CATALYTIC CONSTRUCTION COMPANY
PHILADELPHIA 7, PA.

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PROCESS ENGINEERING REPORT

on

THORIUM SEMI-WORKS PLANT

for the

FEED MATERIALS PRODUCTION CENTER - FERNALD, OHIO

JOB NO. 3542

CLASSIFICATION CANCELLED
DATE FEB 16 1957
For The Atomic Energy Commission
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Chief, Declassification Branch

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THORIUM SEMI-WORKS PLANT - PROCESS DESIGN

This report presents the process design for the thorium semi-works plant which will be located at the Feed Materials Production Center, Fernald, Ohio. It contains the process information required for the layout and detailed mechanical design of the thorium plant.

FUNCTION:

The primary function of the thorium plant is to prepare thorium metal ingots starting with mantle-grade thorium nitrate. No provision is made in the design of this plant to fabricate the thorium ingots into rods. Tentatively, NYOO is considering the use of existing uranium fabrication facilities at the FMPC to accomplish this.

Design Basis:

The thorium semi-works plant is designed for a capacity of 60 tons of fabricated thorium metal per year. Capacity is based upon three shifts operation, five days per week. A stream factor of 90 per cent is used to account for maintenance and operational shutdowns. The capacity is reduced to [illegible]it 20 tons of fabricated thorium metal per year when average operating [illegible] is maintained on a one shift per day basis. When operating at a rated capacity of 20 tons per year, extraction, vacuum casting, and calcium distillation operations will necessitate continuous or semi-continuous operation. The design is predicated upon continuous operation of the extraction area for a period of one week in every three weeks; calcium distillation and vacuum melting will probably require 10 or 11 hours of continuous operation per shift for a total of 40 hours per week. The total operating time will be equivalent to five shifts per week.

The design capacity and through-put, calculated as thorium metal for each step of the operations, is shown as follows:

DESIGN BASIS

	Thorium, percent of capacity	Thorium, tons per year
Fabrication		
Product	76.5	66.7
Turnings recycle	17.5	15.2
Oxide Scrap (stored) — reprocess	5.0	4.4
Turnings Loss — why?	1.0	0.9
TOTAL:	100.0	87.2
Rolling		
Product	98.5	87.2
Recycle to casting	0.84 ?	0.7
Scrap (stored)	0.56	0.5
Loss	0.1	0.1
TOTAL:	100.0	88.5
Dezincing and Casting		
Product	78.1	88.5
Internal Recycle	18.9	21.5
Loss	3.0	3.4
TOTAL:	100.0	113.4
Feed to Dezincing and Casting		
Recycle from fabrication	14.2	15.2
Recycle from rolling	0.7	0.7
Internal recycle	18.9	21.5
Sub-Total -	33.8	37.4
Biscuits from reduction -	66.2	76.0
TOTAL:	100.0	113.4
Reduction		
Product	98.3	76.0
Loss	1.7	1.3
TOTAL:	100.0	77.3

(Continued)

DESIGN BASIS - (Continued)

	Thorium, percent of capacity	Thorium, tons per year
ThF_4 Preparation		
Product	99.4	77.3
Loss	0.6	0.5
TOTAL:	100.0	77.8
Extraction		
Product	99.2	77.8
Loss	0.8	0.6
TOTAL:	100.0	78.4

As is shown above, the plant is designed to handle scrap metal, either as turnings or croppings, but does not include processing of dust residues, metal oxides, slag and liner materials, dust collector residues, or sump recovery residues. No suitable method has been devised for processing these materials. Storage will be provided for these materials at the present time.

The cost of processing thorium scrap materials, other than turnings or croppings, has not been determined. The total amount of these materials is estimated to be about 12 tons as thorium metal per year. It is believed that cost data for uranium scrap processing would not be applicable to thorium materials, since the ratios of scrap materials for the two plants are so different and a suitable process has not been devised for thorium materials. Therefore, even approximate costs for thorium scrap processing are omitted from this report.

DESCRIPTION OF THE PROCESS:

The principal processing steps for the production of thorium metal from mantle-grade thorium nitrate are as follows:

1. Purification of thorium nitrate by solvent extraction.
2. Preparation of thorium tetrafluoride by aqueous precipitation with HF.
3. Filtering and drying of the thorium fluoride-hydrate to anhydrous thorium tetrafluoride.
4. Thorium fluoride reduction to thorium-zinc alloy.
5. Dezincing and casting of thorium.
6. Auxiliary processing such as calcium distillation, zinc chloride drying, crucible fabrication, and turnings recovery.

These steps are described in the following sections of the report. The extraction area is considered as a separate entity in the design of the thorium plant. Estimated costs for plant investment and operation of the extraction area are included in this report.

In addition to a description of the process, the following information is transmitted in this report:

1. Process flow diagrams - Dwg. Nos. 3542-H-02-F, 3542-H-03-F, and 3542-H-04-F.
2. Estimated utility requirements for each section and a summary of the total requirements.
3. Equipment schedules.

A. EXTRACTION:

The feed material for the thorium plant will be mantle-grade thorium nitrate crystals. Information available at the present time indicates that this material is of sufficient purity to permit direct processing to thorium metal without additional purification. It should be pointed out, however, that the primary control for purity of the thorium metal product, especially rare earth metals and uranium contaminants, rests with the thorium nitrate feed material. Recent analyses of the available thorium nitrate by New Brunswick Laboratory show higher concentration of impurities than that reported by Iowa State College. Accordingly, purification of the thorium nitrate by solvent extraction has been incorporated in the design of the semi-works thorium plant. In addition, the possibility of using other feed materials, such as monazite sand, thorium concentrates, and higher grade thorium compounds, would require solvent extraction to obtain a thorium metal product of the required purity.

A cost estimate for the extraction section is included in this portion of the report. A total investment cost for this section is estimated to be about $288,000. The operating costs for this section are summarized below:

OPERATING COSTS FOR EXTRACTION

(Basis: 60 tons of thorium per 260 days; 90% stream factor)

	Dollars per day
Operating Labor	90.00
Amortization (10% of investment)	111.00
Utilities	12.52
Overhead (63% of labor and utilities)	64.70
Chemical Costs (solvent make-up etc.)	19.71
TOTAL:	$297.93

Cost per pound of thorium metal = $0.65

Operation:

The extraction section has been designed to incorporate the greatest possible flexibility in its operation. Digestion of the thorium nitrate can be carried out in either aqueous or organic phase. The same equipment can be used for either method of digestion, with slight differences in flow rates as is shown in drawings; No. SK-3542-H-50-D-4 and No. SK-3542-H-50-D-3. The acidity can be maintained at any value between about 1 and 6 normal in the aqueous phase. Acid can be injected into the extraction column feed, below the feed point, into the digester or into the top of the column. Hot or cold strip water can be fed to the compound strip column.

ORGANIC PHASE DIGESTION - The thorium nitrate is delivered into one of two digesters, D42-3 and D42-4, continuously, from feed hopper (F42-1). The second digester may be used either as a spare or hold tank. Fresh organic from the organic feed tank, F42-9, will be pumped with G42-21 into the agitated digester. The feed will be reset by the level in the digester. The digestion product, which will consist of a mixture of aqueous and organic phases, will overflow from a point near the top of the digester to G42-8 and thence to the primary extraction column. This column feed is flow controlled.

AQUEOUS PHASE DIGESTION: - This digestion is carried out in essentially the same manner as in the organic phase solution process. Dilute nitric acid is introduced into the digester, by means of a level controller and the ore and aqueous solution are agitated continuously. The overflow from the digester is pumped thru a flow controller to the center of the extraction-scrub column, D42-7, by means of column feed pump, G42-8. Provision is made to deliver de-ionized water to the digesters in the event the acidity needs adjustment.

EXTRACTION: - In the extraction-scrub pulse column, the feed to the column is a mixture of the organic and aqueous phases. The organic phase rises counter-current to the descending scrub liquid, dilute HNO_3. The acid flows from the dilute HNO_3 head tank, F42-6, and provision is made to inject deionized water into the line in the event the acidity requires adjustment. The scrub liquid and the aqueous part of the feed flow downward in the extraction section counter-current to the organic phase. Additional acid is injected at or below the feed plate to maintain the desired acidity. The aqueous raffinate flows by gravity to a raffinate storage tank, F42-11. The raffinate effluent is controlled by an interphase level controller situated at the top of the column. The organic solvent is delivered at a point near the bottom of the column from organic feed tank, F42-9, by means of organic feed pump G42-21.

Raffinate, in tank F42-11, is analyzed periodically and in the event it is high in thorium, it can be recycled to the column D42-7 with raffinate pump G42-18, or boiled down before recycling. Normally, raffinate will be pumped to the sump liquor collection tank F42-14, or to sump tank F42-200.

The organic phase, from the scrub section, cascades to the center of the compound strip column, D42-8. A density recorder controller in this line resets the extraction column feed rate to maintain a given level of saturation.

In the compound strip column, the organic from the extraction-scrub column rises counter-current to the aqueous re-extracting medium. The water rate is flow controlled. The organic extract goes overhead and cascades either to the mixer-settler, D42-6, or to diluent fractionator D13-18. The aqueous phase, below the feed plate, flows counter-current to the rising organic reflux. Here, the uranium is selectively stripped from the aqueous phase into the organic phase. The aqueous product from the bottom of the compound strip column, flows by gravity to the boildown tank, F42-12, or to the product hold tanks, F42-5 and F42-13. A level recorder controller will control product withdrawal and maintain the interphase level at the bottom of this column.

Provision is made to inject diluent into the bottom of both pulse columns, since the aqueous effluent from these columns may contain dissolved or entrained solvent. Diluent from F42-8 will be sprayed into the bottom of each column to strip the solvent from the aqueous streams. If this diluent strip operation is found to be necessary to remove the TBP from the aqueous streams, a diluent fractionation will be required. A solvent of greater than 30% TBP will be fed to the column. The diluent strip combined with the organic feed, will adjust the organic extractant to 30% TBP. The fractionation will separate the diluent from TBP and the cycle repeated. In this event, the kerosene fractionator, E13-18, and its auxiliary equipment from Job #3013, will be relocated in the Job No. 3542 area.

Each column will be furnished with a pulse pump. These pumps, G42-15 and G42-16, will pulse the liquid in the column at the rate of 50 to 100 cycles per minute with an amplitude of 1/2 to 1 inch. The pulse action through the sieve plates will cause sufficient mixing to carry out the extractions. The sieve plates are spaced two inches apart.

The aqueous phase solution process is identical to the organic phase solution process in the extraction system, except for minor details:

1. The column of aqueous phase in the extraction section will be greater for the aqueous digestion case. All the organic extractant will be fed to the bottom of the extraction-scrub column, D42-7.
2. The acid injected to the feed plate in the organic phase solution process is not necessary. Acid will be injected into the bottom section of column D42-7.
3. In the event the raffinate tank, F42-11, contains off specification raffinate, the recycle will go to the digesters, rather than the feed plate of pulse column D42-7.

Provision is made to use hot water as the re-extracting medium. For this operation, water heater E42-10 will heat the water to 150° F and then the heated extract from the pulse column will be cooled in the organic cooler E42-11.

ORGANIC TREATMENT: - Impurities, such as uranium, tend to build up in the organic phase. In addition, the solvent forms hydrolysis products which, in turn, form non-re-extractable compounds with thorium. The organic is, therefore, treated after each cycle before re-use.

Organic extract from the compound strip column, D42-8, cascades to mixer-settler, D42-6, where it is agitated in a tank with a dilute Na_2CO_3 solution. The carbonate solution volume will be about 20% of the organic volume. A carbonate solution tank, F42-10, will feed the mixer-settler by means of the carbonate solution pump, G42-13. This carbonate solution is made up batchwise by charging, periodically, the proper amounts of treated water and solid Na_2CO_3 to tank F42-10.

From the mixing tank of mixer-settler D42-6, the organic-aqueous mixture overflows into a settling tank where the two phases separate. The carbonate solution goes to the sump system and the organic to the wash mixer settler. A 20 volume percent water wash is utilized in mixer-settler D42-5. The treated organic goes to the organic feed tank F42-9, and the water to the sump system.

The solvent, which will arrive in drums, will be pumped by means of solvent pump, G42-10, to the solvent storage tank, F42-7. The solvent may be delivered to organic feed tank F42-9, or to the mixer-settler, D42-6.

Provision is made to take treated organic directly from the main refinery at FMPC. The exact location of the extraction area will determine the economic feasibility of the method of solvent delivery.

The diluent, which will be delivered in drums, will be pumped with diluent pump, G42-11, to diluent storage tank F42-8. Provision is made to deliver diluent to the solvent storage tank, F42-7, organic feed tank F42-9, and the pulse columns, D42-7 and D42-8.

BOILDOWN AND STORAGE:- The $Th(NO_3)_4$ product solution flows to the boildown tank, F42-12, or to the thorium nitrate hold tanks, F42-5 and F42-13. The boildown tank is provided with steam coils to concentrate samples to be taken for shotgun analysis. The concentrated sample will be collected from the bottom of the tank into a pail.

The hold tanks are sized to hold the total production of the extraction area over a period of five days. The solvent extraction area will deliver the purified $Th(NO_3)_4$ in solution to the precipitation area through pumps G42-19 and G42-20.

All sump liquors from the extraction area will be pumped with G42-23 to the sump liquor collection tank, F42-14, where any entrained organic present will collect at the top. This organic will be skimmed off and stored in drums. The aqueous phase will then flow to the precipitator D42-200. Provision is made to allow the sump liquors to flow directly to sump tank F42-200. From here, all the liquid in the sump system is pumped, with G42-200, to the sump liquor collection tank F42-14 for organic removal.

Design Basis:

Presented below, is a discussion of the factors employed in the design of the Extraction Area, Thorium Semi-Works Plant. The assumptions are listed and a justification for the selection of process variables is described.

Assumptions:

1. Throughput

   78.4 tons/year

   3 shifts per day, 5 days/week - 90% stream factor

2. Feed

   Mantle-grade thorium nitrate tetrahydrate

3. After either organic or aqueous phase digestion:

   (a) One extraction-scrub column

   Total throughput - 600 gal./(hr.) (sq.ft.)

   Acidity 1N HNO_3 (same acidity in scrub and strip)

   Saturated feed solution

   99.9% recovery of thorium

   30% TBP, 70% diluent (acidified)

   25 feet of pulse height

   9 stages scrub - 9 stages extraction

   Thorium in raffinate - 0.35 g/L

   Thorium in extract - 60 g/L

   Rare earths in extract - negligible

   (b) One compound strip column

   Total throughput - 600 gal./(hr.) (sq.ft.)

