PROPOSAL TO THE UNITED STATES ATOMIC ENERGY COMMISSION

NUCLEAR POWER PLANT

5,000-10,000 KILOWATTS

DOE/NBM--5003577

DE85 003577

FROM

WOLVERINE ELECTRIC COOPERATIVE
BIG RAPIDS, MICHIGAN

REA PROJECT MICHIGAN 46 NEWAYGO

Reactor: FOSTER WHEELER CORPORATION

Secondary Equipment: WORTHINGTON CORPORATION

Consulting Engineer: J & G DAVERMAN COMPANY

February 1, 1956

DISCLAIMER

WOLVERINE ELECTRIC COOPERATIVE
302 S. WARREN AVE.
BIG RAPIDS, MICHIGAN
TELEPHONE 1245

February 1, 1956

United States Atomic Energy Commission
Washington 25, D. C.

Gentlemen:

In a letter dated February 11, 1955, Mr. Ancher Nelson, Administrator of the Rural Electrification Administration, invited four REA financed generation and transmission cooperatives including the Wolverine Electric Cooperative to investigate the costs of nuclear power in the light of the Atomic Energy Commission's Demonstration Reactor Program. Upon receipt of this invitation our Board of Directors directed our Manager, Mr. John N. Keen, and our Consulting Engineer, the J. & G. Daverman Company of Grand Rapids, Michigan to proceed with such investigations as they deemed necessary and advisable. On May 18, 1955, Wolverine was granted your Access Permit No. 115 and since that time we have discussed nuclear power possibilities with many of those who are active in this field.

Upon hearing of the Commission's invitation of September 21, 1955 for proposals to construct nuclear power plants in the 5,000 to 40,000 KW range, we accelerated our survey activities and concluded that the Aqueous Homogeneous Reactor concept being developed by the Foster Wheeler Corporation appears to hold the greatest promise for an early realization of economical nuclear power in the size ranges under consideration. In view of the developmental nature of this program it was also felt advisable to interest the manufacturers of secondary loop facilities in participating in this program and after extending invitations to several manufacturers it was found that the Worthington Corporation was willing to make the most attractive contribution toward this end.

We, therefore, are submitting this proposal thru the combined efforts of the Foster Wheeler Corporation, the Worthington Corporation, the J. & G. Daverman Company and the Wolverine Electric Cooperative, with the assurance that each of these organizations will be making substantial contributions toward the achievement of economical nuclear power.

We will welcome the opportunity to discuss the details of this proposal with you at any time in the hope that thru the cooperative effort of all parties concerned the work proposed herein can be undertaken at an early date.

Very truly yours,

WOLVERINE ELECTRIC COOPERATIVE

CARL JOHNSON, President

JOHN N. KEEN, Manager

Consulting Engineer
J. & G. DAVERMAN COMPANY
Grand Rapids, Michigan

R. J. DAVERMAN, Partner

TABLE OF CONTENTS

*Appendix C-I, Item E, N.P.P. File 4895-4915 included in Classified Supplement separately submitted by Foster Wheeler Corporation:

1. Chemical Considerations and Chemical Processing System.
2. Flow Diagram of Nuclear and Special Materials.

PROPOSAL TO CONSTRUCT
AN
AQUEOUS HOMOGENEOUS REACTOR POWER PLANT

SUMMARY

The Wolverine Electric Cooperative of Big Rapids, Michigan, an REA financed generation and transmission utility supplying electric energy to 20,000 farms and rural residences throughout Central Western Michigan through its three member distribution cooperatives, the Oceana Electric Cooperative of Hart, Michigan, the O & A Electric Cooperative of Newaygo, Michigan, and the Tri-County Electric Cooperative of Portland, Michigan, proposes the construction of a Nuclear Power Plant in response to the invitation released September 21, 1955 by the United States Atomic Energy Commission under its Power Demonstration Reactor Program.

This proposal envisions a research and development program followed by the design and construction of a 10 Megawatt (electrical) Aqueous Homogeneous Nuclear Reactor employing highly enriched uranyl sulfate in heavy water for the fuel solution. The reactor system includes a chemical reprocessing unit as a part of the facility and is to be constructed at the site of the Cooperative's Hersey Generating Plant located approximately ten miles north of Big Rapids, Michigan.

This proposal is being submitted by the Wolverine Electric Cooperative as sponsor and operating utility; the Foster Wheeler Corporation of New York City, as reactor designer and builder; the Worthington Corporation of Harrison, New Jersey as secondary loop designer and builder; and the J. & G. Daverman Company of Grand Rapids, Michigan as consulting engineer.

The Wolverine Electric Cooperative proposes to integrate this nuclear power plant into its electrical generation and transmission system, to provide the site, the reactor containment, and all secondary loop facilities at an estimated cost of $1,088,000, to operate the plant and to purchase all fuel and related materials and to pay for all off site fuel processing in accordance with currently published AEC price schedules.

The Atomic Energy Commission is being requested to contract for and finance the research and development program on the basis of a firm quotation from the Foster Wheeler Corporation in the amount of $1,302,000 and to construct and retain title to the Aqueous Homogeneous Nuclear Reactor, including chemical processing facilities on the basis of a firm quotation from the Foster Wheeler Corporation in the amount of $2,486,000.

PROPOSAL TO CONSTRUCT
AN
AQUEOUS HOMOGENEOUS REACTOR POWER PLANT

STATEMENT OF PURPOSE

The purpose of this proposal is to present a suggested program for the development of an Aqueous Homogeneous Reactor Power Plant for the production of power in the 5000 - 10,000 Kilowatt range under the terms of the Atomic Energy Commission's invitation of September 21, 1955.

