grounding of the lightning arrester ground lead. But adequate lightning protection of 13.8-kv. apparatus having relatively low basic insulation level (such as dry-type transformers) connected to overhead conductors requires more careful selection of arresters for coordination of characteristics. In each area, one particular underground piping system was selected for electrical grounding purposes and was made continuously conductive. In accordance with du Pont Engineering Standards, all lightning arrester grounds were connected to these water mains if within reasonable distance.

During the lightning season in the early summer of 1953, several equipment failures resulted from lightning disturbances on the aerial 13.8-kv. lines in several areas. Investigations and tests indicated that the primary factor involved in these occurrences was the unacceptably high ground resistance generally prevailing in distribution equipment grounds. It was also noted that there were no similar failures on the 115-kv. transmission system where low ground resistance had been assured by means of the buried counterpoise. A general review of the grounding and lightning arrester application procedures in all areas was made by Design, Construction and Operations from which several recommendations for improvements were developed.

A corollary study was made of the characteristics of available lightning arresters for the purpose of selecting a lightning arrester providing a greater margin of protection for the more important cable, transformer, and switchgear installations. The results of this review and study were incorporated in Specification No. 3275, "Grounding and Lightning Arrester Protection - All Areas", which contained the following main provisions.

1. All the presently used grounding systems within an area, including: (a) the water main designated for the areas as a ground source; (b) the primary substation mat; (c) the counterpoise; (d) building grounds; and (e) other presently isolated grounding systems shall be solidly connected together to form a common grounding system.
2. Where reasonable and practical, all lightning arrester ground leads shall be connected to this common system.

3. A specially selected lightning arrester of the rotating-machine protection type shall be applied for the protection of transformer banks, 500-kv.-a. and up, or small ones if on important service, and points of transition from aerial to cable runs feeding such transformers or other important service.
4. A method was prescribed for obtaining low resistance grounds in isolated areas where a tie-in to the common ground system was not practical.
5. Grounds should be tested as installed and every attempt made to keep ground resistance below 5 ohms.

### COORDINATION

On providing circuit-opening devices for the protection of apparatus and the sectionlizing of circuits, each designer of area or building distribution systems was required to exercise due care to insure the proper coordination of these devices. At Gibbs & Hill an extensive study was made of the overall problem of coordination of devices at all voltage levels from 115 kv. to 120/208-v. The aim of coordination is to interrupt the short circuit or overload current and isolate the faulted or overloaded portion of the system with the least effect on the rest of the system. It has not been general industrial practice to extend this concern for coordination of protective devices to the 440-volt, or lower, systems; however, in certain process work, efforts to achieve coordination down to the last fuse device are justified.

In the main process buildings of the #100 Areas, proper coordination between successive fuse devices and between fuses and feeder circuit breakers of the 440-volt distribution systems can result in minimizing the number of process shutdowns. As a result of the studies made at Gibbs & Hill, important aids were developed which were applicable in all areas for the selection and sizing of various types of fuse devices for proper coordination with the various types of air circuit breakers contained in unit load centers throughout the project. On the 13.8-kv. distribution system, fuse ratings and circuit breaker settings were kept as high as possible without compromising apparatus protection, to provide the greatest feasible margin for proper selectivity of any successive overcurrent devices. The information developed was issued as Specifications 3241 and 3253.

POLE-LINE DESIGN

One of the most obvious ways in which the designs of area low-voltage systems were standardized and expedited involved the design of pole lines. General design policy required minimizing the number of poles, wire crossings and conflicts by employing joint-use construction of pole lines to the greatest possible extent for the wide variety of electrical facilities for which overhead construction was necessary or desirable for reasons of economy or flexibility. As a result, it was required that pole lines be designed for nearly all possible combinations of the following facilities:

1. Open-wire power distribution, 13.8-kv. and below;
2. Open-wire, series lighting circuits for fence and road lights;
3. Fence and road lighting luminaries;
4. Bell system, telephone cable;
5. Fire alarm stations; and
6. Miscellaneous communication, control and signal cables normally installed in messenger supported rings, including fire alarm cables, safety alarm cables, blackout control cable, sound-powered telephone system cables and emergency generator starting circuit cables.

As far as possible, standardized arrangements were adopted based upon the National Electric Safety Code (NESC) preferred positions for various circuit classifications and clearance and climbing space requirements. All pole lines were designed in conformance with NESC Grade B requirements. Because the plant site adjoins the boundary between the NESC medium and light loading zones, a line design was adopted suitable for conditions prescribed for both zones. Thus, wire tensions were based upon the heavier ice load of the medium loading zone, whereas, the transverse pole loading was based upon the higher wind velocities of the light loading zone. Beyond these general design considerations, detailed design was based, as far as possible, upon du Pont Engineering Standards and Standard Engineering Specifications. A typical installation is shown on page 549.

501 R-FENCE LIGHTING  
505 R-FIRE ALARM SYSTEMS  
506 R-TELEPHONE CABLES  
507 R-SAFETY ALARM SYSTEM

Libbes & Hill Inc - Engineers - Constructors. New York - Los Angeles.

## DISTRIBUTION SYSTEMS - BY AREAS

#100 AREAS

As noted, final approval of the recommended transmission system scheme, presented early in March, 1951, was delayed pending results of several related studies. Likewise, the design development of the #100 Area electrical distribution system was closely related to the selection of the type of drives for the process and cooling water pumping facilities. The requirement for maximum reliability was responsible for this close relationship. The design of the #100 Area process facilities by the du Pont Design Division included the responsibility for the selection and development of an absolutely dependable method of driving the pumps which were vital to the operation and safety of the process.

During the first quarter of 1951, two basic drive schemes were developed which became known as the hydraulic scheme and the all-electric scheme. During the evaluation of these schemes, some basic concepts were developed which defined three types of power supply required for the pumping facilities, "production power", "on-line power" and "emergency power". Production power was defined as that which is normally available for full production operation of the process facilities. On-line power was to be available in reduced quantity and applied during normal operation so that power would be applied to the drives during the transition period following the loss of production power. Emergency power was to be made available quickly following the loss of production power to provide sufficient power for extended periods of emergency shutdown operations. A detailed description of the development and evaluation of these two drive and supply schemes is included in the section of this history devoted to the #100 Area design development.

It is obvious that the use of steam turbine, hydraulic turbine or other mechanical drivers would have considerable impact upon the design of the electrical distribution system being developed to supply an all-electric drive arrangement. The development of the all-electric drive and supply scheme involved the application of a primary source, a secondary source and an emergency source of power to a large normal-operation motor and a smaller back-up motor connected to each of the process and the cooling water pumps. Numerous circuit and switching arrangements were developed as well as several combinations of different types of motors. During March, 1951, du Pont's electrical engineers concentrated on the problem of selecting the best

combination of motors and supply circuit arrangement that would satisfy the fundamental concepts and rigid requirements. During this period they sought the advice and assistance of both distribution system and motor design experts within the organizations of the several leading manufacturing companies.

In designing an ultra-reliable electrical supply system, two criteria were considered basic: (1) the system should be composed of a minimum number of elements arranged in the simplest and most direct manner so that the exposure to outage is at a minimum; and (2) the system should be flexible and have alternative emergency elements so that, in case of the loss of the normal element, an alternative element can be used immediately. These two criteria, if considered independently, would establish the use of diametrically opposite types of systems with respect to the quantity and arrangement of elements. The first criterion would result in a simple radial system; while the second would result in a network system. After studying all suggestions, the du Pont electrical engineers developed a drive and supply arrangement scheme for the process and cooling water pumps having the following basic features.

1. A 13.8-kv. primary supply bus was established in the power house to which the local generators and the transmission substation transformer were connected. The bus was arranged in a ring with several sectionalizing circuit breakers to isolate and localize system disturbances.
2. Six independent sets of radial feeders would be supplied by a like number of feeder circuit breakers. One feeder in each set would supply a step-down transformer serving one of the main process pump drive motors; while the other feeder in the set would supply a similar independent transformer at the cooling water pump drive motor. Each process pump drive would have a d.c. auxiliary motor to perform the following functions: provide some driving power during normal operation; drive the pump set at half speed following the loss of production power; and provide sufficient power for starting the pump set from rest and accelerating it to half speed.
3. The six d.c. auxiliary drive motors would be supplied from six associated d.c. generators which, in turn, would be driven by three diesel engines.
4. Emergency cooling water pumping would be accomplished by three independent sets of a.c. motor-driven pumps each supplied by a diesel-driven alternator.



The two #100 Area drive and supply schemes -- electric and hydraulic -- were presented at a meeting with Engineering Department management on April 3, 1951. The selection, based largely upon previous experience with such schemes, was made on April 7, 1951. On that date the decision was announced that all-electric drives and supply systems would be provided for all five of the #100 Areas. This decision released the electrical design group to make detailed studies and refinements of the basic scheme, to specify and procure the necessary equipment, and to proceed with the layout and detailed design of the area distribution system. Subsequent changes and refinements to the drive equipment and arrangement are discussed as part of the history of the #100 Area process design development. The changes and refinements to the supply system are discussed here as part of the design development of the #100 Area distribution systems.

In the early system layouts, the power house and primary substations were combined, with the generators and transformers connected to a common 13.8-kv. bus. During the discussions of primary, secondary and emergency power supply, an arrangement was conceived to enhance the reliability of production power by geographically separating the power house and the transmission substation. In this arrangement the 13.8-kv. ring-bus was divided into four sections, two located at the power house and two located at the substation. The ring would be completed by two underground cable connections between the two switchgear locations. Schematically adjacent sections of the ring would be connected by dual tie breakers.

By late May, 1951, switchgear specifications were released for procurement of equipment on the basis of this arrangement. Studies of electrical diagrams and equipment arrangement continued, with emphasis on reliability as well as economy. Because of this, the distance between the power house and the transmission substation, was established at not less than 1400 feet, so that in the event of an air blast, serious damage would be minimized. It was decided also to control the switchgear in the transmission substation from the power house control room in order to provide centralized control of all local operations and reduce the number of operators required. Also, it was considered advisable to house the 13.8-kv. switchgear in blast-proof buildings with a center dividing wall in each to provide isolation between two adjacent switchgear bus sections. A typical #100 Area substation is shown on page 555.

The purchase order for the 13.8-kv., 1,000,000-kv.-a. interrupting rating switchgear required for the five #100

Areas was placed in July, 1951, with the Westinghouse Electric Corporation at an approximate cost of \$4,000,000. Since, at that time, authorization for generation equipment had been given for the first three #100 Areas only, the manufacturer was released for fabrication of switchgear for those three areas. Approval of generation in the "K" Area was given in October, 1951, and at that time switchgear fabrication was released for the last two areas.

In June, 1951, after the arrangement of the 13.8-kv. switchgear was well along in its development, attention was turned to the layout of the electrical distribution cable system for the reliable supply of power to the various process buildings. The design arrangement called for direct burial of power cables approximately three feet below grade and two feet apart. The control cables also were designed for direct burial in a group at the side of the main power cables. All of these important cable runs required un-spliced lengths of cable -- cable splices being often the points at which cable failures occur -- in a triplex arrangement to form a three-conductor assembly. A triplex cable construction permitted the use of three separated single-conductor potheads at the termination of the cable which maintained the phase segregation of the switchgear design and also lessened the dependence upon skillful workmanship for installation.

The sizing of these important cables required more than common care because of their importance. Of a total area load of approximately 22,000 kv.-a., Building #105 represents approximately 75 percent and Building #190, 12 percent of this total. These two buildings, which are practically adjacent, are both served by the underground cable distribution system involving a considerable number of continuously loaded power cables. The sizing of these feeder cables required a careful study of cable layout and thermal interaction during normal load conditions, periods of overload conditions, and even the very short periods of possible short circuit conditions. From these studies, the feeder cable size was selected which would adequately limit the copper temperature under these conditions to 150°C. and then the next larger standard size was specified. For this system, voltage drop along the feeder cable length was an equally important factor. Calculations were carefully made of the voltage drop occurring during the starting at full voltage of one of the large pump motors under the worst conditions of high running load and curtailed power supply.

During the period of the effort on #100 Area distribution system design, developments were reviewed frequently with the du Pont Explosives Department - Atomic Energy Division. Key single-line diagrams and important equipment

Bldg No 151 - 1R - 115 KV Substation

arrangement drawings were submitted to both the AED and the AEC for approval. The basic design (for the #100-RPL Areas) of the 115-kv. substations and the 13.8-kv. switchgear bus arrangements in both the #151-1 and #151-2 Building locations were approved by the AED before the end of August of 1951. Building #151-1 was the designation given the transmission substation and Building #151-2 was the designation given the switchgear and relay house located near the power house. In the earlier arrangements, the switchgear housed in Building #151-2 was to be located in a blast-proof portion of the power house, Building #184.

In August, 1951, the Power Design Group initiated studies of the #100 Area power house design aimed at a reduction in size and cost of that building. Based on these studies, a semi-outdoor design was selected and it was decided to locate the blast-proof relay and switchgear house a slight distance away from the power house so design and construction of the two buildings could proceed on an independent basis. The distance between the two buildings was originally set in mid-September, 1951, at 30 feet; but this distance was later increased to about 70 feet to permit sufficient space between the two buildings for the use of crawler-cranes which might be required for the erection of the outdoor turbine generators.

The allocation of the more important 13.8-kv. feeders to either the transmission station switchgear house or the generating station switchgear house was based upon the concept that the latter, because of its direct, short connections to the local generators, was the more reliable source of supply. Accordingly two of the main #105 Building process pump motors were fed from each of the two switchgear sections in Building #151-2 (located next to the power house). Each of the two switchgear sections in Building #151-1 was assigned a feeder for one of the pump motors. In addition to these important pumping units, Building #105 contains other vital electric equipment important to the control and safe operation of the process. For these and the other general power and lighting requirements of Building #105, one process feeder was assigned to each of the switchgear houses.

Second to Building #105, Building #190, which contained cooling water pumping facilities, was the largest consumer of electric power. For the 13.8-kv. supply to this building, one feeder was assigned to each of the four sections of 13.8-kv. switchgear -- two in each of the Buildings #151-1&2. The arrangement of the 2300-volt supply to the eight contemplated 600 hp. process cooling water pumps received special study during the last part of August, 1951.

As is often the case, the selection of a supply arrangement for Building #190 revolved about the choice between a number of independent units and an interconnected network of units. A comparison was made of the cost and expected reliability of a scheme using four independent 2300-volt bus units, each one feeding two of the pump motors, and a second scheme which interconnected the unit buses to form a double-bus, alternate source of supply for each pump motor. The first of these schemes, with its simpler arrangement and fewer switching elements, was not only less expensive but also involved less exposure to outage due to equipment failure. Although the absence of interconnecting ties between unit buses means that there is no alternate source of supply for each bus, it also means that trouble which develops at any one of the unit load centers cannot affect any of the other units; so that only a small portion of the building equipment will be adversely affected by any single outage. The four single-bus unit arrangements for the Building #190 2300-volt supply was approved by the Operating Department on September 4, 1951.

The electrical supply systems developed for the other power and service buildings in the #100 Areas were based upon the same general concept used throughout the project. Primary, 13.8-kv. power was distributed by feeders to the utilization points, at which locations 2300-volt and 440-volt load centers were installed. Power distribution within Building #184 was designed on the unit principle, in which one 2300-volt and one 440-volt load center were installed to supply auxiliary power to a unit group consisting of a boiler and turbine generator. Two such unit groups were contained in power houses #184-R, P, L&K. Tie circuits were provided between the two 2300-volt and two 440-volt load centers providing an alternative emergency service for each auxiliary group in order to keep both boilers and turbine generators on the line.

An account of the development and detailed design of the electrical distribution system for general purpose power within Building #105 is contained in that section of this history dealing with the development of the #100 Area process. The significant features of the resulting system are discussed here briefly; as an important part of the overall distribution of power within the #100 Areas. As mentioned, two 13.8-kv. feeders (one from each Building #151) were provided for the general supply of Buildings #150. Four 1500 kv.-a., 13.8 kv./440 volt unit load center substations were located in four different transformer rooms within Building #150. An interlocked, manually-operated switching arrangement at each of these substations permits connection to eight of the two 13.8-kv. feeders.

Although an emergency 440-volt power source was provided for the short-time operation of certain vital facilities, including back-up cooling water pumps, the effects of the loss of one of the 13.8 kv./440 volt transformers justified the use of tie circuits between the main bus sections of adjacent load centers. The switchgear in each of the unit load centers contains a main-bus section and an emergency-bus section. Loss of normal voltage at the emergency-bus section initiates, by relay action, the automatic starting of a 1000-kw., diesel-engine-driven generator in each #108 Building. When the generator has reached rated speed and voltage, a sequence of circuit breaker operations applies the emergency power to the appropriate emergency-bus section. A bus-tie breaker between the main-bus section and the emergency-bus section in each unit load center opens on loss of normal voltage so that main-bus loads are not applied to the emergency diesel generators unless the operator deliberately recloses this tie breaker. A tie circuit was established between the emergency generators so that in the event one failed to start, a minimum amount of critical service could be supplied from the remaining generator.

After the basic electrical design had been accomplished for the #100-R Area, the design procedure for the subsequent #100 Areas followed the pattern of reproducing the original design to the greatest extent possible and making minor changes where required by design modifications. For Building #105 electrical design, P Area was almost an exact duplication of R Area. A significant number of changes in the size, shape and arrangement of Building #105 for L Area required a virtually complete new set of electrical drawings, following however the same basic distribution scheme as in the R Area. For Building #105-K, the electrical design was again a nearly identical reproduction of #105-L. Portions of the electrical design for Building #105-C were also reproductions of Building #105-L; however, certain changes to the process, both actual and contemplated, required some additions and changes to the electrical design of that building.

For the power buildings and other service and auxiliary facilities, the design developed for the #100-R Area was applicable almost without change to the #100-P, L and K Areas. Two exceptions to this generalization which had an appreciable effect on the electrical design involved the reduction in the water clarification facilities provided for the last four areas and the increased rating for the turbine generators ordered for the K Area. In the first instance, the electrical switchgear on order for the #100-PLK&C Areas was no longer needed in the form originally contemplated, but it was not feasible to cancel this equipment and re-order switchgear that would exactly suit

the new conditions because the construction schedule required that the original shipping dates be maintained. Therefore, the switchgear units were modified and rearranged to suit the new design requirements even though, in some instances, equipment was larger than actually required.

In the second instance, when generating facilities for #100-K Area were authorized, a study of the design capacity of the generating equipment indicated that generators rated 12,500 kw. instead of 11,500 kw. could be ordered without requiring any other major change in the design. The effect of the higher generating capacity upon the short circuit interrupting duty imposed upon the 13.8-kv. switchgear was carefully calculated and studied. It was found that the 1,000,000 kv.-a. interrupting capacity of the switchgear then on order was adequate with two 12,500 kw. units installed; but, for any further increase in capacity of the generating station, current limiting reactors might be required.

When du Pont recommended to the AEC in October, 1951, that generating facilities be installed in the #100-K Area, it had not recommended similar facilities for the #100-C Area. In fact, its recommendations called for continued negotiations with the South Carolina Electric and Gas Company for the purchase of 30,000 kw. to complete the plant's power requirement. There was no definite decision at that time to the effect that there would be no generation in the C Area -- such a decision would depend upon the success of the power contract negotiations as well as other factors -- but there were strong indications that such would be the case. In view of this development, preliminary layout studies for the #100-C Area were initiated in early December, 1951, to develop a second transmission substation at 115 kv. At that time, however, there did not appear to be any compelling reason for making a decision or selecting a final layout. Negotiations with the SCE&G Co. reached the letter-of-contract stage by February, 1952, further strengthening the possibilities of not having generation in the C Area. The concept of operating a #100 Area without local generation would be a somewhat less rigorous concept of the reliability requirements, which demanded careful deliberation before making such a decision.

Early in April, 1952, Design Division representatives met with members of the AED, seeking a decision on the C Area layout. It was agreed at that meeting to obtain cost estimates for several schemes before making a decision. Accordingly, estimates on the following schemes were prepared: (1) a layout having only one transmission substation, estimated both with and without a Class I

construction relay house; and (2) a scheme having both Building #151-1 and #151-2 primary substations estimated with and without 11,250 kv.-a. transformers at the Building #151-2 location in place of the generator. However, neither of these schemes was accepted.

Studies and discussions of alternate schemes continued. On May 16, 1952, a "hold" was placed on the fabrication of the 13.8-kv. switchgear on order for the C Area to allow time for development and agreement upon a primary supply plan for that area. The switchgear then on order was rated at 1,000,000 kv.-a. interrupting capacity, but such a high rating would not be required if there were no generation or substitute transformers in the area -- switchgear rated 500,000 kv.-a. interrupting capacity would be adequate at a substantial reduction in cost. Subsequently, the original switchgear for the C Area was canceled and a new order based on competition was placed for switchgear of the lower interrupting rating. This was done with the full approval of the operating department representatives who were informed that the addition of generation would impose an interrupting duty which would exceed the rating of the new switchgear.

The design layout, as finally developed, retained as much reliability as possible by maintaining two 13.8-kv. substations, separated by about 1700 feet. One 22,500/30,000 kv.-a. main power transformer was located in each station. The 115-kv. transmission line was looped around the C Area to pass through both substations. Since these two transformer stations now became the sole normal power supply for the #100-C Area, the 115-kv. line sectionalizing and relaying scheme was redesigned to provide quick isolation of any fault that might occur within the confines of the "C" Area, so that one or the other substation remained in service. The new arrangement also required extensive modifications to the supervisory control panels, which were split and rebuilt for installation in each substation to provide supervisory control of each.

The new 13.8-kv. metal-clad switchgear was designed as a single bus section in each location with a buried cable, bus-tie circuit provided between them. This tie circuit was designed for 15,000 kv.-a. capacity to be normally operated with the circuit breakers at each end closed. Automatic synchronizing and tap changer equipment were provided for parallel operation of the two power transformers with the tie circuit closed. The substation auxiliary power 480-volt switchgear was also re-arranged to provide a single-ended unit load center in each substation with a bus-tie circuit with dual tie breakers between.



Local control was provided at both Buildings #151-1C and #151-2C, see page 563. In addition, a panel for the remote control of Building #151-1C was located in Building #151-2C, the station closer to the attended boiler house. Similarly, alarms which originate at Building #151-1C are transmitted to a panel in Building #151-2C and also to the load dispatcher in Building #751-A. A general alarm circuit is extended from the alarm panel to the boiler house to notify the operator there that attention should be given to the controls in Building #151-2C.

The definite location of Building #151-2C was held, pending approval of a preliminary location and general arrangement plan for the #100-C Area boiler house. However, in November, 1952, it was determined that completion of both Buildings #151-1 and #151-2 by an early date in 1953 was imperative to permit the supervisory control cable and terminal cabinets to be installed as a part of the program to give 115-kv. power to the #100-R Area. Accordingly, a location for Building #151-2C was agreed upon which would not interfere with possible sites for the boiler house. This agreement permitted design and construction of the electrical buildings to be accelerated to completion in advance of March, 1953. The 115-kv. line was looped through the C Area substations to permit energizing the line section even though the switchgear and control equipment in Buildings #151-1C and #151-2C were not yet installed.

The process load and distribution cable system requirements were essentially the same for the #100-C Area as for the other #100 Areas. A re-study of the cable size requirements, in view of the reduced short circuit duty imposed, led to the use of 4/0 size motor-feeder cables instead of the 350,000 circular-mil size required in the other areas. An equal number of motor feeders were assigned to the two primary substations in this area because of their reliability.

### #300/700 AREAS

The subcontract for the design of nearly all buildings in the #300-M and adjoining #700-A Areas, with the exception of certain power facilities, was given originally to the firm of Voorhees, Walker, Foley & Smith. The power buildings, that is the primary substation, boiler house, cooling tower, chlorinator building and the refrigeration building, were designed by Gibbs & Hill, Inc. The #300-M Area is basically a production area, having manufacturing facilities plus some semi-works. The #700-A Area is an administration, service and laboratory area having administration, telephone exchange, medical, shops, warehouse, garage, and various laboratory buildings. The combined #300/700 Area was scheduled for early completion in the construction schedule.

*Gibbs & Hill Inc - Engineers, Constructors, New York, Los Angeles.*

The design of the primary distribution system as well as low-voltage and building electrical systems was originally a part of the Voorhees, Walker, Foley & Smith assignment. Preliminary studies were initiated there of suitable types of primary distribution systems and also the relative costs of overhead compared with underground line construction. On April 25, 1951, the primary distribution system design work was transferred to Gibbs & Hill. By this time, 13.8 kv. had been selected as the operating voltage for the primary distribution system and the general layout and type of construction for the system were determined. These last two items were determined largely by two design considerations based upon the type and arrangement of the buildings being served. First, the reliability requirements were not abnormal. Second, there were relatively large numbers of buildings, well-spaced and having light, diversified loads. These and other factors -- primarily economic -- led to the design of a main area overhead distribution double loop system. Feeds to most of the numerous small secondary substations were tapped at convenient points in this double loop. Disconnecting pole-top air-break switches were located between every two (approximately) of these tap points to break the loop and isolate a section or sections thereof for maintenance purposes or to isolate faulted equipment. To avoid paralleling the main power transformers through these loop circuits and to assure positive action of relays associated with the 13.8-kv. feeder circuit breakers supplying the loops, one set of air-break switches should be open and the loop circuits actually operated as radial feeder circuits. Thus, three 13.8-kv. circuit breakers were provided in Building #751-A (local switchhouse) for supplying the double loop. An additional feeder breaker was eventually provided in the switchgear, to supply Building #789-A. Two additional circuit breakers were provided in the switchgear layout to supply Building #784 power facilities.

