Rogers

GEOHERMAL PROJECT DATA

AND

PERSONNEL RESUMES

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GEOHERMAL RESOURCES DEVELOPMENT AND ENERGY UTILIZATION

INTRODUCTION

Rogers Engineering Co., Inc. is one of the original engineering companies in the United States to become involved in geothermal well testing and design of geothermal power plants.

Rogers geothermal energy development activities began almost twenty years ago with flow testing of the O'Neill well in Imperial Valley, California and well tests at Tiwi in the Philippines; a geothermal project for the Commission on Volcanology, Republic of the Philippines, and preparation of a feasibility study on the use of geothermal hot water for electric power generation at Casa Diablo, a geothermal area near Mammoth.

Development of geothermal power proper in the United States began in 1960. In september of that year Pacific Gas and Electric Company started the first unit of 11,000 kW, at the Geysers in Sonoma County, California.

The Geysers operation continues to be the principal geothermal power development source in the United States. Rogers is proud of its association with this development. Rogers designed the foundations, structures, and turbine building for Units 5 and 6, the first 110,000 kW power plants, and was subsequently given responsibility for the complete engineering design package for Units 7 and 8, also of 110,000 kW capacity.

Rogers was retained by Magma Energy, Inc., to prepare the original engineering feasibility study on the binary fluid cycle power plant, called the Magmamax Process. This process utilizes the heat from geothermal hot water, by heat exchange with a clean secondary fluid, which generates electric power through a gas expander turbine-generator in a Rankine Cycle. This method is especially well suited for those conditions in which the geothermal hot water is chemically and thermally unsuited for flashing to steam, for conventional steam turbo-generator installations.

Based on the results of Rogers' feasibility report of the Magmamax Process, San Diego Gas and Electric Co. joined forces with Magma Energy, Inc. to build a 10,000 kW prototype plant in the Imperial Valley, in the vicinity of Heber, California.

The United Nations engaged Rogers to make a feasibility study on the application of the Magmamax Process to generation of electric power at Kizildere, Turkey. At Kizildere the wells produce very large quantities of high temperature water, but the chemical composition of the water is such that the wells seal off from calcite deposits, in less than a month.

Rogers

One of the major problems with these calciting wells is to bring the water to the surface in usable and non-scaling condition. Rogers has researched this very serious problem and has arrived at a process, which it is believed, will effectively solve the problem. International Patent applications have been filed with respect to this process.

Rogers was retained by Watase, Inc. to evaluate Mr. A. T. Van Huisen's patented concept of a downhole heat exchanger for extraction of geothermal heat from those areas, containing motive fluid or geothermal fluids, which by composition would be better left in the ground, to preclude excessive corrosion, erosion or environmental pollution.

Additionally, Rogers has engaged in the following geothermal projects:

Prepared design, equipment specifications and evaluated bids on the major equipment for two 50,000 kW, geothermal double flash steam power generating units for the National Power Corporation of the Philippines.

Planned and organized a drilling program and completed the successful management of the drilling of a deep geothermal research well in Marysville, Montana sponsored by the National Science Foundation.

Selected as A/E by the Atomic Energy Commission to work with Lawrence Berkeley Laboratories in the design of an experimental 10 MW binary fluid cycle geothermal power generation facility for north central Nevada.

Evaluated and prepared budget estimates for a confidential client for a proposed 50 MW geothermal generating plant to be located in the United States.

Continuing engineering services to the Pacific Gas and Electric Company on their Geysers geothermal power plant facilities including the engineering of hydrogen sulfide abatement facilities for these plants.

Contracted to provide engineering consulting services to Arizona Public Services Co., Geothermal Kinetics Systems, Inc., Utah Power and Light Co., Geo-Energy Systems, Inc., and the U. S. Atomic Energy Commission.

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Through research and development activities, industrial experience, and participation in the geothermal community, Rogers has developed the breadth of expertise to fulfill the requirements of any geothermal project.

Following are brief write-ups of recent geothermal resources development and power plant consulting engineering projects undertaken by Rogers in the United States and abroad:

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GEOTHERMAL RESOURCES DEVELOPMENT

Project: HGP-A WELL REPAIR AND RECOMPLETION

The University of Hawaii's discovery well, the facility planned for the Wellhead Generator Proof of Feasibility Project, experienced an incipient failure, evidenced by upward migration of hot geothermal fluids outside the casing. The well repair and recompletion project was carried out prior to final design of the Wellhead Generator. This included testing to identify the problem, perforation of the casing, squeezing new cement to cure cement voids, cutting and pulling original slotted liner, and cementing new 7-inch casing to surface inside 9-5/8 inch casing.

Location: Puna District, Island of Hawaii

Construction Cost: US \$710,000

Completed: October 1979. New flow tests were then run, which formed the basis of final design for the Wellhead Generator.

Services: Drilling consultant to the Project; prepared the specifications for the workover and recompletion contract, and provided regular consultation during the operations; managed the flash separator flow tests.