It envisions a research and development program prior to finalizing fabricating commitments of full scale components for the purpose of proving mechanical and hydraulic operating and chemical processing feasibility with the expectation that such preliminary effort will assure the construction of the reactor at the lowest cost and successful operation at the earliest possible date.

It proposes the construction of a reactor for an eventual net electrical output of ten megawatts but operating initially in conjunction with a five megawatt turbo-generating unit. This unit would be constructed at the site of the existing Hersey diesel generating plant of the Wolverine Electric Cooperative approximately ten miles north of Big Rapids, Michigan.

PARTICIPATING ORGANIZATIONS

It is proposed to accomplish the research, design, construction and operation of the proposed reactor thru the combined resources of the following organizations:

Sponsor and Operating Utility - Wolverine Electric Cooperative
302 S. Warren Avenue
Big Rapids, Michigan

Reactor Developer & Builder - Foster-Wheeler Corporation
165 Broadway
New York 6, New York

Secondary Loop Designer & Supplier -	Worthington Corporation Harrison, New Jersey
Consulting Engineer -	J. & G. Daverman Company Architects and Engineers 924 Grandville SW Grand Rapids, Michigan

The resources and facilities of the above organizations are described in detail in Appendix A.

Inasmuch as the Wolverine Electric Cooperative has been financed in total by funds borrowed from the Rural Electrification Administration and proposes to borrow from this agency such additional funds as will be needed for its contribution to this program it is expected that the full resources of REA will be available to assist in the rapid prosecution of this project.

DESCRIPTION OF OVERALL PROGRAM

The Aqueous Homogeneous Reactor has been selected for this proposal because of our belief that it holds great promise in the field of small reactor application for the following reasons:

1. It possess inherent controlability and self-regulatory characteristics.

2. It can be operated with a minimum of mechanical devices and moving parts subject to radioactive contamination.

3. It provides for continuous fuel addition and fission product removal.

4. It promises substantial savings in fuel processing costs.

However, the realization of economic generation of electricity utilizing this type of reactor involves the development of safe and reliable components automatically controlled as far as is feasible. A demonstration of the integrity, reliable operability and feasibility of the system and its components over the first decade of its operating life would be a considerable contribution to the technical knowledge and experience of the AEC Reactor Program.

A detailed description of the Aqueous Homogeneous Reactor Power Plant contemplated in this proposal is contained in Appendix C. In addition the Foster Wheeler Corporation has submitted directly to the Division of Reactor Development, AEC under cover of their letter of January 27, 1956 Appendix Section I, Item E, NPP File 4895 - 4915 containing certain classified (Secret) information pertaining to this proposal.

In order that monies committed to this project may be wisely expended it is recommended that a research and development program be undertaken to run concurrently with, but always preceding the respective phases of the design and construction program for the full-scale plant.

A. Research and Development

Because of the time and expense involved in changes and modifications of a Reactor Plant after it has been put in operation, a research and development program of the scope outlined below is deemed necessary. This comprises tests of a mock-up of the primary loop components under some simulated operating conditions, tests of a chemical processing pilot plant, and tests of the control systems for both.

An additional feature of the mock-ups is their availability as facilities for preliminary operator training, supplementing training acquired at ORNL on the HRT or at other reactor sites.

1. Primary Loop Mock-up

The mock-up at one-half full scale pipe diameters or one-fourth full scale flow quantities would operate at full temperature and pressure with a circulating uranyl sulfate solution in H_20. The loop would include letdown valves and fuel storage tanks, check and stop valves, pressurizer, hydroclones, and instruments and controls for operating the loop. In addition to the reactor vessel and heat exchanger it may be desirable to provide a means of heating the solution as well as cooling it in the primary loop mock-up. This part of the R & D program would be carried out in the following manner:

Phase A. Design and Engineering of mock-up primary loop components in conjunction with the System Design and System Analysis of the full scale plant.

Phase B. Fabrication, erection and installation at a site preferably owned by Foster Wheeler.

Phase C. Tests to determine the operability of the components, their hydraulic characteristics and time constants under steady and transient conditions using clean uranyl sulfate solution.

Phase D. Tests to establish the operability of the loop components when spent fission products are added to the system and removed by the hydroclones.

Phase E. Development and tests of Operational Procedures under simulated operating conditions, including weak radioactivity and gas formation.

2. Chemical Process Pilot Plant

Operation of a complete pilot plant and control system would be carried out in conjunction with a high pressure circulating uranyl sulfate loop. Partially spent fission products would be fed into the loop. The insolubles taken out by the clones would be concentrated for disposal, and H_20 (in place of D_20) recovered in the process. A stream of solution would be processed to separate uranium from the soluble fission products, these latter concentrated for waste disposal, and the uranium converted to uranyl sulfate for return to the circulating loop.

Phase A. Process Data Survey and Laboratory Tests, in conjunction with the System Design and System Analysis of the full scale plant. Basic data, not already available, on solubility and distribution ratios, would be obtained, utilizing tracer analysis where necessary or advantageous. The effect of radiation on reagents and reaction rates would also be determined.

Some of this work might advantageously be carried out at ORNL because of the facilities already existing there, provided suitable arrangements can be made.

Phase B. Design and Engineering of Pilot Plant.

Phase C. Fabrication, Erection and Installation at a site with Hot Laboratory Facilities.

Phase D. Mechanical Operability Tests - hydraulics, valves, instruments and controls.

Phase E. Pilot Plant Process Tests using partially spent fission products.

Phase F. Mock-up and Test of Final Full Scale Chemical Process Plant prior to operation at reactor plant site.

B. Design and Construction

It is proposed that the final design, engineering, and construction of the Wolverine reactor be undertaken only after the basic concept is established in its various phases and components from time to time during the course of the research and development program. The relationship of the reactor design and construction schedule to the research and development program is shown in outline on the following page.

It is further expected that the design and construction of the secondary loop facilities will be initiated and carried out to coordinate with the reactor construction schedule.