In mid-April, 1951, with some of the facilities in the #300/700 Area, including the primary substation, scheduled for start-up in less than a year, an effort was made to place orders immediately for critical material. On the basis of preliminary data developed by the first project-wide load tabulation, an order was placed for two 10,000 kv.-a. main power transformers with provisions for the future addition of forced-air fans to provide increased capacity for Building #751-A. The 13.8-kv. switchgear specifications for the primary substation were issued also in April and the order was placed in June, 1951. With electrical equipment manufacturers quoting dishearteningly long delivery times, procurement of the many secondary substation units could not await firm development of building load data. So du Pont, providing coordination between the

Voorhees, Walker, Foley & Smith building designers and the Gibbs & Hill distribution system designers, worked out an agreement whereby the latter organization initiated procurement of a number of 13.8-kv./440 volt, outdoor unit substations, covering a range of capacity ratings up to 1000 kv.-a. These unit substations were allocated to individual buildings, or groups of smaller buildings to suit best the load pattern throughout the area as it developed. A few production buildings in the #300-M Area were considered originally to require Class I construction. For these, indoor unit substations were designed and procured at VWF&S, with the G&H design responsibility for 13.8-kv. feeders and secondary distribution terminating four feet outside the building wall.

As building design work progressed, it developed that certain buildings would require nominal quantities of emergency power, Building #320-M -- slug preparation, Building #702-A -- central telephone exchange, Building #703-A -- administration and medical, and Building #773-M -- technical laboratories. Emergency power requirements were met by providing diesel-driven generators procured by G&H, which also provided a unit for the vital load dispatchers facilities in Building #751-A.

During the spring of 1951, the need for a substantial amount of refrigeration for this area was revealed. The Engineering Department was advised by the Operating Department in late June, 1951, that the AEC had several motor-driven centrifugal refrigeration units available at the Hanford Works, and a comparative estimate was made for supplying the refrigeration with individual units and cooling towers located throughout the area as against an arrangement using a centralized refrigeration plant and cooling tower. Immediate inquiries to the Hanford Works revealed that, in addition to these main units, other mechanical and electrical auxiliary equipment was also available for transfer. In August, 1951, du Pont and the original manufacturer of the compressor units sent inspectors to Hanford who reported favorably upon the condition of the available equipment. The usable electrical equipment included the synchronous motor control equipment, motor surge protection equipment, motor-generator exciter sets and control as well as 2300-volt auxiliary power switchgear. However, because of their positions in installed switchgear assemblies at Hanford, the 13.8-kv. circuit breakers required for the supply of the three 2000-hp. synchronous motors were not offered for transfer. Because of the delays involved in buying new switchgear of this type, and because of the urgent need for refrigeration to make the #700 Area administrative buildings tenable during the coming summer, du Pont negotiated, without success, for the inclusion of this switchgear with the

transferred material. When it was decided in mid-September, 1951, that the Hanford equipment could be modified satisfactorily for use at SRP and the transfer arrangements were initiated, specifications were prepared for the procurement of new 13.8-kv. switchgear, two new 13.8/2.4-kv. auxiliary power transformers and a new 440-volt substation.

To provide the electrical design and equipment required for the earliest possible completion of the refrigeration building, (Building #789-A), design work on this facility was given a high priority. Du Pont was able to furnish from its procurement and design record of the Hanford Project valuable information on the equipment being transferred from there. Arrangements were made with the Westinghouse Electric Corporation for the reconditioning of all of the electrical equipment at the Westinghouse manufacturing and repair shop in Atlanta, Georgia, where it was received in February, 1952. When the manufacturer of the new 13.8-kv. switchgear advised that it would be impossible to meet the required delivery of the type of air circuit breaker specified, oil-filled circuit breaker equipment was accepted in its place because of the urgency of the situation. The area distribution system layout was revised and a new circuit breaker in the 13.8-kv. switchgear was added at the primary substation to provide a separate feeder for this heavy power user. An alternate source of power was made available by tapping the area loop feeder.

#### #400 AREA

In January, 1951, the #400 Area was added to Project 8980, its function being a duplicate of the AEC's Dana Plant. The design and experience developed on the Dana Project would logically be the basis for the design of the #400 Area process and its electrical arrangement. It was known that the main process area would be a heavy user of electric power with a rather high degree of reliability required. Du Pont's investigation of several power producers in the vicinity of the project site had clearly indicated that an adequate block of power could not be made available from outside sources in time to meet the process start-up schedule. The power supply plan developed within the Engineering Department in February, 1951, therefore, included a power generating station in the #400 Area.

In order to have the first boiler of the proposed power station ready for scheduled operation in February, 1952 -- just a year away -- it was recognized that not only must the design work be executed speedily but the equipment selected must be of the type most readily obtainable. Working with engineers of the Lummus Company on the process electrical

design, and Gibbs & Hill, on the power, water and general electrical design, du Pont guided, coordinated, expedited and approved design and procurement activities at a pace that would suit the schedule, and checked any tendency to take short-cuts or otherwise slight any design considerations which would lessen the reliability. In addition to the reliability criterion established for the #400 Area power house by the area process requirements, further impetus was given to designing for reliability by the realization at that time that this power house (Building #484-D) might become the backbone of a power supply system for at least some of the #100 Areas, for which local generation had not yet been approved.

The requirement for high reliability extended beyond the power house to the power distribution system for the main #400 Area process units because of the abnormal difficulties, and resultant cost, of any production stoppage. Some conception of the difficulties and cost involved may be gained from the fact that a power outage lasting more than one or two minutes would result in a loss of production and for each additional minute that the power outage lasts, approximately ten hours is added to the time required to return the process unit to full production. As a limit, three days are required to reach full production from a "cold" start. Although the effects, in this case, are rather drastic, they are not unique in the chemical industry.

To the primary distribution system, the main process area appeared as six identical package-substations, arranged in pairs in the three process buildings. Each of these secondary substations supplies one 1000-hp. and four 600-hp., 4160-volt motors and 440-volt motors totaling about 1200-hp. in capacity. Several schemes were studied for the distribution of power to the process buildings #411, #412, and #413. The division of each of these buildings into two independent process groups, except for certain auxiliary functions, suggested a simple radial distribution system with an individual 13.8-kv. feeder directly connecting each process group to the generator switchgear. To increase the reliability of these feeder circuits and to avoid further congestion in an area where it was expected that several transmission line sections would be entering from different directions, it was preferable to use direct-burial cable service. An analysis indicated this was economically sound.

With three boilers and three sets of generation equipment authorized for the power house, two of the process feeders were assigned to each of the three generator bus sections. With the bulk of the area load being carried by these six radial feeders, only one additional 13.8-kv. feeder circuit would be required to supply the other process

and service buildings in the area. When the power supply requirements and plans had been developed to the point where the expansion of the #400 area power house appeared likely, this seventh area feeder was shown on the layout as emanating from the fourth generator bus. This feeder was carried on a pole line because of the lesser degree of reliability required for it and to permit convenient tap connections of the spur lines to the several smaller buildings.

For additional reliability to the main process units, a tap was made to this 7th feeder near the power house and run underground to the process buildings where it loops through all six unit secondary substations. An interlocked switching arrangement at each process substation normally prevents feeding the substation from both the normal and the alternate emergency feeder; however, with the proper key, both switches may be closed at once for transferring the substation load from one feeder to the other.

Over and above the reliability afforded by the measures applied to the distribution scheme, as described, top priority for electricity at each of the six process groups was assigned to certain special motor-operated valves. These valves become especially important at a time of process disturbance, such as might accompany a power failure. At the Dana Plant, emergency power was provided, for these valves especially, by an internal-combustion-engine-driven generator located at the process area. At SRP however, the simultaneous loss of power at both unit substations at any one process building seemed remote because of the nearness and reliability of the #484-D power house, with its multiplicity of generation equipment arranged both mechanically and electrically on a unit basis. Therefore, an emergency 440-volt bus was established at each process building for the supply of the special motor-operated valves and certain other emergency requirements, such as emergency lighting. This bus is common to both halves of the building and normally receives its power through the secondary substation associated with one half, with an automatic transfer switch arrangement to take power from the second unit substation should power from the first fail.

In addition to a reliable source of electricity, the process buildings, together with the power house itself, needed a reliable supply of steam and water. A reliable electrical distribution system, therefore, was required for Building #681-5G, River Pump House, the water treatment facilities, cooling tower and the boiler auxiliaries. The small river pump house (Building #681-5G), independent of the main river pump houses, was designed to supply the #400 Area water requirements. In mid-February, 1951, two unit load center secondary substations were

specified for this building to supply six 300-hp. pump motors at 440 volts, stepped down from 13,800 volts. It was decided that by using pre-assembled, self-supporting, insulated, 15-kv. cables as two radial feeders from different generator buses, the desired reliability could be obtained without resorting to underground construction. By the end of March, 1951, the load center specifications had to be changed to provide increased capacity for supplying six 400-hp. motors.

During the first week of March, 1951, specifications were issued for power house primary and secondary electrical systems equipment as follows: control switchboard, 13.8-kv. switchgear, 2300-volt auxiliary switchgear, 440-volt unit load centers, power transformers and main power transformers. To expedite procurement of this equipment, visits were made to the General Electric Company and Westinghouse Electric Corporation to discuss the specifications and to determine delivery schedules. It was established that, by placing orders with one company for all of the above items, the best possible overall delivery schedule could be obtained by reducing the time normally required to coordinate engineering information. Since it was well established that competitive prices for this type of electrical equipment were normally equivalent between these two manufacturers, the selection of the vendor rested primarily on delivery promises. On this basis, the Westinghouse Electric Corporation was given a verbal commitment on March 12, 1951, which permitted considerable progress in engineering and design work prior to the placement of the formal order in early June, 1951.

The schematic electrical arrangement for the generating station was based upon a unit arrangement in which one high-pressure and one low-pressure turbine generator unit supplied by the same boiler were connected to a common 13.8-kv. bus section. In the earlier arrangements, there were three such switchgear bus sections. Later when the fourth boiler was authorized, a fourth bus was added to the arrangement. The schematic arrangement provided separate step-up transformation for each 13.8-kv. bus section to 115-kv., so that the unit groups of equipment could be paralleled at the higher voltage. This arrangement permitted the use of 500,000 kv.-a. interrupting capacity, metal-clad switchgear instead of the 1,500,000 kv.-a. interrupting capacity cubicle type, at a switchgear cost saving of \$250,000. In the early arrangement, the 13.8-kv. to 115-kv. transformation equipment was specified as three 20,000 kv.-a. main power transformers. During the discussions of delivery schedules, Westinghouse Electric Corporation proposed to furnish, in place of these, six 10,000 kv.-a. transformers with a much earlier delivery promised. This proposal was accepted and it was agreed



that the two transformers in each-pair would be cable-connected in parallel (without disconnecting switches for individual transformers) and the resulting transformer banks were to be connected by circuit breakers to the respective 13.8-kv. and 115-kv. buses. The unit system arrangement likewise was applied to the auxiliary power transformers and switchgear, wherein this equipment would be operated as independent groups corresponding to the boiler and generation groups. Manually-operated, interconnecting ties were provided between the groups on the 2300-volt and 440-volt buses to protect against the remote possibility of an auxiliary transformer failure.

Since the power requirements for the water treatment facilities had increased correspondingly with the river pump house power increase, a separate group of auxiliary power equipment was provided for its supply, consisting of a 13,800/2400 volt transformer, 2300-volt switchgear and a 440-volt unit substation.

During a visit to the main offices of the Westinghouse Electric Corp. on March 19 and 20, 1951, conferences were held with each department responsible for the various types of apparatus in order to discuss the design concepts with a view toward incorporating as many as possible of the manufacturer's standard design features.

Considerable progress was made during March, 1951, on the layout studies for the 115-kv. switching station, the power house and auxiliary power buildings as well as the #400 Area as a whole. The first 115-kv. switching station layout was considered unsatisfactory and arrangements were made for the relocation of certain nearby small buildings so that the station could be expanded in a manner to properly permit the exit of seven 115-kv. line sections. On May 8, 1951, approval was obtained from the AED and the AEC for the #400 Area plot-plan. By the end of May, 1951, all design features of the power facilities for this area were fixed and no further basic changes permitted.

#### #600 AREA

Buildings #681-1G, 2G and 3G, River Pump Houses, were designated to supply the cooling water requirements for the five #100 Areas, originally estimated to be in the order of 450,000 g.p.m. This involved a total electric demand of over 42,000 kw. Basic overall design consideration for the main river pump houses was that interruption of the pumping must be limited to short periods of time as permitted by the storage capacities of the #100 Area water reservoirs. From this consideration came the decision that controlling

electrical switchgear for each of these facilities should be in a blast-proof building because of the time required for repair and replacement of this type of equipment. This consideration, also, led to the purchase of a spare power transformer, stored at a remote point on the project site, for speedy replacement of a damaged transformer at any one of the river pump houses.

Reliability of power supply from the standpoint of the 115-kv. feeders and the step-down transformer substation at each pumping station received careful analysis during the development of the project transmission system. Because of the close spacing of the three river pump houses and the impossibility of providing the desired spacing between the aerial transmission line sections feeding these stations, consideration was given at one time to the use of high voltage underground transmission cables so that the complete loss of electric power at more than one pumping station as a result of a single bomb blast might be avoided. However, the eventual deletion of the center pump house Building #681-2G, from the scope of work removed the need for any further consideration of underground transmission feeders by permitting the routing of a transmission line aerial feeder to each pump house from each of the two nearest switching stations, with but one line-crossing involved. These lines were routed in a manner providing for the erection of aerial feeders to a center pump house in the future with a minimum relocation of existing lines.

The substation at each pump house was designed to have two step-down transformers, either of which could carry the necessary load. Based upon an early estimated operating load of eight 3500-hp. pump motors per station, specifications were prepared and issued early in March, 1951, to obtain quotations for transformers rated 20,000 kv.-a., self-cooled and 25,000 kv.-a., forced-air-cooled. At that time, transformer secondary voltage was tentatively set at 6900 volts pending determination of the most favorable utilization voltage for the pump house equipment. By early May, 1951, the transformer rating was reduced to 15,000 kv.-a. self-cooled and 18,750 kv.-a. forced-air-cooled, with each transformer capable of operating five pumps driven by 3000-hp. motors under its normal rating and six pumps under its fan-cooled rating. At this time, the transformer secondary voltage also was reduced to 4160 volts to match the operating voltage of the selected pump motors.

To guide the selection of the main pump motors, comparative cost estimates were made for the motors, and their associated switchgear and cables, operating at 4160, 6900 and 13,800 volts. At the time the studies were made, the final "HP" rating for the pump motors had not yet been

established, so the cost studies covered motors rated 3000, 3500 and 4000 hp. Furthermore, the study compared the use of synchronous motors against the use of induction motors. The estimate indicated that the most economical operating voltage, regardless of the type of motor, was 4160 volts. The comparative cost of equipment favored the use of synchronous motors, but the equipment cost savings would be offset at least partially by the increased cost of installing the synchronous motors and their auxiliary equipment. Furthermore, there was reason to believe that such a large block of synchronous motor load might have adverse effects on the stability of the system.

A network analyzer study was made on April 1, 1951, to investigate the effect of the two motor types upon the 115-kv. system. The calculating board study indicated that, while the power system in general was very stable, synchronous motors would lose synchronism with system faults. Additional instability effects might well result from the leading power factor imposed on the system under certain conditions of operation of the synchronous motors. Furthermore, synchronous motors, because of their more complex starting, excitation and control equipment, require considerably more operator attention than do induction motors. For these reasons, the induction motor was selected for the main pump drive. Further studies indicated that the overall cost would be less for the installation of water-cooled motors than for air-cooled motors because of the cost of providing adequate ventilation at each motor in the partially-submerged river pump house buildings. Water cooling for these motors, which was approved on May 5, 1951, was accomplished by means of an air-to-water heat exchanger having double-tube construction.

In the early electrical layout studies for the river pump houses, the two main power transformers were located on top of the pump house at the south end. This arrangement persisted until the end of May, 1951, when building structure design had been developed to a point which indicated that a significant increase in roof strength would be required to support the heavy transformers. A new location then was found for the 115-kv. substation on the shoulder of the approach road to the building. One transformer was located 75 feet from the building wall and the second transformer 75 feet beyond that. One of the more difficult design problems involved the routing of the multitude of transformer secondary cables (36-1500 MCM cables per transformer) to the 4160-volt switchgear inside the building. The space required by these cables made it desirable to avoid long runs through the building; therefore, it was decided to bring the direct-burial cables to the east wall of the pump house, thereby placing the cable

entrance near the associated switchgear. The cable entrance was located below the high floodwater level, but the cables were provided with a specially designed, waterproof sealing arrangement at the point of entry to prevent floodwater seepage into the station.

Specifications covering the 4160-volt metal-clad switchgear were completed and issued on May 5, 1951. This switchgear was arranged at each pumping station into two separate switchgear sections, without any bus interconnection. Each switchgear section was arranged to serve four of the main pump motors and was equipped with two incoming-feeder breakers to permit the selection of either of the two main transformers as its source of power. Although the arrangement permitted one transformer to supply two switchgear sections, interlocks prevented two transformers being tied to one common bus. This arrangement limited the maximum short-circuit interrupting duty for the switchgear to that available from a single transformer. The division of the main river pumps between two independent sets of electric supply equipment minimized the possibility of a complete station shutdown in case of the failure of a single 115-kv. line, a main transformer, a main feeder cable or a 4160-volt switchgear bus. The electrical switchgear was located on a balcony over the main water header at one side of the pump house, so that cable trays could be used below the switchgear for routing all cables, resulting in an economical and flexible installation.

Once the equipment and layout requirements were established during the initial planning periods, few problems were encountered which affected the electrical design. However, one of the more important of these problems encountered later involved possible pressure surges in the water-line system which would produce water hammer. A cone valve was inserted in the discharge line of each water pump to control the rate of water flow, which in turn would reduce the water pressure surge. These valves, which are hydraulically actuated, are controlled electrically by means of solenoid-operated valves in the actuator oil system. The combined electrical and hydraulic control of the water pump motors and associated cone valves required carefully coordinated design for reliable operation. The combined design accomplished the following control.

1. Pump Start-up -- pump motor is started against a closed valve and when water pressure between pump and valve reaches a predetermined value, the cone valve opens automatically. The valve opening period is about 7-1/2 minutes.

2. Regulation of Pump Discharge -- a pushbutton enables the operator to adjust the valve opening during pump operation for any intermediate position, should a change of an individual pump output be desired.
3. Normal Shutdown -- the normal pump shutdown is initiated by depressing the valve "close" pushbutton. The valve starts to close but the motor still runs. The closing motion of the valve is completed in about 7-1/2 minutes and the pump motor circuit-breaker is tripped automatically just before the valve reaches its closed position.
4. Emergency Shutdown -- any tripping of a motor feeder circuit breaker, whether caused by control switch operation or by protective relay operation, causes the motor to be de-energized and the valve to start closing. The closing of the cone valve thus initiated is arranged for a closing period of 15 minutes.

Under the emergency shutdown conditions above, the pump unit tripped-off the line comes to rest and then is driven in the reverse direction by the reverse water flow until the valve closes. A field performance test determined that the pump came to rest in 5 seconds and then reached maximum reverse speed 7-1/2 seconds later. An interlock was arranged so that the motor could be started only when the valve was in the closed position. This prevents the application of unusual stresses on the motor resulting from applying power to a motor that is spinning in the reverse direction. The motor was guaranteed by its manufacturer, Allis Chalmers Manufacturing Company, for 25% overspeed. Actual field tests for extreme conditions indicated that a reverse speed of about 1200 r.p.m. could be obtained on this rated 900 r.p.m. motor. The manufacturer, who reviewed with the du Pont Design Division and Gibbs & Hill the safety factors incorporated in the motor construction, offered assurances that the motor would safely withstand the encountered maximum reverse speed, but would not give a written guarantee to that effect. Further field tests for extreme reverse speeds demonstrated that no adverse effects resulted upon the motor parts or windings.

Each main river pumping station required a small amount of emergency power, not for attempted operation of main pumps but to supply critical valve operation, ventilation, lighting and the like. A battery supply was proposed originally for this service, but it was replaced with a diesel engine-driven generator because of the unknown duration of outage of normal power.

On November 9, 1951, a meeting was held with engineering representatives of Gibbs & Hill, and the du Pont Design Division and Operating Department to review design and operating concepts for the river pump houses from the standpoint of control and instrumentation. The following requirements pertaining to electrical design were established.

1. 3000-hp. Main pump motors -- main pump motors were to be started from the switchgear cubicles, with only "stop" and "test run" pushbuttons at the motors. Metering was to be provided at the switchgear for measuring current in each phase of each motor and instrumentation provided at each motor for indicating motor winding temperature (with alarm for high temperatures) cooling water temperature leaving motor air cooler, site flow indication of cooling water flow to motor air cooler, and temperature of oil leaving each bearing.
2. Large motor-operated valve -- valve control pushbutton stations would be located close to each valve and contain signal lights for indicating either open or closed position.
3. Electrical system -- metering and indication would be provided on electrical system equipment as follows: voltmeter on each 4160-volt bus; ammeter and watthour meter on each supply line from the secondary of the main power transformers; ground detector indication on each 4160-volt bus; transformer temperature and low oil level alarm on each main power transformer; controls at switchgear for changing the transformer tap under load; ammeter on 4160-volt supply line to each auxiliary power transformer; and a voltmeter for each 440-volt bus section.
4. Communications -- Bell telephone system phones would be required at the following locations: operators room, chlorination room, pump floor at center on suction side, and in transformer yard. A two-way radio network would be required for water system operation with fixed stations at the two river pump houses, at each Building #183 and Building #483 and with mobile units for the water line maintenance trucks.
5. Miscellaneous -- ventilation fan motor starters would have indicating lights showing whether on or off. Dewatering pump to be started locally and at switchgear cubicle. All other auxiliary equipment would be started locally at the equipment.

In addition to the river water pumping facilities, several smaller miscellaneous facilities and buildings were installed in the #600-G Area, including radio transmitters for the security patrol system and the railroad system, railroad classification yards and locomotive shop building #618-G, CMX experimental facilities (Building #679-G), and a process pilot plant, Building #678-G. Generally, these buildings were supplied with electric power over 13.8-kv. aerial distribution lines originating at the nearest 13.8-kv. bus. The major design consideration for the distribution supply to these facilities was the early start-up schedule date. In many cases, this meant supplying substitutions to permit the use of the most available standard low-voltage electrical equipment. There were also cases where temporary local power supply was provided to permit start-up of facilities prior to completion of the permanent power supply arrangement.

#### #200 AREAS

There is a basic similarity between the systems provided for the #300/700 and the #200-F&H Areas because these areas have similar power supply requirements. The #200-F&H Areas required rather extensive distribution systems with but a few critical loads. The design of the electrical systems for these areas, along with the process facilities, was subcontracted to the Blaw-Knox Company of Pittsburgh, Pa. The design and procurement of internal electrical equipment plus a minor amount of interconnecting lines was subcontracted to Gibbs & Hill for the following facilities: the transmission substation, boiler house, reservoir and pump house, cooling tower, and chemical feed buildings. This group of buildings in each area became known as the "power block".

Although the #200 Area process facilities were scheduled for a relatively late start-up, the transmission substations (Building #251-F&H) were important components in the transmission system loops feeding several of the #100 Areas. For this reason, locations and design layouts for these two buildings were required at an early date. However, little firm area load data was available for sizing the main power transformers and developing switchgear arrangement for these substations. Consequently, the four main power transformers, two for each area, were not placed on order until August, 1951, with ratings of 7500 kv.-a. self-cooled, and 9375 kv.-a. forced-air-cooled, based upon what was considered preliminary load information.

During the first week of June, 1951, distribution system studies culminated in the selection of a sectionalized loop

system similar to that for the #300/700 Area. A few weeks later a decision was reached that design and procurement for the #200 Area boiler houses should proceed on the basis of duplicating the #300/700 Area boiler size and arrangement with Building #284-F having three boilers and Building #284-H having two boilers. These decisions permitted more detailed study of the 13.8-kv. switchgear requirements for the primary substations. In September, 1951, specifications covering the switchgear requirements were issued on the basis of having three process feeders, two water treatment feeders and two boiler house auxiliary feeders.