   Acidity 0-0.5 M HNO_3 in strip, 0.5 M HNO_3 in reflux

   Organic feed - 60 g/L Th, 0.2N HNO_3

   99.5% recovery of thorium

   30% TBP, 70% diluent (unacidified reflux)

   25 foot pulse height

   9 stages strip - 9 stages reflux

(Continued)

Uranium in aqueous product - $.5 \times 10^{-6}$ M

Uranium in organic reflux - 1×10^{-7} M

Uranium in organic - 0.25 g/L

The column sizes were determined, based on 600 gal./(hr.) (sq.ft.) total liquid throughput. This figure is the same as for uranium extraction with a 25% reduction due to a slower reaction time for thorium. The number of equilibrium stages are approximate, based on a height of a transfer unit of about 1.5 feet of pulse height. The factor of safety used for the columns will permit a substantial increase in throughput, should that be desirable at a later date.

The organic mixture, 30% solvent, 70% diluent, was chosen as a result of correlating equilibrium tests run at NBL and BMI. In C. C. Company memorandum on "Purification of Thorium by Solvent Extraction", dated December 12, 1951, the choice of a dilute HNO_3 is shown, predicated principly on the fact that a higher thorium concentration in the feed, and also a higher thorium concentration in the extract, could be attained at lower acidities. The method of determining organic/aqueous ratios is also presented in the above memorandum.

In the same report, the separation of rare earth impurities is discussed and calculated. The conclusion is that with 9 stages of scrub, the rare earth contamination will be negligible, even with a (rare earth)/thorium ratio of 0.1, in the TNT feed.

In the compound strip column, water is used as the strip medium since water works as well with thorium as it does for uranium in the stripping operation. The reflux section is 0.5 M HNO_3. The acidity, as such, is not as important as a high thorium concentration in order to obtain the desired uranium separation. The organic aqueous ratios were chosen to:

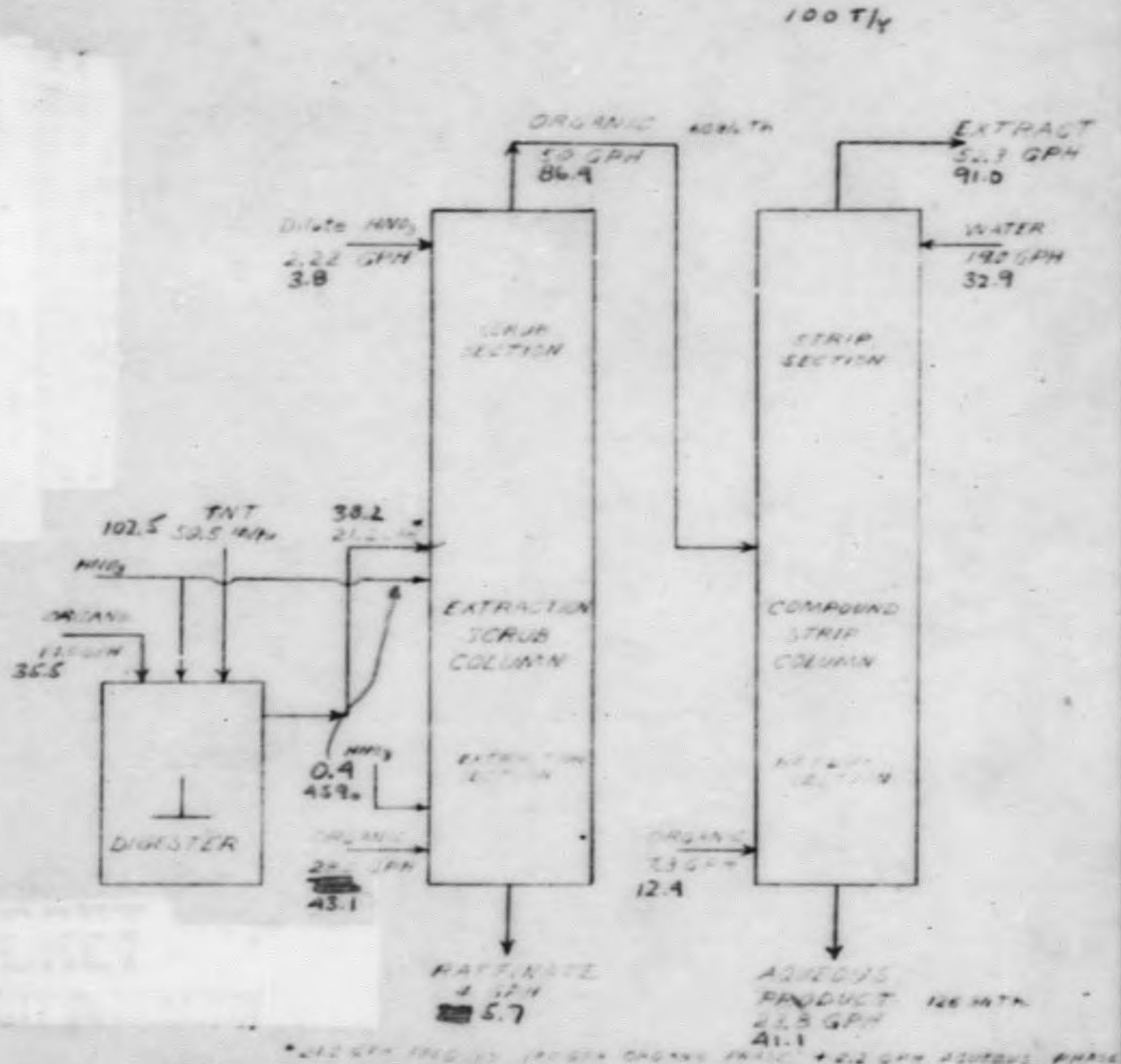
1. Maintain a high thorium concentration in the reflux section. (This increases the uranium separation.)
2. Effect a complete recovery of the thorium in the column.
3. Deliver as high a thorium concentration in the $Th(NO_3)_4$ product consistent with satisfactory uranium separation. (i.e. a uranium content of 1 part/million parts of thorium in the product)

The digesters are sized to permit adequate contact time for the mixture of solids and liquid to approach equilibrium.

Reaction time and settling time, in each mixer settler unit, were determined and the vessels sized accordingly with a safety factor.

Since the extraction part of the thorium plant will probably run intermittently on a continuous basis and the precipitation area may not be able to process the product from the extraction area as it is produced, a large product storage capacity is provided. The capacity provided can store five (5) days production of $Th(NO_3)_4$ solution from the extraction area.

ORGANIC PHASE DIGESTION



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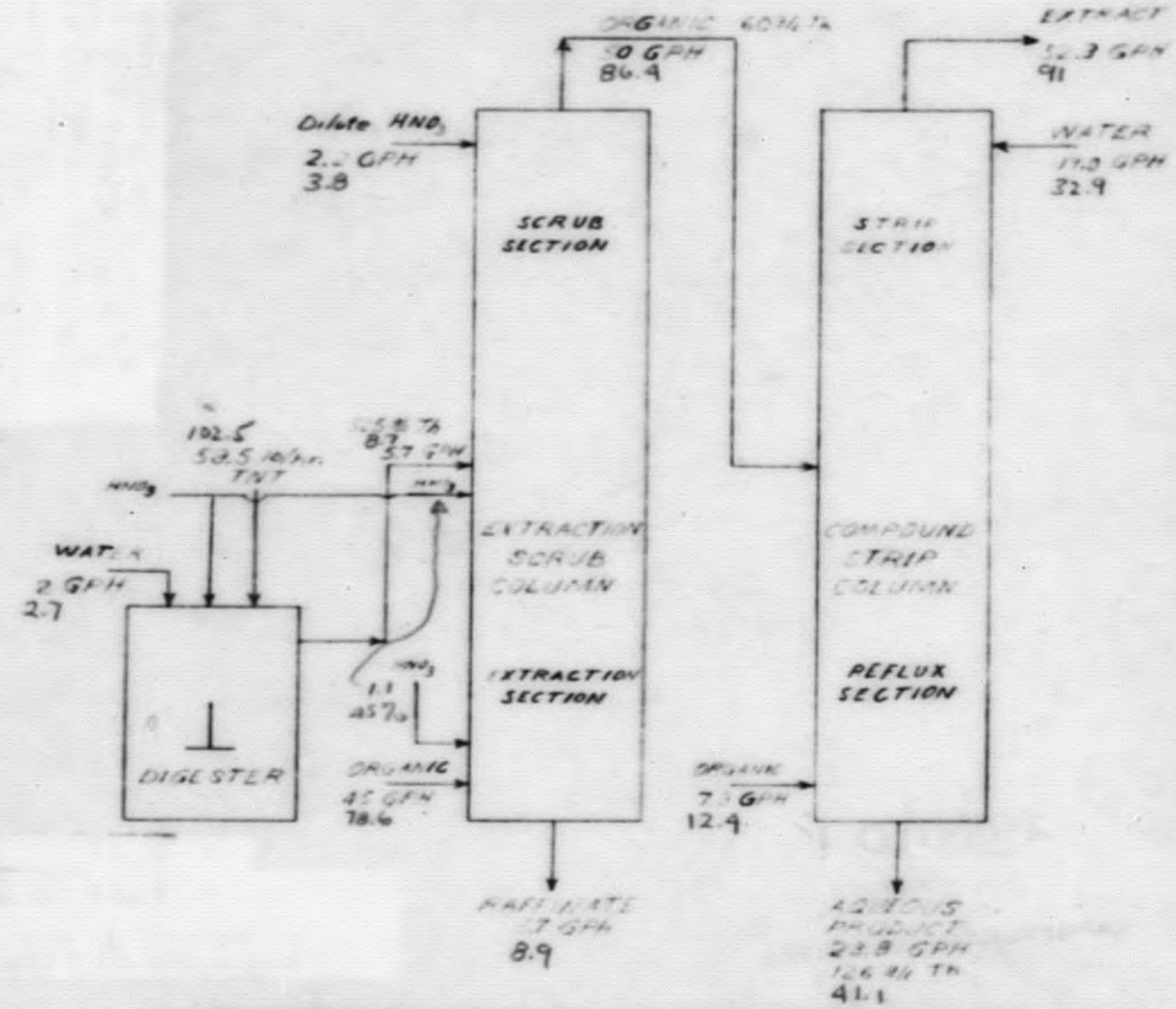
ENGINEERING DEPT. STANDARD

THORIUM ... WORKS PLANT - FMPC
ORGANIC PHASE DIGESTION

MADE BY		DATE	
CHK'D BY		DWG. NO.	
APP'D			SK-3542-H-50-D-3

AQUEOUS PHASE DIGESTION

100 T/y



REVISIONS		
No.	DATE	APPROVED

CATALYTIC CONSTRUCTION CO.
PHILADELPHIA, PA.

ENGINEERING DEPT. STANDARD

THORIUM SEMI-WORKS PLANT • FMPC

Aqueous Phase Digestion

MADE BY		DATE	1-25-52
CHK'D BY		DWG. NO.	
APP'D		SK-3542-H-50-D-4	

FORM OO-104

B. THORIUM TETRAFLUORIDE PREPARATION:

Three different processes for preparing thorium tetrafluoride from thorium nitrate were considered for this section of the plant. The first process, currently used at Iowa State College, involves precipitation of thorium oxalate from an acid solution of thorium nitrate. The precipitate is filtered, dried, and ignited to thorium oxide. Anhydrous HF is used to react with thorium oxide to produce anhydrous thorium tetrafluoride. A satisfactory product for reduction to metal is obtained by this method. The disadvantages of this method are that: (1) oxalic acid costs are high, (2) large amounts of anhydrous HF are required, and (3) the operations require too much handling of product and could easily lead to contamination.

The second process consists of denitration of the thorium nitrate followed by hydrofluorination to thorium tetrafluoride. This process is similar to the one presently employed for the production of uranium tetrafluoride except that intermediate reduction of the oxide is not required. Experiments conducted at the New Brunswick Laboratory indicate that this process is feasible for thorium. However, no bomb reduction tests were made with this material. The inherent disadvantage of this method is that if solvent extraction of thorium nitrate is omitted in the semi-works plant, no purification of the thorium would be obtained except for some minor impurities volatized during the casting operation. A second drawback to this process is that the investment costs for denitration equipment would be exceedingly high for a plant of this capacity.

The third process under consideration is a wet-process for preparing thorium tetrafluoride. The thorium is precipitated from a solution of thorium nitrate using aqueous hydrofluoric acid. The precipitate is filtered, washed, and dried to the anhydrous material. Development work on this process has been carried out at Iowa State College, New Brunswick Laboratory, and Vitro Corporation. The results have shown that the thorium is precipitated quantitatively and that an easily filterable product is obtained. The precipitate can be converted to the anhydrous form by heating first in air or nitrogen and finally under an anhydrous HF atmosphere. Only one bomb reduction of wet-processed thorium tetrafluoride has been made to date at Iowa State College. The results indicate that the material is easily reduced and that the bulk density of the product was a factor only in determining the amount of material which could be charged to the bomb. Experiments are underway to determine the purity of the fluoride product. It is believed that product purity will equal or better material prepared by oxalate precipitation.

After due consideration of the three processes for preparing thorium tetrafluoride, the aqueous hydrofluorination process was selected for the semi-works plant. The design of this section is predicated upon either obtaining a solution of thorium nitrate from the extraction area or solid thorium nitrate in case solvent extraction is by-passed.

Precipitation:

The thorium nitrate solution, containing thorium nitrate equivalent to 1 lb. of thorium metal per gallon, is pumped to the solution heating tank (D42-108). This tank will serve as a dissolving tank for solid thorium nitrate if required. Bulk thorium nitrate will be manually dumped into this tank. The solution is heated by steam to a temperature of 190° to 200° F. and is pumped (G42-111) to one of two precipitation tanks (D42-100 and 101). The solution is slowly agitated, and aqueous hydrofluoric acid is added. An excess of about 5 per cent hydrofluoric acid (48%HF) is required to obtain an easily filterable product. The hydrofluoric acid is pumped (G42-100) to the precipitation tank

2, G42-101

(D42-100 or D42-101) form a storage tank (F42-100). The slurry is digested with agitation for 10 minutes and is cooled to room temperature to minimize corrosion in the succeeding equipment. The cooled slurry is pumped (G42-102) to a rotary vacuum filter (D42-102) to recover the wet product. The filtrate and wash water are collected (F42-101) and clarified by pumping (G42-103) through a clarifier (D42-103). The filtrate is neutralized before disposal in the precipitation tank (D42-200) located in the sump recovery system. Solids collected in the clarifier (D42-103) will be sluiced with deionized water to the precipitation tanks (D42-100 or D42-101) for recovery.

Cake Handling and Drying

The washed thorium tetrafluoride cake is collected in stainless steel drums (F42-104 to 113) for "in process" storage. The wet cake is removed from the drums and loaded onto Hastelloy "C" trays. Tray loading operations will be carried out on a stainless steel table (J42-100) equipped with a hood for dust collection.

The trays are loaded into one of two dryers (B42-100 and 101) to obtain the anhydrous product. It is proposed that the drying operation consist of two cycles. In the first cycle, air will be circulated in the dryer at a temperature of 200° to 300° F. to remove all unbound moisture and part of the bound moisture from the cake. A HF atmosphere is used in the second cycle to complete drying to the anhydrous product. The temperature in this second cycle will be increased gradually to 1022° F. It is expected that the two cycles will require from 6 to 8 hours. One dryer should be sufficient for a one shift per day operation employing overnight cooling of the dryer, but a minimum of two dryers are required for three-shift operations. The HF is vaporized (B42-102) at 90° F from commercial cylinders of liquid anhydrous HF and is metered to the furnaces. The moisture-laden HF from the dryers is filtered (D42-104) to remove dusts and is passed to an absorber (D42-106). The HF gas is absorbed in water, and overflows to the precipitating tank (D42-200) located in the sump recovery system for neutralization.