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GEOHERMAL RESOURCES DEVELOPMENT

Project: HGP-A WELLHEAD GENERATOR PROOF OF FEASIBILITY PROJECT

A 3 MW plant with single flash steam system. Totally enclosed plant building integrated with a visitors' center, within a fully developed site.

Location: Puna District, Island of Hawaii

Construction Cost: US \$8,000,000

Completed: Schedule completion August 1980. (This plant was officially dedicated, July 17, 1981 and is currently delivering energy to HELCO Power System in Hawaii. HELCO is operating this plant for the University of Hawaii)

Services: Concept studies, preliminary design, final design, procurement and construction management.

Associated Firms: Hirai & Associates, Hilo, Hawaii

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GEOHERMAL RESOURCES DEVELOPMENT

Project: BRAWLEY GEOTHERMAL PLANT

A 10 MW plant incorporating Union Oil Company's flash steam system

Location: Brawley, California

Owner: Southern California Edison

Construction Cost: US \$10,000,000

Completion: Scheduled completion December 1979.
(This plant is in successful operation and was officially turned over to SCE, July 29, 1980)

Services: Feasibility studies, preliminary design, final design, equipment procurement, and construction management.

Associated Firms: Union Oil Co., Project Manager for SCE

Rogers

GEOHERMAL RESOURCES DEVELOPMENT

Project: COSTA RICA GEOTHERMAL DEVELOPMENT
AND UTILIZATION PROGRAM

Program management and technical assistance to I. C. E. for the development and utilization of geothermal resources in the Guanacaste Region of Costa Rica in conjunction with consultants engaged for the program by ROGERS. Work has included:

Phase I: Exploration
Phase II: Exploratory Drilling,
well testing, reservoir
evaluation, and feasibility
report

Location: Guanacaste Region, Costa Rica

**Phased
Program:** Phase I: 90% Costa Rica
10% ROGERS San Francisco Office
Phase II: 90% Costa Rica
10% ROGERS San Francisco Office

Client: Instituto Costarricense de Electricidad

**Construction
Cost:** Phase I: NIL
Phase II: \$4,500,000

Completed: Phase I: Exploration, 100%.
Phase II: Complete, except for
pending modification of
Feasibility Report

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GEOHERMAL RESOURCES DEVELOPMENT

Project: MARYSVILLE GEOTHERMAL PROJECT

Management of the drilling program for a deep research well into a zone of abnormally high heat flow near Marysville, Montana, for a potential "hot dry rock" experiment. The site work included: preparation of site plans and specifications, selection of a construction contractor, and supervision of site construction. Following preparation of drilling specifications, selection of drilling contractor, and procurement of all drilling materials, and services; on-site management was provided for the entire drilling and coring program. The well was drilled to 6,790 feet into a granite intrusive.

Location: Marysville, Montana

Construction Cost: \$1,300,000

Client: National Science Foundation (with Battelle Pacific Northwest Laboratories functioning as prime contractor)

Completed: July 1975

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GEOHERMAL RESOURCES DEVELOPMENT

Project: KRAFLA GEOTHERMAL PLANT

A 60 MW plant (two 30 MW units utilizing the double flash steam system). Total enclosed plant designed for extreme climate and seismic conditions. International procurement of materials. Supervision of construction, training of operating personnel, and start-up.

Location: Krafla, Iceland

Construction Cost: \$30,000,000

Completed: December 1976

Services: Feasibility studies, preliminary design, final design, procurement and construction management, training and start-up.

Associated Firms: Thoroddsen and Partners, Reykyavik, Iceland for civil work only

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GEOHERMAL PROJECT FINANCING

Project: Resource Exploration, Management
and Construction of Geothermal
Power Plants

Developed plan and financial pack-
age with foreign governments and
banks to undertake total develop-
ment from exploration of known
geothermal area to electric power
on-line to serve their utility
grid.

Location: Far East

Client: Confidential

Completed: 1980

Services: Provide plan, cost estimates and
develop financing from governments
and banks to carry out the energy
development reports, documents and
proposals.

Rogers

GEOTHERMAL CONSULTING SERVICES

Project: Geothermal Resource Supplier and Utility Relations and Exploration

Assist foreign electric utility understand how geothermal resource suppliers relate to electric utilities in the United States. Review and comment on geothermal exploration program at specific sites in foreign country.

Location: Far East

Client: Foreign Utility (confidential)

Complete: 1980

Services: Preparation of reports, economics and exploration plans. Determination of types of geothermal resource sales contracts and evaluation of proper electric energy sales price from geothermal power facilities.

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GEOHERMAL POWER PLANT

Project: 50 MW Geothermal Power Plant

Power plant optimization with resource characteristics and preliminary design of power plant. Determination of costs of geothermal electric power plants against other plant costs. Power plant utilized steam provided from flashed geothermal resource.