Since it had been determined during the development of the #100 Area substation design that all transmission loop substations should be arranged for a straight-through entrance and exit of transmission lines, layout studies of the substation building and transformer yard could now proceed on a more detailed basis. There was still the problem of locating these stations in the most favorable positions within the #200-F&H Area. Discussion of a preliminary "F" area plot plan at the end of May, 1951, revealed that Building #251-F should be removed from its original tentative location. After further development of the process and service facilities design, a location for this substation was found which permitted straight-through transmission line approaches and satisfactory 13.8-kv. feeder circuit exits and would not interfere with process building expansions. This location was approved early in August, 1951.

Design development of the distribution system for the #200-F Area proceeded during the summer of 1951, and a design based upon overhead pole-line construction was adopted. As in the #300/700 Area, the process area feeders were formed into a loop with a number of sectionalizing disconnect switches, one of which would normally be open for operation as radial feeders. Even before building loads were firm, it was necessary to estimate the number and size of secondary substations required and to initiate procurement of these. It had been decided that for Class I buildings indoor unit substations would be provided for 13.8-kv. to 440-volt transformation to provide building power distribution. The usual primary fused disconnect switches for these load center units would be mounted outdoors on poles. Buildings having other than Class I construction were to be provided with outdoor unit load center substations for transformation of power from 13.8-kv. to 440-volts.

All of the secondary substations, with but few exceptions, were of the load center type having ratings of 750 kv.-a. or less. Again as in the #300/700 Area design, pole-top disconnect switches were inserted in the area 13.8-kv. loop circuit to provide line sections, each of which normally was tapped



to feed two secondary substations. The flexibility of this system proved to be of particular advantage later in the design development.

As late as mid-November, 1951, it had not yet been decided by what means water would be supplied to the #200 Areas. Studies were underway to determine if lines should be provided to extend the river water system to the #200 Areas or whether individual wells should be provided within the areas. Design development eventually determined upon five deep wells for each of the #200 Areas, two for process and boiler make-up water and three for fire and domestic service. The pump motors at the first two well locations were supplied with power from the 13.8/2.4-kv. unit substation located at the cooling tower (Building #285). Each of the other three well-pump motors was provided with power at 2.4-kv. by individual step-down transformers having connections to the 13.8-kv. area loop.

During the summer and early fall of 1951, the development of electrical design for both the process area distribution system and the facilities within the power block had developed to a point where there was evident need for a clearer definition of design limits and a method for combining and coordinating the designs into an overall electrical system. A series of conferences was held during October, 1951, bringing together representatives from Blaw-Knox, Gibbs & Hill, the site clearance group at Voorhees, Walker, Foley & Smith, and the du Pont Design Division to establish a complete understanding of the several design responsibilities. The requirements for 13.8-kv. feeders originating in Building #251 were established as follows: (1) two overhead lines for the process area loop with a tap from this loop to serve as an alternate supply to the secondary substation at the boiler house; (2) one overhead line for direct supply to the secondary substation at the boiler house; and (3) additional feeder for power supply to buildings within the power block. The responsibility for the design and procurement of material for all of these 13.8-kv. power distribution feeders emanating from the primary substation was assigned to Blaw-Knox. This subcontractor also was given responsibility for the routing and installation of all control cables between the primary substation building and the power house building, with procurement by Gibbs & Hill.

All secondary distribution design and procurement of associated material within the power block were to be accomplished at Gibbs & Hill. At the end of November, 1951, the division of design responsibility between Gibbs & Hill and Blaw-Knox was clarified further, with Blaw-Knox receiving the following assignments:

1. Fence and road lighting inside and outside the power block;
2. 13.8-kv. distribution within the power block to Building #251 and outside the power block;
3. 2400-volt and 480-volt distribution to wells, either inside or outside the power block area;
4. Fire alarm system both inside and outside the power block; and
5. Telephone and safety alarm to the building wall within the power block and all such requirements outside the power block.

As a result of the decision to provide water for the area from isolated wells, the number of 13.8-kv. feeders leaving Building #251 was reduced to three, two for the process area and one for the power block. Following the division of design responsibilities, design work proceeded concurrently at the two design subcontractors until March, 1952, on the basis of the above reassignments. At that time, a single-line distribution diagram was presented for approval by du Pont. After some deliberation, a decision was made that all power within the power block should be obtained by tapping the 13.8-kv. process area feeder circuits. It was still possible at that date to revise the order for the 13.8-kv. switchgear to reduce the number of circuit breakers to a total of five: one for bus tie, two for main transformer connections, and two for the combined process area -- power block feeders.

One of the early design requirements thought necessary for the boiler house, Building #284, was the ability to produce steam for an 8-hour period without normal electrical service. This requirement demanded the continuity of operation of the important boiler house auxiliary equipment. This raised the question of whether to provide an emergency electrical supply source or install steam turbine drives on the auxiliaries. A study was made of the use of a turbo-generator emergency electrical supply for this service. However, on June 30, 1951, at a conference between the Operating Department and the Design Division, it was decided that the 8-hour emergency operation without normal electrical supply should be accomplished by the use of steam turbine drives on the mechanical auxiliary equipment and that the station battery would supply emergency lighting and control power. Further study of the emergency electrical supply requirements and the availability of emergency power elsewhere in the area led to the decision to obtain such power over an open-wire line from the Building #292

emergency diesel-generator to supply the steam station, and a similar line from the Building #221 emergency diesel-generator for the supply to the primary substation.

The largest power user in the #200 Area is Building #221 where the process equipment is arranged in five process units or "lines". Normal electric power supply for this building is provided by individual 13.8-kv. feeders supplying five load center unit substations.

As mentioned previously, the loads -- that is, the electric power users -- of the #220 Area are not critical from the standpoint of continuity of supply. However, in certain buildings, loss of ventilation can result in a personnel health hazard, also, in windowless Class I buildings, complete loss of electrical lighting would produce a safety hazard. For such emergency service, a number of diesel-driven generators were provided to supply power either directly or through underground 440-volt cable circuits in the following process buildings: #235-F, #772-F, #701-1F, #217-F, #221-F&H, #232-F&H and #292-F&H, plus Buildings #251-F&H and #284-F&H in the power block and back-up supply for the area road and fence security lighting circuits.

#### #500 AREA

Auxiliary power for lighting, circuit breaker air compressors and other uses at the 115-kv. switching stations, Buildings #504-1G, #504-2G and #504-3G, is obtained through a 150 kv.-a., 13.8/0.48-kv., dry-type transformer that receives 13.8-kv. feed by overhead lines from other areas. For these isolated facilities, cross-country, single-circuit 13.8-kv., 3 phase, open-wire, wood-pole lines were employed to deliver normal power. In the case of #504-1G, the west switching station, and #504-3G, the south switching station, the 13.8-kv. service lines originate in the #400-D Area; while the line supplying Building #504-2G, the north switching station, originates in the #300/700 Area. Because the switching station facilities are vital to the operation of the transmission network, they were provided with independent sources of emergency power. In each case, a 50 kv.-a. emergency diesel-driven generator, set in an enclosure adjoining the control house at the station, provides auxiliary power automatically in case of loss of the normal supply. A signal indicating the switch from normal to emergency supply at any of these stations is transmitted to the system load dispatcher's office.

## LIGHTING SYSTEMS

Lighting systems may be divided conveniently into two categories, (1) systems for buildings, and (2) systems for fences, roads and outside areas. These two types of lighting systems are dissimilar with respect to design requirements, design problems, methods and materials. As these systems are generally independent, so was the development of their designs. However, the provision for centralized blackout control was common to both systems.

### BUILDING LIGHTING

The development of lighting systems for the buildings followed a normal pattern with occasional special problems. Each building was considered, with special thought given to the function of lighting within the building, personnel safety, and good housekeeping, as well as comfort and morale. Based upon standards and experience, the following lighting intensities in foot-candles were used as a guide to design.

Process Areas, general --- 5 - 10 ft.-c.

Process Areas, close visual work --- 30 - 50 ft.-c.

Control Panels, vertical plane 5 ft. high --- 20 ft.-c.

Corridors and galleries --- 5 - 10 ft.-c.

Offices --- 50 ft.-c.

Lunchrooms --- 20 ft.-c.

Shower rooms and lavatories --- 30 ft.-c.

Locker rooms --- 15 ft.-c.

Laboratories, on horizontal plane --- 30 ft.-c.

Laboratories, on vertical plane 12-in. inside table's edge --- 15 ft.-c.

Storage areas --- 3 - 5 ft.-c.

Du Pont electrical design standards and symbols were used wherever applicable to obtain uniformity of design and consistency with established du Pont safety requirements. A procurement aid which proved to be especially valuable was the establishment of a bulk purchase suspense account (#2615). This permitted quantity purchases of electrical equipment and material (such as lighting fixtures, motor

starters, motors and cable), expected to have wide-spread application throughout the project. The quantities of such equipment covered by the early purchase orders were based upon preliminary estimates. Occasionally, supplemental orders were issued to maintain an adequate supply of such equipment in anticipation of design needs. Items from the #2615 stores account were allocated to a specific facility for installation by transferring such items in the Material and Equipment List.

In a few instances, lighting installations involved special design considerations. These included underwater mobile lights, mono-chromatic lights, and installations where the effects of radiation upon glass, insulation and other materials required careful consideration. Such installations are discussed in the sections of the history relating to the design development of the facilities concerned.

#### FENCE AND ROAD LIGHTING

In March, 1951, the Design Division started the coordination of design and procurement for the following items on a plant-wide basis:

1. All normal communication requirements;
2. Security requirements;
  - a. Protective lighting,
  - b. Protective alarm systems,
  - c. Protective communication systems, and
  - d. Blackout requirements.

To initiate mutual consideration of these systems and their requirements by both the Operating Department and the Engineering Department, a number of questions were raised relative to each of the design items in an effort to establish basic design criteria. The following questions applied to fence lighting.

1. Is fence lighting required? If so, what intensity?
2. Would it be desirable to have alternate fixtures on different circuits?

It was necessary to study the appropriate security regulations for Atomic Energy Commission installations and

consult the security sections of both the Atomic Energy Division and the Atomic Energy Commission for agreement on interpretation of regulations and how best to satisfy requirements. By letter of April 2, 1951, the AEC recommended that "all area and street lighting, including fence lighting, should be a series circuit system so cascaded together that the security patrol or guard headquarters could drop all external lighting at one spot and at the same time".

Fence lighting systems, because of their importance as security measures, had received considerable attention throughout industry during the years preceding the start of the Savannah River Plant design, but fence lighting methods had not been standardized in a way comparable to street lighting methods. During April and May, 1951, articles on protective lighting appeared in a number of electrical periodicals conveniently describing the basic requirements for protective lighting systems, new techniques and methods, and special protective lighting luminaries. These articles were given careful study and the information was used during discussions with the several design subcontractors and the Atomic Energy Division.

Designs for the road lighting systems were more easily established and, at a meeting on April 14, 1952, the Operating Department and the Design Division agreed upon the following criteria.

1. Roads, where lighted, would be lighted in conformance with the American Standards Association Standard for industrial plants, which specifies minimum intensities of 0.2 ft.-c. along roads adjacent to buildings and 0.05 ft.-c. along roads remote from buildings.
2. Only roads on which pedestrian travel is expected would be lighted, for safety reasons.
3. Patrol roads would not be lighted.
4. Roads immediately outside lighted fences (exclusion area fence, etc.) would not be separately lighted if the fence lighting intensity gave adequate coverage of the roads.
5. Roads and parking lots in the vicinity of buildings occupied only in daytime shifts would not be provided with safety lighting.
6. Main plant roads would be lighted at the peripheral gates for a distance of approximately 250 feet both inside and outside the peripheral fence, primarily for security reasons.

Except for these points and the short distances between parking areas and adjacent gate houses, no plant roads outside the numbered areas would be lighted. (The du Pont Construction Division at that time was lighting several major road intersections, but it was judged that Operations' traffic would not be heavy enough to require such lighting. Two years later this decision was reversed and many of the road intersection installations, with some modifications, were turned over to the Operating Department as part of the permanent electrical facilities.)

The early studies and discussions led to the decision to provide the following general types of fence lighting.

1. Production Areas, Outer Fences

180° horizontal projector fixtures, 10° vertical projection, to be mounted about 20 feet above ground on poles 10 feet inside the fences (6 feet absolute minimum).

2. Administration Building #703-A, Building Fence

Symmetrical street-lighting type fixtures, mounted on 6-foot arms, 30 feet high, on poles 6 feet inside the fence on 100-foot spacing, to light a zone 100 feet wide on each side of the fence (10,000 lumen lamps).

3. #300/700 Areas, Inner Fences

Medium wide, asymmetric street-lighting type fixtures, mounted on 6-foot arms, 28 feet high, on poles 6 feet inside the fence on 150-foot spacing to light the areas just inside and approximately 50 feet outside the fence (6000 lumen lamps).

4. #300/700 Areas, Outer Fences

Same as for production area (1).

Inasmuch as the lighting fixtures proposed in Categories #1 and #4 above were rather new developments and had not been used on any plants within the du Pont Company's experience, it was proposed to the Operating Department on May 28, 1951, that trial installations at the CMX Area be made to test approximately four varieties of this general type of fixture.

Area fences and exclusion building fences generally were to be illuminated to an intensity of 0.2 ft.-c. minimum and a zone 50 feet or more outside the fence was to

be lighted to 0.1 ft.-c. minimum. Lower intensity light was to be provided just inside the fence, but not far enough inside to illuminate the patrol road. Also, light striking the fence mesh was not to mask visibility outward through the fence. All fence and gate lighting was to be provided with emergency supply in event of loss of normal power. Where it could be accomplished without appreciable addition of wiring and equipment, area fences were to be illuminated from two circuits, alternate fixtures being connected to alternate circuits. All fence lighting, in common with other outside lights, was to be extinguished by control from the area blackout pilot-circuit, in addition to the normal lighting control employing astronomical clocks. At area and periphery gates, lighting adequate for inspection of photographic passes and vehicle contents was to be provided. Intensity on vehicle interiors at periphery gates was to be approximately 1 ft.-c. while that for trunk inspection was to be at least 0.5 ft.-c.

#### PRELIMINARY FENCE LIGHTING

Design proceeded on the basis of using a Fresnel type of lighting luminaire for area outside fences. Tests were set up at the CMX, Building #679-G, to verify the selection of the type fixtures for outer area illumination. These tests were held early in September, 1951, and witnessed by representatives of the AEC, the AED and the Engineering Department. The results of the tests were published in a report dated September 14, 1951, which is quoted in part as follows:

"It is intended that . . . boundary security employ mobile patrol units operating principally on patrol roads approximately 50 feet inside the cyclone type fences. This method requires that the guards be afforded good visibility, through the fence mesh, of objects in the cleared zone outside the fence. Only unit #2, the Fresnel lens type was adequate in this requirement, in the unanimous opinion of AED, AEC and Engineering Department representatives who witnessed the demonstration. The uniform degree of illumination of vertical surfaces over a zone up to 300 feet wide outside the fence was also a very desirable feature of this type. All the other types (1, 3, and 4) cast a much higher intensity light on the upper surfaces of the meshes on the wire fence and caused a severe 'masking' effect, such that even brightly lighted objects outside the fence were difficult to see from inside. These three types illuminate the fence at intensities of 0.6 to 0.8 ft.-c., with lower intensities beyond the fence, while the Fresnel Type #2 unit places only 0.1 ft.-c. of light on the fence with higher intensity outside the fence."



From this choice, design of the security lighting was completed, using the Fresnel type unit in all locations where its glare outside the fence was not objectionable, such as where roads parallel the fence within 200 feet or where other area fences are within 200 feet. A less directional lighting was required for these less-isolated boundaries, and for inspection at the gates.

From that point fence lighting design proceeded in an orderly fashion with only an occasional question arising out of special conditions. One such question involved security lighting at the transmission line switchyards, Buildings #504-1, 2 and 3G. It was decided that no special security lighting would be provided for these buildings and that they would be lighted only in the manner suitable for normal electrical substations. The lights at these stations normally would be extinguished except when required for inspection or maintenance. A light switch was installed accessible to the security guard force patrolling these buildings. In November, 1951, it was decided that security exterior lighting at the main river pump houses would be provided by fixtures mounted on the upper part of the buildings rather than on poles. However, early in February, 1952, because of a change in the type of security patrol at these buildings, it became desirable to provide the security lighting of the area adjacent to the fence at each of these buildings from lights mounted on poles immediately inside the fence.

#### BLACKOUT LIGHTING AND CONTROL

After studying the requirements set forth in the Physical Security Standards "AEC Bulletin GM-153" and in memoranda from the AEC, the Design Division submitted to the Operating Department early in April, 1951, the following criteria for blackout control and lighting.

1. There will be a blackout control system in each area with the control switch located at patrol headquarters of that area at the local communications center. This control system will extend throughout the area and will instantaneously extinguish the following lights should it be required:
  - a. All normal intensity outside lights;
  - b. All normal intensity lights inside windowed buildings; and
  - c. All normal intensity lights in outer hallways of windowless buildings.

2. The following lights will remain lighted:
  - a. All lights in the inner zones of windowless buildings;
  - b. Very low intensity blue lights in the outer hallways of windowless buildings;
  - c. Very low intensity blue lights in the corridors of windowed buildings;
  - d. Moderate intensity lights in windowed, continuously-tenanted buildings with readily closeable shutters; and
  - e. Very low intensity hooded lights in some outdoor process areas and nearby roadways where evacuation may be necessary during blackout.
3. The lights which would remain on during blackout will be so connected as to receive power from an emergency power source and will remain lighted at all times for maintenance and monitoring reasons.

A month later, after reviewing these criteria with the Operating Department, this information was distributed to the several design subcontractors along with specifications covering the blackout lighting fixtures and lamps, the power transfer switches, and the blackout control pilot relays, in addition to block diagrams showing the schematic arrangement. As finally developed, the blackout control pilot circuit is energized continuously at 120-v., 60 cycle, a.c. current. This circuit normally energizes control relays and/or contactors having normally open contacts interposed in the lighting circuits under control. Thus, opening of the pilot circuit serves to de-energize all lighting circuits having blackout control. Buildings isolated from major areas were provided with internal, individual blackout systems. For such isolated systems, a single switch was provided to extinguish all lights visible outdoors. Such switches were located generally at the main control center of normally-attended buildings.

As design development progressed, questions arose over the interpretation and application of blackout lighting and blackout control criteria with reference to specific buildings. One such case involved the power houses. It had been intended that these buildings should be lighted at all times for safe operation so their design proceeded on the basis of windowless construction and providing one or more exit door light-traps. When, in the interest of economy, it was decided to delete light-traps from the design, it appeared

necessary to extinguish all lights within the building with the possible exception of any lights deep within the interior of the building from which direct light would not reach the outside. Because of the safety hazard resulting from inadequate lighting, the requirement for extinguishing lights within the power houses was reviewed, in mid-August, 1951, with both the Operating Department and the AEC Security representatives. It was decided then that all interior lights should be left on in such buildings and light-locks or the equivalent could be added at a later date if required.

#### EMERGENCY ELECTRIC POWER SUPPLY

In a letter to the Atomic Energy Division on April 9, 1951, proposing the original blackout control and blackout lighting criteria, the Design Division also proposed to provide emergency sources of electric power for certain vital functions. By letter of May 1, 1951, the Atomic Energy Division announced its general agreement with the systems proposed, although it suggested that instead of the 10 per cent to 20 per cent normal building lighting on emergency power, 5 per cent to 10 per cent would be sufficient. All design sections were then informed of the emergency electrical system requirements whereby a source of emergency electric power, independent of the normal source and generated within each individual area, was to be provided for the following functions.

1. Five to 10 per cent of all normal building lighting, strategically selected to provide necessary minimums of safety, operation and security. In process buildings, this would include control panel lighting, some area lights and some corridor passageway lights. In service or office buildings, only corridor and security areas would require lighting.
2. Fence lighting of all areas and process buildings.
3. Safety lighting (showers, masks, shelters, etc.).
4. Safety and security alarm systems.
5. All communication system power.
6. Instrument and control panel power.
7. Blackout lights.
8. Power equipment designated by process groups as necessary for safety or process reasons.

These items were to be supplied with normal power through control panels segregated from the non-emergency loads and connected by means of automatic throw-over switches so that they would be connected immediately to the emergency source in event of failure of the normal supply. In general, the emergency source would be an instant-start, internal-combustion engine generator, controlled to start on loss of power at any of the throw-over switches.

As the design of each area progressed, the development of area emergency lighting systems resulted in scattered requirements for emergency energy supplies, usually of low demands. Study of the problem revealed greater economy and practicability in extending a 480-volt emergency distribution circuit from a common emergency unit to service such scattered demands, instead of providing a number of small units. As a result, such a circuit was provided in each major area and automatic load transfer switches were furnished for each emergency service. A control circuit was included to start the diesel engine when required, consisting of a cabled pair of wires installed in the messenger-and-ring-supported bundle of communication and alarm cable. The normal-to-emergency supply load transfer switches were arranged to operate in the following manner.

1. When normal supply voltage drops below approximately 70% for 3 seconds, the engine-starting contact would close.
2. When generator voltage reaches approximately 90% for each phase, load would be transferred to the generator.
3. About 3 seconds after normal supply voltage returns to at least 90%, load would be transferred back to normal supply.
4. The diesel engine would not shut down automatically, although that feature could have been provided. Rather, it must be stopped manually for two reasons: first, to avoid too rapid cooling and warping of engine parts; and second, to insure that substations will be visited after each supply interruption at which time the substations should be inspected and diesel fuel levels checked.

## COMMUNICATIONS AND ALARMS SYSTEMS

### REQUIREMENTS

The auxiliary electrical systems required for the coordinated operation and protection of the Savannah River Plant and its personnel were numerous and extensive. The geographical spread of the plant, its strategic value, and the sensitivity and potential health hazard involved in its process operation were all of concern in the planning and development of the communications and alarms systems. Reliability, back-up power supply, alternate media, speed, and effectiveness under extreme conditions were given consideration as design factors.

Underground telephone cable between areas was considered for blast resistance, and radio contact was studied for the operation of the plant railroad system. Also, the necessity of giving area-wide oral instructions or alarms, radio communications with patrol cars, and contact by radio with military field headquarters was investigated. These considerations plus several others were brought to the attention of the Operating Department early in March, 1951. They indicate the many ramifications involved in defining the communications and alarms systems requirements for the Savannah River Plant.

In a letter of April 26, 1951, the AED outlined the preliminary plans for communications facilities.

#### "1. NORMAL INTERNAL COMMUNICATIONS

- a. Normal communications are to be provided by a dial type telephone system.
- b. Approximately 100 phones should be unrestricted; that is, they should be able to dial numbers in Augusta directly in the same manner that Wilmington numbers can be dialed from the office buildings. The remainder should be partially restricted; that is, should be able to reach Augusta only by calling the operator.
- c. From the standpoint of resistance to blast, satellite exchanges in the areas would be desirable.

#### "2. SECURITY COMMUNICATIONS SYSTEM

##### a. Patrol Radio

A short-wave radio system will be provided for the patrol force. Except for the mobile

elements, this system should be Class I and should have emergency power supplies. AEC will supply the wave length information for this system.

b. Emergency Phone Connections

A secondary emergency system will be provided by connecting area patrol headquarters through permanently interconnected phones. This will form a 'party-line' system which will be unaffected by jamming of the exchange.

c. 'Burglar' Alarms

Alarm systems will be required on all classified information storage vaults and similar locations.

d. Fence Alarms

At this time it is expected that fence alarm systems will not be used.

e. Guard Reporting Stations

An electrical system of guard reporting will be required. This system should indicate in guard headquarters when each station is checked.

"3. EMERGENCY COMMUNICATIONS

a. Air Raid Alarms

The air raid alarm system will be controlled by the patrol force. Sufficient alarms must be provided so that they can be heard any place within the operating areas, including the interior of Class I buildings. This system should be independent of the fire alarm system.

b. Evacuation Alarm

Certain of the process buildings will require evacuation alarm systems. These must be arranged so that there is no possibility of confusing them with air raid alarms. In general, they will be controlled by the operating supervision from the control room. Once the alarm has sounded the emergency will be handled by the patrol force.

c. Fire Alarms

A normal fire alarm system will be required.

d. Disaster Control

Disaster control plans will be handled by the patrol force with the plant control center in Building #720-A. A secondary plant control center, which will take over if Building #720-A should lose its communications, will be located in the #200-F area. Area disaster control centers will be in the gate houses. The patrol communication system will be used.

e. Bomb Shelter Communications

Bomb shelters should be connected by telephone to the area guard headquarters. This connection should be Class I and should be independent of the plant system.

A loud-speaker system will be required in each area to give vocal instructions regarding wind directions, extent of contaminated area, and other details.

"4. OPERATING CONTROL AND MAINTENANCE COMMUNICATIONS SYSTEMS

a. #200 Area Dispatcher System

It is expected that the #200 Area will require a phone system similar to that used at Hanford. This should be suitable for classified information and, if practical, the two #200 Area systems should be interconnected. Details will be supplied in the #200 Area design data report.

b. Instrument Calibration Systems

In some locations, a phone system will be needed for instrument calibrations. In such instances, details will be supplied in the design data reports.

c. Emergency Maintenance Contacts

It may be desirable to provide radio contact with some of the electrical maintenance personnel and possibly others. If so, this will be done through the transportation radio system.