Nitrogen is provided to purge the dryers and to backwash the tube filter (D42-104). The spent gases are passed through the absorber (D42-106) before discharge to the atmosphere.

Product Handling and Grinding:

The dry thorium tetrafluoride product can either be cooled inside or outside the dryer depending upon the shift-operations schedule. The cooled product is fed to a micro-pulverizer (G42-104) for grinding thru 100 mesh. The ground product is stored in drums (F42-104 to 113), lined with plastic film to reduce contamination, and sent to the bomb reduction area.

C. REDUCTION TO THORIUM-ZINC ALLOY

In this step of the process, the anhydrous thorium tetrafluoride is reduced to thorium-zinc alloy. The operation is carried out in a reduction bomb using calcium metal as the reductant. Zinc chloride is mixed with the thorium tetrafluoride to provide additional heat for this reaction and to combine with the thorium metal forming an alloy which is fluid at the reduction temperature. Massive thorium-zinc alloy biscuits, weighing about 60 pounds, are produced in this step.

The reduction step consists of four operations: - (1) preparation of the bomb, (2) charging the bomb, (3) firing the bomb, and (4) breakout of the biscuit alloy. These operations are described in the following paragraphs.

Preparation of the Bomb:

The reduction bomb (B42-509 to 520) is a mild steel cylinder, 8 3/16" I.D. x 3'8" with 1/2 " wall, closed at one end and flanged at the other end. The bomb is equipped with a blind flange cover plate and hanger (Dwg. No. SK-3500-G-19D). In firing, the temperature reached is above the limits of mild steel, and therefore, it is necessary to protect the steel bomb casing. A dry packed refractory lining is used for this purpose. Depending upon its availability, electrically fused dolomitic oxide (EFD) will be used. The refractory liner material is blended with about 3 1/3 per cent by weight calcium (-50 to + 80 mesh) to react with any water present. Elimination of water from the liner prevents hydrolysis of the thorium tetrafluoride to the oxide and hydrofluoric acid. Blending is effected in a 12 cubic foot batch-type blender (G42-500). A charge of 450 pounds of EFD and 15 pounds of calcium metal are blended for approximately 15 minutes and are then transferred to a storage hopper (F42-500). The same mixture of refractory and calcium will be used for lining both the bottom and sides. Approximately 45 pounds of lining are required for each bomb.

In forming the liner, about 6 to 8 pounds of liner material is added to the bomb. A tapered mild steel mandril (G42-502 to 505), chromium plated, is placed in the bomb, (Dwg. No. SK-3500-G19-D). An adapter (G42-506), which centers the mandril and holds the bomb in place, is secured to the bomb. Liner material is then added through the adapter, and the bomb is jolted slowly on a #5 Arcade jolter (G42-501) until the bottom liner is formed. Additional liner material is added and jolting continued until the complete liner is formed. Final jolting is done at 180 strokes per minute.

Charging the Bomb:

A charge for five bombs is prepared by blending 377 lbs. of thorium tetrafluoride, 135.5 lbs. of calcium, and 37.5 lbs. of zinc chloride in an 8 cubic foot blender (G42-528). The charge is then blended for 15 minutes, weighed out in 109.5 lb. lots, and packaged in 8 gallon drums (F42-507 to 511).

For filling the bomb, an adapter and funnel with a 3" discharge pipe (G42-506) are fitted to the top of the bomb. About half the charge is added to the bomb through the funnel, and the funnel and adapter (G42-506) are removed. The charge is tamped with a manually operated pneumatic tamp (G42-590). The remainder of the charge is added through the adapter and is tamped. Graphite plugs (G42-507 to 526), 7 1/8" diameter by 2" thick, are added to fill the void above the charge, and the bomb cover and hanger are bolted in place.

The calcium for use in the bomb liner and charge, and the zinc chloride used in the charge, are prepared by processes described later in this report.

Firing the Bomb:

The bomb is fired in a Rockwell muffle type furnace (H42-500), similar in design to those used for FMPC, uranium tetrafluoride reduction, but adapted to take the bomb described above. The temperature of the furnace is to be controlled at 1240° ± 50 F by a recording temperature controller. The sharp rise in temperature, which occurs when the reduction takes place, will actuate a signal light or annunciator. The bomb is removed from the furnace and is placed in an induced air cooling station (E42-501), where it is cooled to a temperature of 600° - 700° F. In moving the bomb from the firing station to air cooling, swaying should be held to a minimum. This can probably be accomplished by careful handling. The bomb is then placed in a water bath (E42-502) and cooled to approximately 200° F.

Breakout of the Biscuit:

Biscuit breakout will be done manually. The bomb cover and hanger are removed and the graphite plugs are dug out with a pneumatic chisel. The side liner is broken down with a pneumatic drill and the bomb is inverted on a jolter (G42-530). The biscuit is cleaned with hammers and hand operated pneumatic tools (G42-531 and 532).

D. DEZINCING AND CASTING

Dezincing of the thorium-zinc alloy and melting and casting of thorium metal will be carried out in one operation. Induction furnaces (B42-501 to 504), to be designed by National Research Corporation, will be used for this operation. The detailed design of these furnaces and their operation are not abailable at this time. Power will be supplied to the furnaces by a 100 KW or 200 KW motor-generator set at 3000 cycles. The furnaces will be maintained under vacuum by mechanical and oil diffusion pumps. The power and vacuum systems will be specified by National Research Corporation.

It is visualized that the furnaces and auxiliary equipment will require an area of 34' x 18' x 20' high. This takes into consideration the possibility of installing four furnaces, but it is believed that two furnaces will be adequate. It may be desirous to enclose the motor-generator set or sets in a separate room, the space stipulated, will provide for this.

Melting will be done in beryllia or zirconia crucibles which are stabilized with small amounts of calcium oxide. Preparation of the beryllia crucible is described elsewhere in this report.

Cropping, Machining, and Sampling of the Cast Ingots

The exact sizes and shapes of the cast thorium ingots have not been specified at the present time. It is believed that these sizes will probably be the same as those currently produced at Iowa State College, which are cylindrical ingots 3-5/16" O.D. by 34" long and rectangular ingots 2 1/2" x 5" x 20" long. The surfaces of the ingots are irregular due to low superheat at pouring. It is necessary to machine the ingot to sound surfaces and to remove open pipes before fabrication. A sample of the ingot (about

1/4 pound of metal) is taken for analysis in the course of the machining operation.

For cylindrical castings, machining and cropping (removal of open pipes) will be done with a lathe (G42-542) and power hacksaw (G42-533). Rectangular ingots will be surfaced by a milling machine (G42-543). Equipment for both these operations are incorporated in the design of this plant.

E. CRUCIBLE PREPARATION

Various graphite molds which will be required for casting and dezincing of thorium metal, can be machined from graphite blocks using existing facilities at the FMPC. However, crucibles required for melting thorium in preparation for casting must be specially fabricated from either beryllia (BeO) or zirconia (ZrO_2). Beryllia crucibles are currently employed at Iowa State College for this purpose. Information available from melting tests at Oak Ridge indicates that zirconia crucibles can be used successfully for melting thorium. Larger scale tests are in progress at the National Research Corporation using both beryllia and zirconia crucibles to corroborate these results. The use of zirconia crucibles at about \$1.50 per pound of ZrO_2 as against \$22.00 per pound of BeO would result in a saving of about \$1.75 per pound of thorium produced, based upon the design rate for the semi-works plant and crucible life experienced for beryllium oxide materials. Another factor, favoring zirconia over beryllia, is the health hazard involved in the use of the beryllium compounds.

The design of the crucible fabrication section is based upon operations employed at Iowa State College for preparing beryllia crucibles. It is expected that minor changes, such as the selection of particle sizes, binder material, firing sequence, and crucible size may be different for preparing zirconia crucibles, but not to the extent that these changes would effect the selections or types of equipment shown in the equipment lists for this operation.

The ground refractory, either stabilized zirconia or beryllia, will be received in drums. The refractory is screened (Gh2-300) to obtain a desired range of particle sizes and to remove foreign particles. Results at Iowa State College on a desired screen analysis of BeO is shown below:

BeO SCREEN ANALYSIS

50 mesh	---
- 50, + 70	17.7
- 70, + 100	17.1
- 100, + 140	10.5
- 140, + 200	6.6
- 200, - 270	4.8
- 270, - 325	3.3
- 325	40.0
	100.0

The BeO is blended with 1.5 parts by weight lime in a tumbler mixer (G42-304), and drum storage (F42-300) is provided for "in process" material. Each crucible requires about 10 pounds of the screened beryllia and screened lime mixture.

The crucibles are prepared by jolting the mixture in an annular space, formed by a graphite mold and mandril. After the mixture is jolted in place, the mandril is removed and a graphite lid and chimney are placed on the mold. The mold is lowered into a firing assembly which consists of a vertical quartz tube and a graphite heater, mounted on a cart. A sketch of this assembly is shown in Dwg. No. SK-3500-G-08-D.

The crucible is fired by lowering a circular induction coil over the graphite tube and applying power supplied by a 50 KW frequency converter

(B42-300). The power is increased gradually over a period of one hour to obtain a temperature of 1200° C (2200° F) in the crucible. Heating is continued for two additional hours, after which time the powpr is shut off and the assembly is cooled in air.

The crucible is removed and inspected for flaws. Small cracks are repaired with a slurry of BeO in water, and the crucible is placed in a resistance furnace (B42-303) to heal the cracks and burn off clinging graphite particles. The crucible is oven-cooled and stored until needed.

Other forms besides crucibles can be fabricated using the same equipment except for molds and mandrils. For small parts, the proportion of CaO is different, 3/8 of one part of CaO to 100 parts of BeO. The firing schedule is somewhat faster than for crucibles, and these parts are usually satisfactory after one firing. A second firing is necessary only if graphite particles cling to the surface.

Recovery of thorium and beryllia from discarded crucibles is not practiced at Iowa State College, and is not contemplated in these operations.

It is important to re-emphasize the extreme health hazards in using beryllium and its compounds. Ample ventilation must be provided to remove dusts and vapors of beryllia. An air velocity of 100 to 200 feet per minute to the hood openings is required for these purposes.

F. CALCIUM DISTILLATION AND GRINDING

Calcium metal is used to reduce the thorium tetrafluoride and zinc chloride to thorium-zinc alloy and is used to react with any water present in the refractory lining. Impurities present in the calcium appear in the final thorium product in the approximate ratio of one part in the thorium for every two parts in calcium. It is therefore necessary to refine the calcium to a high degree of purity before use in the reduction operation. It has not been possible to obtain calcium metal which meets purity specifications for this use; therefore, it is necessary to provide equipment in the thorium plant to redistill or resublime calcium metal under vacuum to meet these specifications.

This operation will be carried out in stainless retorts (B42-506 to B42-508) (Dwg. No. SK-3542-H-50-D-1) which are heated under vacuum in a gas-fired furnace (B42-505). The operation consists of a batch distillation carried out under a vacuum of about 10 microns. The impure calcium is vaporized from the bottom of a retort up through a layer of Rashigs rings and is condensed on a liner and condenser in the upper section of the retort. Nitrogen, aluminum, iron, and manganese are removed from the calcium metal by this process. A detailed description of the stainless steel retort and accessories is found in the equipment lists for this operation.

For most effective use of the equipment, three retorts will be used as is shown in the Process Flow Diagram #3542-H-04-F. It will be possible to distill 400 pounds of calcium per day on a three-shift operation.

The calcium product from distillation must be ground before use in the reduction step. This is accomplished by first shredding the calcium metal in a hog grinder (G42-556) which produced - 4 mesh size material. It is further reduced in size in a Wiley mill (G42-591) and is run over a magnetic separator

(C42-558) between each grinding step to remove iron particles. The ground calcium is screened to three sizes: + 50 mesh, - 50 to + 80 mesh, and - 80 mesh. The + 50 mesh is blended with the thorium tetrafluoride; the - 50 to + 80 mesh is mixed with the liner; and the - 80 mesh is discarded since it contains mostly oxides and hydroxides of calcium.

G. ZINC CHLORIDE PREPARATION

Mallinckrodt reagent-grade zinc chloride is used in the present process at Iowa State College as a booster in the reduction of thorium tetrafluoride. Either this material or its equivalent will be used in this plant. The material, as received, contains 2 to 3 per cent water and is about 10 mesh in size. Prior to its use in reduction, it must contain less than 0.1 per cent water and be ground to 60 to 100 mesh.

Zinc chloride drying will be accomplished in a batch operation using approximately 30 pounds of material per charge. The operation will be carried out in an evacuated retort (B42-521) at a temperature of 500° F. The vacuum on the retort is kept at 100 microns by means of a mechanical pump (G42-560). Heating is accomplished in a gas-fired furnace (B42-521). The detailed description of this equipment is shown in the equipment lists.

After drying and cooling under vacuum, the material is ground to 60 to 100 mesh in a Wiley mill (G42-557). During the grinding operation, nitrogen is used to keep the material dry. The ground product is packaged in air-tight containers (F42-590 to 599).

H. SCRAP RECOVERY AND PROCESSING

In the production of thorium metal, various types of scrap material are produced. These materials and the disposition of each are discussed in the following paragraphs.

Ingot Croppings:

This material is obtained from machining the cast ingot to remove open pipes. It is estimated that 5 to 15 pounds of thorium metal are obtained from each 100-lb. ingot. This material is recycled to the casting operation for melting without additional processing.

Turnings:

Thorium metal turnings obtained from machining the cast ingots and slugs will be recycled for casting. It is estimated that about 27.5 tons of thorium metal per year (based on 3-shift operation) will come from this source. Before these turnings can be melted-down for casting, they must be cleaned and dried.

These operations will consist of a series of 50-lb. batches of turnings. The turnings are first chopped in a Wiley mill (G42-567) to 1" to 2" for ease in handling. A 50-lb. lot of turnings is placed in a stainless steel basket (F42-570 to 572). They are passed (1) through a solvent degreasing unit (G42-568), using trichlorethylene, (2) dipped in an acid solution (30 gallons of 1:1 mixture of 60% nitric acid and water plus 5 grams of sodium fluosilicate maintained at a temperature of 140 to 160° F, and (3) rinse in water (F42-506). The turnings are then dumped into a basket-type centrifuge (G42-569) to remove surplus water. Final drying takes place in a laboratory muffle furnace (B42-522) held at a temperature of 300° F. The dry turnings are charged with the thorium-zinc biscuits for melting and casting.

High Carbon Scrap

This material is obtained from the graphite molds used in the casting operation. It will be stored for future processing.

Dross from Melting Crucibles

A residue remains in the melting crucible after casting of a thorium ingot. This material will also be stored.