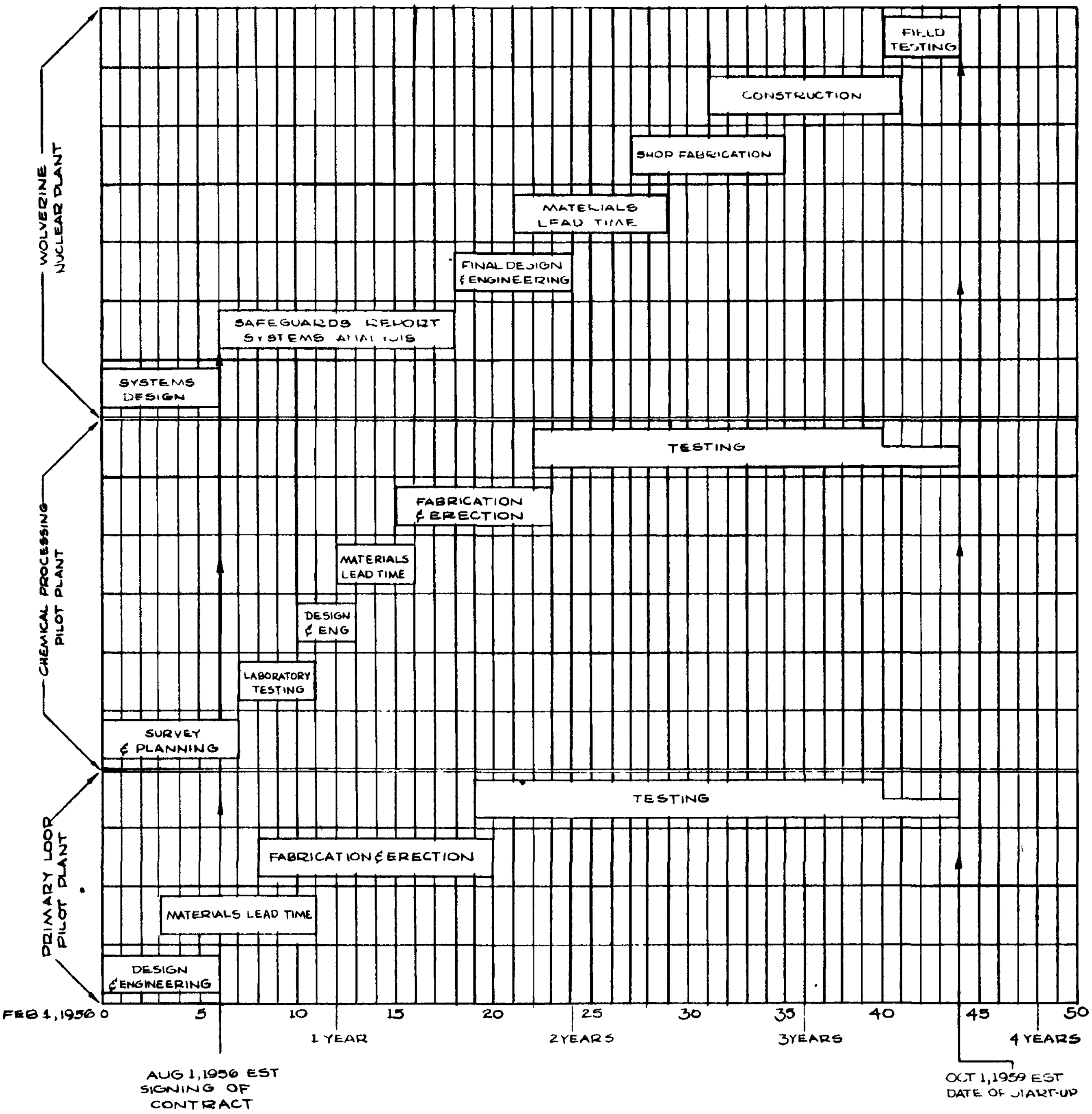
OPERATION

The Wolverine Electric Cooperative proposes to undertake the training of operators and assume full responsibility for operation of the plant at such time as it is ready to be placed in service. However, it is proposed that consideration be given to a continuing research and development contract between the Atomic Energy Commission and the participants in this proposal for the purpose of improving this type of reactor and further developing and perfecting the chemical processing features of this installation.

INSURANCE

The Wolverine Electric Cooperative has been advised that it will be able to obtain at a reasonable cost, insurance covering the normal hazards of fire, machinery breakdown etc. However, to date it has been impossible to obtain commitments with respect to third party liability. It is understood that such insurance coverage is being

APPROXIMATE PERFORMANCE SCHEDULE



LETTER	DATE	DESCRIPTION
REVISIONS		

WOLVERINE
PERFORMANCE SCHEDULE

This Drawing is the Property of the
FOSTER WHEELER CORPORATION
165 BROADWAY, NEW YORK
AND IS LENT WITHOUT CONSIDERATION OTHER THAN THE BORROWER'S AGREEMENT THAT IT SHALL NOT BE REPRODUCED, COPIED, LENT OR DISPOSED OF DIRECTLY OR INDIRECTLY NOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS SPECIFICALLY FURNISHED. THE APPARATUS SHOWN IN THE DRAWING IS COVERED BY PATENTS

DRAWN BY:	DLF	12-20-56	SCALE: NONE	=1'-0"
CHECKED BY:			ND 562-14	

ORDER NO
AP-46975

studied by all of the major underwriters in connection with the Atomic Energy Commission and it is presumed that this aspect of insurance requirements will have been satisfactorily solved when and if this project should proceed.

LICENSING

A license period of 35 years is requested to tie in with the term of the REA loan contract which would apply to that portion of this project financed by the Wolverine Electric Cooperative.