## "5. RAILROAD CONTROL

A radio system will be provided for railroad control."

As a first step toward implementing this plan, the Design Division began an intensive study of commercially available communications systems and equipment and at the same time prepared basic system specifications and instructions for dissemination to the various design groups. By the middle of May, 1951, the preliminary scope-of-work specification for the fire alarm, safety alarm and watchman's reporting systems, together with allocation of design responsibilities, were prepared and issued. However, facility #508, the watchman's electric reporting system, had only reached the estimating stage of design when it was canceled by the Operating Department on June 20, 1951. The instructions covering the first two systems contained the following details.

### FIRE ALARM SYSTEM

The control panel, registers, gongs, horns and boxes, together with miscellaneous equipment for this system in each area, will be specified and procured by Voorhees, Walker, Foley & Smith. The control panel will be located in the fire house (Building #709-A) of the #700 Area and in the electric-shop office of all other areas. Registers will be installed at the control panel location and at each gate house (or Building #720-A in the #700 Area) and power house in each area. Each of the #100, #200 and #400 Areas will have an individual alarm system of its own, including a master box near Building #701 which will be connected into one overall loop system including all areas, so as to register an alarm in Building #709-A in event of an alarm in any area. In the #300/700 Areas, a single system for the two areas will suffice. The master loop system for the plant will make use of conductor pairs in the telephone cable between areas.

### SAFETY ALARM SYSTEM

This system will consist of the following elements.

1. Electronically generated alarm system including:
  - a. Air raid alarm -- siren tone, 300 - 800 cps, siren cycle 1/2 cps;
  - b. Evacuation alarm -- rapid warble tone, 300 - 800 cps, warble cycle 5 cps;



- c. All clear signal -- steady tone, 800 cps; and
  - d. Other signals, as required, by combinations of tones and other pitches.
- 2. Speech input by microphone.
  - 3. Pre-amplifier, taking inputs from (1) and (2) above, located at Building #701 in each production area (Building #720-A in the #700 Area). Control points in each Building #701 will be provided at both the normal control center and at the emergency control center with the amplifying and power equipment in the Class I portion of the building. Wiring to the normal control room should be carried through a "normal-emergency" switch at the emergency operating position so that the breaking or the short-circuiting of the normal control line will have no effect when the switch is in the "emergency" position.
  - 4. Pilot line, carrying 10 d.b.m. level alarm or speech signals from Building #701 throughout the area with taps to each building which has power amplifiers for internal paging and alarm systems. In addition to the pilot audio line, a d.c. relay line is required to operate the power relays for the several power amplifiers.
  - 5. Power amplifiers conveniently located in service buildings supplying power via overhead outside lines to loud-speakers outdoors and to large service buildings. Speaker sound intensity sufficient to overcome engine noise at bus parking locations outdoors and average ambient noise levels at other locations.
  - 6. Within each large process building, and possibly power building, a complete amplifier-alarm-paging system will include the following components.
    - a. Evacuation alarm source (at control center of building).
    - b. Microphone.
    - c. Preamplifier with provision for connecting to outside pilot line so that outside alarms will be sounded on internal system; also evacuation alarms originating inside would be transmitted out over the pilot line. Speech should be put on the outside pilot line only when a separate switch is pressed.

- d. Relay power source adequate for local and general control of power amplifiers, applied locally for speech alarm and generally for alarm only, except for special switch which will permit general speech from each process building.
- e. Power amplifiers as required.
- f. Speakers throughout building wherever men may be, giving rated amplifier sound level at 5 db above ambient noise level, minimum, with speakers located to minimize "echo", or appreciable sound from more than one speaker at any one point.
- g. Energizing control for power amplifiers from local relay control or pilot control lines.

A design guide and the basic equipment specifications for the safety alarm system were developed in connection with the process portion of the #400 Area design. The Safety and Fire Protection Division of the du Pont Company was consulted in the preparation of the requirements for the fire alarm systems.

The other type of alarm system called for in the operations plan, in addition to the fire alarm and safety alarm systems, was the type commonly known as burglar alarms. Burglar alarm systems, used at SRP for the security of classified information and vital material, are classified in accordance with appropriate codes and specifications. Such systems at SRP were designed in accordance with the appropriate AEC Physical Security Standards and the Underwriters Laboratory Code to meet the particular situation in the building where required. Hence, burglar alarm systems were designed on an individual building or area basis rather than on an over-all project basis. The history of design development and description of each of these systems will be found in the sections of this history covering the appropriate buildings. This is true also of other miscellaneous alarm systems covering process, power house, pumping and other operations.

#### BELL TELEPHONE SYSTEM

At a very early date in the project schedule, the du Pont Engineering Department began negotiations with the Southern Bell Telephone and Telegraph Company for the supply of telephone communication facilities required by the Construction forces, Operating personnel, and Atomic Energy Commission representatives at the Savannah River Plant. By

March 6, 1951, du Pont furnished to the SBT&T Company its estimate of telephone service requirements for the operation of the Savannah River Plant's permanent facilities. By letter of that date, the utility was asked to prepare a draft of contract, covering the installation of permanent service facilities, for execution by the du Pont Company subject to approval by the Atomic Energy Commission. This service agreement, dated March 13, 1951, was quickly executed and plans were made immediately for a conference of technical representatives from both organizations. A technical planning meeting was held on March 27, 1951, to discuss the type of telephone distribution system, routing and scheduling of project trunk lines, construction force telephone requirements in each area, alternate routes for tielines to the project, system of numbers to be used, building space requirements for telephone exchange facilities, type of telephone line construction and applicable AEC security requirements.

The requirements and plans for the telephone system had developed sufficiently by mid-September, 1951, to enable the Design Division to outline the Bell Telephone System to the Operating Department.

1. The Bell Telephone System on the project would be on overhead pole lines except within the individual areas, where economics would dictate whether it would be overhead or underground.
2. The main board and switching equipment would be located in Building #702-A and positions provided for eight operators. However, it was estimated that six operators would be sufficient for normal operation.
3. In the #700 Area, there would be approximately 100 phones that dial directly into Augusta.
4. There would be 30 trunk lines to Augusta, 10 trunk lines to Aiken, via Augusta, 20 lines directly to the Augusta exchange for long distance calls, 3 private long distance lines, 5 lines for private teletype circuits and 2 public teletype circuits with their origins in the #702-A Building. The telephone company would have 10 paystation phones located in the plant.
5. The maximum number of phones planned for use on the project was 2500, of which about 1700 would be initially installed.

6. Each area would have its own switchboard located in the #701 Building (Class I structure) having an emergency source of power, whereby, if cut off from the rest of the system, it could operate independently within the area. Calls made in and between areas would be made automatically by dialing. Calls made outside the plant would go through the operator in #702-A Building.

#### PATROL TELEPHONE SYSTEM

The Operating Department's statement of communications requirements of April 26, 1951, called for an independent telephone system for the security patrol force. This requirement was discussed with the telephone company along with the normal Bell system. As a result, the following system was planned: a magneto-ringing type party system interconnecting the #701 Buildings of all areas, using wires in the same cables with the Bell system but having no electrical connections with the latter.

#### RADIO SYSTEMS

Preliminary studies and discussions of radio system requirements during the first quarter of 1951 led to the proposal of the following systems.

##### Patrol

Two channels, adjacent or alternate adjacent; one main fixed station, 2 frequencies, 60 watts; 11 subsidiary fixed stations, 2 frequencies, 30 watts; 50 mobile units, 30 watts.

##### Railroad

One channel; one main fixed station, 30 watts; eight mobile stations, 30 watts.

##### Supervision

One channel; one main fixed station, 60 watts; eight subsidiary fixed stations, 30 watts; 60 mobile units, 30 watts.

##### Transportation

Two channels, adjacent or alternate adjacent; one main fixed station, 60 watts; 200 mobile units, 30 watts.

Of the total of six channels, three would serve for common usage by Operations and Construction and three would be used for the Construction period only and released at the end of that period.

For the patrol radio system, a two-channel transmitter-receiver installation at each area and at each periphery gate, and a single channel installation in each mobile unit were selected. A central transmitter, controllable from either of two areas ("A" and "F") would also be included. Normal traffic would be between the central transmitter (from "A" Area) and mobile units on Channel 1. Inter-area traffic or any traffic in which mobile units were not concerned would be carried on Channel 2. However, all areas and the central station would continuously monitor Channel 1 for messages from mobile units. The Engineering Department was instructed to proceed to obtain frequency allocations and equipment for the patrol system.

For the railroad radio system, a single frequency would suffice. A fixed station located tentatively at the fire watch tower west of Dunbarton and controlled from the dispatcher's office, plus mobile units in each locomotive would make up this system. The Engineering Department was instructed to proceed to obtain frequency allocations and equipment, charging the fixed station and the mobile units for the 80-ton locomotive to Operations costs codes; while the cost of the mobile units for the 120-ton locomotives would be charged against construction.

(The Engineering Department's Design Division had also been requested by the Construction Division to obtain frequency application and procure the radio equipment for two additional radio systems for use by Construction supervision and transportation groups.)

At area radio stations, a blast-proof antenna would be required. The design incorporated steel pipe masts, 30 feet high, 4 inches in diameter for 20 feet, then 3 inches in diameter for 10 feet, set in concrete and guyed at 25-foot height with 1/2 inch steel guy cable similar to utility pole guying. The antenna itself would be selected as the strongest type available, basically capable of withstanding hurricane winds of 150 miles/hr. It was, also, intended to install a second small antenna directly on the roof of the gate house at the area with alternate antenna feed lines, which would be usable in case of damage to the main antenna.

Further discussions with the Construction Division during the early weeks of April, 1951, revealed an increase in the requirements of the radio systems for construction use. The "supervision system" then required 75 mobile

units for construction use and 6 mobile units for AEC use, plus four spare units for a total of 85 mobile units required. The equipment contemplated for use in this system would provide a car-to-car contact range of ten miles on level or high ground and four miles or less when either or both cars are at creek bottom locations. The main station-to-car range would be about 30 miles on level or high ground and about 20 miles to cars located at creek bottom elevations. The number of mobile units required for the transportation or truck dispatching system was increased from 200 to 266. Long range contact between mobile units on this system was not considered vital; therefore, the power requirements for these mobile units was reduced from 30 watts to 7 watts minimum. It was anticipated that the traffic load for this system would require the installation of three independent transmitters operating on separate channels. Normal traffic would require each station to make contact with about 85 mobile units at ranges up to 25 miles.

A request for quotations including technical specifications covering radio equipment for the patrol system, the railroad system, construction supervision system, and the transportation system was issued on April 18, 1951. During the following month, two manufacturers of radio equipment visited the plant site separately to make propagation surveys and to test the ability of their radio equipment to cover the site and surroundings with mobile communication signals. These tests demonstrated the ability of the type of equipment specified to maintain satisfactory contact with cars operating on the plant site or in Aiken, Augusta, Daniel Field, Camp Gordon, Baldock, Barnwell, Elko or Williston. In addition to these demonstrations, tests were conducted at the plants of the several interested manufacturers to determine the inter-modulation and adjacent channel noise characteristics of the equipment being offered. These latter tests became very important factors in the final selection of equipment. By June 15, 1951, the bids from the several manufacturers were compared and a vendor selected.

During the summer months of 1951, attention was turned toward the design of suitable wind-resistant antennae, building space for housing the equipment and reliable means for supplying electric power to it. Locations for the several fixed transmitters were selected.

At a meeting with the Operating Department, on September 17, 1951, all of the communications systems were reviewed and an additional system for the operation and maintenance of the water supply systems was discussed. The newly proposed system included fixed receiver stations at the two river pump houses and in Buildings #183 of the #100

Areas, and also Building #483-D. In addition to the fixed stations, mobile units would be provided on the water line maintenance trucks. The advisability of including the electric line maintenance trucks in this system was also studied. In November, 1951, a frequency was obtained for the operation of the new "process water and electric line maintenance system" and control points for the new system were established at: Building #716-A - for local control on Channel 8; Building #751-A - for remote control on Channel 7; and Building #720-A - for remote control on Channels 7 and 8.

The design of the facilities and the installation of the equipment proceeded in good order. In the summer of 1952, the radio installations at SRP were visited by the Chief of Communications Section, U.S. A.E.C., who offered comments and suggestions.

In the fall of 1953, based upon their experiences with the existing radio telephone system, #623-1, 2 and 3G, the Operating Department requested additional coverage on the existing systems and outlined requirements for two systems, #623-4 and 5G, for automotive transportation and miscellaneous portable system respectively. The radio-telephone facilities system requirements are outlined below.

#### Channel 1 - Patrol

|                             |                                     |
|-----------------------------|-------------------------------------|
| Single channel mobile units | - 63 (Patrol)                       |
| Single channel mobile units | - 7 (Health Physics cars)           |
| Single channel mobile units | - 1 (Health Physics boat)           |
| Dual channel mobile units   | - 6 (AEC) (Channels 1 & 3)          |
| Dual channel mobile units   | - 1 (Patrol chief) (Channels 1 & 3) |
| Dual channel mobile units   | - 1 (Fire chief) (Channels 1 & 3)   |
| Fixed stations              | - 14 (Patrol)                       |
| Control consoles            | - 2 (Fire, #709-A & #709-F)         |
| Control console             | - 1 (#703-A for AEC)                |
| Control console             | - 1 (#720-A for Patrol)             |
| Control console             | - 1 (#701-1F for Patrol)            |
| Main 60-watt transmitter    | - (#623-1G Bldg.) (Existing)        |

Channel 3 - Patrol

Single channel mobile units - 8 (Supervisory cars)

Channel 4 & 8 - Transportation

Single channel mobile units - 45 on Channel 8

Single channel mobile units - 30 on Channel 4

Main transmitter for each channel - Total of 2

Existing set-up on presently installed transmitter will not be changed.

New channel 4 transmitter to be installed in #716-A.

Channel 6 - Railroad

Single channel mobile units - 8 (Locomotives)

Single channel mobile units - 5 (Section crew motor cars)

Single channel mobile units - 3 (Chief Supervisor, Yard master, and road master, respectively)

Existing transmitter and its facilities are satisfactory.

Channel 7 - Process Lines

New 60-watt transmitter to be installed in Building #710-A (8320M)

Single channel mobile units - 1 (Power superintendent)

Single channel mobile units - 8 (Power cars and trucks)

Single channel mobile units - 1 (Electric superintendent)

Single channel mobile units - 5 (Electric trucks)

Single channel mobile units - 4 (Equipment as portable units)

Console in Power superintendent's office - 1 (#703-A)

Channel 5 - Miscellaneous

One new fixed station in #720-A

Handie Talkies - 50

Single channel mobile units - 4

Pack sets (walkie talkie) - 4



These requirements were changed later to delete one of the fixed transmitters for the transportation dispatching system, leaving one transmitter on Channel 4 only for control of the 75 mobile units. Much of the additional equipment required to meet the total requirements of the Operating Department for radio-telephone systems, was transferred from the Construction transportation and supervision systems.

SECTION VI —  
INSTALLATION AND START-UP

## VI - INSTALLATION AND START-UP

In general, the facilities described in the preceding chapters were put into service with a minimum of start-up problems. Any difficulties associated with the telemetering system have been described; those associated with electrical work in the various areas are discussed in their respective histories.

The Westinghouse generators in Building #484-D proved on test to be slightly short of rated capacity, but this difficulty was corrected by the manufacturer with very little impact. The operating experience of the electrical system generally has been satisfactory, with minor modifications and expansions being accommodated easily. Additional blocks of power have been purchased from the South Carolina Gas & Electric Company as load increases warranted. There have been no difficulties associated with this increase which, together with the freedom from major trouble, bears testimony to the flexibility of the design and construction of the system components.

## SECTION VII —

DESCRIPTION OF FACILITIES

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## VII - DESCRIPTION OF FACILITIES

### AREAS #100-RPLK&C

#### BUILDING #151-1RPL&K - PRIMARY SUBSTATION

##### FUNCTION

Electric power, generated in the #184 Power House and delivered through the #151-2 Substation, is transformed in this substation to the transmission voltage of 115-kv. Conversely, power from the 115-kv. transmission system is transformed to 13.8 kv. for distribution within the area.

This facility provides part of the #100-R, P, L & K Area distribution system in conjunction with #151-2R and has two transformers, each with adequate capacity to carry sufficient power from the 115-kv. transmission system substation to meet all area demands without the use of the local power generation. Provisions are included to transmit the excess power to the 115-kv. transmission system when the area generation facility is operating at full capacity.

##### PRINCIPAL COMPONENTS

##### Control House

The Control House contains all electrical equipment requiring indoor installation. It is constructed with two operating floor levels with each level divided into three major installations. Two of the upper sections contain the 13.8-kv. power switchgear and accessories. The other upper section houses controls, relays, panels, supervisory and line protection cabinets, blackout contactors, lighting panels, and miscellaneous fans and heater controls. Two of the lower sections contain all of the high voltage (13.8 kv.) cable terminations, including some potential devices mounted below the ceiling. This area also contains the air compressors necessary to the operation of the 13.8-kv. switchgear. The other lower section contains the 480-v. auxiliary switchgear, motor generator sets, batteries and two sets of lighting transformers. The 13.8-kv. power sections of the #151-1 and #151-2 substations are interconnected by two 13.8-kv. tie feeder circuits to form the primary distribution ring-bus.

### Outdoor Installation

The outdoor installation consists of outgoing and incoming strain structures, switch structures, an oil circuit breaker and transformers with all appurtenances and line material. There are two 13.8/115-kv., 22,500/30,000 kv.-a. oil-insulated, air-cooled power transformers. When the transformers operate at 30,000 kv.-a. forced air coolers are employed.

All necessary lightning arresters and all other protective measures are provided. The outdoor grounding grid completely loops both the outdoor and the indoor installations. Facilities are provided for full local electrical control. The Load Dispatcher's control board, located in the #700 Area, provides remote control for all 115-kv. equipment and the two 13.8-kv. transformer secondary breakers. All 13.8-kv. and 440-v. apparatus can be controlled remotely from the switchboard in Building #151-2 control room.

This substation, in conjunction with the #151-2 substation, supplies power to Buildings #105, #183, #190 and the #100 Area general distribution system.

### BUILDING FLOOR SPACE

|                                                                | <u>Approx.<br/>Sq. Ft.</u> |
|----------------------------------------------------------------|----------------------------|
| Battery Room (Lower level)                                     | 150                        |
| Control Room (Upper level)                                     | 890                        |
| Switchgear Room (Upper level)                                  | 1,950                      |
| Total area of each operating level                             | 2,540                      |
| Outside installation - Fenced area                             | 17,550                     |
| (Including: two 20-ft. double gates<br>two 4-ft. single gates) |                            |

### BUILDING DETAILS

The Control House is of Class I construction, the major structure being 105 ft. long by 20 ft. wide. There is a rectangular extension centered on the east side, 49 ft. by 19 ft., and a pit 11 ft. by 8 ft. is located on the north side of the building to provide access to the lower level for installing and removing large equipment.

There are two major operating floors, one below grade and the first floor which includes both the control and switchgear sections. A fire-stop wall separates the primary equipment sections on both floors. The basement sections have one-inch waterproofing. The total area of the building is approximately 3000 square feet and the volume 86,500 cubic feet.

## CONSTRUCTION DETAILS

The Control House, towers and major installations are erected on reinforced concrete foundations. The major foundation and concrete structures include foundations for thirty-two tower legs, two transformers, an oil circuit breaker and the Control House. The one-story Control House is of reinforced concrete throughout with a flat slab roof. There are eight steel towers consisting of two T1 bus structures, two T3 bus structures which are strain insulators only, two T4 incoming-outgoing structures, and two T5 disconnect switch structures at the 115-kv. oil circuit breakers. There are also eight 70 ft. Class II treated southern pine poles.

The Control House is heated by unit heaters and air is exhausted by fan ventilators. A sump pit and pump are provided. All supervisory and control panels are illuminated by fluorescent fixtures, and fifty-foot candle illumination is used for the lighting design within the Control House. The outside lighting arrangement has an upward component of light to illuminate the towers and a downward component to illuminate the paths and equipment installations made at grade elevation. The Control House is equipped with six loud-speakers for safety alarm, a dispatcher's telephone, and a Bell telephone station.

## EQUIPMENT

### Electrical

- 1 150-kv.-a. 13,800-480-v. a.c. Duplex unit substation.
- 1 14.4-kv. RH Cubicle switchgear section.
- 1 14.4-kv. LH Cubicle switchgear section.
- 2 22,500/30,000 kv.-a. Transformers.
- 2 45-kv.-a. - 480-208Y/120-v. Transformers.
- 2 115-kv., 1,200 amp. Disconnect switches.

- 4 115-kv., 1,200 amp. Hōrngap switches.
- 1 115-kv. Oil circuit breaker.
- 2 Bushing potential devices.
- 1 a.c. Distribution panel.
- 1 Lighting panel - Indoor (24-circuit).
- 1 Lighting panel - Outdoor (12-circuit).
- 1 Lighting panel - Indoor (6-circuit).
- 1 Blackout control cabinet.
- 1 Substation duplex control board.
- 1 Supervisory control board.
- 1 30 amp. Automatic transfer switch.
- 1 200 amp. Automatic transfer switch.
- 6 Manual motor starting switches.
- 7 Magnetic motor starters (30 amp. fuse type).
- 3 Magnetic motor starters (60 amp. fuse type).
- 4 Momentary start-stop pushbutton stations.
- 2 Selector switches.
- 1 100 amp. Remote control contactor.
- 3 Circuit breaker air compressor with starters and pushbuttons.
- 2 Underfrequency relays.
- 1 Set supervisory control and protective equipment.
- 6 Loud-speaker assemblies.
- 1 125-v. d.c. battery with racks, charging equipment, 2 - 2-KW MG sets, control and distribution panel and 2 relay shunts.

Lighting fixtures, with necessary brackets and other appurtenances.

All required cable trays, cable, receptacles, switches pull-boxes, junction boxes, and other miscellaneous equipment.

Architectural

- 1     -1/2-hp. 440-v. Duplex sump pump with necessary float switch.

Heating and Ventilating

- 1     3/4-hp. 440-v. Ventilating fan set with necessary automatic dampers.
- 1     1.5-hp. 440-v. Ventilating fan set with necessary automatic dampers.
- 1     Small unit heater in battery room with necessary thermostatic control.
- 3     7-1/2 kw. 440-v. Unit heaters with necessary thermostatic control.
- 2     4-kw., 440-v. Unit heaters with necessary thermostatic control.

DRAWINGS - BUILDING #151-1R

(For other areas, consult the drawing schedule.)

Electrical

- W-135618 - Outdoor Plan and Sections - Electrical  
W-136183 - Indoor Arrangement  
W-137982 - One Line Diagram 13.8 kv.-115-kv.

Drainage, Heating and Ventilating

- W-136185 - Drainage, Heating and Ventilating

Architectural

- W-136196 - First Floor and Basement Plan - Door Schedule and Details - Control House

BUILDING #151-1C - PRIMARY SUBSTATION

## FUNCTION

The function of the #151-1C and #151-2C Primary Substations is to receive power from the 115-kv. transmission system and to reduce the voltage to 13.8-kv. for distribution within the #100-C Area.

No power is generated in the #100-C Area. Therefore, all of the normal power for all facilities must be obtained from the transmission system. In order to approximate the same degree of reliability of power supply as attained in the other #100 Areas, where power is generated, it was necessary to provide two transmission stations. This was accomplished by installing one of the 22,000/30,000 transformers in each station, instead of both units in one station as in the other areas.

Elimination of generation greatly reduced the current interrupting duty of the circuit breakers in the area. This permitted the use of "Metal Clad" switchgear with a rating of 500,000 kv.-a. instead of 1,000,000 kv.-a. Breaker cost was reduced by approximately half.

Use of the smaller type switchgear introduced further economy in the construction of the control house units since space requirements were greatly reduced.

Also, as a result of the use of smaller switchgear and single transformer supply at each station, only one 13.8-kv. bus section was required in each station. This step eliminated the necessity of bus tie breakers with a further reduction of cost.

Because controls for the smaller breakers are contained on the switchgear, it was unnecessary to install switchgear control boards as in the other stations.

Due to the fact that each station has its own power transformer and all power is derived from the transmission system, only one 13.8-kv. tie feeder between stations is necessary. With the feeder layout, the station tie is required to carry only one-half the area load. Cable trench cover cost was correspondingly reduced as compared to the other areas.

## PRINCIPAL COMPONENTS

### Control House

The Control House contains all electrical equipment requiring indoor installation. This is a one-story structure, divided into two major sections; as compared with the larger, two-level structures required in the #100-R, P, L and K Areas. The eastern section contains the 13.8-kv. switchgear, while the western section contains the control room, the 480-v. switchgear, supervisory board, batteries, M.G. sets, line protector cabinet, lighting transformers, auto-transfer switches, power and lighting panel, blackout control equipment and related components. A cable vault was constructed the full length of the building under the 13.8-kv. switchgear room, and a cable pit was provided under the supervisory board.