Slag and Liner

From the reduction operation, approximately 100 pounds of this material are produced every 58 pound thorium-zinc biscuit. The average thorium content of this material is 1.7%. Since no suitable method has been devised to process this material, it will be stockpiled.

Dust Collector Residues

Two types of dusts will be encountered in the metals section of the thorium pilot plant. These are (1) contaminated dust, containing thorium or thorium compounds and (2) noncontaminated dusts. Both types of dust are encountered in other areas of the plant, and an attempt should be made to integrate the dust collection system for the entire plant. In such integration, three categories of dust should be considered, and provision made to keep these three types separate. The types or categories are:-(1) dust which does not contain thorium or thorium compounds, (2) dust which contains thorium and halogens or a thorium halide, and (3) dust which contains thorium or thorium compounds but not containing any halides.

In the metals section, all three types are encountered. Process Flow Diagram, Dwg. No. 3542-H-04-F, shows dust points and types encountered in the metals section. These materials will be stockpiled.

Sump Recovery Cake

Sump treatment and recovery have been embodied in the thorium tetrafluoride precipitation area. Treatment is designed to permit disposal of process wastes after reclamation of all value bearing materials.

Sump liquors from the thorium tetrafluoride precipitation area and the extraction area flow to sump collection tank (F42-200); if these liquors are free of organic solvent material, they are fed directly (G42-200) to the sump precipitation tank (D42-200). Liquors carrying organic solvent material are fed from the sump collection tank (F42-200) to a settling and skimming tank (F42-14) to permit removal of organic solvent prior to entering the sump precipitation tank (D42-200).

All clarified filtrate and the overflow of the HF absorber (D42-106) from the thorium tetrafluoride preparation are fed to the sump precipitation tank (D42-200).

Lime is added to the precipitator (D42-200) to neutralize all acid wastes and precipitate thorium carried with the waste materials. The slurry produced is clarified (D42-201). Cake is held for storage and the filtrate is pumped (G42-202) to sump collection tank (F42-201) for disposal. Provisions are made to bypass the clarifier if no valuable material is contained in the waste.

EQUIPMENT LIST
EXTRACTION

Item Number	Description	Type	Capacity	Source
D42-3	Digester	Agitated Vessel	200 Gal.	BMI Pilot Plant #D-6
D42-4	Digester	Agitated Vessel	200 Gal.	BMI Pilot Plant #D-7
D42-5	Mixer-Settler	Agitated Vessel and Settling Tk.	Same as D13-11	S. S.
D42-6	Mixer-Settler	Agitated Vessel and Settling Tk.	Same as D13-12	S. S.
D42-7	Extraction Column	Pulse Column	6"D x 30'	S. S.
D42-8	Extraction Column	Pulse Column	6"D x 30'	S. S.

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EQUIPMENT LIST
EXTRACTION

Item Number	Description	Capacity Gallons	Source
F42-1	Weigh Hopper		C. S.
F42-5	Product Hold Tank	1500	S. S.
F42-6	Dilute HNO_3 Head Tank	BMI HNO_3 Head Tk.	BMI Pilot Plant #F-7
F42-7	Solvent Storage	200	BMI Pilot Plant #D-1
F42-8	Diluent Storage	200	BMI Pilot Plant #D-10
F42-9	Organic Feed Tank	500	S. S.
F42-10	NA_2CO_3 Solution Tank	BMI NA_2CO_3 Solution Tank	BMI Pilot Plant #D-5
F42-11	Raffinate Tank	200	BMI Pilot Plant #D-13
F42-12	Boildown Tank	BMI Head Tank S.S.	BMI Pilot Plant #F-6
F42-13	Product Hold Tank	1500	S. S.
F42-14	Sump Liquor Collection Tank	200	BMI Pilot Plant #D-11

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EQUIPMENT LIST
EXTRACTION

Item Number	Description	Capacity	Material
G42-1	Valve 8" Rotary - Ore	75#/hr.	C. S.

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EQUIPMENT LIST
THORIUM TETRAFLUORIDE PREPARATION

Item Number	Description	Capacity	Material
D42-100	Precipitation Tank	150 gal.	Teflon-lined
D42-101	Precipitation Tank	150 gal.	Teflon-lined
D42-102	Rotary Filter	1' x 1'	S. S.
D42-103	Clarifier - Twin Strainer		S. S.
D42-104	Tube Filter	52 ft.^{2}	Adams, porous carbon
D42-105	Dust Collector	#6 Rotoclone	C. S.
D42-106	Absorber	4" B & K	Haveg.
D42-200	Precipitator-Sump	850	S. S.
D42-201	Sump Clarifier - Twin Strainer		C. S.
D42-108	Dissolving Tank	200 gal.	S. S.

EQUIPMENT LIST
THORIUM TETRAFLUORIDE PREPARATION

Item Number	Description	Capacity	Material
B42-100	Drier, includes heating elements	36" x 39" x 63" 266# Dried ThF_4 per Shift - Remove 480 lbs. water per shift	Inconel
B42-101	Drier, includes heating elements	Same as B42-100	
B42-102	AHF Cylinder Heating Tank	120 Gal, S & K Steam Sparger	C. S.
J42-100	Table, tray loading	6' x 3'	S. S.
P42-500	Hood	12' x 8'	S. S.
P42-501	Hood	7' x 5'	S. S.

EQUIPMENT LIST
THORIUM TETRAFLUORIDE PREPARATION

Item Number	Description	Capacity	Material
F42-100	HF Storage Tank	500 gal.	Inconel
F42-101	Filtrate holding tk.	150 gal.	S. S.
F42-102	N_2 Surge Tank	55 gal.	C. S.
F42-200	Sump Tank	700 gal.	S. S.
F42-201	Sump Tank	700 gal.	C. S.
F42-104 to 115	Product Drums	5 gal.	S. S.
G42-104	Micro Pulverizer	300 lbs./hr Thru 100 mesh	S. S.

EQUIPMENT LIST
METALS AREA

Item Number	Description
G42-500	Blender - 12 ft.^{3} - Patterson or MacLellon type mixer, detachable body to serve as a transfer hopper - material SS #347
G42-501	Jolter - #5 Arcade - 0 to 180 strokes per minute with load of 550 lbs. - station to be similar to jolter station of #3005
G42-502 to 505	Mandrils - per dwg. SK-3500-G19-D
G42-506	Adapter & Charging Auxiliaries - adapter for charging bomb & tamping charge. Detailed design pending charging procedure Material SS#347
G42-507 to 526	Bomb Caps - Graphite, 7 1/8" diameter by 1 1/2" to 2 1/2" thick. Machined from 8" electrode carbon stock
G42-527	Torque Wrench - tighten flange bolts on bomb
G42-528	Blender - 8 ft.^{3} - Patterson or MacLellon type
G42-529	1/2 ton Electric hoist
G42-530	5" Arcade Jolter
G42-531 to 532	Pneumatic hammer - hand operated with chisel & drill set
G42-539	Electric hoist - 1/2 ton
G42-542	Lathe - handle ingots 3" to 5" diameter x 40" long.
G42-543	Milling Machine - handle ingots 2" to 5" square, 40" long
G42-544	Power Hacksaw - to cut ingots
G42-545	Oil diffusion pump - NRC or equal
G42-546	Vacuum Pump - size as recommended by NRC
G42-554	Filter - NRC 4" baffle filter or equal
G42-564	Blower - for Calcium retort cooler
G42-555	Crusher - cob - crush Calcium to 2" to 4" size
G42-556	Grinder - hog - grind Calcium to 1/4" mesh

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EQUIPMENT LIST
METALS AREA

Item Number	Description
G42-557	Mill - Wiley - to grind to 100 mesh
G42-558	Separator - Magnetic - remove tramp iron
G42-563	Extruder - for Calcium crowns
G42-559	Electric hoist-1/2 ton on necessary mono rail
G42-565	Oil purifier - Hiles for Kenney pump
G42-560	Vacuum Pump - Kenney Cat. No. VSD-5-5-6 6 liters/ sec, 10 microns
G42-561	Filter - NRC baffle filter or equal
G42-567	Mill, Wiley - capable of chopping to 1" to 2" size
G42-568	Trichloroethylene Degreaser - Detrix or equal
G42-569	Centrifuge - Basket type, SS for water separation from turnings
G42-579	Chain hoist - 1/4 ton capacity
G42-566	Blower - Air for cooling station
G42-590	Pneumatic Tamp - hand operated
G42-591	Mill, Wiley to grind to - 80 mesh
G42-592	Screen - Vibrating, 50 and 80 mesh, Rotex or equal

EQUIPMENT LIST
METALS AREA

Item Number	Description
F42-500	Storage bin - liners, 12 ft.^{3} conical or truncated bottom at 45° - equipped with flexible hose discharge & syntron feeder, SS #347
F42-504	Pit - Loading - Pit to receive lined bomb & hold bomb in a fixed position for withdrawal of mandril & charging. Pit to be designed to catch and hold charging spills - Material, concrete and mild steel
F42-505	Acid Wash Tank - SS #304 ELC 2' Dia. x 2' high, off floor with drain connection, equipped with steam heating coil, 304 ELC SS coil - pancake type, manually controlled, capable of maintaining 150° acid bath.
F42-506	Tank - Water wash, mild steel with water connections for continuous circulation
F42-570 to 572	Baskets - 304 ELC SS mesh basket, 12" O.D. 8" overall length
F42-576 to 578	Pans - SS pans for drying oven
F42-507 to 511	Drums - Storage 8 gal. M.S.
F42-590 to 599	Drums - Storage, with insert Plastic bag, size - 2 gal.
F42-507 to 510	Drums - Calcium Storage, 8 gal., C.S.

EQUIPMENT LIST
METALS AREA

Item Number	Description
B42-500	Dehumidifier - for air conditioned room - to control grinding room humidity - relative humidity equivalent to 0.1% water vapor - size of room or volume of air to be set by design & vendors recommendations
B42-501	Air Cooler - 3 port similar to that in #3005
B42-502	Water Cooler - 8 port similar to that in #3005
J42-573 to 575	Brackets - 304 ELC SS brackets to support baskets in baths with eye for handling with hoist
J42-533	Table - SS top
B42-521	Vacuum Oven - SS - gas fired to operate at 500°F & 100 micron pressure - handle 100# batch
B42-522	Furnace - Laboratory muffle, electric, with temp. indicator 2 heostat 300°F - 0.2 ft.[3]
B42-509 to 520	Bomb cases - as per dwg. SK3500-G-19-D
B42-500	Furnace - Reduction & controls, type used for #3005 Rockwell or equal. Variable power control on three heating zones to maintain approx. temp. of 1240 ± 5°F & 1 Brown electronic temp. recorder & controller.
B42-505	Resublimation Equipment Calcium - furnace (a) Vertical gas fired furnace approx. 3' Dia. x 4' high internal dimensions, with 12 burners positioned for maximum heat distribution. Must be capable of supporting retort described in (b) below. Operating temperature 1740°F.
B42-506 to 508	Retorts, (b) cylindrical type 310 SS 21 1/2" I.D. 60" high, 3/4" wall thickness with dished bottom & flanged top. The upper 22" to be water jacketed with mild steel. A 4" vacuum connection just below flange. Flanged end to be equipped with rubber gasket and blank to be bolted in place. Three external lugs to be welded to shell at juncture of welded sections for support of retort in the furnace See sketch - Internals -(continued on next page.)

Item Number	Description
B42 - 506 to 508 continued.	(a) 18" high type 310 SS sleeve app. 21" I.D. with 1/2" wall thickness, supported on pegs 35" above B.L. of retort. (b) 21" diameter type 310 SS plate 1/2" thick, to be bolted to top edge of liner with 1/2" spacing between liner & plate. Plate to be equipped with eyes for lifting from retort. (c) SS basket, containing a 3" layer of SS Raschig Rings, suspended on pegs 22" above bend line of retort. (d) Stainless steel plate with 10" dia. chimney
B42-501 to 504	Vacuum induction heated castings furnace; - furnace, vacuum system, high frequency equipment & controls to be supplied by National Research Corporation. Major equipment will be: (1) Vacuum induction heated casting furnaces approx. 5' dia. x 10' high, equipped with condensers for collecting zinc. (2) 100 KW or 200 KW motor generator sets for each furnace, 3000 cycle, 800 volt & auxiliary equipment. (3) Vacuum systems consisting of 2 NRC B-6 oil diffusion pumps backed up by two 100 cfm Kinney pumps. Auxiliary vacuum piping & electrical system. (Similar to Job #3005) (4) Brown electronic temp. recorders or equal. (5) Alphatron vacuum recorders, NRC type 510S

EQUIPMENT LIST
METALS AREA

Item Number	Description
E42-580	Thermometer - ASTM 30° - 220°F
E42-547	Variac - for diffusion pump - sizes as per vendor
E42-548 to 550	DPI quarter swing valves
E42-551	Alphatron - vacuum recording instrument NRC type 510S
E42-552	Brown electronic temperature recorder, indicator & controller (on condenser) or equal.
E42-553	Brown electronic temperature controller, recorder and indicator (air to furnace) or equal.
E42-562	Brown electronic recording temperature controller.
E42-537	Scale - 100 lbs. in 1/10 lb. points.
E42-538	Scale - print weigh Toledo scale, 0.1 lb graduation

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EQUIPMENT LIST
METALS AREA

MISC. EQUIPMENT

Number	Description
2	Dollies - for mold handling
3	Shovels
3	brooms
1	marking set - to number biscuits
3	Dollies - to hold 6 biscuits 7, to be manually manueverable

EQUIPMENT LIST
CRUCIBLE PREPARATION

Item Number	Description
B42-300	Induction Furnace: 1. 50 KW induction converter 2. Coil - 15" I.D. & 24" high 3. Must be able to reach max. temp. of 3500°F.
B42-303	Resistance Furnace: 1. Inside dimensions 36" x 36" x 20" to hold 5 crucibles 2. Must be able to reach max. temp. of 3500°F
D42-300	Dust Collector 1. #6 Roto Clone
F42-300	Mix Storage Drum 1. Stainless Steel 2. 5 gal. capacity
F42-301 to 303	Molding Assembly - 3 needed 1. Capacity of 1 crucible 2. Graphite tube - 10" O.D., 8 7/8" I.D., overall length 16" - bottom is flat 3½" & tapered to a 30° angle to walls of tube - 1 Lip at top, 2 diagonally opposite holes of 1/16" dia. are drilled 7/16" below top of mold. 3. Mandril - tapered cyld. - is 8 3/8" O.D. at point corresponding to top of mold & tapers 1/16" per foot. Bottom shaped to fit mold - chrome plated mild steel (hollowed) - total of 2 mandrils are needed. 4. Retainer ring - for centering mandril - chrome plated steel - total 2 needed. 5. Funnel - 1/16" chrome plated steel - total 2 needed.
F42-306 to 308	Crucible Firing Assembly - 3 needed 1. Capacity of 1 crucible 2. Dolly: platform 19" x 24" made of 1/2" transite supported by wheels & casters with solid rubber tires to a height of 8" & handle. 3. Quartz Crucible Quartz tube 14 3/4" O.D., 14" I.D. - 36" long (Quartz crucible is mounted permanently on each dolly on 1" layer of K-20 fine brick with air setting refractory cement. 4. Graphite heater Graphite tube having a 3/4" wall, 11" O.D., 21 1/4" overall length & 1 1/4" bottom - heater will be placed inside quartz crucible on 4" layer powered graphite & 6" layer of K-30 fire brick 5. Graphite lid & chimney - Dwg. No. SK3500-G-13-D.