Location: Milford, Utah

Client: Utah Power and Light Company

Complete: 1976

Services: Preliminary design and optimization study and report

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GEOHERMAL POWER PLANT

Project: 50 MW Geothermal Power Plant

Preliminary design and construction cost estimates for facility on hydrothermal resource. Determine financing packages and ownership alternatives for power plant and gathering and injection system to have geothermal electric power be competitive with other area electric power costs.

Location: Western United States

Client: Resource Producer and Local Utility

Complete: 1978

Services: Preliminary design and cost estimate. Development of cost of electricity under different financing plans. Development of contracts for sale of geothermal resource and electric power from project. Reports and documents.

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PROJECT: IRANIAN GEOTHERMAL SURVEY

Upon completion of resource exploration which is currently in progress and successful evaluation of the resource, a geothermal power plant of undetermined capacity will be constructed.

Location: Northwestern Iran, Sabalan-Sahand-Damavand-Khoy-Maku

Owner: Imperial Government of Iran
Ministry of Energy

Project Cost: US \$14-17,000,000

Completion: Operations were suspended as of May 1979 owing to Iran's internal disruption.

Services: Resource exploration including geology, geohydrology and geochemistry. The project should proceed through drilling and testing exploratory wells, reservoir assessment, feasibility study, design and construction.

Associated Firm: GeothermEx, Berkeley, California, USA

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GEOHERMAL RESOURCE DEVELOPMENT

Project: PHILIPPINES GEOTHERMAL POWER PLANT

Two 100 megawatt power plants with two 50 MW units in each one, powered by steam obtained from hot water piped from the wells. A double-flash system is utilized with dual inlets to the turbines.

Locations: Tiwi, and Los Banos, Philippines

Owner: National Power Corporation
Manila, Republic of the Philippines

Construction Cost: US \$66,000,000

Completed: 1977

Services: Feasibility studies, preliminary design for both power plants, final civil/structural design, procurement of major equipment, construction supervision (Los Banos plant only)

Associated Firms: Mitsubishi Heavy Industries
Nagasaki, Japan

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GEOTHERMAL RESOURCES DEVELOPMENT

Project: UNITS 7 AND 8, GEYSERS GEOTHERMAL PLANT

A 110 megawatt power plant utilizing two 55 MW units powered by natural steam piped directly from the wells.

Location: The Geysers, California, USA

Owner: Pacific Gas Electric Co.
San Francisco, California, USA

Construction Cost: US \$12,000,000

Completed: 1970

Services: Prepared design and construction drawings for the complete plant. Assisted with construction supervision.

Associated Firm: None

CORPORATE ORGANIZATION CHART

NOTES:

- (1) CHAIRMAN ENGINEERING REVIEW BOARD.
- (2) MEMBER ENGINEERING REVIEW BOARD.
- (3) ENGINEERS, DESIGNERS, DRAFTSMEN AND CONSTRUCTION MANAGERS ARE ASSIGNED TO PROJECTS BY THE MANAGER OF DEPARTMENTS AND THE RESPECTIVE DEPARTMENT CHIEFS.

ROGERS ENGINEERING CO., INC.
ENGINEERS ARCHITECTS

APPROVED BY *HR*

DATE JAN. '82

Rogers

HERBERT ROGERS, JR.

POSITION

Chairman of the Board and President

EXPERIENCE

Mr. Rogers, as President, is responsible for overall administration of both the overseas and domestic operations for Rogers Engineering Co., Inc. In this capacity, he actively supervises the planning of projects, with particular attention to contract negotiations and project financing arrangements with financial institutions, both local and international.

Since founding his firm in 1946, Mr. Rogers has maintained a keen interest in the solution of special problems and new technology areas where the state-of-the-art is not yet clearly defined or well developed. This has resulted in the growth of a nucleus of highly skilled and creative engineers within the firm, which has been responsible for the successful completion of a number of unusual projects.

ROGERS entered the geothermal resource field in 1961, when it was in its infancy and sophisticated methods of utilization were being developed. Some nineteen years later, ROGERS has participated in, and is continuing in, the development and utilization of geothermal resources at locations in the United States, Iceland, Costa Rica, Iran, Turkey, the Republic of the Philippines and Hawaii.

By the end of 1980, ROGERS had participated in the engineering of over one-third of the capacity of the world's geothermal-electric generating plants. ROGERS engineers have developed a system for controlling the deposition of solids from highly mineralized geothermal fluids. This research resulted in U. S. Patent No. 3,782,468, "Geothermal Hot Water Recovery Process and System".

Mr. Rogers participated in the preparation of a portion of the Hickel Geothermal Report as Co-Chairman of the Geothermal Utilization Panel. He is a former member of the Board of Directors of the Geothermal Resources Council.

Under the direction of Mr. Rogers, the firm has successfully completed a diversity of projects for major industrial firms on the West Coast, all branches of the armed forces, U. S. Government Agencies, and the governments of the Philippines, Thailand, and Guam.