The 13.8-kv. power sections of the #151-1C and #151-2C Substations are interconnected by one 13.8-kv. tie feeder circuit.

### Outdoor Installation

The outdoor installation consists of strain structures, switch structures, oil circuit breaker, transformer, and similar equipment with all appurtenances and line material.

One 13.8/115-kv., 22,500/30,000 kv.-a. oil-insulated, air-cooled power transformer was provided. When the transformer operates at 30,000 kv.-a., forced air coolers are employed.

All necessary lightning arresters and all other protective provisions were installed.

The outside grounding grid completely loops both the outdoor and indoor installations.

Facilities were provided for complete local electrical control. The Load Dispatcher control board located in the #700 Area provides remote control of all 115-kv. equipment, the 13.8-kv. transformer secondary breaker and the 13.8-kv. breaker on the station tie feeder. All other 13.8-kv. and 440 volt apparatus is locally controlled.

## BUILDING FLOOR SPACE

|                                                 | <u>Approx.<br/>Sq. Ft.</u> |
|-------------------------------------------------|----------------------------|
| 13.8-kv. Switchgear Room                        | 935                        |
| Control Room                                    | 730                        |
| Cable Vault (Under 13.8-kv. Switchgear)         | 935                        |
| Cable Pit (Under Supervisory Board)             | 35                         |
| Outside Installation--Fenced Area (125' x 112') | 14,000                     |

## BUILDING DETAILS

The Control House, of Class I construction, is "L" shaped with overall dimensions of 57 ft. by 38 ft. The building floor and cable vault floor slabs are pitched for drainage.

Area - 3000 square feet

Volume - 32,000 cubic feet

## CONSTRUCTION DETAILS

Reinforced concrete foundations support the control house, towers and major equipment installations. All concrete piers were constructed to one foot above grade. The major foundations and concrete structures include foundations for twenty tower legs, one transformer (Power), one grounding transformer, one oil circuit breaker, and one control house (one-story with cable vault and pit).

The Control House is constructed of reinforced concrete with a flat roof. There are five steel towers consisting of one T2 Bus Structure, one T3 Bus Structure (strain insulators only), two T4 Incoming-Outgoing Structures, one T6 Disconnect Switch Structure, and six 70' Class II treated Southern Pine poles.

Unit heaters and ventilation fans are installed and a sump pump is provided.

All supervisory and control panels are illuminated with fluorescent lamps, fifty foot candle illumination being used for the lighting design within the control house.



The outside lighting arrangement has an upward component of light to illuminate the towers and a downward component to illuminate paths and equipment installations made at grade elevation.

The Control House is equipped with six loud-speakers for safety alarms, a dispatcher's phone, and a Bell telephone station.

## EQUIPMENT

### Electrical

- 1 150 kv.-a. 13,800-480-v. a.c. Single-ended unit substation.
- 1 Metal clad 13.8-kv. switchgear equipment.
- 1 22,500/30,000 kv.-a. Transformer - with cooling fans.
- 1 Zig-zag grounding transformer and grounding resistor unit.
- 2 45 kv.-a. - 480-208Y/120-v. Transformers.
- 2 115-kv., 1200 amp. Disconnect switches.
- 2 115-kv., 1200 amp. Horngap switches.
- 1 115-kv., Oil circuit breaker.
- 1 a.c. Distribution panel (3-circuit).
- 1 Lighting panel - Indoor (24-circuit).
- 1 Lighting panel - Outdoor (12-circuit).
- 1 Power panel - Indoor (6-circuit).
- 1 Blackout control cabinet.
- 1 Supervisory control board.
- 1 Overcurrent ground relay, covers and nameplate.
- 1 480-v. a.c. Power receptacle with safety switch.
- 1 30 amp. Automatic transfer switch.
- 1 200 amp. Automatic transfer switch.

- 2 Outdoor auxiliary switches.
- 6 Manual motor starting switches NEMA I.
- 5 Magnetic motor starters (30 amp. fuse type).
- 2 Magnetic motor starters (60 amp. fuse type).
- 2 Momentary contact start-stop pushbutton stations NEMA IV.
- 1 Pushbutton - 2 unit - 2 position - maintain contact.
- 2 Selector switches - NEMA IV.
- 1 100 amp. Remote control contactor.
- 1 Capacitor and auxiliary SG relay.
- 1 Set supervisory cable terminal and protective equipment.
- 6 Loud-speaker assemblies - type 3.
- 1 125-v. d.c. Battery with racks, charging equipment - two 2-kv. MG sets - control and distribution panel and two D3 relay shunts.

Lighting fixtures with necessary brackets and other appurtenances.

- 10 W.T. Deck fixtures - 100-W

#### Architectural

- 1 1/2-hp. 440-v. Duplex sump pump with necessary flow switch.

#### Heating and Ventilating

- 1 3/4-hp. 440-v. 3/8" S.P., 1725 c.f.m. Exhaust fan with low limit cut-off switch.
- 2 1/6-hp. 440-v. 3/8" S.P., 450 c.f.m. Control room exhaust fans (vent sets) with thermostats.
- 2 7-1/2-kv. 440-v. Unit heaters with necessary thermostatic control.
- 2 5-kw. 440-v. Unit heaters with necessary thermostatic control.

## DRAWINGS

### Electrical

- W-141679 - One Line Diagram - 13.8-kv. and 115-kv.
- W-142322 - Outdoor Plan
- W-142363 - Outdoor Sections
- W-142809 - Control and Switchgear House Arrangement
- W-138893 - Safety Alarm System
- W-141694 - Miscellaneous Control
- W-141621 - Control and Switchgear House Miscellaneous Elevations and Sections - Sheet 1
- W-141600 - Control and Switchgear House Miscellaneous Elevations and Sections - Sheet 2

### Drainage, Heating and Ventilating

- W-142830 - Drainage, Heating and Ventilating
- W-142829 - Sump Pump Piping - Details
- W-142828 - Drainage Plan

### Architectural

- W-142831 - First Floor and Basement Plan - Door Schedule and Details - Control House

### Structural (#151-1C and 2C)

- W-142267 - #151-1C - Foundation Plan - Concrete
- W-142272 - #151-2C - Foundation Plan - Concrete
- W-142273 - #151-2C - Plan and Sections - Steel
- W-142278 - 115-kv. Primary Substation Plans and Sections - Steel

BUILDING #151-2RPL&K - PRIMARY SUBSTATION

## FUNCTION

Housing is provided in the control house of this installation for a major portion of the #100-R, P, L and K Area 13.8-kv. bus. The remainder is included in Building #151-1. Space is provided for a future bus ring. This facility provides the area loads with power supplied from the Power House, Building #184, the normal source of power for the #100 Area. The 115-kv. transmission system through the #151-1 Primary Substation comprises the alternate source of power for the area.

## PRINCIPAL COMPONENTS

All equipment for this facility is installed in the control house which is divided into upper and lower levels each of which has three installation sections. Two of the upper sections house two sections of 13.8-kv. main switchgear. The other contains the power station control and relay board and the #151-1 Primary Substation remote control board, including a synchronizing panel and other supervisory and 13.8-kv. feeder protection equipment. One of the lower sections contains the battery, MG set and other associated equipment, 480-v. switchgear and two lighting transformers. The air compressors, potential transformer compartments and protective equipment are located in the other two lower sections. All necessary surge protectors and other protective devices are installed. The switchboard in the control house includes control for the electrical operation of the #151-1 Substation. Two tie feeder circuits interconnect this substation with the #151-1 Primary Substation to form the primary distribution ring-bus.

## BUILDING FLOOR SPACE

|                                    | <u>Approx.<br/>Sq. Ft.</u> |
|------------------------------------|----------------------------|
| Control Room (Upper level)         | 1150                       |
| Switchgear Room (Upper level)      | 2300                       |
| Battery Room (Lower level)         | 155                        |
| Total area of each operating level | 3220                       |

## BUILDING DETAILS

The control house is of Class I construction. The major structure is rectangular in shape, 126 ft. long by 20 ft. wide. An extension centered on the west side of this main block is 63 ft. long by 19 ft. wide, and a pit 10 ft. wide by 12 ft. long adjoins the southwest corner for handling large equipment. One of the two operating floors is below grade and is reached by steel stairs. This basement floor, in general, has a ceiling height of 14 ft. while the upper floor switchgear and control sections are 13'-6" high. A fire stop wall separates the first floor primary equipment sections. The total area is 3800 square feet and the volume is 109,000 cubic feet.

## CONSTRUCTION DETAILS

The structure has a reinforced concrete mat foundation and reinforced concrete walls, floor and roof with built-up roofing. Heating and ventilating units are provided complete with automatic dampers, thermostatic controls and accessory components. There is a duplex sump pump on the lower floor for the removal of water seepage. Fifty foot-candle illumination is provided within the control house with lighting provisions at control panels and boards. Fixtures are generally fluorescent. There are six loud-speakers for safety alarms, a dispatcher's telephone and a Bell telephone station.

## EQUIPMENT

### Electrical

- 1 150-kv.-a. - 13,800/480-v. a.c. Unit substation.
- 2 45-kv.-a. - 480/120-v. Dry type transformers.
- 1 34 Circuit lighting panel.
- 1 30 amp. Automatic indoor transfer switch.
- 1 200 amp. Automatic transfer switch.
- 2 14.4-kv. Cubicle switchgear sections.
- 3 Circuit breaker air compressors.
- 1 Substation and switching station duplex control board.

- 4 Underfrequency relays.
- 1 125-v. Storage battery with racks and battery charging equipment.
- 3 Momentary start-stop pushbutton stations.
- 2 Selector switches.
- 1 2-Unit 2-position pushbutton station.
- 7 30 amp. Fuse type magnetic motor starters.
- 3 60 amp. Fuse type magnetic motor starters.
- 6 Manual motor starting switches, NEMA I.

All necessary cable and cable trays with associated equipment including connectors, blind ends, cross-tee-reducer sections, elbows and dropouts.

All necessary cable splicing material.

All required lighting fixtures with necessary brackets and other appurtenances.

- 6 Loud-speaker assemblies.

All required receptacles, switches, pull boxes, junction boxes, conduits, colored coded wire, cable supports, grounding material, cable connectors, etc. were obtained by field procurement.

#### Heating and Ventilating

- 1 1/2 hp. 440-v. Duplex sump pump with necessary float switch.
- 1 3/4 hp. 440-v. Ventilating fan set with necessary automatic dampers.
- 1 1.5 hp. 440-v. Ventilating fan set with necessary automatic dampers.
- 1 Small unit heater in battery room with necessary thermostatic control.
- 3 7-1/2 kw. 440-v. Unit heaters with necessary thermostatic control.
- 2 4-kw. 440-v. Unit heaters with necessary thermostatic control.

## DRAWINGS - BUILDING #151-2R

(For other areas, consult the drawing schedule.)

### Electrical

W-138035 - 13.8 kv. Main One Line Diagram - Buildings #184 and #151-2

W-136355 - One Line Diagram - 440-v. - 208/120-v.

W-136163 - 13.8 kv. Switching Station - Electrical Arrangement

W-136262 - Conduit and Tray Layout and Grounding

## BUILDING #151-2C - PRIMARY SUBSTATION

### FUNCTION

The function of the #151-2C and #151-1C Primary Substations is to receive power from the 115-kv. transmission system and to reduce the voltage to 13.8-kv. for distribution within the #100-C Area.

The principal differences between #100-C and the other #100 Area substations is discussed under Building #151-1C.

### PRINCIPAL COMPONENTS

#### Control House

The Control House contains all electrical equipment requiring indoor installation. It is a one-story structure, divided into two major sections, as compared with the larger, two-level structure required in #100-R, P, L and K. The northerly section contains the 13.8-kv. switchgear. The southerly section is the control room and houses the 480-v. switchgear, supervisory board, remote control board, batteries, MG sets, line protector cabinet, lighting transformers, auto-transfer switch, lighting panel, blackout control cabinet and contactor, and related components. A cable vault was constructed the full east-west length of the building under the 13.8-kv. switchgear room, and a cable pit was provided under the supervisory board.

The 13.8-kv. power sections of the #151-2C and #151-1C Substations are interconnected by one 13.8-kv. tie feeder circuit.

### Outdoor Installation

The outdoor installation consists of strain structures, switch structures, oil circuit breakers, transformer and similar equipment, with all appurtenances and line material.

One 13.8/115-kv. 22,500/30,000 kv.-a. oil-insulated, air-cooled power transformer was provided. When the transformer operates at 30,000 kv.-a., forced air coolers are employed.

All necessary lightning arrestors and all other protective provisions were installed.

The outdoor grounding grid completely loops both the outdoor and indoor installations.

Facilities were provided for complete local electrical control.

The Load Dispatcher's control board located in the #700 Area provides remote control of all 115-kv. equipment, the 13.8-kv. transformer secondary breaker and the 13.8-kv. breaker on the station tie feeder. All other 13.8-kv. and 440-v. apparatus is completely controlled locally.

### BUILDING FLOOR SPACE

|                                         | <u>Approx.<br/>Sq. Ft.</u> |
|-----------------------------------------|----------------------------|
| 13.8-kv. Switchgear Room                | 935                        |
| Control Room                            | 735                        |
| Cable Vault (Under 13.8-kv. Switchgear) | 935                        |
| Cable Pit (Under Supervisory Board)     | 35                         |
| Outside Installation - Fenced Area      | 23,750                     |

### BUILDING DETAILS

This Control House is of Class I construction. The major structure is "L" shaped with over-all dimensions of 38 ft. by 57 ft.

|        |   |                   |
|--------|---|-------------------|
| Area   | - | 3000 square feet  |
| Volume | - | 32,000 cubic feet |



## CONSTRUCTION DETAILS

### Foundations

Reinforced concrete foundations support the control house, towers and major equipment installations. All concrete piers were constructed to one foot above grade.

### Major Foundations and Concrete Structures

- 32 Tower-Leg Foundations
  - 1 Transformer (Power) Foundation
  - 1 Grounding Transformer Foundation
  - 2 Oil Circuit Breakers Foundation
  - 1 Control House (One-story with cable vault and pit)

### Superstructure

The Control House is constructed of reinforced concrete throughout, with built-up roofing.

Eight steel towers were provided:

- 1 T1 - Bus Structure
- 2 T3 - Bus Structures
- 1 T5 - Disconnect Switch Structure
- 2 T5A - Disconnect Switch Structures
- 1 T5B - Disconnect Switch Structure
- 1 T6 - Disconnect Switch Structure
- 8 Class II Treated Southern Pine Poles

### MISCELLANEOUS

Heating and ventilating units complete with automatic dampers, thermostatic controls, and other auxiliaries were provided throughout the building.

The outside lighting arrangement was designed with an upward component of light to illuminate the towers and a downward component to illuminate paths and equipment installations made at grade elevation.

Fifty foot-candle illumination was designed within this control house. Illuminating provisions were made at control panels and boards. In general, fluorescent lamps were used.

A duplex sump pump was provided.

Six loud-speakers were installed to give safety alarms. A dispatcher's phone and a Bell telephone station were provided.

## EQUIPMENT

### Electrical

- 1 150 kv.-a. - 13,800/480-v. a.c. Single-ended unit substation - indoor.
- 1 22,500/30,000 kv.-a., 3-phase Outdoor transformer - with cooling fans.
- 2 45-kv.-a. - 480/208Y/120-v. Lighting transformers.
- 1 Zig-zag grounding transformer and grounding resistor unit.
- 2 1200 amp. 115-kv., 3500-mv.-a. Outdoor circuit breakers.
- 1 34 Circuit lighting panel.
- 1 12 Circuit lighting panel - Outdoor.
- 1 3 Circuit a.c. distribution panel.
- 1 Duplex control board.
- 1 115-kv., 1200 amp. Horngap switch.
- 4 115-kv., 1200 amp. Disconnect switches.
- 1 125-v. Storage battery with racks and battery charging equipment (two 2-kw. MG sets, control and distribution panel and two D3 relay shunts).
- 1 Supervisory control board.

- 18 Tons fabricated galvanized structural steel.
- 6 Loud-speaker assemblies - type 3.

#### Heating and Ventilating

- 1 3/4 hp. 440-v. 3/4" S.P. 1725 c.f.m. Exhaust fan with low limit cut-off switch.
- 2 1/6 hp. 440-v. 3/8" S.P. 450 c.f.m. Control room exhaust fans (vent sets) with thermostats.
- 2 7-1/2-kw. 440-v. Unit heaters with necessary thermostatic control.
- 2 5-kw. 440-v. Unit heaters with necessary thermostatic control.

#### DRAWINGS

##### Electrical

- W-141601 - One Line Diagram, 13.8-kv., 115-kv.
- W-142964 - Safety Alarm System
- W-142971 - Indoor Lighting Plan
- W-141605 - Outdoor Lighting Plans
- W-142809 - Control and Switchgear House Arrangement

##### Plumbing, Heating and Ventilating

- W-142167 - Heating and Ventilating
- W-142164 - Drainage and Sump Detail
- W-142166 - Duplex Sump Pump - Piping Details

##### Architectural

- W-142277 - First Floor, Basement Plans - Door Schedule and Details

##### Structural

See #151-1C Primary Substation for structural drawings.

BUILDINGS #152-R AND #152-3R - SECONDARY SUBSTATIONS

## FUNCTION

Substation #152-R transforms electric power, supplied at 13.8-kv., to 480-v. potential for use in Buildings #122-R, #501-R, #701-R, #704-R and #711-R.

Substation #152-3R transforms electric power, supplied at 480-v. by Substation #152-R, to 7620-v. for use at Gate House #701-4G.

## PRINCIPAL COMPONENTS

Substation #152-R is an outdoor double-ended, unit-type. It consists primarily of two 500 kv.-a., 13.8-kv./480-v. transformers and six air circuit breakers. Two spaces are provided for instrumentation and one for a future circuit breaker, if desired. The substation, supplied by a 13.8-kv. underground feeder, is located approximately 150 ft. north of Building #704-R and is fence-enclosed in an area approximately 25 ft. wide by 42 ft. long.

Substation #152-3R, approximately 200 ft. east of the #100-R Area boundary fence, consists of a 10 kv.-a., 480/7620-v. transformer installed on a single wood pole.

## EQUIPMENT

- 1 1000 kv.-a. Outdoor unit load center (#152-R).
- 1 10 kv.-a., 7620/13,200, 240/480-v. Transformer (#152-3R).

All other necessary equipment and materials were obtained by field procurement.

## DRAWINGS

- W-138546 - 1000 kv.-a., 13.8-kv. Unit Substation #152-R
- W-138533 - 10 kv.-a. 480-v.-7620-v. - Substation #152-3R

## BUILDING #152-P - SECONDARY SUBSTATION

### FUNCTION

The function of the #152-P Substation is to transform electric power, supplied at 13.8 kv., to 480 volt potential for use in Buildings #501, #701-1, #701-2 and #704. Building #711-P is fed through Building #704-P. The required 13.8 kv. power to the Classification Yard is supplied also from this substation through the use of a 225 kv.-a. 480-v./13.8 kv.

### PRINCIPAL COMPONENTS

This is a double-ended unit-type outdoor substation. It consists primarily of two 500 kv.-a., 13.8-kv./480 volt transformers, two main air circuit breakers, a bus-tie air circuit breaker, four air circuit breakers for secondary feeders to buildings and one for the protection of the 225 kv.-a. step-up transformer. Two spaces are provided for instrumentation and one for a future breaker, if required.

The 225 kv.-a. step-up transformer was installed in the same fence enclosure to provide service to the Classification Yard.

The unit substation is supplied by two 13.8 kv. underground feeders, and the step-up transformer is supplied by an underground feeder from the unit substation. All secondary feeders to buildings are underground. The feeder to the Classification Yard is overhead on poles.

This substation is fence-enclosed in an area 26 ft. wide by 62 ft. long located approximately 100 ft. west of Building #704-P.

### EQUIPMENT

- 1 1000 kv.-a., 13.8-kv./480-v. Substation.
- 1 225 kv.-a. Step-up transformer (480-v. 13.8 kv.).
- 3 Lightning arresters, line-type.

All necessary conduit, elbows, grounding wire, ground rods, clamps and other hardware, fence and gates, unit substation foundations, crushed stone and poles and arms, were provided by field procurement.

## DRAWING

W-138541 - 1000 kv.-a., 13.8 kv./480 v. Substation

BUILDING #152-LK&C - SECONDARY SUBSTATIONS

## FUNCTION

The function of the #152 Substation is to transform electric power, supplied at 13.8-kv., to 480-v. potential for use in Buildings #501, #701-1 and 2, #704 and #711.

## PRINCIPAL COMPONENTS

This is a double-ended, unit-type outdoor substation. It consists primarily of two 500 kv.-a., 13.8-kv./480-v. transformers and six air circuit breakers. Two spaces are provided in the switchgear for instrumentation and one for a future circuit breaker, if desired.

It is supplied by either of two 13.8-kv. underground feeders; one preferred, from #151-1, and one auxiliary, from #151-2. It is located approximately 100 ft. from Building #704. The substation is fence-enclosed in an area approximately 25 ft. wide by 42 ft. long.

## EQUIPMENT

- 1 1000 kv.-a. Outdoor unit load center.

All necessary conduit, elbows, ground wires, ground rods, clamps and other hardware, fence and gates, unit substation foundations and crushed stone were obtained by field procurement.

## DRAWINGS

W-142973 - 1000 kv.-a., 13.8-kv. Unit Substation #152-C

W-142972 - 1000 kv.-a., 13.8-kv. Unit Substation #152-K

W-139463 - 1000 kv.-a., 13.8-kv. Unit Substation #152-L

BUILDING #501-RPLK&C - FENCE AND ROAD LIGHTING

## FUNCTION

This system of fence and road lighting contributes to the maintenance of security around each of the #100 Areas.

## PRINCIPAL COMPONENTS

The required fence and road lighting fixtures for security operations are mounted on wood poles, with control and auxiliary equipment located inside each of the fenced areas to prevent tampering by unauthorized persons.

Fresnel units are utilized generally in the lighting system because of their wide range of illumination. All lighting is controlled automatically from astronomical time switches, but can be controlled manually if desired. All lighting is controlled further by the centralized, remote blackout control system. One 100-kw. emergency diesel generator provides the main source of auxiliary and standby power. Remotely located switching stations transfer to this source of power under emergency conditions. Approximately two miles of fence lighting and one mile of road lighting are provided for each area. The fence lighting is designed to illuminate an area 100 ft. wide outside the fence.

## EQUIPMENT (For each Area)

Electrical

- 3 Constant current transformers.
- 1 3-kv.-a., 480/120-v. Transformer.
- 2 Disconnect switches.
- 1 Synchronous time switch.
- 1 Automatic transfer switch.
- 1 Blackout control relay.
- 1 Emergency 100-kw. diesel generator.
- 6 Disconnect drop-out cutouts.
- 1 Test by-pass.
- Luminaires.

Necessary transformer mounting structure, poles, hardware, guys, anchors, insulators and wire were obtained by field procurement.

DRAWINGS (Buildings #501, #503, #505, #506 and #507)

W-138499, W-138690, W-139407, W-139543, W-142974 - One Line Diagram - #503-RPLK&C respectively.

W-138543, W-138691, W-139408, W-139435, W-142976 - Outside Wiring Diagram - Telephones - RPLK&C respectively.

W-138544, W-138692, W-138965, W-139435, W-142977 - One Line - Control Circuits - RPLK&C respectively.

W-135545, W-138960, W-139413, W-139452, W-142980 - Constant Current Transformer and Emergency Generator - RPLK&C respectively.

W-136053, W-137054, W-137051, W-142560, W-142354 - #100 Area Outside Lines - Underground Electric Lines - Schematic Cable Runs - #503-RPLK&C respectively.

W-137142, W-137269, W-138964, W-139461, W-138898 - Safety Alarm System - Block and Control Diagram - #184, #190, #183-1 (R only), #183-2, #186 and part of #507 for #501-RPLK&C respectively.

Map 3311 - Outside Lines - Electric and Telephone - Sheets #649, 496, 523, 583, 732 - RPLK&C respectively.

Map 3311 - Outside Lines - Electric and Telephone - Sheets #619, 497, 762 - RP&C respectively.

Map 3311 - Outside Lines - Electric and Telephone - Sheet #466 - C only.

Map 3319 - Outside Lines - Electric and Telephone - Circuit Layout - Sheets #619, 496, 523, 580, 732 - RPLK&C respectively.

Map 3319 - Outside Lines - Electric and Telephone - Circuit Layout - Sheets #649, 497, 762 - RP&C respectively.

Map 3311 - Outside Lines - Electric and Telephone - Circuit Layout - Sheet #467 - L only.

Map 3319 - Outside Lines - Electric and Telephone - Circuit Layout - Sheets #466, 467 - L only.



Map 3326 - Outside Lines - Underground Electric Lines -  
Sheets #649, 496, 523, 580, 732 - #503-RPLK&C  
respectively.