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EQUIPMENT LIST
CRUCIBLE PREPARATION

Item Number	Description
G42-300	Sieve Shaker 1. Tyler Lab testing sieve shaker 2. One set of test screens (a) 40 mesh (b) 50 mesh (c) 70 mesh (d) 100 mesh (e) 140 mesh (f) 200 mesh (g) 270 mesh (h) 325 mesh 3. One hand screen 50 mesh S.S. screen 1 1/2' x 1 1/2'
G42-301	Molding Jolter One 3" Arcade jolter or equal
G42-302	Vent Blower 1000 cfm @ STP
G42-303	Electric hoist One ton hoist
G42-304	Double Cone Mixer - S.S. lining 5 gal.
J42-300 to 302	Tables Stainless Steel - 6' x 4' top
K42-300	Scale - 100 lb. capacity
K42-301	Scale - Lab Balance & weights - 500 gm capacity
P42-300 to 303	Fume hoods 1. Stainless Steel - size - 7' x 5'
Misc. Equip.	1. Hand scoops (3) S.S. 2. Screen brushes (2) 3. Wooden Tampers (4) 4. Spatulas (4) 5. 500 cc pyrex beakers (4) 6. Mortar & pestle 7. K-20 fire brick 8. K-30 fire brick 9. Powered graphite(Thermax or Norblack) 10. Storage shelves for crucible storage 11. Brooms

Reduce ~~[illegible]~~ 30%

ITEM NUMBER	NUMBER OF UNITS	SERVICE	MATERIAL HANDLED: COMPOSITION	GRAVITY: 60°F	GRAVITY: SP. GR AT PUMP TEMP	PUMP TEMP. °F	BOILING LIQUID	NORM. OPER. CONDITIONS: BBLS/STREAM DAY AT 60°F	QUANTITY AT PUMP TEMP US GPM	SAFETY FACTOR	DESIGN CONDITIONS (PUMPS TO BE SUPPLIED AS BELOW): CAPACITY AT PUMP TEMP US GPM	SUCT PR #/in² NOT INCL. STATIC HD	DISCH PR #/in²	DIFTL PR.	DIFTL HD.	CALC HYD H.P.	PUMP EFF. %	B.H.P.	REMARKS CODE:
G42-3		Dioniser H_2O Pump	Water	1.00		80			1-2		2								
G42-4		HNO_3 to Head Tank	45% Acid	1.28		80			1-2		2								
G42-8		Column Feed	(A) Organic	1.10		80			0.5		1								
			(B) Aqueous	1.85		80			0.1		1								
G42-9		Spare for G42-8																	
G42-10		Organic to F42-7	Solvent	1.00		80			1-2		2								
G42-11		Diluent to F42-8	Diluent	0.80		80			1-2		2								
G42-13		Na_2CO_3 Solution	Dil. Na_2CO_3	1.05		80			0.2		0.5								
G42-15		Pulse Pump	Aqueous	1.05		80					(Frequency 50-100 cycles/min.								
G42-16		Pulse Pump	Aqueous	1.05		80					(Amplitude 0.5 - 1.0 inches								
											(Wave Form 2/1 to 1/2								
G42-18		Raffinate from F42-11	Aqueous	1.05		80			1-2		2								
G42-19		Product to Precipitation	Aqueous Prod	1.25		80			1-2		2								
G42-20		Spare for G42-19																	
G42-21		Organic to D42-7	30% Solvent 70% Diluent	.84		80			1		1								
G42-22		Spare for G42-21																	
G42-23		Sump Liquor Pump	Aqueous	1.05		80			1		1								

LIVE STEAM ______

EXHAUST STEAM ______

ELECTRIC CURRENT ______

EXTRACTION

THORIUM SEMI-WORKS PLANT

DESCRIPTION

CATALYTIC CONSTRUCTION CO.
1528 WALNUT ST.
PHILADELPHIA, PA.

PUMP SCHEDULE

J.N. 3542 — 1-18-52

JWD-HRE — SHEET NO. 1

Reduce ~~#10%~~ 30%

Page 56

ITEM NUMBER	NUMBER OF UNITS	SERVICE	MATERIAL HANDLED: COMPOSITION	GRAVITY: 60°F	GRAVITY: SP. GR. AT PUMP TEMP	PUMP TEMP °F	BOILING LIQUID	NORM. OPER. CONDITIONS: BBLS/STREAM DAY AT 60°F	NORM. OPER. CONDITIONS: QUANTITY AT PUMP TEMP US GPM	NORM. OPER. CONDITIONS: SAFETY FACTOR	DESIGN CONDITIONS (PUMPS TO BE SUPPLIED AS BELOW): CAPACITY AT PUMP TEMP US GPM	SUCT PR. % NOT INCL STATIC HD	DISCH PR #/"	DIFTL: PR.	DIFTL: HD	CALC HYD H.P.	PUMP EFF. %	B.H.P.	REMARKS (CODE:)
G42100		HF to F42-100	48% HF	1.16		70°			7		7								
G42101		F42-100 to D42-100 & D42-101	48% HF	1.16		70°			5		5								
G42102		D42-100 to D42-102	dil. HNO_3 dil. HF	1.07					1.3		2½								Slurry 16.3 wt. % solids 0.15% HF
			Solids 16.3%	2.4															11.6% HNO_3 - Slurry wt. 10.5#/gal.
G42103		Filtrate (D-42-102)	dil. HNO_3	1.03		60°			2		4								slurry 1 wt. % solids 0.6% HNO_3
		to D42-103	solids 1%	2.4		60°													slurry wt. 8.9#/ gal.
G42105		Vent Blower																	800 cfm @ STP
G42106		Recycle-D42106	dil. HF	1.02		140			25		40		60						
G42107		Air from B42100	Air																@ 1 ft.^{3} @ 200°F = 0.0602 - cfm to be moved at 200°F 300 ft.^{3}
G42109		Spare for G42101																	
G42110		Spare for G42102								—									
G42111		D-42-108 to D-42-100	TBT Solution	1.26		150°			10		15								

LIVE STEAM ____________________

EXHAUST STEAM ____________________

ELECTRIC CURRENT ____________________

Thorium Tetrafluoride

Thorium Semi-Works Plant

DESCRIPTION

CATALYTIC CONSTRUCTION CO.
1528 WALNUT ST
PHILADELPHIA, PA.

PUMP SCHEDULE

JN 3542 | 1-22-52

HB-WMR | SHEET NO. 1

reduce ~~[illegible]~~ 30%

Page 57

ITEM NUMBER	NUMBER OF UNITS	SERVICE	MATERIAL HANDLED: COMPOSITION	GRAVITY: 60°F	GRAVITY: SP GR AT PUMP TEMP	PUMP TEMP °F	BOILING LIQUID	NORM. OPER. CONDITIONS: BBLS/STREAM DAY AT 60°F	NORM. OPER. CONDITIONS: QUANTITY AT PUMP TEMP US GPM	SAFETY FACTOR	DESIGN CONDITIONS (PUMPS TO BE SUPPLIED AS BELOW): CAPACITY AT PUMP TEMP US GPM	SUCT PR #/" NOT INCL STATIC HD	DISCH PR #/"	DIFF'L PR	DIFF'L HD	CALC HYD H.P.	PUMP EFF %	B.H.P.	REMARKS (CODE:)
P42200		F42-200 to F42-14	Neutral liquor	1.0[illegible]					1	—	5								
			solids (5%)	1.5															
P42201		Liquor (F-42-201) to drain	neutral liquor	1.0[illegible]		70°			1		5								
P42202		D42-200 to D42-201	slurry	3.18		70°			9.2		12								0.3 wt. % solids slurry - wt. 8.[illegible]/gal.
			neutral liquor	1.01		70°													

LIVE STEAM

EXHAUST STEAM

ELECTRIC CURRENT

Thorium Tetrafluoride
Thorium Semi-Works Plant

DESCRIPTION

CATALYTIC CONSTRUCTION CO.
1528 WALNUT ST
PHILADELPHIA, PA

PUMP SCHEDULE

JOB 3542 | 1-22-52

SHEET NO. 2

Release ~~[illegible]~~ 3090

Page [illegible]

ITEM NUMBER	SERVICE	SIDE	HEAT EXCHANGER MEDIUM: MATERIAL	LBS/HR	GRAVITY °API	MOL. WT	% VAPORIZED BY WEIGHT	% CONDENSED BY WEIGHT	TEMP °F: IN	OUT	MTD	DUTY 1000BTU/HR	OVERALL HEAT TRANS. COEFF.	SURF. FT² TOTAL	MAX. ALLOWABLE PRESS DROP P.S.I.	OPERATING PRESS P.S.I.		REMARKS (CODE: Source)
[illegible]-10	Water Heater	SHELL	Steam	20			0	100	365	365				3		150		BMI Pilot Plant
		TUBE	Water	250	1.0	18	0	0	80	150		17.5				20		E-1
[illegible]-11	Organic Cooler	SHELL	Water	450	1.0	18	0	0	85	125				3		20		BMI Pilot Plant
		TUBE	Organic	500	1.0	220	0	0	135	90		18.0				20		E-2
		SHELL																
		TUBE																
		SHELL																
		TUBE																
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		SHELL																
		TUBE																

DETAILED DATA ON HEAT EXCHANGE MEDIUM

ENTERING LBS/HOUR: H.C. VAPOR	MW	H.C. LIQUID	SP. GR.	STEAM	LEAVING LBS/HOUR: H.C. VAPOR	MW	H.C. LIQUID	SP. GR.	STM	WATER

EXTRACTION

THORIUM SEMI-WORKS PLANT

DESCRIPTION

CATALYTIC CONSTRUCTION CO

PHILADELPHIA, PA.

EXCHANGER SCHEDULE

J.B. 3542

1-18-52

JHD - HRB

CATALYTIC CONSTRUCTION COMPANY
PHILADELPHIA 7, PA.

ESTIMATED UTILITIES REQUIREMENTS THORIUM SEMI-WORKS PLANT FMPC

1. Cooling Water

1. Extraction Area		72 GPH
2. Fluoride P.P.T. Area		800 GPH
3. Metals Area		5,850 GPH
4. Crucible Area		960 GPH
	Total	7,682 GPH

2. Treated Water

1. Extraction Area		36 GPH
2. Fluoride P.P.T. Area		13 GPH
	Total	49 GPH

3. Deionized Water

1. Extraction Area		36 GPH
2. Fluoride P.P.T. Area		73 GPH
	Total	109 GPH

4. Steam

1. Extraction Area		84 lb/hr
2. Fluoride P.P.T. Area		63 lb/hr
	Total	147 lb/hr

5. Air

1. Metals Area		10,800 cfhr
	Total	10,800 cfhr

(*These figures include a 20% contingency)

ESTIMATED UTILITIES REQUIREMENTS THORIUM SEMI-WORKS PLANT FMPC

6. Fuel Gas

1.	Metals Area	60 cfhr

7. Electricity

1.	Extraction Area	45 KWH
2.	Fluoride P.P.T. Area	90 KWH
3.	Metals Area	240 KWH
4.	Crucible Area	105 KWH
	Total	580 KWH

(*These figures includea 20% contingency.)

ESTIMATED UTILITIES REQUIREMENTS - EXTRACTION AREA

1. Treated Water

a. Org - Carbonate Mixer Settler - 15 GPH

b. Org - Water Mixer Settler - 15 GPH

Total 30 GPH x 1.2. 36 GPH

2. Deionized Water

a. Digester - 4.00 GPH

b. Top of extraction-scrub column 2.22 GPH

c. Top of compound strip column 23.8 GPH

Total 30.02 x 1.2 36 GPH

3. Steam

a. Water heater 20 lb/hr x 1.2 =

b. Boildown Tank (cake on 25% of 23.8 GPH) $\frac{50}{70}$ x 1.2 84 lb/hr

4. Cooling H_2O

a. Organic cooler 500 #/hr = 60 GPH x 1.2 72 GPH

5. Electricity - approximately 50 HP

50 x 746 = 37.3 x 1.2 45 KWH

(*These figures include a 20% contingency)

ESTIMATED UTILITIES REQUIREMENTS
THORIUM FLUORIDE PREPARATION

1. Treated Water

a. water to absorber		10 GPH	
b. Sluicing water for sump clarifier		1 GPH	
	Total	11 x 1.2	13 GPH

2. Deionized Water

a. Dissolving Tank		30 GPH	
b. Filter Wash Water		30 GPH	
c. Sluicing water for filtrate clarifier		1 GPH	
	Total	61 x 1.2	73 GPH

3. Steam

a. Solution heating tank		25 #/hr	
b. AHF vaporizer		8 #/hr	
c. Drier Air preheater		19 #/hr.	
	Total 52 #/hr x 1.2		. 63 #/hr

4. Cooling Water

a. Precipitation tanks		670 GPH	
	Total 670 x 1.2		800 GPH

5. Electricity

a. Approximately 60 hp		
60 x 0.746 x 1.2	54 KW-h	
b. Drier heater 30 KW-h		
30 x 1.2	36	
	Total 90 KW-h	90 KWH