Rogers

HERBERT ROGERS, JR. (Page 2)

EXPERIENCE

Power systems projects, under Mr. Roger's direction, have included design and supervision of the installation for geothermal, thermal-electric, diesel-electric and hydroelectric generating plants, both in the United States and overseas. The engineering of the associated electrical transmission and distribution systems has also been a major part of the firm's operations, including the design of several hundred step-down substations ranging in voltage from 220 kV to 4.16 kV.

Rogers Engineering, under the supervision of Mr. Rogers, has actively participated in the engineering design for petroleum and chemical processing facilities; and also for bulk handling systems for asphalt and petroleum, including military and commercial airport hydrant refueling systems.

EDUCATION

Polytechnic College of Engineering, Bachelor of Science in Electrical Engineering, 1937

REGISTRATION

Registered Electrical Engineer, California

MEMBERSHIPS

The Engineers Club of San Francisco, Institute of Electrical and Electronic Engineers, Illuminating Engineering Society, The World Trade Club, Geothermal Resources Council

Rogers

FRED D. DUNN

POSITION

Vice President

EXPERIENCE

Mr. Dunn has over thirty-five years of experience in all phases of engineering design and project management of electric power, industrial, and process facilities for public utilities, industrial complexes and government installations, in both domestic and international applications.

As a firm principal in charge he has been responsible for the supervision of the preparation of feasibility studies, economic analyses, and conceptual, preliminary, and final design for a multitude of projects in the fields of electric power generation and distribution, steam generation and distribution systems, petroleum products storage and transfer facilities, and miscellaneous chemical process and industrial manufacturing plants.

On electric power generating projects Mr. Dunn has performed as firm principal and/or engineer in charge for preparation of design and construction drawings for (a) four hydroelectric power plants (120 MW each); (b) a major heavy fuel-fired total energy diesel-electric plant (50 MW); (c) several geothermal electric power generating plants including a single wellhead unit (3 MW) in Hawaii, a two unit (30 MW each) 60 MW plant in Iceland, a single unit 10 MW plant in California's Imperial Valley, two 2-unit (55 MW each) 110 MW plants at PGandE's Geysers geothermal power plants in California; and (d) a number of small diesel-electric stations (5 MW +) and standby and emergency power installations for utilities and government installations.

In the geothermal field, Mr. Dunn has been directly involved in the performance of a geothermal well testing and report program for a geothermal well in California's Imperial Valley; preparation of well drilling contracts and procurement of drilling accessories and tools for a well drilling program in the Philippines; preparation of numerous studies and publications on geothermal conversion systems and gathering and injection systems analyses and evaluations; and in development of feasibility studies, preliminary designs and cost estimates for numerous geothermal power generating plants.

Mr. Dunn's background also includes environmental engineering and pollution abatement studies and projects for H₂S abatement at geothermal power plants, solid and gaseous waste incineration, industrial fume control and chemical and industrial waste treatment facilities.

EDUCATION

University of Nevada, Bachelor of Science, Mechanical Engineering

REGISTRATION

Professional Mechanical Engineer, California, Nevada, Arizona and Montana

MEMBERSHIP

Consulting Engineers Association of California

Rogers

WINSTON F. BOTT

POSITION

Project Manager - Well Drilling Advisor

EXPERIENCE

Thirty-two years diversified professional experience with principal emphasis in the energy field starting as a designer with successive assignments as field engineer, construction superintendent, drilling manager, exploration manager and project manager.

In April, 1980, Mr. Bott rejoined the staff of Rogers Engineering Co., Inc. and since then has served as Project Coordinator for the Costa Rica geothermal program. This work included the final reporting of the successful exploration and test well drilling phase, and the preliminary planning and feasibility study for development drilling, gathering system and reinjection well system.

During 1979-80 Mr. Bott served as Project Coordinator on the staff of PB-KBB, Inc., consulting specialists in the field of solution mining and construction of underground storage caverns by the solution-mining process. Mr. Bott coordinated projects including: drilling wells for solution mining of salt in bedded salt and shale formations; hydraulic fracturing of bedded salts; a report detailing the state-of-the-art in the field of feedwater treatment with additives to effect the in-situ (underground) purification of the solution-mined salt product; a proposal to DOE for a research program to develop a variety of stimulation techniques for the in-situ production of natural gas from coal deposits.

During 1977-78 Mr. Bott was designated as Drilling Supervisor for the Instituto Costarricense de Electricidad for their geothermal exploration program. He furnished guidance and advice on drilling specifications, drill site engineering, contractor solicitation and selection, drill rig inspection and mobilization, and contract administration.

In preparation for the first Costa Rica geothermal power plant construction phase, Mr. Bott was Project Manager for the Feasibility Study preparation. This included reservoir evaluation, preliminary design of well field, gathering and injection system, and power plant, as well as evaluation of environmental impact factors.

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WINSTON F. BOTT (Cont'd)

Concurrently with the above assignment during 1977-78 Mr. Bott was Project Manager for geothermal exploration for the Ministry of Energy of Iran. Mr. Bott performed contract administration at the home office and in Iran, and coordinated the work of scientific subcontractors in the fields of geochemistry, geology, volcanology and photo-geology.