DEVELOPMENT AND CONSTRUCTION COSTS

A. Research and Development Program

* Foster Wheeler firm quotation	$1,302,000

B. Ten Megawatt (electrical) Aqueous Homogeneous Nuclear Power System including an appropriate chemical reprocessing unit, operator and maintenance personnel training and operation supervision training for six months after reactor criticality is established but not including the costs of site improvement, steam electric plant and biological shielding.

* Foster Wheeler firm quotation	$2,486,000

*(See quotation letter immediately following)

C. Reactor Containment, biological shielding, control room, crane facilities, and miscellaneous site improvement features pertaining to the Reactor.

Estimated cost including contingencies, overhead, engineering and legal	$ 349,000

D. Secondary Loop Facilities

Building Modifications including foundations	$ 60,000	
General Auxiliaries	$ 24,000	
Superheater-Economizer	$118,000	
5 Megawatt Turbo-Generator & Auxiliaries, installed	$450,000	
Electrical including step-up substation to 44 KV	$ 87,000	
Total estimated cost including contingencies, overhead, engineering and legal		$ 739,000
		$4,876,000

FOSTER WHEELER CORPORATION

165 BROADWAY
NEW YORK 6, N.Y.

CABLE ADDRESS
REWOP

BRANCHES IN
PRINCIPAL CITIES OF THE
UNITED STATES AND CANADA
ALSO
LONDON AND PARIS

January 27, 1956

Mr. John M. Keen, Manager
Wolverine Electric Corporation
302 South Warren Avenue
Big Rapids, Michigan

Dear Mr. Keen:

We are pleased to quote you for the design, development, manufacture, and installation of a 5-10 electrical MW aqueous homogeneous nuclear power system, including an appropriate chemical reprocessing unit on your site, and for training your operating and maintenance personnel, for starting up and for supervising operation for six months after reactor criticality is established, at a firm price of $3,790,000 (exclusive of cost of site development, steam electric plant, and biological shielding). Of this price $2,486,000 is expected to cover only our actual costs for engineering, design, manufacture, delivery and installation of the nuclear power system, and the chemical reprocessing unit and $1,302,000, the actual cost of setting up and operating necessary laboratory and pilot plant facilities and for the cost of the development work required to establish final design criteria for the power and reprocessing systems, - all as described in our Proposal No. 8P46975 and classified (Secret) attachment, Appendix Section I, Item E, N.P.P. File 4895-4915.

The price quoted reflects a reduction from our normal pricing basis of approximately $522,000, which we would normally add for general and administrative overhead (10%) and profit (10%) to the $2,486,000 portion of the quoted price, and another $130,000 for general administrative overhead which we would normally add to the $1,302,000 portion of the price, or a total of $652,000. In addition, by quoting a fixed price we are assuming a sizable risk for unanticipated costs which further increases our contribution.

We hope you will find our proposal and quotation worthy of your serious consideration.

We look forward to the privilege of becoming associated with you in this project and shall exert our best efforts to make the installation a milestone in nuclear power plant progress.

Sincerely,

FOSTER WHEELER CORPORATION

Martin Frisch

Martin Frisch
Vice President and General Manager
Equipment Division

MF:JM

FINANCING

The following method of financing the program outlined herein is proposed.

A. By the Atomic Energy Commission

1. Research and Development thru a contract with the Foster Wheeler Corporation under Section 31 of the Atomic Energy Act of 1954	$1,302,000
2. Financing and retaining title to the Reactor System as proposed by Foster Wheeler Corporation with all energy generated in the reactor subject to disposition in accordance with Section 44 of the Atomic Energy Act of 1954	$2,486,000
Total	$3,788,000

B. By Wolverine Electric Cooperative with funds borrowed from the Rural Electrification Administration

1. Reactor Containment, biological shielding, control room, crane facilities, and miscellaneous site improvement features pertaining to the Reactor.	$ 349,000
2. Secondary Loop Facilities	$ 739,000
Total	$1,088,000

C. In addition, Wolverine proposes to purchase all fuel and related materials from AEC at currently published (Confidential) prices, and to pay all fuel processing and handling costs and to provide normal operating and security personnel.

OPERATING COSTS

Because of the lack of certain cost information with respect to chemical processing, the shipping of radioactive materials, etc., at the time of submitting this proposal no attempt has been made to prepare a detailed operating budget. It is expected that this aspect of the proposal can be developed in detail at a later date. However, it is estimated that if this proposal is accepted essentially as submitted the bus cost of power to Wolverine for energy produced by the proposed nuclear power plant based upon Wolverine's investment in the project will develop within the following limits on the basis of 100% load factor and 90% availability.

	COST - MILLS/ KWH	
ITEM	LOW	HIGH
U-235 Burn-up	2.00	3.00
U-235 Inventory	0.20	0.60
D_2O Loss	0.05	0.10
D_2O Inventory	0.10	0.30
Fuel Processing & Handling	0.30	0.60
Superheater Fuel	0.90	1.20
Operating Labor (Estimated $40,000/yr.)	1.00	1.00
Maintenance (Reactor & Steam Electric Plant @ $40,000/yr.)	1.00	1.00
Interest, Depreciation, Insurance and Taxes at 6% on Wolverine investment of $1,088,000	1.63	1.63
Bus Cost of Power	7.18	9.43

EDUCATIONAL INTERESTS

The Wolverine Electric Cooperative believes that it is imperative that students in the scientific and engineering fields be exposed to all phases of the atomic development program to the greatest possible degree. If this project should proceed, it is our intention to make these facilities available to educational institutions for observation and training to the greatest extent possible within the limits of AEC security and safety requirements and the limitations of our own operating practices.

The reactions of the University of Michigan and Ferris Institute, a state operated technician grade college located in Big Rapids, Michigan to this policy are contained in letters from these institutions included in Appendix D.