*These figures include a 20% contingency -

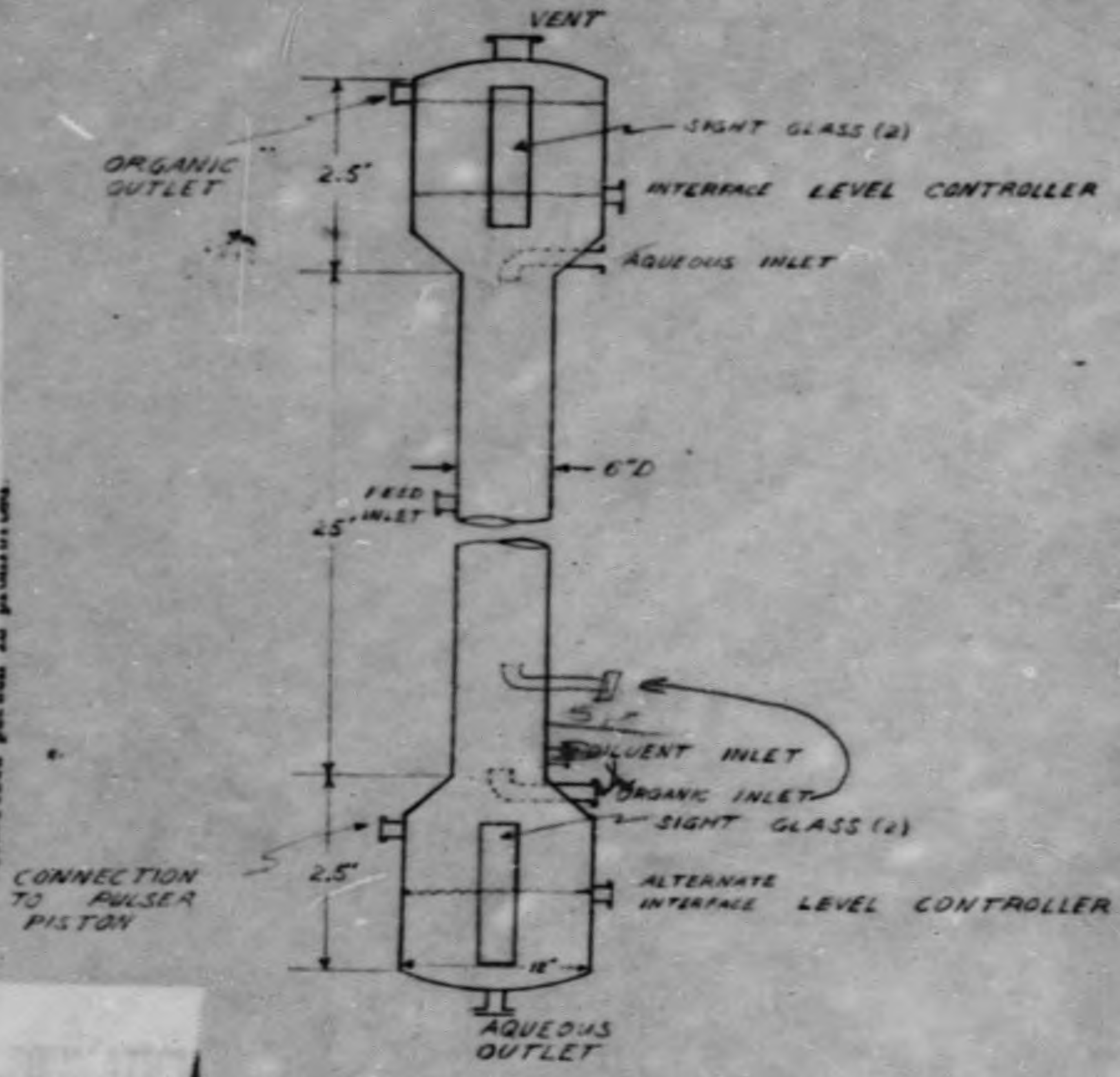
CHEMICAL AND UTILITY COSTS

EXTRACTION AREA

	Unit	Units/Day	Cost, $/Unit	$/Day
CHEMICAL COSTS:				
Sodium Carbonate	lb.	40	.013	.52
Diluent	lb.	72	.077	5.53
Solvent	lb.	8.3	.635	5.26
Nitric Acid	lb.	240	.035	8.40
TOTAL CHEMICAL COSTS:				$19.71
UTILITY COSTS:				
Cooling Water	1000 gal.	1.730	.03	.05
Treated Water	1000 gal.	.865	.08	.07
Deionized Water	1000 gal.	.865	.15	.13
Steam	1000 lb.	2.02	.73	1.47
Electricity	KWH	1080	.01	10.80
TOTAL UTILITY COSTS:				$12.52

Dwg. #1

EXTRACTION - SCRUB COLUMN, D42-7
and COMPOUND STRIP COLUMN, D42-8



ccco #416

REVISIONS		
NO.	DATE	APPROVED

CATALYTIC CONSTRUCTION CO.
PHILADELPHIA, PA.

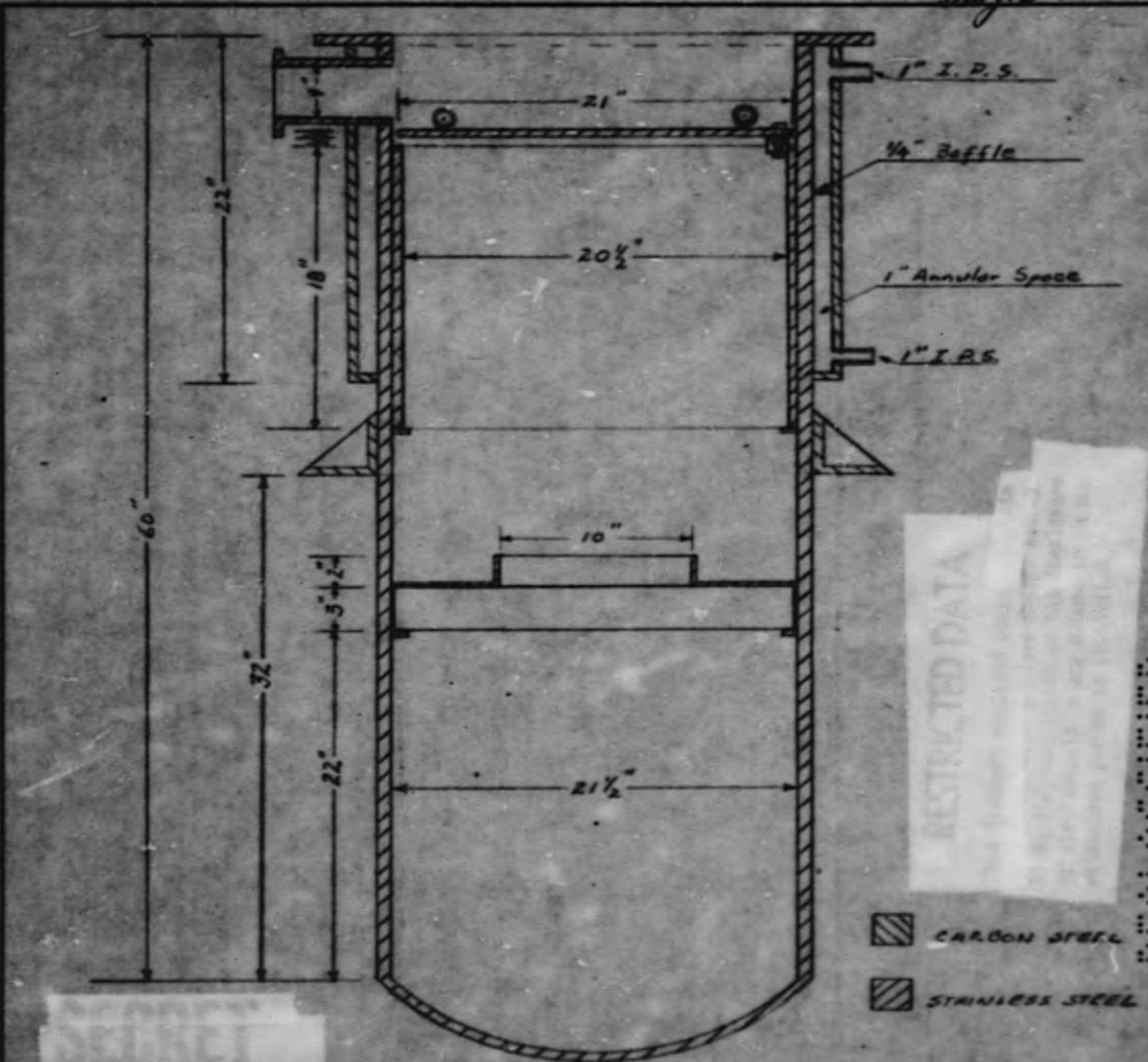
ENGINEERING DEPT. STANDARD

THORIUM SEMI-WORKS PLANT - FMPC
SOLVENT EXTRACTION AREA

MADE BY		DATE	1-25-52
CHK'D BY		DWG. NO.	
APP'D		SK-3542-H-50-D-2	

FORM CO-104

Dwg. # 2



SECRET

CCCA #406

REVISIONS		
NO.	DATE	APPROVED

CATALYTIC CONSTRUCTION CO.
PHILADELPHIA, PA.

ENGINEERING DEPT. STANDARD

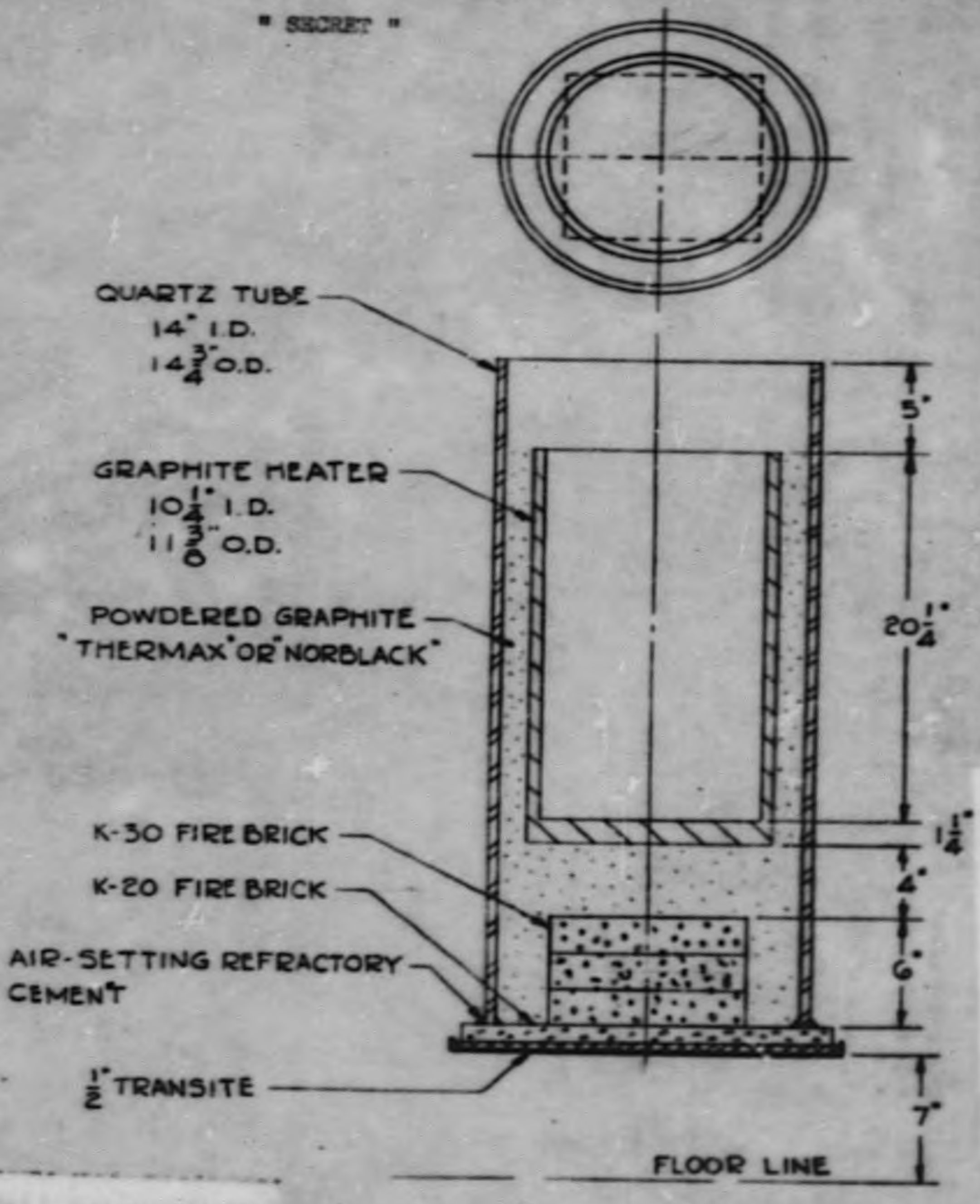
RETORT - CALCIUM DISTILLATION

JOB No. 3520 ITEM 242-506

MADE BY	BJR	DATE	1/24/52
CHK'D BY		DWG. NO.	SK-3542-H-50-D-1
APP'D			

FORM CC-104

" SECRET "



REVISIONS		
NO.	DATE	APPROVED

CATALYTIC CONSTRUCTION CO.
PHILADELPHIA, PA.

ENGINEERING DEPT. STANDARD

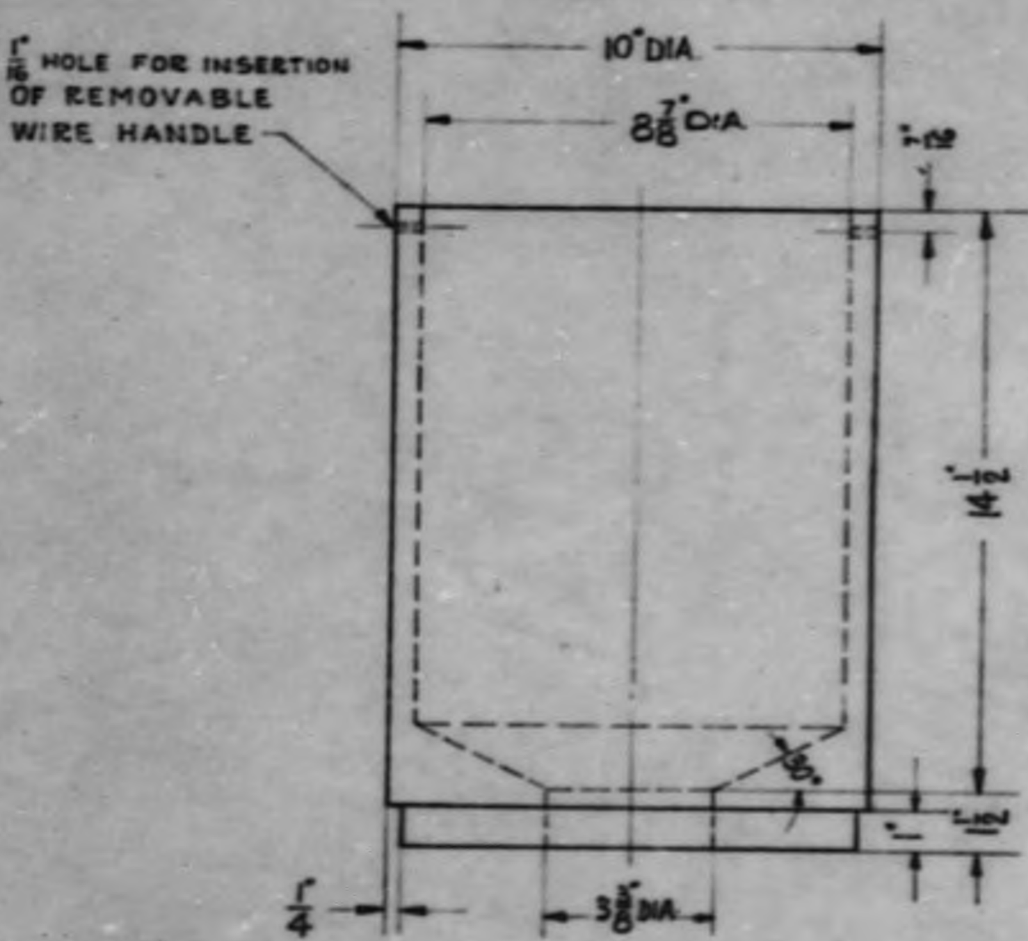
FIG. 7. GRAPHITE HEATER ASSY FOR CRUCIBLES