Map 3326 - Outside Lines - Underground Electric Lines -  
Sheets #619, 497, 581, 762 - #503-RPK&C respectively.

Map 3326 - Outside Lines - Underground Electric Lines -  
Sheets #610, 611 - K only.

### BUILDING #503-RPLK&C - DISTRIBUTION LINES

#### FUNCTION

These lines provide a firm tie between the 13.8-kv. bus sections to which generated power is connected and between bus sections to which transmission line power is introduced. Power is distributed by a radial system to the #100 Area loads from the Primary Substations, Buildings #151-1 and #151-2.

#### PRINCIPAL COMPONENTS

Approximately one-half mile of 480-v. overhead distribution system mounted on wood poles is utilized in #100-RP&C. An underground system for distribution of 13.8-kv. and some lesser potentials is installed in the R and C Areas, an overhead 13.8-kv. system in P, and overhead 600-v. cable on wood poles, 600-v. cable underground for normal distribution, and 600-v. cable underground for emergency distribution in the L and K Areas.

Two station ties are provided between #151-1R and #151-2R, and one between the C Area Primary Substations. The primary substations in #100-P are connected to the various buildings in the area requiring service by 350-mcm cable. Those in L and K are connected by 3/C, 350-mcm, 15-kv. PL and A buried cable, and are connected to the various buildings requiring service by 350-mcm and 500-mcm cable.

Feeders provided include six motor feeders for #105-RPLK&C, two building feeders for #105-RPLK&C, four feeders for #105-R, four each for #190-RPLK&C, two feeders for #152-C and #183-2C, and two sub-feeders for #184-C.

#### EQUIPMENT

All necessary cable, lightning arrestors, and fused disconnect switches are provided. All conductors, splices,

poles and cross-arms, insulators, guys, anchors and other line materials were obtained by field procurement.

In #100-C (with no local generation) #4/0 size cables were used for primary underground feeders in place of the 350-mcm size required in the other #100 Areas.

#### DRAWINGS

Listed under Building #501-RPLK&C.

#### BUILDING #505-RPLK&C - FIRE ALARM SYSTEM

##### FUNCTION

A fire alarm system with conveniently located fire alarm stations throughout each #100 Area is provided by this facility.

##### PRINCIPAL COMPONENTS

Coded alarms for local fire emergencies are registered and indications received at the Safety and Fire Protection Building #709-A and at the Fire House #709-F. The system consists of a series loop which begins at Building #704, the main station in each area, and connects the Power House, Building #184. Fire alarm horns and boxes are strategically located along this loop, with a gong and a punch register installed in Building #184. Power for the fire alarm horns throughout the area is supplied over a separate circuit from Building #704. The master box is located in #701-1, with terminal boxes installed on poles to provide for taps to the required buildings and fire alarm boxes. There are approximately two miles of two-conductor cable within each area carried on the power and light poles. The fire alarm boxes are mounted on wood poles, with a fire-alarm luminaire placed at each box location.

##### EQUIPMENT

All necessary cable, cable grips and auxiliary material was provided. Necessary alarm equipment was procured by a subcontractor.

##### DRAWINGS

See tabulation under #501-RPLK&C.

## BUILDING #506-RPLK&C - TELEPHONE CABLE AND INSTRUMENTS

### FUNCTION

This facility provides telephone service on the plant-wide system, intercommunication between facilities within the #100-Areas, and outside administrative communication.

### PRINCIPAL COMPONENTS

The necessary instruments, equipment and materials are the property of the Southern Bell Telephone Company. The switching equipment is housed in Building #701-1, with cables to Buildings #701-1, #105 and #190 installed underground. In general, all other cables required for the communication systems are mounted on the power and light poles.

### DRAWINGS

The physical location of the installations required for this facility are indicated on the maps shown under the listing for Building #501.

## BUILDING #507-RPLK&C - SAFETY ALARM SYSTEM

### FUNCTION

This facility provides warning signals indicating air raid evacuation, "all clear", and other security alarms at vital locations within the #100 Areas. It includes provisions for the amplification of oral security instructions at important facilities within this area.

### PRINCIPAL COMPONENTS

The area-wide intercommunication and control system central office is located in Building #701-1. It connects the amplifying paging equipment in the process and power facilities with the amplifying speaker equipment at Building #701-1 which serves as the general area outside warning center. This facility provides tonal signals and is equipped also to transmit oral instructions for air raids, evacuation, "all clear" and other security alarms necessary within this area.

Provisions are made to issue evacuation alarms and oral instructions from major facilities when emergencies develop which could endanger the welfare of plant personnel.

The loud-speaker paging systems provided in the major facilities in this area are a part of the safety alarm system, all other uses of these systems being cut out automatically when safety alarms are being transmitted. Area-wide alarm horn assemblies are located to provide coverage for the area. Radio communication and a special telephone system connect the main gate house at all areas to provide inter-area safety alarm warnings.

There are approximately eight and a half miles of cable within each area for safety alarm, safety alarm speaker, blackout control, emergency generator starting, and both sound-powered telephone systems. The cable and other equipment are carried on pole lines or run underground as required.

Sound-powered telephone systems and emergency generator starting circuits required within each area are part of this facility.

In each area one control center is provided for normal operation, and another is installed for emergency security uses.

#### EQUIPMENT

All necessary cable connectors, cable grips and terminal boxes.

All necessary resistors, messenger cable, cable rings, guys, anchors and other line material were obtained by field procurement.

#### DRAWINGS

See tabulation under Building #501-RPLK&C.

#### AREAS #200-F&H

#### BUILDING #251-F&H - PRIMARY SUBSTATION

#### FUNCTION

This facility provides the means for utilizing power from the 115-kv. plant transmission system to the loads in each of the #200 Areas.

## PRINCIPAL COMPONENTS

The switchgear, control equipment, protective relaying, charging sets, and all necessary auxiliary equipment are installed in a control house. Two 7500/9375 kv.-a. 115/13.8-kv. transformers are set up outside the control house in a fence-enclosed area. Eight steel towers and eight class II, 70 ft. poles support the disconnect switches, lightning protection apparatus and other equipment requiring elevated mountings.

Emergency power at 440-v., 3-phase, 60 cycles, of approximately 5-kv.-a. capacity is furnished from Building #221. Two pits filled with crushed stone, one adjacent to each of the transformers, provide for the disposal of waste oil. Safety alarm signals are broadcast over a loud-speaker which is part of the Building #284 signal system. A Bell telephone station and a dispatcher's telephone are installed in the control house.

## BUILDING DETAILS

The control house is a Class I single story structure approximately 33 ft. by 55 ft. by 19 ft. high, with a small battery room in one corner. The outdoor transformer enclosure is approximately 125 ft. by 140 ft. and has two 20 ft. double gates and two 4 ft. single gates.

The area of the control house is 1844 square feet and its volume is approximately 25,000 cubic feet. The area of the fenced yard is 17,542 square feet.

## CONSTRUCTION DETAILS

### Control House

The control house has reinforced concrete foundations with wall footings, reinforced concrete walls 20-in. thick, and a concrete roof slab insulated and finished with built-up roofing. There is no covering material on the concrete floor. Louvers and a fan set are provided for ventilation. Partition walls in the battery room are of concrete block, and the ceiling is the underside of the concrete roof slab as in the rest of the control house.

There are two unit heaters in the main section of the control house, one a 7-1/2 kw. and the other a 5 kw., and a 2 kw. unit heater in the battery room.

The outside lighting installation provides an upward lighting component to illuminate the disconnect switches and other elevated equipment.

#### Steel Towers

- 2 T1 Disconnect switch structures.
- 2 T3 Disconnect switch structures.
- 2 T4 Disconnect switch structures.
- 2 T5 Disconnect switch structures.

#### Concrete Foundations

- 2 Main transformers.
- 32 Tower-Legs.
- 1 Oil circuit breaker.
- 1 Control house.

### EQUIPMENT

#### Electrical

- 1 13.8-kv. Metal clad switchgear.
- 1 440-v. Unit substation.
- 2 30-kv.-a. 480-120/208-v. 3-phase Transformers.
- 1 1-kv.-a. Single-phase transformer.
- 1 12-Circuit lighting panel - outdoor.
- 1 18-Circuit lighting panel.
- 1 a.c. Distribution panel.
- 1 Control board.
- 1 Blackout control cabinet.
- 1 Power panel, 3-phase, 2-wire 600-v.
- 1 Distribution panel, 3-phase, 3-wire, 600-v. - indoor.

- 1 Ground testing device and wall mounted cabinet - for area-wide use.
  - 1 100 amp. Automatic transfer switch.
  - 1 30 amp. Automatic transfer switch.
  - 1 3-pole, 30 amp. 575-v. a.c. Automatic transfer switch.
  - 6 Disconnect switches (4 motor-operated and 2 manually-operated).
  - 3 Combination motor starters.
  - 3 Motor start switches.
  - 1 115-kv. Outdoor oil circuit breaker with 12 - bushing transformer.
  - 2 Bushing potential devices.
  - 2 7500/9375-kv.-a., 115/13.8-kv. Transformers with lightning arrestors and all appurtenant material.
  - 5 Relays (miscellaneous equipment for transformer tap changer control).
- All necessary supervisory cable and protective equipment.
- 3 Pushbutton start-stop station (maintained contact type).
  - 1 60-cell 125-v. Battery with charging equipment including two relays and shunts.
  - 1 Loud-speaker assembly including transformers.

Lighting fixtures with necessary brackets.

All necessary cable, suspension insulators, post insulators, clamps, shackles, bolts, rods, supports, connectors, clips, strips, thimbles, cable trays, covers, elbows, reducers, and all other required line material.

All necessary conduits and fittings, ground material, some switches, junction boxes and receptacles were obtained by field procurement.

Heating and Ventilating

- 1 Ventilating fan set.
- 1 Electric unit heater with thermostat (2 kw.).
- 1 Electric unit heater with thermostat (5 kw.).
- 1 Electric unit heater with thermostat (7-1/2 kw.).

## DRAWINGS

Architectural

- D-117606 - Control House, Plan, Door Schedules and Details - #251-F
- D-117621 - Control House, Plan, Door Schedules and Details - #251-H

Structural

- W-135916 - Foundation Plan - Concrete - #251-F
- W-136453 - Foundation Plan - Concrete - #251-H
- W-137994 - Control House, Sections - Concrete - #251-F
- W-136668 - Control House, Sections - Concrete - #251-H

Electrical (#251-F)

- W-137965 - One Line Diagram
- W-136118 - Outdoor Electrical Arrangement
- W-137952 - Indoor Electrical Arrangement
- W-138425 - Miscellaneous Wiring Diagrams

Electrical (#251-H)

- W-137067 - One Line Diagram
- W-136152 - Outdoor Electrical Arrangement
- W-136669 - Indoor Electrical Arrangement
- W-139734 - Miscellaneous Wiring Diagrams



## BUILDING #252-F&H - DISTRIBUTION SUBSTATIONS

### FUNCTION

These installations provide power and lighting service to the two #200 Areas.

### PRINCIPAL COMPONENTS

Of the secondary substations in the #200-F Area, four are load center type with load breaker primary switches, 750-kv.-a. OISC transformers and three 25,000 amp. interrupting capacity secondary air circuit breakers. One additional 750-kv.-a. unit and one 500-kv.-a. unit are similar except that secondary circuit breakers are not included. There are also three 150-kv.-a. 13,800/480-v. transformers and three 15-kv.-a., 13,800/120-208-v. transformers. The 150-kv.-a. substations consist of OISC transformers with fused disconnect switches on wood pole structures. Secondary metering equipment is included for all units. The substations are installed on concrete pads with wood pole structures for aerial primary and secondary lines. The substation areas are enclosed by chain link fencing.

In the #200-H Area one of the secondary substations is a load center type with a load breaker primary switch and primary fuses, 750-kv.-a. OISC transformer. No secondary air circuit breakers are provided in this unit but plastic case circuit breakers were added for disconnecting purposes on each feeder. Secondary metering equipment is included. This substation also is installed on a concrete pad with wood pole structure for aerial primary lines. Five 150-kv.-a. substations are located also in this area. These consist of OISC transformers with fuse disconnect switches on wood pole structures. Chain link fences enclose the substation areas.

Secondary substations which are located within separate buildings have been included in the building description for Buildings #221-F, #235-F, #285-F and #292-F and for Buildings #221-H, #292-H, #282-H and #285-H.

### EQUIPMENT

#### #200-F Area

- 5     750-kv.-a., Load centers, 13,800/480-v.
- 1     500-kv.-a., Load center, 13,800/480-v.

- 3 150-kv.-a., Transformers, 13,800/480-v.
- 3 15-kv.-a., Transformers, 13,800/120-208-v.

#### #200-H Area

- 1 750-kv.-a., Load center, 13,800/480-v.
- 5 150-kv.-a., Transformers, 13,800/480-v.

#### DRAWINGS

W-147853 - Distribution Diagram - Power (#252-F)

W-148398 - Distribution Diagram - Power (#252-H)

#### BUILDING #501-F&H - FENCE AND ROAD LIGHTING

##### FUNCTION -

These installations provide security lighting at outside area fences and at interior fences around the restricted Buildings #211-F&H, #217-F, #221-F&H, "A" Line, #232-F, #235-F and #292-F&H. Safety lighting is also provided on the main roads within the areas.

##### PRINCIPAL COMPONENTS

Fresnel type fence lighting fixtures are installed along fences where patrol roads exist. Conventional fixtures are used for fences in the vicinity of gates and buildings and for road lighting. All circuits are 20 amp. series supplied from the 480-v. primary constant current regulators with a back-up power supply from emergency generators located in Class I buildings. Floodlights are provided for the #241 Waste Storage Buildings and for the parking lots. Low intensity blue lights are placed along the main roads for personnel guidance during blackout conditions, and red indicating lights are installed at fire alarm boxes.

##### EQUIPMENT

Equipment for the installation of fence and road lighting consists of fixtures, poles, terminal boxes, protective devices, fittings, wire and cable.

## DRAWINGS

W-147730 - Distribution Diagram - #501-F

W-149142 - Distribution Diagram - #501-H

Map 3311 - Outside Electrical Lines --  
#501-F - Sheets 853, 854, 884  
#501-H - Sheets 826, 796

## BUILDING #503-F&H - DISTRIBUTION LINES

### FUNCTION

These lines supply electrical power requirements to all electrical loads in the two #200 Areas.

### PRINCIPAL COMPONENTS

The main element of the facility is a 13,800-volt distribution system consisting of two #4/0 feeders emanating from Building #251, connected as a loop but operated as aerial feeders. Air break disconnecting switches are provided between groups of substations for sectionalizing the loop. Power at 13,800-v. is supplied to twenty-eight transformers in the #200-F and to twenty-one transformers in the #200-H Area. In general, all 480-v. and 120/208-v. distribution is aerial except for service entrances to buildings and for feeders to Class I buildings which are underground. Power at 2300-v. is supplied to one well pump motor in each area from the power block area. Emergency power at 480-v. is supplied to some smaller buildings from emergency generators located in larger buildings. A tie connection between emergency generator buses is provided in Buildings #221 and #292. Control cables are installed both underground and overhead on messenger wire as required.

### EQUIPMENT

Necessary wire, cable, poles, and messenger hangers are provided for a complete installation as specified on drawings.

## DRAWINGS

W-147853 - Distribution Diagram - Power - #503-F

W-148398 - Distribution Diagram - Power - #503-H

Map 3311 - Outside Electrical Lines --  
#503-F - Sheets 853, 854, 884  
#503-H - Sheets 796, 826

Map 3319 - Outside Electrical Lines --  
#503-F - Sheets 853, 854, 855  
#503-H - Sheets 796, 826

### BUILDING #505-F&H - FIRE ALARM SYSTEM

#### FUNCTION

The purpose of this facility is to provide a fire alarm signal when any fire alarm box in the area has been operated.

#### PRINCIPAL COMPONENTS

A conventional battery-powered fire alarm system is provided with fire alarm boxes strategically placed outside buildings and in Bldg. #221 to give alarm signals. A central control panel and related equipment is located in Bldg. #709. Punch registers are located in the Fire House, Bldg. #709, and in the Power House, Bldg. #284. Gongs and horns inside buildings and horns outside buildings give audible signals. The fire alarm signals are transmitted by telephone cable to the Fire House, Bldg. #709-A, in the #300/700 Areas.

#### EQUIPMENT

All necessary cable, cable grips and auxiliary material was provided. The fire alarm equipment was procured by a subcontractor.

#### DRAWINGS

W-148154 - Block Diagram - #505-F

Map 3319 - Sheets 853, 854, 884 - Outside Electrical Lines -- #200-F Area

W-149143 - Block Diagram - #505-H

Map 3319 - Sheet 796 - Outside Electrical Lines -- #200-H Area

## BUILDING #506-F&H - TELEPHONE CABLE AND INSTRUMENTS

### FUNCTION

This facility provides telephone communication for both normal operations and emergency requirements in each of the two #200 Areas.

### PRINCIPAL COMPONENTS

The telephone requirements for normal plant operation are fulfilled by equipment and apparatus leased from the Southern Bell Telephone Company. The necessary cables were purchased (less salvage value) from the Southern Bell Telephone and Telegraph Company. Switching equipment is housed in Building #701-1, and aerial cables are provided from this point throughout each area. Private security telephone requirements are provided through an automatic telephone exchange capable of handling fifteen conversations simultaneously. This exchange has 140 lines and may be expanded to 200 lines. Switching equipment, batteries, chargers and other components are housed in Building #221 from which all cables are run underground to Class I buildings.

### EQUIPMENT

Necessary frames, instruments, jacks, terminal boxes and cable for designated installation.

### DRAWINGS

W-148055 - Block Diagram - #506-F

Map 3319 - Sheets 853, 854, 884 - Outside Electrical Lines -- #200-F Area

W-149144 - Block Diagram - #506-H

Map 3319 - Sheet 796 - Outside Electrical Lines -- #200-H Area

## BUILDING #507-F&H - SAFETY ALARM SYSTEM

### FUNCTION

The purpose of this system is to provide the means for alerting all persons in the area of an air raid, to give the necessary signals for evacuation, and to broadcast oral instructions for safety measures to be followed in the event of an emergency.

## PRINCIPAL COMPONENTS

The safety alarm system consists of amplifier racks for speakers, located both within buildings and in the open, with interconnections between amplifier racks so that instructions may be given to all area personnel from selected central locations. Back-up power for amplifier operations is supplied from emergency diesel generators. Interconnections between amplifier cabinets consist of a 2-conductor cable and a 4-conductor cable run overhead on messenger, except for those underground runs between Class I buildings. The safety alarm equipment in Bldgs. #221-F&H, #235-F, and #772-F is used also for local intercommunication.

## EQUIPMENT

The necessary amplifier racks, microphones, speakers and cable are provided for a complete installation as specified on the drawings.

## DRAWINGS

W-146772 - Block Diagram - #507-F

W-148393 - Block Diagram - #507-H

Map 3319 - Outside Electrical Lines --  
           #507-F - Sheets 853, 854, 884  
           #507-H - Sheets 796, 826

## AREA #300-M

## BUILDING #352-1.2 & 3M - SECONDARY SUBSTATIONS

### FUNCTION

These outdoor secondary substations transform electric power, supplied from the 115-kv. transmission system to the 115/13.8-kv. primary substation, Building #751-A, to required potentials in Buildings #777-M and #305-M.

## PRINCIPAL COMPONENTS

Located in a single fence-enclosed area south of Building #777-M, all three substations are supplied by a common 13.8-kv. feeder from the primary substation, Building #751-A.

Consisting of a 750-kv.-a., a 300-kv.-a. and a 45-kv.-a. transformer, respectively, each substation provides underground or overhead feeders to Process Building #305-M and Laboratory Building #777-M.

The substation structures are of the wood pole type, with each having a grid to tie together the fence ground, lightning arrester ground and electrical equipment ground. The area is surfaced with crushed stone.

#### CONSTRUCTION DETAILS

Transformers at Bldgs. #352-1M and #352-2M are installed on concrete foundations; the transformer at Bldg. #352-3M is mounted on a platform between wood poles to isolate the high-voltage bushing beyond reach.

#### EQUIPMENT

##### Substation #352-1M

- 1 750-kv.-a. Outdoor unit load center.
- 3 15-kv. Outdoor fuse mountings (65 amp. fuses).

##### Substation #352-2M

- 1 300-kv.-a., 208Y/120-v., 3-phase, 13.8-kv. Transformer.
- 3 15-kv., 200 amp. Outdoor fuse mountings (25 amp. fuses).

##### Substation #352-3M

- 1 45-kv.-a., 13.8-kv., 208Y/120-v., 3-phase Transformer.
- 3 15-kv. Outdoor fuse mountings (5 amp. fuses).

All other material and equipment except the necessary cable, used in these installations was obtained by field procurement.

## DRAWINGS

W-138566 - #352-1M Substation

W-138567 - #352-2M Substation

W-138568 - #352-3M Substation

BUILDING #501-M - FENCE AND ROAD LIGHTING

## FUNCTION

This installation furthers night security by lighting the #300 Area circumferential fences and main roads.

## PRINCIPAL COMPONENTS

There is a lighting loop around the #300 Area fed from the #501-1M Substation. In the event of failure of the normal power supply, the fence lighting is backed up by a 150-kw. diesel generator in Building #320-M.

The #501-1M Substation is a constant current transformer substation supplied with a feeder to provide either normal or emergency power service. This substation is a pole type installation near Building #777-M and the Secondary Substation, Building #352-M. The two transformers are mounted on wood platforms between the poles.

## EQUIPMENT

- 1 3-kv.-a. 480/120-v. Transformer.
- 1 400/5 amp. 2.5-kv. Current transformer.
- 1 480/120-v., 1.2-kv. Current transformer.
- 1 Constant current transformer.
- 1 Synchronous time switch.
- 1 Blackout control relay.
- 1 Emergency lighting diesel generator.
- 1 Automatic transfer switch.

Fresnel luminaires.

Cable.



All necessary testing and metering devices.

Transformer structure and all necessary poles, hardware, guys and anchors, insulators and wire were obtained by field procurement.

#### DRAWINGS

Map 3311 - Sheet #1123 - Outside Lines - Electric and Telephone

Map 3311 - Sheet #1153 - Outside Lines - Electric and Telephone

Map 3311 - Sheet #1183 - Outside Lines - Electric and Telephone

W-136383 - Constant Current Transformers and Emergency Generator Fence and Road Lighting -  
#501-A&M - Sheet #1

W-138590 - Constant Current Transformers and Emergency Generator Fence and Road Lighting -  
#501-A&M - Sheet #2

W-138797 - Street Lighting Standard - #501-A

#### BUILDING #503-M - DISTRIBUTION LINES

##### FUNCTION

These lines handle the distribution of 13.8-kv. and lower potentials of electric power in the #300 Area.

##### PRINCIPAL COMPONENTS

Included in the system are 13.8-kv., 480-v. and 120/208-v. overhead distribution lines, and 480-v. emergency overhead distribution lines. A double-loop feeder arrangement was installed, and horn gap type disconnect switches are provided to isolate desired portions of the 13.8-kv. feeder.

##### EQUIPMENT

- 2 15-kv. Outdoor disconnecting fuse mountings (200 amp. fuses).

- 1 15-kv. Outdoor disconnecting 200 amp. fuse mounting (100 amp. fuses).
- 1 15-kv. Gang-operated horn gap switch.
- 3 15-kv. Station type lightning arresters.
- 6 15-kv. Line type lightning arresters.

Necessary cable.

#### DRAWINGS

See tabulation under Building #501-M.

#### BUILDING #505-M - FIRE ALARM SYSTEM

##### FUNCTION

This facility provides a complete fire alarm system for the #300/700 Area, including fire alarm boxes, punch registers and gongs.

##### PRINCIPAL COMPONENTS

The central station for the entire project is located in the #700 Area in Building #709-A.

The system consists of a series loop which starts at Building #709-A and connects with Buildings #784-A and #720-A. A number of fire alarm boxes are located on this loop.

A gong and register are installed in Buildings #709-A and #720-A, and a gong is installed in Building #784-A.

Power for the fire alarm horns, located throughout the area, is supplied over a separate circuit from Building #717-A.

Terminal boxes are installed to provide for taps to the required buildings and fire alarm boxes.

Fire alarm cable installed in the #300 Area is carried on the power and light poles.

##### EQUIPMENT

Necessary cable and accessories.

## DRAWINGS

See tabulation under Building #501-M.

### BUILDING #506-M - TELEPHONE CABLE AND INSTRUMENTS

#### FUNCTION

This facility provides outside administrative communication to other areas in the project and intercommunication within the #300/700 Area.

#### PRINCIPAL COMPONENTS

The entire project main telephone exchange is located in this area. Du Pont and the Bell Telephone Company collaborated in the design and installation of this system.

The lines are carried on the power and light poles at a normal elevation of approximately 18 ft. above grade, but a 30-ft. clearance is provided at road and railroad crossings.

#### EQUIPMENT

All equipment and material was provided by the Bell Telephone Company.