APPENDIX A

I. Sponsor and Operating Utility -

WOLVERINE ELECTRIC COOPERATIVE

II. Reactor Developer and Builder -

FOSTER WHEELER CORPORATION

III. Secondary Loop Designer & Supplier -

WORTHINGTON CORPORATION

IV. Consulting Engineer -

J. & G. DAVERMAN COMPANY

WOLVERINE ELECTRIC COOPERATIVE
302 S. Warren Avenue
Big Rapids, Michigan

Sponsor and Operating Utility

I. WOLVERINE ELECTRIC COOPERATIVE

A. History

The Wolverine Electric Cooperative (REA Project Michigan 46 Newaygo) was conceived and organized in 1946 to investigate the economic feasibility of a plan to create a generation and transmission Cooperative which would supply wholesale electrical energy to the participating member distribution cooperatives. Three distribution cooperatives of Central Western Michigan joined in the incorporation of the Wolverine Cooperative:

O & A Electric Cooperative (REA Project Michigan 40 Allegan)
Tri-County Electric Cooperative (REA Project Michigan 26 Ingham)
Oceana Electric Cooperative (REA Project Michigan 41 Oceana)

A fourth cooperative, Western Michigan Electric Cooperative (REA Project Michigan 42 Mason), while indicating an interest to the extent of cooperating in the preliminary feasibility study, decided not to become a member of the Wolverine Cooperative.

After extensive engineering studies demonstrated economic advantages for consolidation, the generating facilities of the member distribution cooperatives were acquired by Wolverine, an interconnecting transmission system was constructed and additional generating facilities were provided as needed.

Since its inception the Wolverine Cooperative has experienced substantial growth:

	1950	1955
Member's Customers	12,706	20,018
Sales, MWH	38,000	65,000
Generating Capacity, KW	11,889	18,397

During this period of growth Wolverine has established an enviable operating record and today is one of the most successful generation and transmission cooperatives in the nation. The increase in sales and reduction in production costs achieved throughout the years are indicated on Pages 4 and 5, following. The map on Page 6 shows the number of customers and approximate area presently served by Wolverine through its three member Cooperatives.

I. WOLVERINE ELECTRIC COOPERATIVE (Continued)

B. Organization

The Wolverine Electric Cooperative is an REA financed electric generation and transmission cooperative with headquarters at Big Rapids, Michigan. This power Cooperative is administered by a six-man Board consisting of two members elected by the Executibe Boards of each of the three member distribution Cooperatives. The officers, board members and administrative personnel are:

Officers:	Mr. Carl C. Johnson, President Mr. Harry Burmeister, Vice President Mr. Leonard Balgoyen, Secretary-Treasurer
Board Members:	Mr. Eugene TenBrink Mr. Glen Chase Mr. I. E. Royer
Administration:	Mr. John N. Keen, Manager Mr. S. Donald King, Superintendent Mr. Robert J. Holzschu, Office Manager

C. Plant and Facilities

1. Generation

The Wolverine Electric Cooperative owns and operates four diesel engine generating plants which produce all the power requirements of its three member Cooperatives:

Plant Location	Installed Capacity	Fuel
Hersey	10,060. Kolowatts	Dual-Fuel
Portland	4,086 Kilowatts	Oil
Vestaburg	2,441 Kilowatts	Oil
Burnips	1,805 Kilowatts	Oil & Dual
Total	18,397 Kilowatts	

In addition, a physical interconnection is maintained with the Western Michigan Electric Cooperative and it is expected that by the end of 1956 interconnection with Consumers Power Company will be completed to provide capacity required in excess of existing generating facilities. The locations of these facilities are shown on Page 7, following.

I. WOLVERINE ELECTRIC COOPERATIVE (Continued)

2. Transmission

The Wolverine Electric Cooperative owns and maintains 328 miles of 44,000 volt transmission line and 19 distribution substations by which it serves the various load areas of the member Cooperatives. The transmission network is shown on the map on Page 7, while Page 8 contains a tabulation of the pertinent data on various components of the Wolverine transmission system.

D. Operation

The generating plants of the Wolverine System are operated in parallel. The Hersey Plant, utilizing natural gas for fuel, serves as the base load plant for the system. In recent years, the Hersey plant has been recognized as the most efficient REA diesel generating plant in the nation.

Although a physical interconnection is maintained with the Western Michigan Electric Cooperative, normally no power is transferred through the interconnection. Some power is sold to the City of Portland, Michigan, which operates a diesel generating plant in parallel with the Wolverine System through an interconnection maintained with this municipality.

Power sold to the member Cooperatives for distribution throughout their respective systems is delivered and metered at the load side of the several distribution substations. Total energy sales for 1955 amounted to 65,000,000 KWH with a system peak of 15,000 kilowatts.