Mr. Bott managed the drilling of an exploratory well for the Marysville Geothermal Project, sponsored by the National Science Foundation, which was completed in 1974. On this project, Mr. Bott handled all local, state and federal government agency contracts and supervised drafting of an environmental impact report. He also supervised the preparation of contracts and specifications for the deep-hole drilling and for all site preparation. As drilling manager, he had full charge of drilling strategy and drilling supervision, and administered all contracts.

Mr. Bott has maintained a close contact with the drilling industry through the years as the inventor of a specialized safety device for which he holds a patent, and which is used by major oil well drillers throughout the world.

Prior experience has included: seismic exploration with a major oil company; construction supervision of refinery projects; area engineer on the construction management staff of a nuclear project; and other civil, process, and industrial projects.

EDUCATION

University of Missouri, Bachelor of Science in Civil Engineering
Tau Beta Phi and Phi Kappa Phi Member

REGISTRATION

State of Texas, Civil Engineer
State of California, Civil Engineer

Rogers

H. I. ROGERS

POSITION

Senior Electrical Engineer
Vice President

EXPERIENCE

Mr. Rogers has had extensive experience in the electric utility and computer applications fields. He has professional experience in planning, engineering design, economics, systems analysis, management of projects, and construction management.

Geothermal experience includes: project management, construction management, specifications, design criteria, capital and operating cost determinations, cost of electric power, project financing and overall economic analysis.

Electric Utility experience has been gained in consulting to and being an employee of investor owned, municipal and government owned systems. He has conducted and participated in field investigations, technical studies, and implemented electric system improvements and expansion projects to meet existing and future system load requirements. In planning the system requirements, his experience has included the total utility electrical situation from load development through transmission line design, routing and planning; economic evaluation of generation methods resources to coordinate with load characteristics and demand. Electric utility technical analysis includes: load flow, short circuit, and transient stability studies. Distribution work has been in operations, planning and design.

Economic Study experience includes: power supply contracts, wheeling agreements, rate structures, engineering economic alternatives, generation operating cost alternative comparisons, utility plant appraisal, project capital costs, cost of power and international project financing.

Computer Applications experience includes: system analysis and program writing in electrical and mechanical engineering, economics, business accounting, finance, public utility technical studies and critical path project scheduling.

Legal Research in the utility field relating to administrative and statute law of government power projects, regulatory commissions (FPC, CPUC, CERDC), and contractual regulations. This information was utilized in engineering and economic work.

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H. I. ROGERS (Cont'd)

EDUCATION

Whitman College 1959-62, Walla Walla, Washington
Arizona State University, BSE 1964, Tempe, Arizona
University of Santa Clara, MSEE 1970, Santa Clara, California
Stanford University, 1976, Utility Economics, Stanford, California

REGISTRATION

Professional Electrical Engineer, California

MEMBERSHIP

Institute of Electrical and Electronic Engineers - Power Society
Consulting Engineers Association of California
Geothermal Resources Council

Rogers

BRUCE FRASER

POSITION

Chief, Chemical & Process Department

EXPERIENCE

Mr. Fraser has over forty years experience in all phases of process and power plant design, construction, start-up, production operations, process improvements, and air and water pollution abatement.

He is responsible for process engineering in the design of geothermal power production facilities including standards for well testing and evaluation; heat and materials balance for power cycle diagrams and process flow diagrams; evaluation of turbine condensers and noncondensable gas removal systems; application and evaluation of environment abatement processes applicable to the disposal of geothermal waste water and non-condensable gas including H_2S ; and application of Rogers' process system for handling calcifying geothermal waters.

He is also responsible for evaluation of turbine condenser heat sink systems including: dry cooling systems (radiators), mechanical draft cooling water towers, cooling ponds and canals, river, lake and sea water circulation.

Mr. Fraser provided process engineering services on the Geysers Units 7 and 8 and the Krafla, Iceland 60 MW geothermal power plant. Most recently, he has directed or performed process design for 10 MW and 3 MW geothermal power plants including H_2S abatement for the latter.

His experience in pollution abatement projects includes:

Removal of chlorine, sulfur chlorides and sulphenyl chloride from the exhaust air system of a semi-works fungicide plant and from a similar full-scale fungicide manufacturing facility, plus additional disposal of liquid chlorinated sulfur compounds via dual liquid gas incineration and a flue gas scrubbing unit.

A field survey and plan to handle industrial wastes at Sharpe Army Depot, involving degreasing, chromate stripping and solvent removal units, and a similar, but more comprehensive plan for the Riverbank Army Ammunition Depot including waste water clarification, sludge dewatering and disposal and thermal reduction.

The collection and disposal of relief vent gases from petroleum processing which included a liquid interceptor and vent stack with smokeless flare.

Design of a process to remove H_2S from turbine exhaust steam at PGandE's Geysers' Power Plant.