MADE BY	H. HECK.	DATE	11-1-51
CHK'D BY	[illegible]	DWG. No.	SK3500-G-08-D
APP'D.	[illegible]		

" SECRET "

FORM CC-104

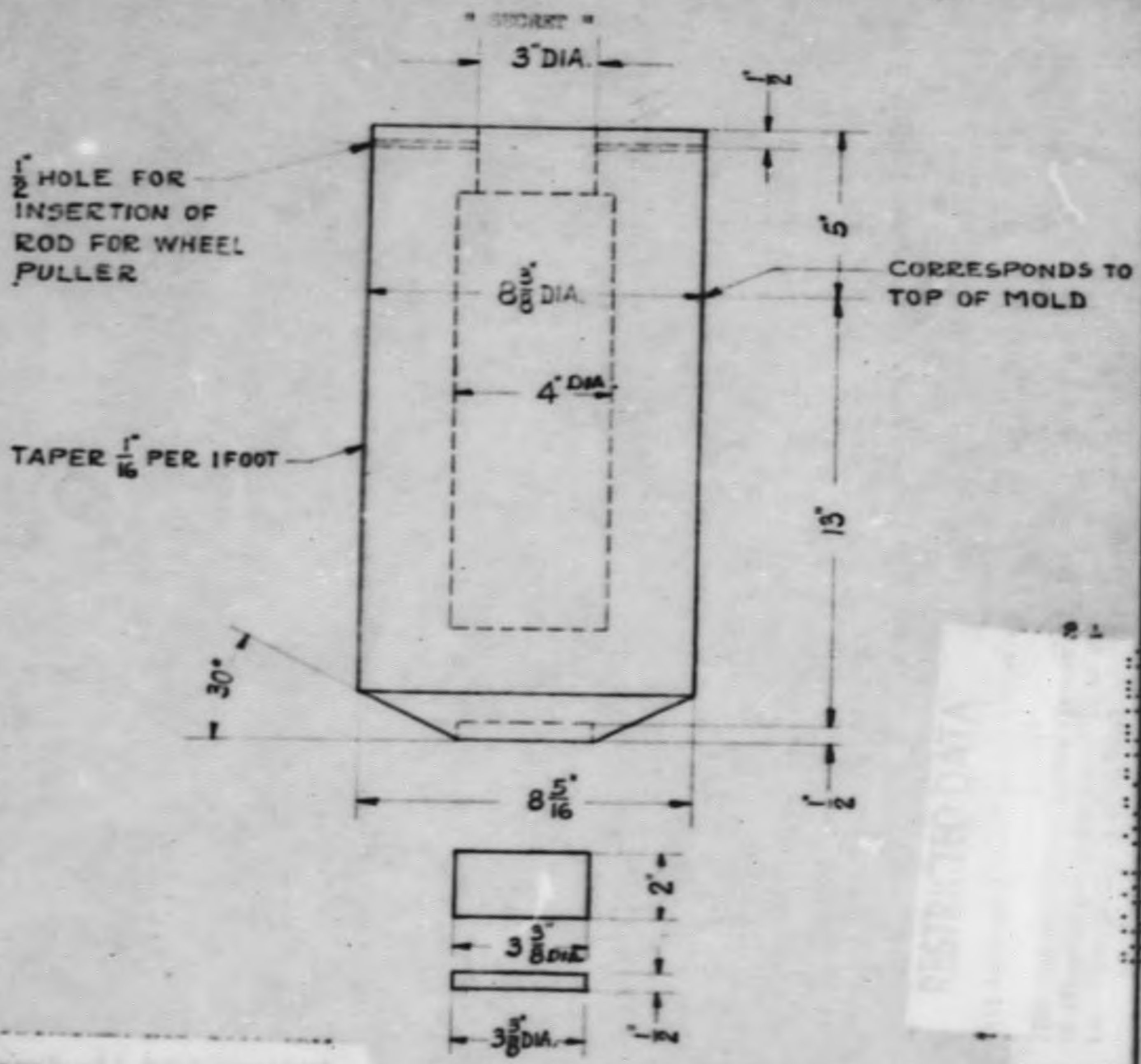
Dwg. #4



REVISIONS			CATALYTIC CONSTRUCTION CO. PHILADELPHIA PA.			
NO.	DATE	APPROVED	ENGINEERING DEPT. STANDARD			
			FIG 8. GRAPHITE MOLD FOR FORMING CRUCIBLES			
			MADE BY	V. GRUZDYS	DATE	11-1-51
			CHK'D BY		DWG. NO.	SK3500-G-09-D
			APP'D			

FORM CD-104

Dwg #5



REVISIONS		
NO.	DATE	APPROVED

CATALYTIC CONSTRUCTION CO.
PHILADELPHIA, PA.

ENGINEERING DEPT. STANDARD

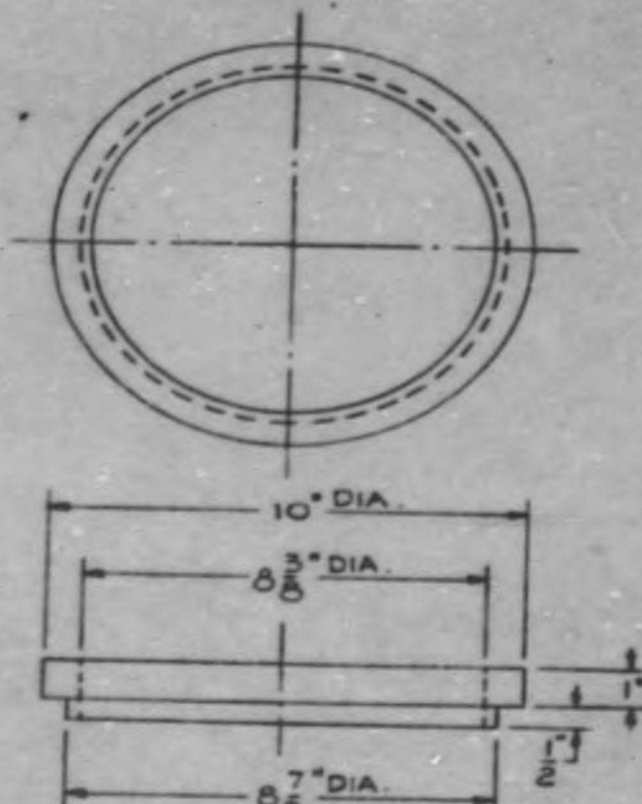
FIG. 9. GRAPHITE MANDREL FOR CRUCIBLES

MADE BY	V. GRUZDYS	DATE	11.1.51
CHK'D BY		DWG. NO.	SK 3500-G-10-D
APP'D			

FORM CC-104

Dwg #6

" SECRET "



RESTRICTED DATA

REVISIONS		
NO.	DATE	APPROVED

CATALYTIC CONSTRUCTION CO.
PHILADELPHIA, PA.

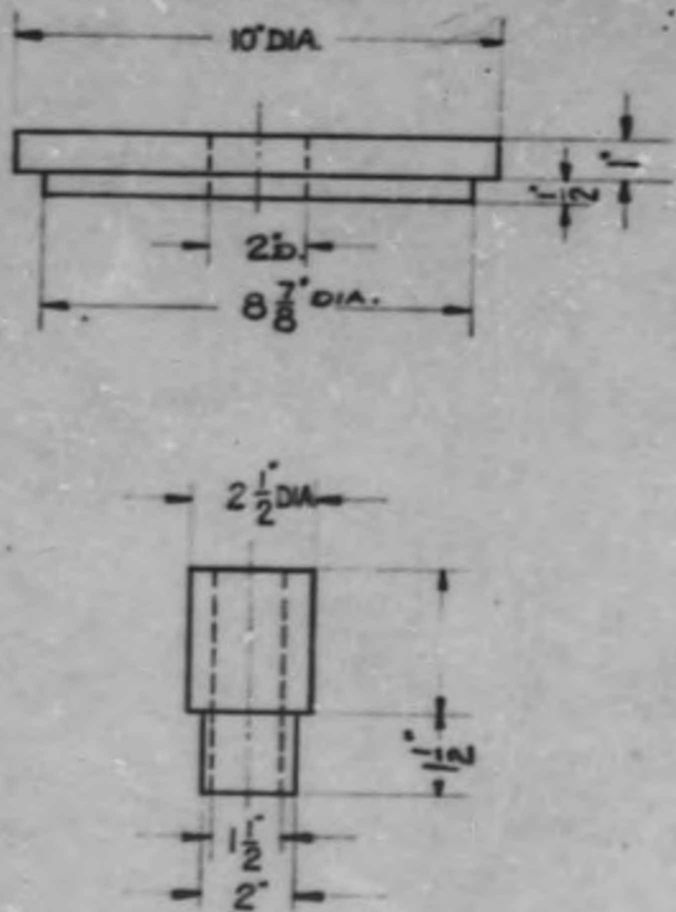
ENGINEERING DEPT. STANDARD

FIG. 10. RETAINER RING FOR CENTERING MANDREL

MADE BY	H. HECK.	DATE	11-1-51
CHK'D BY		DWG. NO.	SK 3500-G-11-D
APP'D			

FORM CC-104

Pag 17



FORM CC-104

REVISIONS		
NO.	DATE	APPROVED

CATALYTIC CONSTRUCTION CO.
PHILADELPHIA, PA.

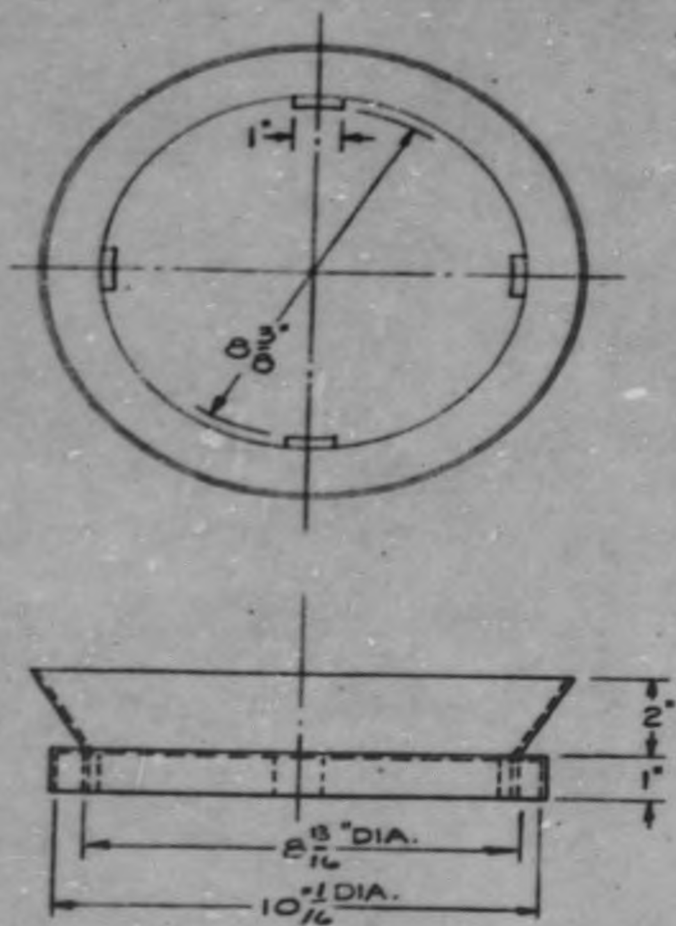
ENGINEERING DEPT. STANDARD

FIG. 12. GRAPHITE LID AND CHIMNEY

MADE BY	V. GRUZDYS	DATE	11-1-51
CHK'D BY		DWG. NO.	SK 3500-G-13-D
APP'D			

Dwg. #8

" SECRET "



RESTRICTED DATA

REVISIONS		
NO.	DATE	APPROVED

CATALYTIC CONSTRUCTION CO.
PHILADELPHIA, PA.

ENGINEERING DEPT. STANDARD

FIG. 11. FUNNEL FOR CENTER MANDREL AND MOLD

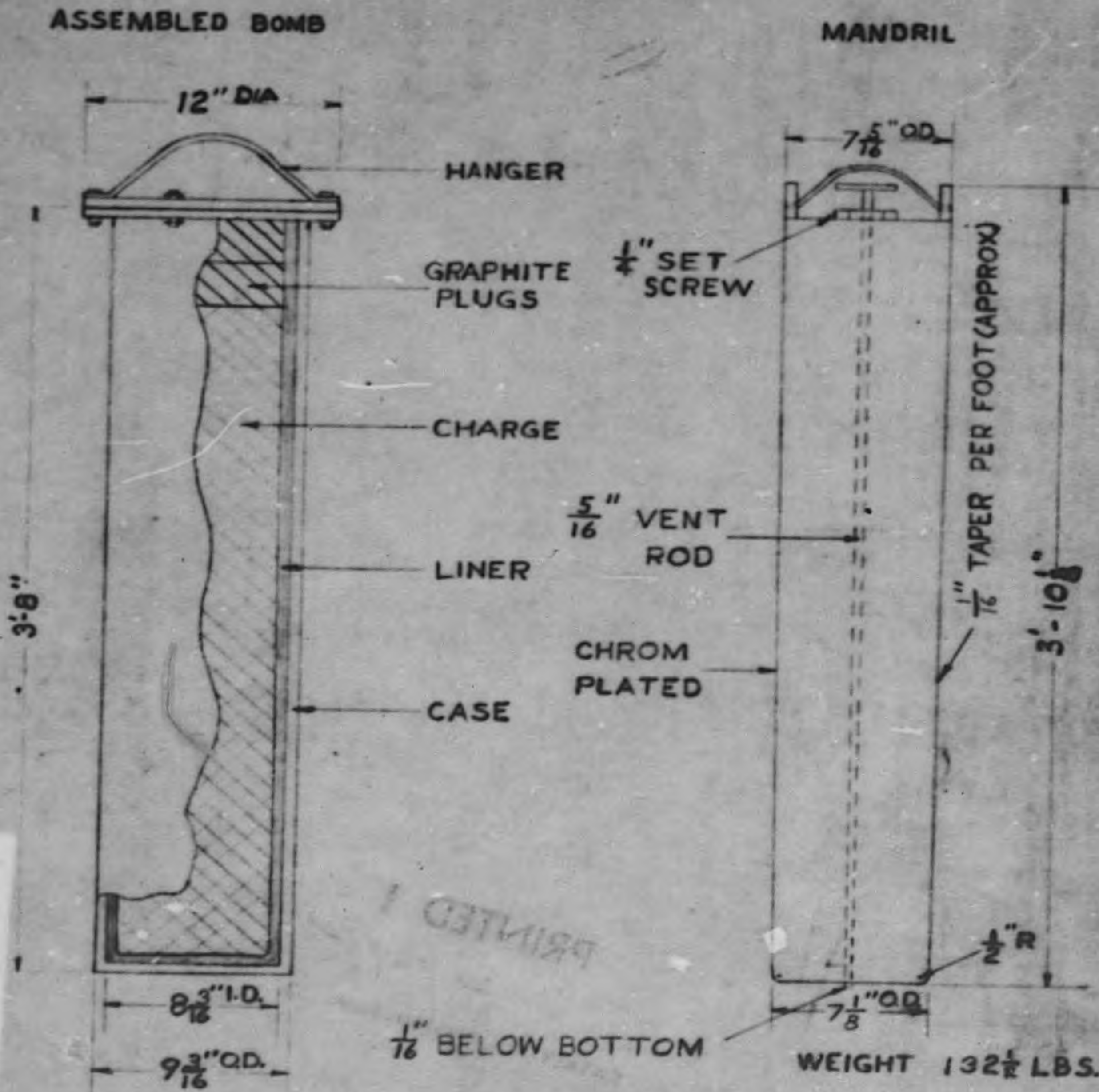
MADE BY	H. HECK.	DATE	11-1-51
CHK'D BY	[illegible]	DWG. NO.	SK3500-G-12-D
APP'D	[illegible]		