## DRAWINGS

Included in drawing tabulation under Building #501-M.

### BUILDING #507-M - SAFETY ALARM SYSTEM

#### FUNCTION

This facility provides security warning signals at vital locations and an autocall signaling system to key executives and personnel.

#### PRINCIPAL COMPONENTS

The central station is Building #720-A Patrol Headquarters. An area-wide alarm horn is centrally located, and other alarm horns are installed at vital locations.

The loud-speaker installations in this area are provided specifically for the safety alarm system.

Radio communication and special telephone systems interconnect the main gate houses for all areas to provide a project-wide safety alarm warning system.

The cable is carried on the power and light poles.

#### EQUIPMENT

Solid copper cable.

3 Pole-mounted terminal boxes and accessories.

30 Cable grips.

All necessary steel messenger cable, rings, hardware, guys and anchors and resistors were obtained by field procurement.

#### DRAWINGS

See tabulation for Building #501-M.

#### AREA #400-D

#### BUILDING #451-D - PRIMARY SUBSTATION

##### FUNCTION

This primary substation transforms the electric power generated by the #484-D Power House turbogenerators from 13.8-kv. to the suitable transmission voltage of 115-kv.

##### PRINCIPAL COMPONENTS

A switchboard, control equipment, battery and charging sets, and complementary equipment are housed in a Control House. Three rows of strain structures are provided on both the north and south ends of the substation, each structure on the north end being 120 ft. long and each on the south end 180 ft. long. The supporting steel towers along these structures are 60 ft. on centers and 67 ft. high. Major electrical installations include seven 10,000 kv.-a. transformers installed adjacent to the east side of the Power House, four (#484-D) auxiliary transformers installed in

the switchyard, and ten 115-kv. outdoor oil circuit breakers with necessary bushings, potential devices, terminals, and compressor equipment for air mechanism. A loud-speaker assembly unit in the Control House is connected to the #484-D Power House control room. Both a hand-powered telephone system and a Bell telephone station are provided in the Control House. The lighting installation gives an upward lighting component to illuminate the disconnect switches and other elevated equipment on the towers. Two unit heaters and a ventilating fan are installed in the Control House.

#### FENCED AREA

Main Substation 686 ft. by 220 ft.

Main Transformers 238 ft. by 52 ft.

#### BUILDING DETAILS

The Control House, of Class III construction, is a single-story, rectangular building approximately 22 ft. wide by 25 ft. long by 12 ft. high with an area of about 560 square feet and a volume of 7400 cubic feet.

#### CONSTRUCTION DETAILS

The Control House, towers and major equipment installations have reinforced concrete foundations.

The Control House is constructed with reinforced concrete walls and flat concrete roof. The bus towers, strain structures, and other elevated supports for major equipment are of structural steel, including 22 strain towers, 27 trusses, 17 bus towers, 28 switch stands, and 4 bus potential device stands.

#### EQUIPMENT

7 115/13.8-kv. Power transformers.

1 3-kv.-a., 120/240-v. Transformer.

26 Disconnect switches.

115-kv. Capacitor potential device with adjustment unit.

4 Bushing potential devices.

13 115-kv. Oil circuit breakers.

3 Motor starters.

2 Combination starters.

All necessary cabinets, lighting, power and distribution panels, switches, cable, line material, and communication equipment.

Lighting fixtures.

2 Portable floodlights.

125-v. Battery with charger and racks.

#### DRAWINGS

W-135097 - Plot Plan

W-135317 - #400 Area Electrical Distribution System

W-135217 - General - One Line Diagram

W-135186 - Lighting Distribution - One Line Diagram

W-138341 - North End - Three Line Diagram

W-138342 - South End - Three Line Diagram

W-138043 - Miscellaneous Wiring Diagrams

W-136218 - Miscellaneous Wiring Diagrams

W-135303 - Transmission Line #503-G Take-Off from #451-D

W-136264 - Circuit Assignment, Supervisory Control, Telemetry and Relay Circuit Cable. 115-kv. Transmission System

W-135257 - South End - Line and Bus Plan - Units 1,2,3, and 4

W-135258 - North End - Line and Bus Plan

W-135259 - Line and Bus Sections

W-135291 - South End - Cable Runs - Plans and Details

W-135292 - North End - Cable Runs and Control House Plans and Sections

- W-135248 - South End - Grounding Plan - Units 1,2,3,  
and 4
- W-135269 - North End - Grounding Plan
- W-135286 - Main Transformer Arrangement Plan -  
Section and Elevation - Units 1,2,3 and 4
- W-135325 - Line and Bus Details
- W-136146 - Main Transformers, Fire Walls, Lighting Plan
- W-135284 - Foundation Plan - Concrete

#### BUILDING #452-D - SECONDARY SUBSTATION

##### FUNCTION

Electric power generated by the Power House, Bldg. #484-D, turbo-generators or supplied by the 115-kv. transmission system is transformed from 13.8-kv. to desired potentials at required locations in the #400 Area by the facilities provided in these secondary substations.

##### PRINCIPAL COMPONENTS

There are seven substations and one tap-switch structure. All of these stations except one are fence-enclosed and all are of the wood-pole type installation.

##### SIZE OF FENCED AREAS

|         | <u>Approx.</u>  |
|---------|-----------------|
| #452-1D | 25 ft. x 30 ft. |
| #452-2D | 20 ft. x 25 ft. |
| #452-3D | 20 ft. x 25 ft. |
| #452-4D | 20 ft. x 25 ft. |
| #452-5D | 20 ft. x 25 ft. |
| #452-6D | 20 ft. x 25 ft. |
| #452-7D | (Open)          |

## CONSTRUCTION DETAILS

The larger transformers are supported on concrete foundations while the smaller ones are located on elevated timber structures between the poles.

## EQUIPMENT

- 1 750-kv.-a. Outdoor load center.
- 1 300-kv.-a. Transformer.
- 2 225-kv.-a. Transformers.
- 1 150-kv.-a. Transformer.
- 1 30-kv.-a. Transformer.
- 3 3-kv.-a. Transformers.

## DRAWINGS

- W-136173 - Substation - #452-1D
- W-136076 - Substation - #452-2D
- W-136064 - Substation - #452-3D
- W-136104 - Substation - #452-4D
- W-136322 - Substation - #452-5D
- W-136375 - Substation - #452-6D
- W-136399 - Substation - #452-7D

## BUILDING #501-D - FENCE AND ROAD LIGHTING

### FUNCTION

This fence and road lighting system contributes to the security measures around the #400-D Area.

### PRINCIPAL COMPONENTS

All control and auxiliary equipment used in conjunction with the lighting is installed within the fenced area to prevent tampering by unauthorized persons.



Fresnel units spaced approximately 120 ft. on centers are used generally for the lighting systems because of their wide range of illumination. All lighting is controlled automatically by the use of astronomical time switches but it can be controlled manually if desired. In addition, the lighting system is connected to the centralized, remote, blackout control system.

One 150-kw. emergency diesel generating unit provides the main source of auxiliary and standby power. Remotely located pushbutton stations are installed for this emergency condition.

## EQUIPMENT

### Electrical

- 4 Secondary constant current transformers.
- 5 Disconnect, drop-out, cut-outs.
- 1 Test by-pass.
- 1 3-kv.-a., 480-v. Primary, 120-v. secondary transformer.
- 2 Disconnect switches.
- 1 Synchronous time switch.
- 1 Transfer switch - automatic.
- 1 Blackout control relay.
- 1 Emergency lighting diesel generator unit.
- 7 Blackout luminaires.

Fresnel luminaires.

All necessary transformer mounting structures, poles, conductors, splices, line material, grounding systems, conduits, switches, generator foundations, etc. were provided by field procurement.

### Mechanical

- 1 Emergency diesel unit.
- 1 Charging generator.

**DRAWINGS (Buildings #501-D, #503-D, #505-D, #506-D & #507-D)**

- W-135283 - Plan and Profile 13.8-kv. Aerial Cable  
(#503-D & G)
- W-135215 - Pole Details 13.8-kv. Aerial Cable Circuits  
(#503-D & G)
- W-136225 - 13.8-kv. Direct Burial Cable - Plan and  
Details (#503-D)
- W-135252 - 13.8-kv. Aerial Cable Line Details and  
Arrangement of Potheads and Supports (#503-D)
- Map 3311 - Outside Lines - Electric and Telephone -  
Sheets #695, 696, 725, and 726

**BUILDING #503-D - DISTRIBUTION LINES**

**FUNCTION**

The purpose of this facility is to distribute electric power to desired locations within and near the #400 Area. These lines distribute 13.8-kv. and lower potentials as required.

**PRINCIPAL COMPONENTS**

The system is composed of 13.8-kv. overhead distribution, 13.8-kv. aerial cable to Building #681-5G, 13.8-kv. underground distribution, 480-v. overhead distribution, and 480-v. emergency overhead distribution.

**EQUIPMENT**

- 1 15-kv. Outdoor load breaker oil switch.
- 3 Disconnecting type fuse mountings (15-kv.) and  
refills (400 amp.).
- 9 Disconnecting type fuse mountings (15-kv.) and  
refills (100 amp.).

Line type lightning arresters.

- 3 440-v. Motor starting switches.
- 6 Fuse disconnect switches (600-v.).

All necessary cable and equipment.

## DRAWINGS

See drawing tabulation for Building #501-D.

### BUILDING #505-D - FIRE ALARM SYSTEM

#### FUNCTION

This facility provides fire alarm signals and call boxes at vital points within the #400 Area. The project central stations are located in the #700-A and #200-F Areas, and fire alarm warnings are relayed by an all-area fire alarm system utilizing telephone lines between areas.

#### PRINCIPAL COMPONENTS

The main station of the fire alarm system in the #400 Area is in Building #717-D. The system consists of a series loop which originates at Building #717-D and connects with Buildings #484-D and #701-1D. Fire alarm boxes are located strategically on this loop. A gong and register are installed in Building #484-D. Power for the fire alarm horns, located throughout the area, is supplied over a separate circuit from Building #717-D. A master box is located in Building #701-1D. Junction boxes installed on poles provide for taps to the required buildings and to the fire alarm boxes.

#### EQUIPMENT

All necessary cable and accessories.

## DRAWINGS

See drawing tabulation for Building #501-D.

### BUILDING #506-D - TELEPHONE CABLE AND INSTRUMENTS

#### FUNCTION

Outside administrative communication to the #400 Area and intercommunication within the area are supplied by this facility.

## PRINCIPAL COMPONENTS

The system was designed jointly by du Pont and the Bell Telephone Company, the lines being carried on the power and light poles normally 18 ft. above grade but with a 30 ft. clearance at road and railroad crossings.

## EQUIPMENT

All equipment and materials were furnished by the Bell Telephone Company.

## DRAWINGS

See drawing tabulation for Building #501-D.

## BUILDING #507-D - SAFETY ALARM SYSTEM

### FUNCTION

This facility provides security alarm signals at vital locations in the #400-D Area.

## PRINCIPAL COMPONENTS

The central station in the area is in Building #701-1D, Gate House. The area alarm horn is centrally located adjacent to Building #451-D, Primary Substation.

The loud-speaker paging system provided for Building #484-D, Power House, Building #483-D, Water Filtration and Treatment Plant, and the Primary Substation is part of the safety alarm system. All other uses of this system are automatically cut out when safety alarms are being transmitted.

Inter-area safety alarm facilities are provided by radio communication and a special telephone system, carried on the power and light poles, connecting the main gate houses.

The design and procurement for this facility also included the sound-powered telephone system within the #400-D Area and the emergency generator starting circuit.

## EQUIPMENT

12      Communication and control boxes.

Copper cable.

All necessary resistors, messenger cable and line material were obtained by field procurement.

#### DRAWINGS

See drawing tabulation for #501-D.

#### AREA #500-G

#### BUILDING #501-G - FENCE AND ROAD LIGHTING

##### FUNCTION

This protective fence lighting system is designed to provide security illumination around the water pump houses. No road lighting installation was made in these areas.

##### PRINCIPAL COMPONENTS

Fence lighting is required around each of the pump houses, Buildings #681-1G, #681-3G and #681-5G. Supporting poles are of Class 5 yellow pine, spaced approximately 120 feet on centers.

##### EQUIPMENT

Fence lighting at #681-1G and #681-3G is supplied from a series circuit with a constant current transformer installed on a 2-pole structure. Fence lighting at #681-5G is supplied from a multiple circuit fed from a lighting circuit within the building. Equipment furnished for these facilities includes synchronous time clocks, constant current transformers, constant current regulators, 3-kv.-a. 480/120-v. transformers, Fresnel luminaire protective lighting units, I.E.S. Type IV lighting luminaires, transfer switches, disconnect switches, cutouts of the drop-out type, series fixtures, a test by-pass, disconnect drop-out cutouts, conduits and cables. Luminaires, synchronous time clocks and 10-kv.-a. 7620/13,200, 120/240-v. transformers and a 10-kv.-a. 13.8-kv. 120/240-v. transformer are listed as part of the #500-G Area for accounting purposes only.

## DRAWINGS

#681-1G - W-138509 - Fence Lighting Circuit (#501-G)

W-139955 - Substation Constant Current Transformer

#681-3G - W-142254 - Protective Fence Lighting

W-139859 - Substation Constant Current Transformer

#681-5G - W-138558 - Protective Fence Lighting

(See tabulation under #503-G)

BUILDING #503-G - TRANSMISSION AND DISTRIBUTION LINES

## FUNCTION

The 115-kv. transmission lines in conjunction with the 115-kv. Primary Substations in the various areas serve to connect all power sources and loads and thus form a unified power system between areas.

Distribution of 13.8-kv. power supplies outside deep wells, outlying gate houses, air monitoring buildings and a railroad shop.

## PRINCIPAL COMPONENTS

Transmission lines of 115-kv. were installed. The supporting structures are of the conventional H-frame, wood-pole type. All necessary grounding and lightning protection measures were taken.

Three separate circuits cross the principal process area and are connected into switching stations, Buildings #504-2G and #504-3G, to obtain maximum power reliability. Power supply is supplemented by transmission lines from the switching stations in the #400 Area.

Aerial cable of 13.8-kv. is installed from the #400 Area to the three outlying pump houses. Building #504-G provides a second source of power for the pump houses. Overhead transmission lines of 13.8-kv. were installed also to other outlying facilities and approximately sixty-five miles of supervisory cables were used. This cable was generally installed underground but portions passing through swampy areas were mounted on poles.

## EQUIPMENT

Equipment provided for distribution facilities includes line type 15-kv. lightning arrestors, a 5-kv.-a. and a 10-kv.-a./13.8-kv. 120/240-v. transformer, a 5-kv.-a. and a 10-kv.-a. 7620/13,200, 120/240-v. transformer, copper cable with splicing sleeves and all required tools, and two 15-kv. 200 amp. fuse mountings with 15 amp. fuses. Transmission equipment consists of 397.5 mcm, ACRS cable, 3/c. #6, 30% cable, 2/0 bare copper cable, 3/c. #6 bronze wire, supervisory control cable, and suspension insulator, brackets, clamps, hooks, rods, splices, tools and spacers and all required conduits and bell ends and other appurtenances. All necessary #4, soft-drawn bare wire, all sizes of galvanized steel strand and hardware were obtained by field procurement. Equipment provided for #623-1G, #618-G, and #623-2G and #614-4G includes a gasoline engine generating unit, 5-kv.-a. and 10-kv.-a., 7620/13,200, 120/240-v. transformers, a 150-kv.-a. 13.8/480-v. transformer, 15-kv. 200 amp. outdoor fuses mounted with two 15 amp. fuses, 15-kv. line type lightning arrestors and one combination 60 amp. motor starter, a momentary contact pushbutton station 1/c. #2 600-v. direct burial cable, 4/c. 3L9/22 direct burial control cable, and cable grips.

## DRAWINGS

115-kv. Transmission Lines

- W-135236 - Tangent Structure - Type A
- W-135247 - Running Corner Structure - Type B
- W-135261 - Corner Structure - Type C
- W-135273 - Deadend Structure - Type D
- W-135324 - Anchors and Miscellaneous Details
- W-135336 - Take-off from #504-1G
- W-135649 - Take-off from #504-2G
- W-135676 - Take-off from #504-3G
- W-135270 - Transmission Line and 13.8-kv. Distribution Line - Location, Sheet 1
- W-135650 - Transmission Line and 13.8-kv. Distribution Line - Location, Sheet 2

W-137801 - Take-off from #151-1C  
 W-137800 - Take-off from #151-K  
 W-136106 - Take-off from #151-L  
 W-136052 - Take-off from #151-P  
 W-135707 - Take-off from #151-R  
 W-135746 - Take-off from #251-F  
 W-135083 - Take-off from #251-H  
 W-135303 - Take-off from #451-D  
 W-135337 - Take-off from #751-A  
 W-136141 - Take-off from #681-3G  
 W-136049 - Take-off from #681-1G  
 W-138157 - Deadend Structure - Type DX  
 W-142252 - Take-off from #151-2C  
 W-135868 - Phasing Diagram  
 W-136138 - Relaying - One Line Diagram  
 W-136264 - Circuit Arrangements - Supervisory Control,  
 Telemetering and Relaying Circuit Cable  
 W-137997 - Installation Details for Supervisory Cable  
 W-139456, W-139457, W-139458, W-139459 - 115-kv. Trans-  
 mission System - Supervisory Control Cable-  
 Connection to Protector Cabinet Terminals

#501-G and #503-G

W-137841 - #503-G Typical Pole Assembly and Design Data  
 for 13.8-kv. Distribution Lines to  
 #504-1,2,3G  
 W-138211 - #503-G 13.8-kv. Distribution Lines - One  
 Line Diagram  
 W-138700 - #503-G 13.8-kv. Distribution Lines - #451-D  
 to #504-1G Details of Crossing over Railroad



- W-138701 - #503-G 13.8-kv. Distribution Lines -  
#451-D to #504-3G Details of Crossing over  
Railroad
- W-138794 - #503-G 13.8-kv. Distribution Lines -  
#504-3G to #701-2G Details of Crossing  
over Railroad
- W-138562 - #501-G and #503-G 13.8-kv. Distribution  
Line and Lighting at #701-2G
- W-138563 - 5-kv.-a. 7620-v. 120-v. Substation #623-1G  
and 5-kv.-a. 7620-v. 120/240-v. Substations,  
#623-2G and #614-4G
- W-138565 - Transformer - #618-G
- W-138509 - Protective Fence Lighting for #681-1G and  
#501-1G
- W-138558 - Protective Fence Lighting for #681-5G and  
#501-5G
- W-138623 - 7620-v. Single-Phase Distribution Line and  
Lighting at #701-5G
- W-139955 - #501-G Constant Current Transformer for  
#681-G
- W-139312 - #501-G, #503-G 13.8-kv. Single-Phase Distri-  
bution Line and Lighting at #701-6G
- W-139314 - #501-G and #503-G - 7620-v. Single-Phase  
Distribution Line and Lighting at #701-3G
- W-139315 - #501-G and #503-G - 7620-v. Single-Phase  
Distribution Line and Lighting at #701-4G
- W-142231 - #503-G - 215-kv.-a. 120/240-v. - 7620-v. in  
Line from #152-P to #623-2G and #614-4G
- W-142238 - #503-G - 2-10-kv.-a. Single-Phase Trans-  
former Installation - 13.8-kv. 120/240-v. -  
7620-v. in Line from #751-A to #701-5G
- W-142253 - #503-G Typical Pole Assembly and Details  
for #600 Area.
- W-142254 - #501-3G - Protective Fence Lighting for  
#681-3G

W-139859 - Substation Constant Current Transformer -  
#681-3G

Map 3311 - Sheet 408 - Outside Lines

Map 3311 - Sheet 438 - Outside Lines

#### BUILDING #504-1,2 & 3G - SUBSTATIONS

##### FUNCTION

These switching stations are provided to connect all present and future sources of electric power to insure maximum reliability of supply to vital areas.

They provide flexibility in the source of power supply to the #100-C, #200-F, #200-H, #300-M and #700-A Areas where no power is generated.

##### PRINCIPAL COMPONENTS

Substation #504-1G is located northeast of the #400-D Area, with Substation #504-2G north of the #200-H Area and Substation #504-3G west of the #100-L Area.

The major installations are made with strain and suspended bus structures, including miscellaneous switching and potential transformer supporting structures.

There is a control house at each station to house the relay and supervisory board, switchgear, MG set, battery and charging set, and other electrical equipment requiring indoor installation.

All three of these switching stations are interconnected by loops for power source flexibility.

The main power dispatching office is located in the control house of Building #751-A, Primary Substation, and a complete supervisory control and protective relay system is installed for this purpose.

Small diesel units are provided at each station as a 440-v. standby source of power in case of failure in the normal power supply for the 440-v. auxiliaries.

##### BUILDING FLOOR SPACE

Each control house

576 sq. ft.

## BUILDING DETAILS

All control houses are of Class I construction.

The fence enclosed areas of Buildings #504-1G, 2G, and 3G are approximately 250 ft. by 337 ft., 297 ft. by 446 ft. and 278 ft. by 297 ft. respectively. The volume of each control house is 9490 cubic feet.

## CONSTRUCTION DETAILS

The foundations for the control houses, towers and major equipment are of reinforced concrete. The walls, floor slab, flat roof and cable pit of the control houses are also of reinforced concrete. Each substation area is surfaced with crushed stone.

### Steel Structures

#### #504-1G

15 Strain Towers.

8 Bus Towers.

16 Switching Stands.

Bus Potential Device Stands.

20 Trusses.

#### #504-2G

24 Strain Towers, 21 installed +3 future.

14 Bus Towers.

28 Switching Stands.

6 Bus Potential Device Stands.

25 Trusses.

All necessary carrier systems for voice, relays and metering for the purchase power tie-line.

#### #504-3G

15 Strain Towers.

10 Bus Towers.

- 12 Switching Stands.
- 2 Bus Potential Device Stands.
- 15 Trusses.

#### MISCELLANEOUS

Unit heaters and a ventilating fan were provided for each control house. The lighting at these switching stations is similar to that designed for the Primary Substations, with an upward component of light to illuminate the towers.

All lighting is connected to the blackout control system.

#### DRAWINGS

| <u>#504-1G</u> | <u>#504-2G</u> | <u>#504-3G</u> |                                                                                                     |
|----------------|----------------|----------------|-----------------------------------------------------------------------------------------------------|
| W-135367       | W-135356       | W-135576       | - Outdoor Plan and Sections - Electrical                                                            |
| W-135394       | W-135552       | W-135384       | - Outdoor Cables Conduits and Grounding                                                             |
| W-139908       | W-138481       | W-138489       | - Interconnection Diagram - Oil Circuit Breakers, Potential Devices, Supervisory and Control Boards |
| W-135952       | W-135626       | W-135953       | - Control Diagram Schematic                                                                         |
| W-136174       | W-136175       | W-136176       | - Substation Lighting Plan                                                                          |
| W-135956       | W-136240       | W-136241       | - Control House - Electrical Layout                                                                 |
| W-138851       | W-139779       | W-139780       | - Diesel Generator - Concrete Foundation and Electrical Installation                                |
| W-136413       | W-138970       | W-138971       | - 125-v. d.c. Distribution Diagram                                                                  |

#### Structural

|          |          |          |                                     |
|----------|----------|----------|-------------------------------------|
| W-135358 | W-135371 | W-135372 | - Plan and Section - Steel          |
| W-135398 | W-135653 | W-135654 | - Foundation Plan - Concrete        |
| W-136203 | W-136204 | W-136205 | - Control House Plan Concrete       |
| W-136197 | W-136527 | W-136528 | - Heating, Ventilating and Drainage |

BUILDING #505-G - FIRE ALARM SYSTEM

## FUNCTION

This facility alerts fire fighting personnel at Fire Houses, Buildings #709-A and #709-F, in the event of a fire in any of the areas.

## PRINCIPAL COMPONENTS

A loop system traverses all the areas. Control equipment is installed in Building #717-A and recording and gong equipment is located in the Fire Houses to advise firemen in Buildings #709-A and #709-F of an area fire. Inter-area wiring is part of telephone cable system.

## EQUIPMENT

All necessary cable and accessories.

## DRAWING

W-156100 - Fire Alarm System - All Areas

BUILDING #506-G - TELEPHONE CABLE AND INSTRUMENTS

## FUNCTION

This facility provides telephone service to the entire Savannah River Plant.

## PRINCIPAL COMPONENTS

Dial type telephone service is installed in all plant areas, with off-plant calls being routed through the operator in the Telephone Exchange in Building #702-A. There are some dial telephone connections in the #700-A Area for direct calls to Augusta. Inter-area equipment is installed in Building #702-A, with local branch exchanges in the #701-1 buildings in the several areas.

## EQUIPMENT

Instruments and switching equipment are leased from the Southern Bell Telephone Company, with cable purchased.

## DRAWING

W-137776 - Plant-wide Telephone System

## AREA #700-A

BUILDING #501-A - FENCE AND ROAD LIGHTING

## FUNCTION

This facility provides the necessary security lighting along area fences and main roads.