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BRUCE FRASER (Cont'd)

Mr. Fraser was the technical adviser for a coal gasification conceptual design program for Lawrence Livermore Laboratory (LLL). This project involved process engineering consulting services for optimum system control design to provide maximum safety for equipment and personnel during the operation of LLL's steam/oxygen injection test for in-situ coal gasification experiment at the Hoe Creek, Wyoming test site.

EDUCATION	B. S. in Chemical Engineering, University of California
REGISTRATION	Professional Chemical Engineer, California
MEMBERSHIPS	American Chemical Society Instrument Society of America

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JOHN H. G. STUART

POSITION

Senior Staff
Mechanical Engineer

EXPERIENCE

Mr. Stuart's professional career embraces more than thirty-five years experience in the operation, maintenance and design of geothermal and fossil fuel electric generation plants, marine propulsion equipment and aerospace test facilities.

He was Lead Start Up Engineer and Project Manager for the start up and commissioning of the Brawley 10 MW Geothermal Power Plant (owned by Southern California Edison Co.) in Imperial County, California. He was responsible for the training of the plant operating personnel. He was Lead Start Up Engineer for the HGP-A Geothermal Power Plant in Hawaii.

Mr. Stuart's experience in geothermal power plant design covers the evaluation of conversion of Pacific Gas and Electric Co.'s Unit 1 thru 12 conversion to comply with the California environmental requirements; the bid evaluation for the Heber, Imperial County's 50 MW geothermal power plant (Southern California Edison Co.) turbine-generator and brine flasher units; design of steam flasher test facility in Costa Rica; and Project Manager for the Salton Sea 10 MW geothermal power plant, Feasibility Report (Southern California Edison Co.) in Imperial County, California.

For the Krafla Geothermal Power Plant in Northern Iceland, Mr. Stuart served as project engineer, and in this capacity developed the design and carried it through to completion. His work included preparation of specifications and procurement documents, evaluation of bids, monitoring vendor submittals and progress and providing support to the construction effort, both from the home office and through considerable time spent at the project site. Additionally, Mr. Stuart was in residence at the site throughout the start-up period and made significant contributions to this phase of the project as well as training of the permanent operating staff. The Krafla project consists of two 30 MW steam turbine-generators with turbines of the double flow mixed pressure condensing type.

Mr. Stuart was mechanical discipline engineer for the preliminary design of the Tiwi 110 MW geothermal power plant in the Philippines and was involved in the specification preparation, and bid evaluations covering the main and auxiliary equipment.

Mr. Stuart was chief construction engineer for Food Industries Research and Engineering in charge of construction in California for several firms totaling forty million dollars.

Mr. Stuart was successively senior construction engineer, facility design engineer, supervisor of facility design and construction, and senior research engineer with Lockheed Missile and Space Co., Sunnyvale, California, and was responsible for the design, instal-

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JOHN H. G. STUART (Cont'd)

lation and test of several facilities for aerospace vehicle, ocean vehicle and missile development. Disciplines included selection of specialized materials for high and low temperatures, anti corrosion, anti galling for highly stressed assemblies, and the design to provide vacuum furnaces and ultra clean room conditions for manufacture and test. Test facilities included very high pressure-high flow gas and hydraulic equipment, cryogenic, vacuum, power equipment, and high pressure/temperature deep sea simulator. Project work included development work on DSRV high pressure joints and development work on "clean sweep" oil spill recovery equipment for ocean systems.

Prior to joining Lockheed, Mr. Stuart was technical assistant, mechanical, with Pacific Gas and Electric Co. and was responsible for planning and economic analysis for the turbine-generator and boiler overhaul and maintenance program for the entire Pacific Gas and Electric system of seven million kilowatts installed capacity.

His experience includes service with the Calcutta Electric Supply Corp. in India as boiler and turbine house superintendent in three steam-electric power plants where he was responsible for operation, maintenance and construction for over five years.

Mr. Stuart's professional career included seven years service in the Royal Navy with assignments of chief engineer officer and inspector of naval machinery.

Post College practical engineering training was with Metropolitan-Vickers Electrical Co., Ltd., Manchester, England in both electrical and mechanical engineering.

EDUCATION

University of Dublin, Trinity College
B. S. Mechanical Engineering
M. S. Mechanical Engineering

University of London, Imperial College
Diploma in Generation, Distribution and Utilization of
Electric Power

Hartnell College, Salinas
Industrial Electronics

REGISTRATION

Chartered Mechanical Engineer
Great Britain

MEMBERSHIPS

Member, Institution of Mechanical Engineers
Electrical Power Engineers Association
American Society for Metals
American Vacuum Society

Rogers

FRANK PRENDERGAST, AIA

POSITION

Assistant Vice President
and Project Manager, Architecture

EXPERIENCE

Mr. Prendergast has had a wide range of experience in the design of industrial, commercial, and residential buildings. He is responsible for the architectural design of major building structures for the firm. Recent design work has included programs for geothermal power plants in California and Hawaii.