" SECRET "

FORM CO-104

Dwg #9

"SECRET"



REVISIONS			CATALYTIC CONSTRUCTION CO. PHILADELPHIA, PA.
NO.	DATE	APPROVED	ENGINEERING DEPT. STANDARD
			FIG. - 3 REDUCTION EQUIPMENT
			MADE BY: K. HAHN — DATE: 11-17-51
			CHK'D BY: C. EDWARD — DWG. NO.: SK 3500-6-19-D
			APP'D: [illegible]

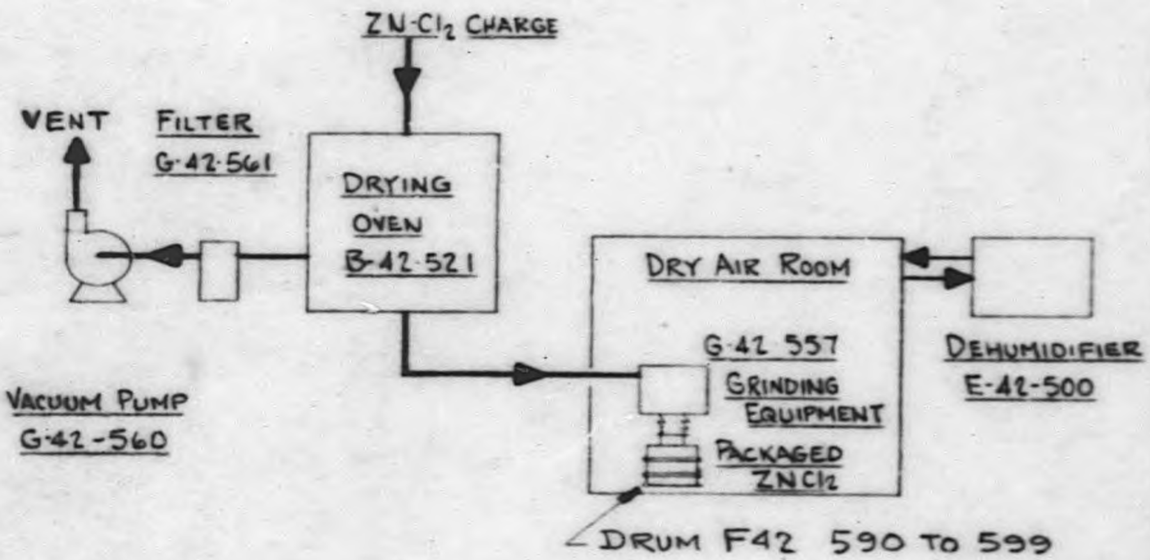
"SECRET"

FORM 00-104


3542-H-02-F
CHARGE HOPPER F42-1
TO DUST-COLLECTOR
G42-1
CHUTE
ORE DRUM
DIGESTER D42-3
DIGESTER D42-4
G42-8
G42-9
DEIONIZED WATER
DILUTE HNO3 HEAD TANK
F42-6
HNO3
G42-3
G42-4
SOLVENT F42-7 STORAGE
DILUENT F42-8 STORAGE
SOLVENT DRUM
DILUENT DRUM
G42-10
G42-11
SOLVENT FEED TANK F42-9
G42-21
G42-22 (SPARE)
MIXER SETTLER D42-5
MIXER SETTLER D42-6
Na_2CO_3 SOLUTION TANK F42-10
G42-12
TREATED WATER
STEAM
D13-18 DILUENT FRACTIONATOR
EXTRACTION SCRUBBER D42-7
E42-11
COMPOUND STRIPPER D42-8
G42-15
G42-16
RAFFINATE TANK F42-11
G42-18
BOIL DOWN TANK
STEAM
PAIL
THORIUM NITRATE HOLD TANK F42-5
THORIUM NITRATE HOLD TANK F42-13
TO PRECIPITATION D42-108
G42-19
G42-26 (SPARE)
TO SUMP F42-200
FROM F 42-200
SUMP LIQUOR F42-14 COLLECTION TANK
TBP TO DRUM
TO D42-200
PROCESS FLOW DIAGRAM
SOLVENT EXTRACTION AREA FOR
THORIUM SEMI WORKS PLANT
DATE: 1-31-52
SCALE-NONE
DRAWN BY A. KLINGBERG
CHECKED BY
OFFICE OF CATALYTIC CONSTR. CO. 1528 WALNUT ST. PHILA. 2, PA.
PRELIMINARY
DRAWING NO. 3542-H-02-F
APPROVED
REVISION NO.
11" x 55"

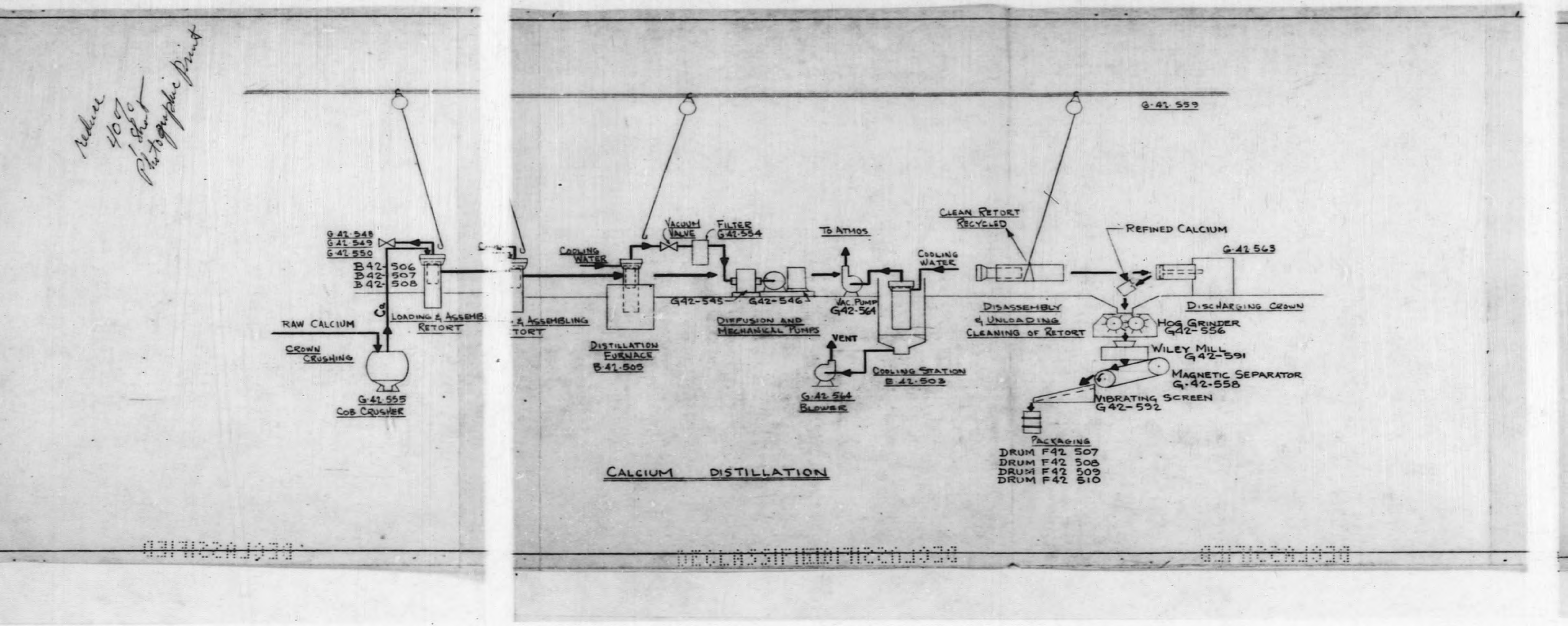
3542-H-04-F

Photographic Print



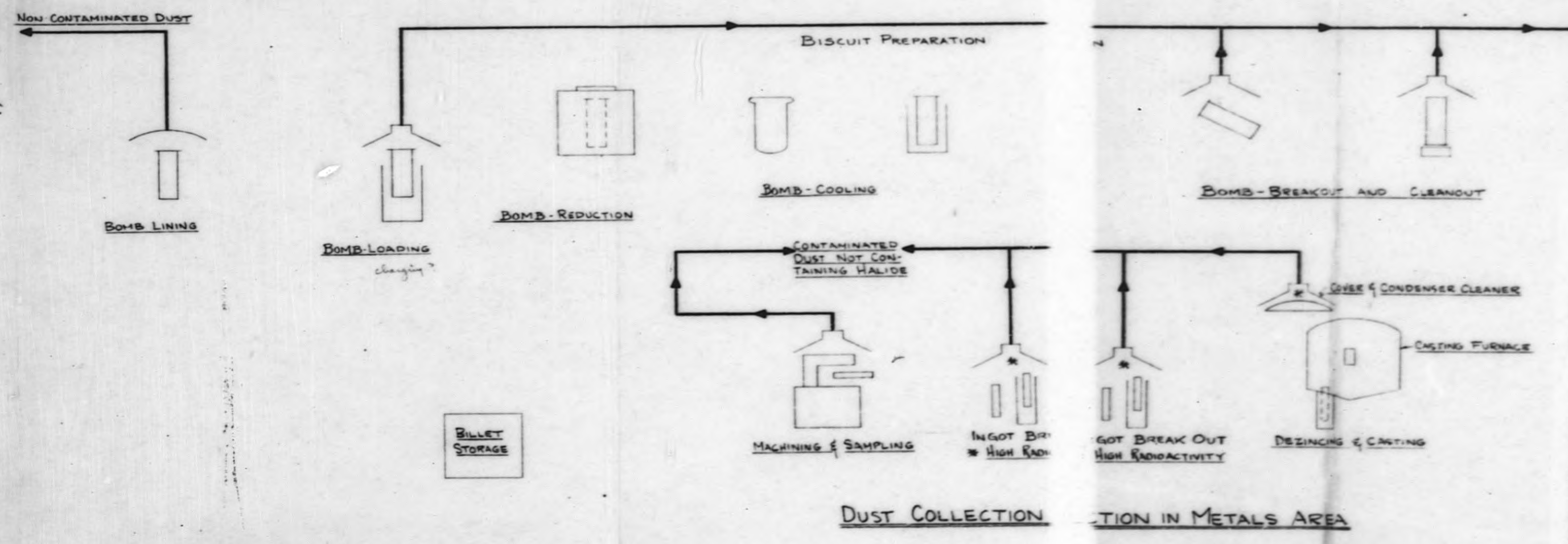
ZINC CHLORIDE DRYING


Photographic Print
Reduce 55% 1 shot
Reduce 55% 1 shot
Beryllium Oxide Crucible Preparation Area
Note:
Forms other than crucibles can be made in the same equipment, except for the graphite molds.
To Atmos
Dust Collection D-42-300
G-42-302
P-42-500
Scale K-42-300
Scale K-42-301
BeO
Beryllium Oxide
Drum Receipt
G-42-300 Screening
Foreign particles to waste
Blending G42-304
Drum Storage F-42-300
-500
Blending -42-304
Frequency Converter
P-42-301
Crucible Preparation
Jolter G-42-301
Molding Asse'y F-42-301 F-42-302 F-42-303
Firing B-42-300-Furnace
F-42-306 F-42-307 F-42-308 Firing Asse'y
P-42-302
Air Cooling
P-42-303
BeO + H_2O Crack Repair
Inspection & Repairing
J-42-300 J-42-301 Tables
B-42-303 Firing (Furnace Cooling)
Crucible
To casting or storage
DECLASSIFIED



reduce 40% 1 Sheet Photographic Print
G-42-559
G-42-548
G-42-549
G-42-550
B42-506
B42-507
B42-508
Ca
LOADING & ASSEMBLING RETORT
RAW CALCIUM
CROWN CRUSHING
G-42-555
COB CRUSHER
COOLING WATER
DISTILLATION FURNACE
B-42-505
VACUUM VALVE
FILTER G-42-554
G42-545
G42-546
DIFFUSION AND MECHANICAL PUMPS
TO ATMOS
VAC. PUMP G42-564
VENT
G-42-564
BLOWER
COOLING WATER
COOLING STATION
B-42-503
CLEAN RETORT RECYCLED
DISASSEMBLY & UNLOADING
CLEANING OF RETORT
REFINED CALCIUM
G-42-563
DISCHARGING CROWN
HOG GRINDER G42-556
WILEY MILL G42-591
MAGNETIC SEPARATOR G-42-558
VIBRATING SCREEN G42-592
PACKAGING
DRUM F42 507
DRUM F42 508
DRUM F42 509
DRUM F42 510
CALCIUM DISTILLATION

Dwg #12



Dust Collection ... ction in Metals Area

reduce 60% 1 that Photographic Print

3.				
2.				
1.				
Rev. No.	Date	Revision	Made By	Appr'd

Approved for A.E.C. by
Date

United States Atomic Energy Comm.
New York Operations Office
Contract No AT-(30-1)-1060
Feed Materials Production Center
Fernald Area

Process Flow Diagram
Thorium Semi-Works Reduction Plant
Accessories

Print Record

Date	Stage	No. Prts.

Date: 1-31-52
Scale: None
Drawn: W.A. Wright
Checked:

Office of
Catalytic Constr. Co.
1528 Walnut St.
Phila. 2, Pa.

Approved

Preliminary

Dwg. No
3542-H-04-F

Revision No

11 x 108"

60% reduction
Photographic Print
THORIUM TETRAFLUORIDE PREPARATION AREA
AQUEOUS FEED
DEIONIZED WATER
COOLING WATER
BOMB PREPARATION
BOMB REDUCTION
BILLET FINISHING
TURNINGS RECOVERY
STEAM
WATER
WATER WASH
CENTRIFUGE
G42-569
PANS.G42-576,577,578
OVEN
B42-522
PAN F42
PROCESS FLOW DIAGRAM
PREPARATION — REDUCTION & FINISHING
OF THORIUM METAL IN SEMI-WKS REDUCTION PLANT
DATE
1-31-52
SCALE- NONE
DRAWN BY:-
Broughton
CHECKED BY
OFFICE OF
CATALYTIC CONSTR. CO
1528 WALNUT ST
PHILA, 2, PA
PRELIMINARY
DRAWING NO
3542-H-03-F
APPROVED;
REVISION NO
DECLASSIFIED

END