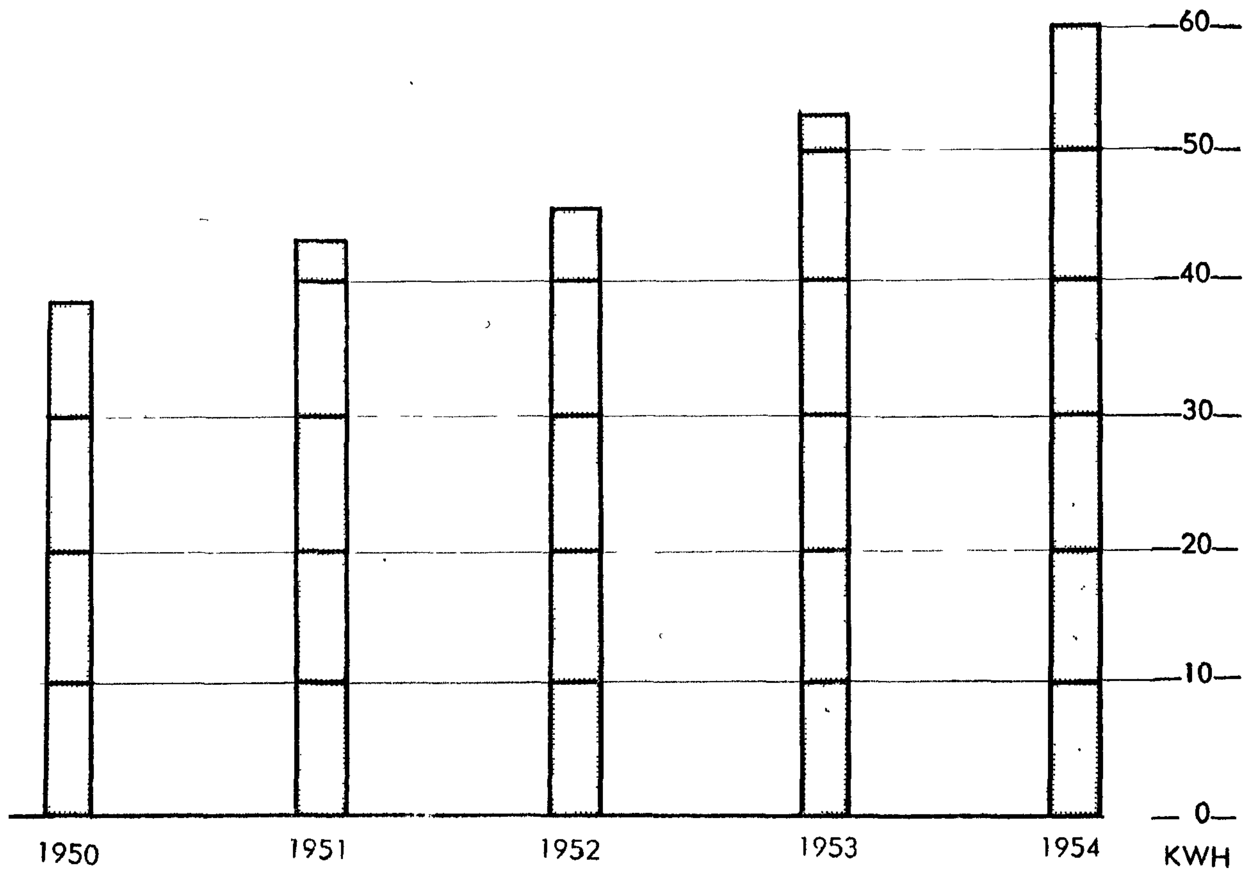
E. Financial Position

Reference is made to the following exhibits indicating the financial position of the Wolverine Electric Cooperative:

Exhibit	Page No.
Balance Sheet, December 31, 1954	9
Balance Sheet, December 31, 1954	10
Revenue and Expenses	11
Debt Service	12

MILLIONS OF KWH SOLD BY WOLVERINE ELECTRIC COOPERATIVE

Wolverine's sales increased 6,690,812 kilowatt hours over last year making a total of 59,097,849 kilowatt hours for the year 1954. This increase in sales is reflected by the increased number of consumers added to the three distribution coops and the increased sale of dump power to the City of Portland and Western Michigan Electric Cooperative. All the power was produced at the four generating stations with the exception of 4,856,355 kilowatt hours being purchased from the City of Portland, Western Michigan and Miller Dairy Farms. Our purchased power amounted to 7.8% while the Winder Plant at Portland produced 12.5%, the VanDyke Plant at Burnips produced 7.8%, the Vestaburg Plant produced .1% and the Johnson Plant at Hersey 71.8% of the total requirement for the system. To produce this amount of power it required 39,787 man hours of labor while the total running time of the engines amounted to 56,260.5 hours at all plants. These engines consumed 374,360,490 cubic foot of gas, 1,250,795 gallons of fuel oil, and 42,905.5 gallons of lube oil. The average cost of power delivered by our plants was 6.6 mills per kilowatt hour.