Project architect assignments for Rogers have included diverse development programs, namely: A major research and development center for Del Monte Corporation, Walnut Creek, California; a bag manufacturing plant and regional office for St. Regis Paper Co., Union City, California; various industrial and maintenance buildings at military installations throughout California; a complex facility for the United States Navy at Pearl Harbor; several structures for Pacific Gas and Electric Company including environmental substations and control buildings; a 50 MW diesel generation power plant for Anamax Mining Co., Sahuarita, Arizona; and geothermal power plants for Pacific Gas and Electric Company, and National Power Corporation, Tiwi, the Philippines.

As Project Manager he was responsible for a maintenance area planning and development study for the Golden Gate Bridge and Highway District; a headquarters fire station and sheriff's substation for valley of the Moon Fire Protection District; a bag manufacturing plant for Bemis Company, Union City, California, an enological research center for United Vintners, Inc., and an industrial plating shop for the U. S. Army Corps of Engineers.

Prior to his association with Rogers, Mr. Prendergast was engaged in the design of bank buildings for the Royal Bank of Canada and the Bank of America. For the Royal Bank of Canada, Montreal, he was assistant to the Chief Architect and had overall project responsibility from design concepts through preparation of drawings, coordination with associated engineers, site supervision of construction and final responsibility for the interior furnishings. He was also employed by a large architectural firm in the Bay Area involved primarily in the design of apartment build-

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FRANK PRENDERGAST, AIA (Cont'd)

ings, townhouses, office buildings and custom residential work. This assignment covered full responsibility in all planning, design and construction phases, including major apartment and townhouse complexes and design essays in environmental planning.

EDUCATION University of London, Sir John Cass School of Art, and
University of Cambridge, Department of Estate Management

REGISTRATION Registered Architect, California, Hawaii

MEMBERSHIP American Institute of Architects

Rogers

WILLIAM W. LINDSAY

POSITION

Senior Staff Electrical Engineer

EXPERIENCE

Over twenty-seven years of professional experience in electrical engineering has provided Mr. Lindsay with a background in planning, design and project management for power systems for public and private utilities and industrial firms both in the United States and abroad. Over thirteen years of experience has been in the Philippines, Thailand, Laos and Iceland.

Mr. Lindsay's experience in geothermal design includes responsibility for the design of the electrical systems relating to the steam supply and treatment system, construction supervision and start-up service for the 10 MW geothermal power plant at Brawley, California. He also had design responsibility for the electrical systems for a 3 MW wellhead geothermal power plant on the island of Hawaii including on site supervision and start-up operations.

Mr. Lindsay performed as a resident construction advisor and the electrical start-up engineer for the 60 MW Krafla geothermal plant in Iceland requiring his presence at the project site for extended periods of time.

As a consultant to the power authority in Bangkok, Thailand, Mr. Lindsay provided advice on substation design and studies on gas insulated substations and was responsible for preparing a 5-year program for system expansion.

As Chief Electrical Engineer in Rogers' Manila office, Mr. Lindsay was responsible for field investigation, design, preparation of specifications and purchase orders, contract negotiations and field inspection for industrial and marine facilities, power plants, overhead and underground distribution, substations and high voltage transmission in the Philippines.

As project engineer for Rogers in Thailand, he conducted field surveys and prepared feasibility studies for rehabilitation and extension of distribution systems in Northern Thailand. He was also engaged in sub-transmission and distribution system planning and design for the power system in the City of Bangkok, including preparation of procurement specifications and evaluation of equipment bids. Also included in his responsibilities were supervision of electrical design, equipment procurement and construction supervision for a 10 MW diesel plant and a 12.5 MW steam electric generating plant, together with related 69 kV transmission and substation facilities.

Rogers

WILLIAM W. LINDSAY (Cont'd)

Mr. Lindsay has designed electrical power and control systems for a roofing plant and airport fueling and lighting systems. Additionally, he has spent over five years in planning, design supervision, preparation of specifications and purchase orders, and bid analyses for industrial power and control systems for various petrochemical facilities in California, Texas, Louisiana, British Columbia, and Australia. His experience also includes design of hydroelectric power plants and high voltage substations.

EDUCATION	B. S. in Electrical Engineering, University of California
REGISTRATION	Professional Electrical Engineer, California
MEMBERSHIP	Institute of Electrical and Electronic Engineers

Rogers

RAYMOND J. FARRINGTON

POSITION

Project Manager

EXPERIENCE

Mr. Farrington is a Project Manager who has specialized in complex power and industrial projects. In addition to Project Management, he has a diversified experience in the mechanical design of equipment and components for geothermal and diesel electric power plants, oil refineries, industrial waste treatment, and various projects for the U. S. Corps of Engineers. With Rogers since 1960, a description of his principal assignments follow:

Project Manager for the 60 MW Double Flash Geothermal Steam Power Plant at Krafla, Iceland, for Krafla Project Executive Committee, an agency of the Government of Iceland. This project was a "fast track", design-construct program, including design, procurement, construction management, start-up, and operator training. All equipment was bid and purchased on the international market, and all installation labor contracts were awarded to Icelandic contractors on a competitive bid basis after prequalification interviews.