## PRINCIPAL COMPONENTS

Fence Lighting

The system consists of an Administration Building Loop, a Technical Area Loop and a #700 Area Loop, all fed from the #501-A substation. In general, the lighting is by 6000 lumen lamps as an added protective measure at this important area. Most of the lines are overhead, but the ornamental standards at the entrance to the Administration Building and the parking lots are connected to an underground system. Sectionalizing, drop-out, and cutout devices are incorporated to isolate separate portions of each loop and minimize the likelihood of failure in an entire loop from a breakdown at any one point. In conformance with normal practice, the lighting facilities are backed up by a 100-kw. emergency generator if the normal power supply should be cut off.

Road Lighting

The source for illuminating the parking lots and main roads is the #501-A substation. The road lighting system is on three circuits and equipped with sectionalizing switches. Jumpers are included at each light on the circuits and the failure of one or more lights anywhere on the line may reduce full scale illumination but enough lights stay on to provide adequate lighting until necessary repairs can be made. It was decided that a 20 amp. series circuit type of fence and road lighting design was the most satisfactory as well as the most economical.

#501-A Substation

The substation consists of a constant current transformer and emergency generator for back-up of fence lighting.

The five transformers are mounted on a wood platform between poles. An automatic transfer switch puts the diesel generator into operation upon failure of the normal power source.

Most of the pole supports are treated yellow pine, but there are ornamental steel poles for street lighting in the vicinity of the Administration Building and parking lots.

#### EQUIPMENT

- 1 3-kv.-a. 480/120-v. Transformer.
- 1 400/5 amp., 2.5-kv. Current transformer.
- 1 480/120-v., 1.2-kv. Current transformer.
- 6 Constant current transformers.
- 24 Isolating current transformers.
- 11 Disconnect drop-out cutouts.
- 4 Disconnect switches.
- 1 Synchronous time switch.
- 1 Blackout control relay.
- 1 Emergency diesel generator.
- 1 Automatic transfer switch.
- 1 Test by-pass.

Fresnel luminaires.

Street lighting standards - steel.

Cable.

All necessary testing and measuring devices.

Transformer structure and all necessary poles, hardware, guys and anchors, insulators and wire obtained by field procurement.

#### DRAWINGS

Map 3311 - Sheet 1123 - Outside Lines, Electric and Telephone

- Map 3311 - Sheet 1153 - Outside Lines, Electric and Telephone
- Map 3311 - Sheet 1183 - Outside Lines, Electric and Telephone
- Map 3319 - Sheet 1123 - Electric and Telephone Circuit Layout
- Map 3319 - Sheet 1153 - Electric and Telephone Circuit Layout
- Map 3319 - Sheet 1183 - Electric and Telephone Circuit Layout
- W-136383 - Constant Current Transformers and Emergency Generator Fence and Road Lighting - Sheet 1
- W-138590 - Constant Current Transformers and Emergency Generator Fence and Road Lighting - Sheet 2
- W-138797 - Street Lighting Standard
- W-138800 - Control Circuits Terminal Box Modification
- W-139969 - Wire Sag and Tension Data for #4/0, #1/0, #2 and #4 Bare and TBWP Conductors
- W-142243 - Construction Details for Installation of Direct Burial Cable - Buildings #501, #503, #505 and #507-A
- W-136386 - Control Diagram for Fire, Blackout, Safety Alarm and Emergency System
- W-137769 - Local Area Alarm and Communication Systems

#### BUILDING #503-A - DISTRIBUTION LINES

##### FUNCTION

These lines handle the distribution of power at 13.8-kv. and lower potentials as required in the #700 and #300 Areas.

##### PRINCIPAL COMPONENTS

Included in the system are 13.8-kv., 480-v. and 120/208-v. overhead distribution lines, and 480-v. emergency overhead distribution lines. Three radial feeders with ties and one express feeder to Building #789-A are installed, and horn gap type disconnect switches are provided to permit isolation of portions of the 13.8-kv. feeder.



**EQUIPMENT**

- 4 15-kv. Outdoor disconnecting fuse mountings (200 amp. fuses).
- 5 15-kv. Outdoor disconnecting 200 amp. fuse mountings (100 amp. fuses).
- 9 15-kv. Gang-operated horn gap switches.
- 15 15-kv. Station type lightning arresters.
- 21 15-kv. Line type lightning arresters.
- 7 Fused disconnect switches (60 amp.) 480-v. ground system, rods, wires, etc.
- 3 Contact pushbutton stop-start stations.

Cable and line equipment.

**DRAWINGS**

- Map 3311 - Sheet 1123 - Outside Lines, Electric and Telephone
- Map 3311 - Sheet 1153 - Outside Lines, Electric and Telephone
- Map 3311 - Sheet 1183 - Outside Lines, Electric and Telephone
- W-135734 - One Line Diagram 13.8-kv. and 480-v. Distribution
- Map 3319 - Sheet 1123 - Electric and Telephone Circuit Layout
- Map 3319 - Sheet 1153 - Electric and Telephone Circuit Layout
- Map 3319 - Sheet 1183 - Electric and Telephone Circuit Layout
- W-136386 - Control Diagram for Fire, Blackout, Safety Alarm and Emergency Systems
- W-137769 - Local Area Alarm and Communication Systems
- W-138800 - Control Circuits Terminal Box Modification

W-142243 - Construction Details for Installation of Direct Burial Cable - Buildings #501, #503, #505 and #507-A

W-142245 - One Line Diagram - 480-v. and 120/208-v. Emergency Distribution

### BUILDING #505-A - FIRE ALARM SYSTEM

#### FUNCTION

This facility provides a complete fire alarm system for the area, including fire alarm boxes, punch registers and gongs.

#### PRINCIPAL COMPONENTS

The central station for the entire project is located in this area with the main #700 Area station in Building #709-A. A loop circuit using three telephone circuits in parallel is used to relay fire warnings between areas.

The system consists of a series loop which starts at Building #709-A and connects Building #784-A, #709-A and #720-A. A number of fire alarm boxes are located on this loop, with a gong and register installed in Buildings #709-A and #720-A, and a gong only in Building #784-A. Power for the fire alarm horns located throughout the area is supplied over a separate circuit from Building #709-A. There is a master box in Building #702-A through which communication with other remotely located master boxes is possible.

Terminal boxes are installed to provide for taps to the required buildings and fire alarm boxes.

The fire alarm cable and fire alarm horn cable are installed in rings on messenger and carried on power and light poles.

#### EQUIPMENT

All necessary cable and accessories.

#### DRAWINGS

W-136386 - Control Diagram for Fire, Blackout, Safety Alarm and Emergency Systems - Buildings #501, #503, #505 and #507-A

## W-137769 - Local Area Alarm and Communication Systems

### BUILDING #506-A - TELEPHONE CABLE AND INSTRUMENTS

#### FUNCTION

This facility provides outside administrative communication to other areas in the project and intercommunication services within the #700-A Area.

#### PRINCIPAL COMPONENTS

The project main telephone exchange is located in the #700 Area in Building #703-A. The du Pont Company and the Bell Telephone Company collaborated in the design and installation of this system.

The lines are carried on the power and light poles normally 18 ft. above grade, but with a 30-ft. clearance at road and railroad crossings.

#### EQUIPMENT

All equipment and material were provided by the Bell Telephone Company.

#### DRAWINGS

Map 3311 - Sheet 1123 - Outside Lines, Electric and Telephone

Map 3311 - Sheet 1153 - Outside Lines, Electric and Telephone

Map 3311 - Sheet 1183 - Outside Lines, Electric and Telephone

Map 3319 - Sheet 1123 - Electric and Telephone Circuit Layout

Map 3319 - Sheet 1153 - Electric and Telephone Circuit Layout

Map 3319 - Sheet 1183 - Electric and Telephone Circuit Layout

W-136114 - Outside Wiring Diagrams, Telephones

- W-136386 - Control Diagram for Fire, Blackout, Safety Alarm, and Emergency Systems
- W-137769 - Local Area Alarm and Communication Systems
- W-137771 - Radio, Telephone Systems
- W-133776 - Plant-wide Telephone Systems
- W-138352 - Telephone, Underground Duct and Manhole Layout between Buildings #703-A, #702-A and #506-A
- W-142243 - Construction Details for Installation of Direct Burial Cable - Buildings #501, #503, #505 and #507-A

#### BUILDING #507-A - SAFETY ALARM SYSTEM

##### FUNCTION

Safety alarm signals and security warning signals are provided by this facility at vital locations.

##### PRINCIPAL COMPONENTS

The central #700 Area station is located in Building #720-A. An area-wide alarm horn is centrally located with auxiliary alarm horns installed at vital locations.

The loud-speaker installations in this system are provided specifically for the safety alarm system. Radio communications and a special telephone system interconnect the main gate houses for all areas to provide a project-wide safety alarm warning system. The cable is carried on the power and light poles.

The design and procurement for this facility also includes the sound-powered telephone system, emergency generators and starting circuits within the #700 Area.

##### EQUIPMENT

Copper cable.

12 Pole-mounted terminal boxes and accessories.

All necessary steel messenger cable, rings, hardware, guys and anchors, resistors and other accessories were obtained by field procurement.

## DRAWINGS

- Map 3311 - Sheet 1123 - Outside Lines, Electric and Telephone
- Map 3311 - Sheet 1153 - Outside Lines, Electric and Telephone
- Map 3311 - Sheet 1183 - Outside Lines, Electric and Telephone
- Map 3319 - Sheet 1123 - Electric and Telephone Circuit Layout
- Map 3319 - Sheet 1183 - Electric and Telephone Circuit Layout
- W-136386 - Control Diagram for Fire, Blackout, Safety Alarm and Emergency Systems
- W-137769 - Local Area Alarm and Communication Systems
- W-138124 - Connection Diagram, Terminal Boxes for Control Circuits - Sheet 1
- W-139930 - Connection Diagram, Terminal Boxes for Control Circuits - Sheet 2
- W-138800 - Control Circuits Terminal Box Modification
- W-142243 - Construction Details for Installation of Direct Burial Cable - Buildings #501, #503, #505 and #507-A

BUILDING #751-A - PRIMARY SUBSTATION

## FUNCTION

This installation provides access to power from the 115-kv. transmission system to the loads in the #300-M and #700-A Areas and a central control station for the plant-wide transmission and generating system.

## PRINCIPAL COMPONENTS

The necessary switchgear, load dispatching station, control equipment, batteries, charging sets, and all installations requiring weather protection are housed in a Control House.

The switchyard for this substation is an outdoor installation consisting essentially of two 12,500 kv.-a. 115/13.8-kv. outdoor transformers and all appurtenant installations necessary to provide a tie between the 115-kv. transmission system and the 13.8-kv. distribution system. Eight steel towers and eight Class II wood poles support the disconnect switches, 115-kv. busses, the lightning protection and other equipment requiring elevated mountings.

A diesel house contains the equipment necessary to supply the essential auxiliary power to Buildings #751-A and #784-A, in the event of a failure of the normal power supply. This installation consists of a four-cylinder engine operating at 1800 r.p.m. which is directly connected to a 30-kw. 37.5-kv.-a. 480-v. generator with a mechanical governor and all necessary mechanical equipment including fuel tanks, gauges, safety devices, and other pertinent equipment, mechanically controlled.

#### BUILDING FLOOR SPACE

|                                          | <u>Approx.<br/>Sq. Ft.</u> |
|------------------------------------------|----------------------------|
| Fenced Yard Area (140' by 125')          | 17,500                     |
| Control House                            | 3250                       |
| Switchgear Room                          | 1750                       |
| Toilet                                   | 40                         |
| Battery Room - Station Battery           | 100                        |
| Battery Room - Load Dispatcher's Battery | 60                         |
| Load Dispatcher Station                  | 960                        |
| Diesel House                             | 290                        |

#### BUILDING DETAILS

The load dispatcher's area and the diesel house are of Class I construction. The remainder of the facility is Class III construction. The control house is rectangular in shape, approximately 36 ft. wide by 91 ft. long with an average height of 13 ft. The diesel house is 16 ft. wide and 18 ft. long with an over-all height of 11 ft.

The control house has a volume of 42,750 cubic feet, and the diesel house, 3170 cubic feet.

## CONSTRUCTION DETAILS

The control house is of Class I construction, with reinforced concrete throughout. The roof slab is insulated and finished with built-up roofing. Two 3 ft. square, adjustable louvers are provided in the switchgear room.

Interior partitions in the switchgear room are of concrete block separating this area from the battery room and toilet, and of reinforced concrete between it and the load dispatcher's office. In the toilet and battery rooms, they are concrete block. The concrete floor has a Class I finish in the switchgear room and toilet and an asphalt tile floor covering in the battery rooms. Ceilings in all these areas are the exposed underside of the concrete roof slab. The load dispatcher's station is bombproof, and both concrete block and reinforced concrete are used in interior partitions. This room has a suspended egg crate ceiling for lighting distribution, and a gamma ray-proof concrete cell.

The diesel house is blast-proof and has reinforced concrete foundations with wall footings and reinforced concrete frame, roof and walls.

The reinforced concrete roof slab is finished with built-up roofing.

### Towers - Steel

- 1 T1 - Disconnect Switch Structure
- 1 T2 - Disconnect Switch Structure
- 2 T3 - Disconnect Switch Structures
- 2 T4 - Disconnect Switch Structures
- 1 T5 - Disconnect Switch Structure
- 1 T6 - Disconnect Switch Structure

## EQUIPMENT

### Electrical

- 1 440-v. Motor control load center.
- 1 440-v. Unit load center substation.
- 2 10,000/12,500 kv.-a. Outdoor transformers and arresters.

- 1 10,000/12,500 kv.-a. Outdoor transformer, a spare-remotely located.
- 2 25-kv.-a. 480/208Y/120-v. 3-phase, 4-wire dry type transformers.
- 1 9-kv.-a. 480/208Y/120-v. 3-phase, 4-wire dry type transformer.
- 1 3-phase 13.8-kv. Switchgear with one MG relay.
- 6 Outdoor 115-kv. disconnecting switches, 4 motor-operated and 2 manually-operated.
- 3 30 amp. 3-pole 575-v. Automatic transfer switches.
- 1 115-kv. Outdoor circuit breaker with bushing, current transformers and potential devices and one additional terminal block.
- 1 30 amp., 30 amp. trips, 3-pole, 440-v. Circuit breaker.
- 1 30 amp., 15 amp. trips, 3-pole, 440-v. Circuit breaker.
- 2 Loud-speaker assemblies - complete.
- 1 Control board.

Necessary telephones and equipment - Load Dispatcher's Area only.

- 1 Supervisory control board - complete.
- 2 D3 Relays and one shunt.
- 1 Acid type station control storage battery with two sets of charging equipment.
- 1 Ground testing device - wall mounted.
- 4 Maintaining contact pushbutton stations.
- 3 Momentary contact pushbutton stations.
- 2 Combination motor starters.
- 5 Manual motor starters.
- 1 Acid type supervisory control storage battery with separate charging equipment.



- 1 2-wire 125-v. d.c. Power distribution panel (Load Dispatcher's Room).
- 2 W.L. Relays - (13.8-kv. gear).
- 1 Blackout contactor and relay panel.
- 1 4-Circuit a.c. distribution panel.
- 1 Automatic transfer switch (lighting panel).
- 1 Automatic transfer switch (blackout panel).
- 2 Pilot wire and telemetering lines - entrance cabinets.
- 1 20-Circuit lighting panel.
- 1 24-Circuit lighting panel.
- 1 12-Circuit Outdoor lighting panel.
- 1 8-Circuit lighting panel.
- 1 500 Watt portable floodlight.

All necessary 115-kv. substation hardware was obtained by field procurement.

- 1 Cabinet-enclosing 3-2 pole, 440-v., single phase starters.
- 1 3-phase, 440-v., 4-circuit Deion cabinet - 30 amp. breakers.
- 1 3-phase, 440-v., 4-circuit Deion cabinet - 15 amp. breakers.

Cable - (600-v., armored, and control cable.)

All necessary grounding material and hardware were obtained by field procurement.

All necessary conduit, conduit fittings, junction and pull boxes, underfloor duct, floor outlets, receptacles, supporting miscellaneous steel, splicing material, lugs and terminals, etc., were obtained by field procurement.

- 91 Lighting fixtures with necessary brackets.
- 60 Plastic louvers with necessary supporting material, fittings and hardware.

Mechanical

- 1 30-kw. Diesel emergency generating unit with accessories.

Heating and Ventilating

- 1 7-1/2-ton Packaged air conditioning unit (2100 c.f.m.).
- 1 10-kw. Electric strip heater with thermostat.
- 2 3-kw. Electric unit heaters with thermostats.
- 1 Automatic control system with two auxiliary switches.
- 1 Battery exhaust ventilation fan (115 c.f.m.).
- 1 Propeller type fan and back-draft damper - (200 c.f.m.).
- 1 Propeller type fan and back-draft damper - battery room (200 c.f.m.).
- 1 30-in. dia. Power roof ventilator (capacity through head at .25 S.P. is 6500 c.f.m. Capacity under gravity conditions is 2150 c.f.m.)
- 1 5-kw. Under heater with thermostat for Diesel House.
- 1 22-in. Ventilating fan for Diesel House (4900 c.f.m.).

Architectural

- 1 Electric water heater with 66-gal. storage tank.
- 1 Water cooler.

## DRAWINGS

Electrical

- W-135354 - Main One Line Diagram
- W-135294 - Outdoor Plan and Sections

W-142327 - Blue Print File Reference List - Electrical  
Equipment - #300/700 Area

Architectural

W-136398 - Floor Plan - Elevation, Door Schedule, and  
Details

BUILDING #752-A - SECONDARY SUBSTATION

FUNCTION

The purpose of these secondary substations is to transform electric power, supplied from the 115-kv. transmission system to the 115/13.8-kv. primary substation, Building #751-A, from 13.8-kv. to 480-v. or 208/120-v., for use as required by various buildings in the #700-A Area.

PRINCIPAL COMPONENTS

Fourteen substations are provided. Substation 1A consists of a 1000 kv.-a., 13.8-kv.-a. unit load center, with four air circuit breakers, used to furnish underground service to Building #722-A, overhead service to Buildings #714-A, #725-A and #713-A, and overhead service to Building #717-A. The 9A substation consists of a 300 kv.-a., 13.8-kv.-120/208-v. transformer to provide overhead services to Buildings #714-A and #717-A and underground service to Building #722-A. The 2A substation consists of a 1000 kv.-a., 13.8-kv.-480-v. unit load center, with five air circuit breakers, which furnishes three underground services to Building #703-A, overhead service to Buildings #719-A, #720-A, and #616-G, and overhead service to the #501-A Fence and Road Lighting Substation. The 3A substation consists of a 1000 kv.-a., 13.8-kv.-480-v. unit load center, with five air circuit breakers, which provides three underground services to Building #703-A, overhead service to Building #702-A and overhead service to Building #708-A. The 5A substation consists of a 750-kv.-a., 13.8-kv., 480-v. unit load center, with four air circuit breakers, to provide an underground service to Building #773-A. Substation 6A consists of a 750-kv.-a., 13.8-kv., 480-v. unit load center, with three air circuit breakers, to supply overhead services to Buildings #789-A, #735-A and a single overhead service to Buildings #776-A and #736-A. The 7A substation consists of a 1000 kv.-a., 13.8-kv., 480-v. unit load center, with four air circuit breakers, to serve four underground feeds to Building #773-A. The 8A substation consists of a 1000 kv.-a., 13.8-kv., 480-v. unit load center

furnishing four underground services to Building #773-A. The 11A substation consists of a 112.5-kv.-a., 13.8-kv., 208Y/120-v. transformer which provides overhead services to Buildings #713-A and #614-A. The 12A substation consists of a 75-kv.-a., 13.8-kv., 208Y/120-v. transformer for instrumentation service. The transformer serves one underground feeder to Building #773-A and one overhead line to Building #735-A. The 13A substation consists of a 300-kv.-a., 13.8-kv., 480-v. transformer which serves an overhead feed to Buildings #709-A, #715-A, #716-A, #725-A and #607-1A. The 14A substation consists of a 225-kv.-a., 13.8-kv., 208Y/120-v. transformer which serves an overhead line to Building #740-A. The 15A and 16A substations each consist of a 1000 kv.-a., 13.8-kv.-480-v. unit load center and serve underground lines feeding Building #773-A, Part III. The 17A substation consists of a 750-kv.-a. unit load center and serves Building #723-A. All of the substations are of the wood-pole type and all except two are provided with fenced enclosures.

#### SIZE OF FENCED AREAS

|                             | <u>Approx.</u> |
|-----------------------------|----------------|
| #752-1 and 9A (Common yard) | 30' x 50'      |
| #752-2A                     | 26' x 30'      |
| #752-3A                     | 26' x 30'      |
| #752-5A                     | 22' x 30'      |
| #752-6A                     | 26' x 30'      |
| #752-7A                     | 22' x 30'      |
| #752-8A                     | 22' x 30'      |
| #752-11A                    | (Open)         |
| #752-12A                    | (Open)         |
| #752-13A                    | 20' x 26'      |
| #752-14A                    | 20' x 26'      |
| #752-15A                    | 22' x 25'      |
| #752-16A                    | 22' x 30'      |
| #752-17A                    | 16' x 22'      |

## CONSTRUCTION DETAILS

The unit load centers and the larger transformers have concrete foundations. The smaller transformers at 11A, 12A, 13A and 14A are supported on elevated timber structures between poles.

## EQUIPMENT

### #752-1A

- 1 1000-kv.-a. Unit load center.
- 3 15-kv. Outdoor fuse mountings with 100 amp. fuses.
- 1 600 amp. 15-kv. Outdoor air break switch.

### #752-2A

- 1 1000-kv.-a. Unit load center.
- 3 15-kv. Outdoor fuse mountings with 100 amp. fuses.

### #752-3A

- 1 1000-kv.-a. Outdoor unit load center.
- 3 15-kv. Outdoor fuse mountings with 100 amp. fuses.

### #752-5A

- 1 750-kv.-a. Outdoor unit load center.
- 3 15-kv. Outdoor fuse mountings with 65 amp. fuses.

### #752-6A

- 1 750-kv.-a. Outdoor unit load center.
- 3 15-kv. Outdoor fuse mountings with 65 amp. fuses.

### #752-7A

- 1 1000-kv.-a. Outdoor unit load center.
- 3 15-kv. Outdoor fuse mountings with 100 amp. fuses.

#752-8A

- 1 1000-kv.-a. Outdoor unit load center.
- 3 15-kv. Outdoor fuse mountings with 100 amp. fuses.

#752-9A

- 1 300-kv.-a., 208Y/120-v. 3-phase Transformer.
- 3 15-kv. Outdoor fuse mountings with 25 amp. fuses.

#752-11A

- 1 112.5-kv.-a., 208Y/120-v. 3-phase Transformer.
- 3 15-kv. Outdoor fuse mountings with 15 amp. fuses.

#752-12A

- 3 15-kv. Outdoor fuse mountings with 10 amp. fuses.
- 1 75-kv.-a. Transformer.

#752-13A

- 1 300-kv.-a., 480-v. Transformer.
- 3 15-kv. Outdoor fuse mountings with 25 amp. fuses.

#752-14A

- 1 225-kv.-a., 208Y/120-v. 3-phase Transformer.
- 3 15-kv. Outdoor fuse mountings with 20 amp. fuses.

#752-15A

- 1 1000-kv.-a. Unit load center.

#752-16A

- 1 1000-kv.-a. Unit load center.

#752-17A

1 750-kv.-a. Unit load center.

All other material and equipment necessary to the installations were obtained by field procurement.

## DRAWINGS

- W-136237 - 300-kv.-a., 13.8-kv., 120/208-v. Substation - 9A and 1000-kv.-a., 13.8-kv., 480-v. Substation - 1A
- W-136382 - 1000-kv.-a., 13.8-kv., 480-v. Substation - 2A
- W-138223 - 1000-kv.-a., 13.8-kv., 480-v. Substation - 3A
- W-138203 - 750-kv.-a., 13.8-kv., 480-v. Substation - 5A
- W-138557 - 750-kv.-a., 13.8-kv., 480-v. Substation - 6A
- W-138041 - 1000-kv.-a., 13.8-kv., 480-v. Substation - 7A
- W-137821 - 1000-kv.-a., 13.8-kv., 480-v. Substation - 8A
- W-138046 - 112.5-kv.-a., 13.8-kv., 120/208-v. Substation - 11A
- W-138508 - 75-kv.-a., 13.8-kv., 120/208-v. Substation - 12A
- W-138586 - 300-kv.-a., 13.8-kv., 480-v. Substation - 13A
- W-142239 - 225-kv.-a., 13.8-kv., 120/208-v. Substation 14A
- W-135989 - 1000-kv.-a., 13.8-kv., 480-v. Substation - 15A
- W-135991 - 1000-kv.-a., 13.8-kv., 480-v. Substation - 16A
- W-164158 - 750-kv.-a., 13.8-kv., 480-v. Substation - 17A

**DATE**

**FILMED**

**8 / 10 / 94**

**END**