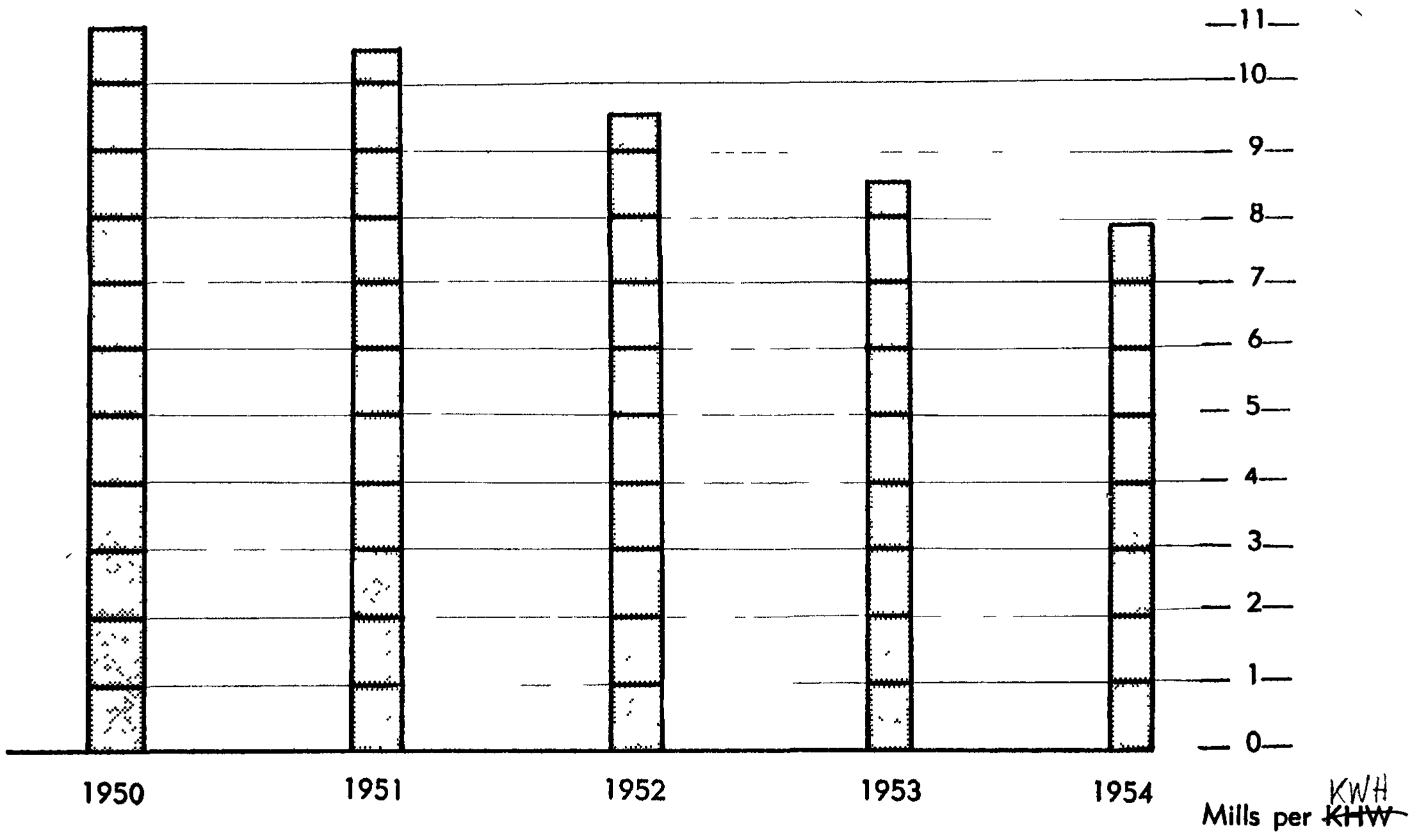


Copy from Wolverine Annual Report, 1954

PRODUCTION COST

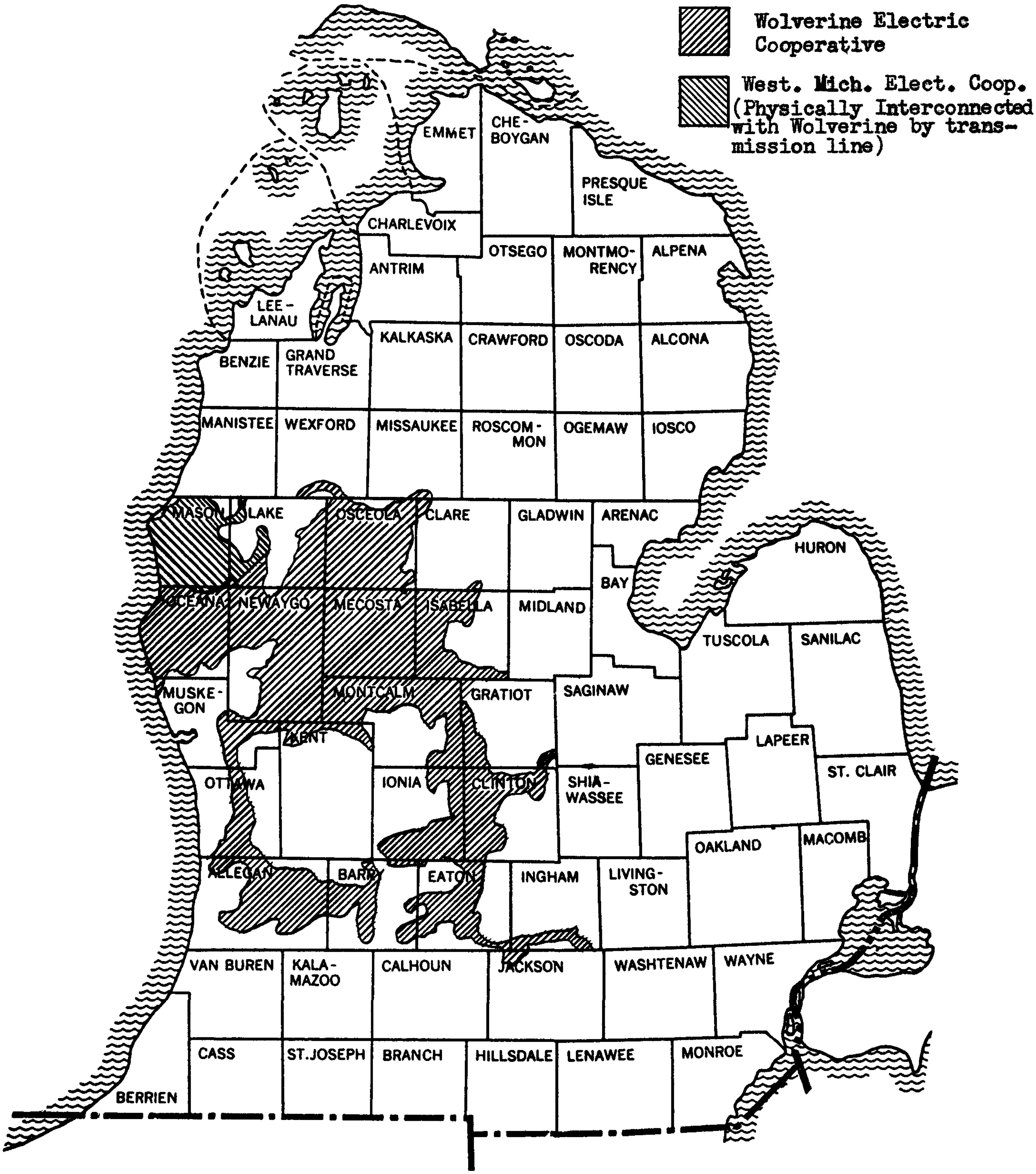
The production cost of delivery power to our various load centers has been consistantly decreasing due to the continued load growth and the streamlining of operations and various improvements to our system. The figures used to compile this graph includes all the direct costs pertaining to the production and transmission charges However, they do not include principal and interest payments, taxes or depreciation