Project Manager for HGP-A Wellhead Generator Proof of Feasibility Project, Poho District, Island of Hawaii, for the Research Corporation of Hawaii. This 3 MW geothermal plant included design, procurement, construction management, start-up and operator training.

Project Manager for the 57 MW Diesel Power Plant in Arizona, for Anamax Mining Company. This project was a "fast-track", design-construct program completed in eighteen months, on schedule and within budget in February, 1975. In addition to the basic generating plant the project included extensive supporting facilities.

Project Manager for Solid Waste Incinerators for the U. S. Corps of Engineers, two for installation in California and one in Ohio. Although the projects were simultaneously designed, each design was unique because of the variations in feed stock and climatic conditions. Construction documents were prepared for each installation, including basis of design, construction drawings, specifications, and construction estimate.

Project Manager for Audio Tape Production Plants in California, for Memorex Corporation. The Plant No. 1 Project involved a three phase program including development of the design criteria, preparation of construction drawings and specifications, and supervision of construction. The project was completed on schedule in eighteen months and within budget. The Plant No. 2 Project involved a four phase program including the master planning of a ninety acre site, development of design criteria, preparation of construction drawings, specifications, and supervision of construction. The project was completed on schedule in twenty-four months and within budget.

Rogers

RAYMOND J. FARRINGTON (Page 2)

In addition he has contributed technical advice and design for many geothermal feasibility and design and construction projects.

EDUCATION

Bachelor of Science, Heald College of Engineering, San Francisco

Rogers

KERMIT K. SCHULTZ

POSITION

Project Manager

EXPERIENCE

Mr. Schultz' has had 24 years of experience in the design and application of gas and oil burners, associated equipment and piping, and combustion systems. In recent years his experience included the application of equipment and planning for engineering and manufacturing organizations.

His basic areas of activity have been:

- Designed 35 direct-fired, refractory-lined air heaters for the mineral and process industry.
- Designed several thermal incineration systems.
- Applied and designed special burners for oil refineries, extractive metallurgical operations, and pyro-processing plants.
- Supervised the engineering application and design of thousands of burners and automatic control systems to boilers and process heaters.
- As a Project Manager, converted six utility boilers from coal to crude oil firing; designed and furnished gas and oil firing burner systems firing directly into turbine exhaust gas streams for combined cycle utility applications.
- In the geothermal field, Mr. Schultz has been directly involved in the design and application of heat rejection equipment and for processes associated with geothermal power plants.

EDUCATION

- M. B. A. - San Francisco State University
- B. A. (Business) - San Francisco State University
- B. S. (Engineering) - San Francisco State University (lower division completed at U. C. Berkeley)
- Cartography - U. S. Army Engineer's School, Fort Belvoir, Virginia

REGISTRATION

Registered Professional Mechanical Engineer, California

MEMBERSHIPS

American Society of Mechanical Engineers
Air Pollution Control Association
Geothermal Resources Council
American Management Association

Rogers

ROBERT G. BRINDLE

POSITION

Chief, Procurement and Estimating Department

EXPERIENCE

Management of procurement and construction cost estimating for projects engineered by Rogers. Procurement operations include preparation of quotation requests, requisitions, and purchase orders; expediting of certified drawings and equipment deliveries; traffic; coordination of shop inspections.

In the management of Rogers construction cost estimating, Mr. Brindle utilizes current cost data on materials and equipment obtained in his procurement operations. Labor and other construction costs are based on the cost data of prior Rogers' projects, updated by the application of cost indices.

Prior experience includes twenty years of diversified engineering experience in refinery, petrochemical and chemical plants. This involved supervision in operation and maintenance in a grass-roots refinery, as well as 16 years experience in engineering construction firms involving instrumentation, control design, and project engineering, cost estimating and field start-up assistance.

Project Manager on several geothermal power plant feasibility studies including binary cycle and flashed steam plants. Mr. Brindle has currently been involved in the procurement of equipment for a 60 MW Geothermal Power Plant in Iceland.

Prior to his joining Rogers Engineering Co., Inc. Mr. Brindle's experience has included the following types of plants.

Refinery & Petrochemical

Atmospheric and vacuum distillation units, thermal and fluid catalytic crackers, gas concentration, platformers, polymerization, ultraformers, caustic treating, tetraethyl lead, crude and gas pipeline pumping stations, etc.

Chemical

Ammonia, nitric acid, urea, caustic-chlorine electrolysis, ethylene, polymer, detergent.

Miscellaneous

Boiler plants, water treating, direct reduction ore, and nickel refining plants.

EDUCATION

University of Saskatchewan, Canada, 1951
Bachelor of Science, Electrical Engineering