With a completed transmission system in 1954 three of our plants were integrated giving us a flexibility of utilizing all our resources to a better advantage, while in 1950 it was impossible to coordinate the loads to the various plants because our transmission system was just under construction at that time

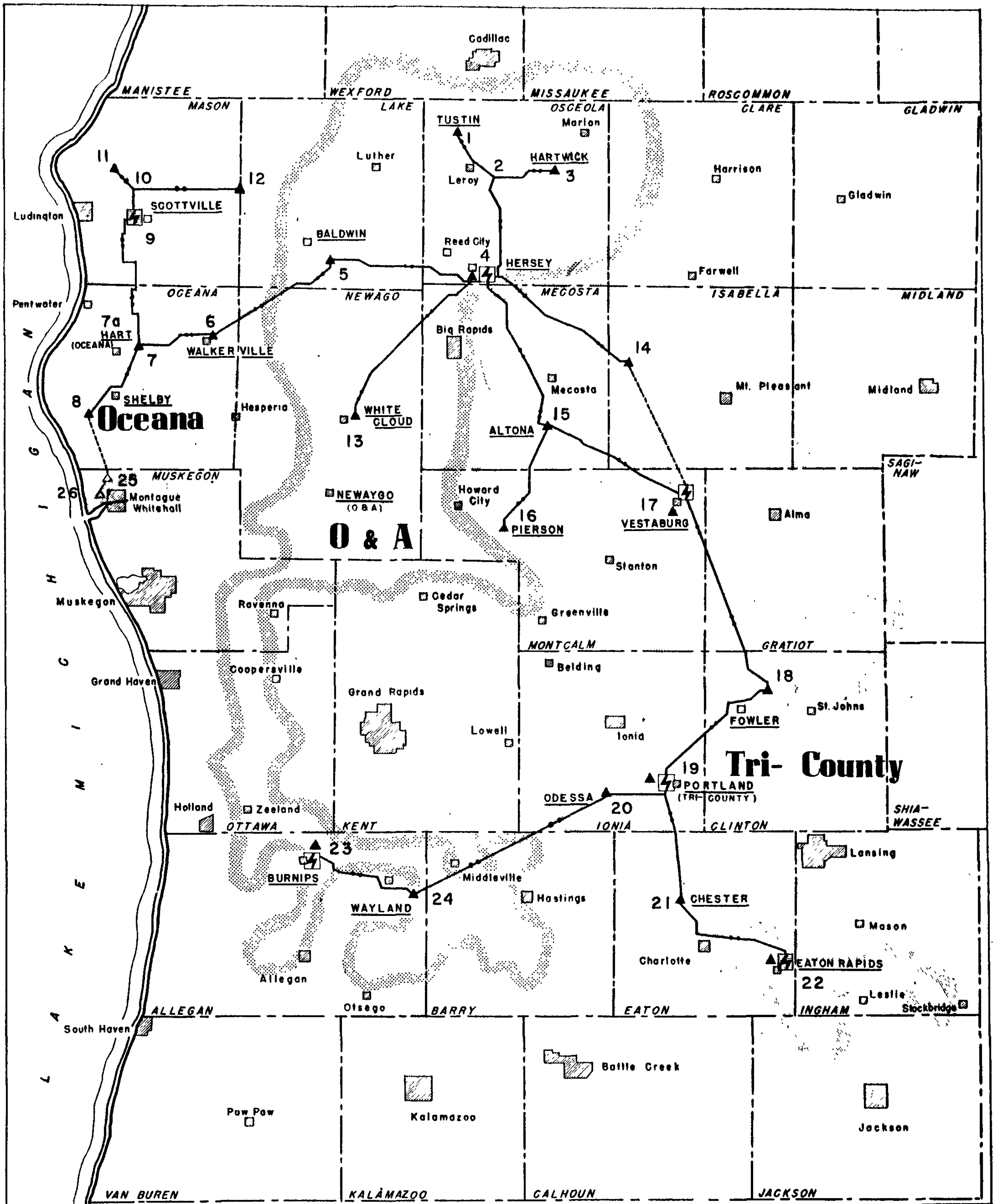


Copy from Wolverine Annual Report, 1954

WOLVERINE ELECTRIC COOPERATIVE
CUSTOMERS AND AREAS SERVED



Member-Customers served by Wolverine Member Cooperatives: 20,018
Oceana Electric Cooperative - 3,675
O. & A. Electric Cooperative - 8,734
Tri-County Electric Cooperative - 7,609



J. & G. DAVERMAN CO.
ARCHITECTS & ENGINEERS
GRAND RAPIDS, MICHIGAN

0 8 16
SCALE IN MILES

LEGEND

- SYSTEM GENERATING STATION
- FOREIGN GENERATING STATION
- ▲ EXISTING DISTRIBUTION SUBSTATION
- △ PROPOSED DISTRIBUTION SUBSTATION
- ——•—— EXISTING TRANSMISSION LINES
- ------ PROPOSED TRANSMISSION LINES

WOLVERINE ELECTRIC COOPERATIVE
BIG RAPIDS, MICHIGAN
GENERATION & TRANSMISSION SYSTEM

SERVING:

OCEANA ELECTRIC COOPERATIVE	HART,	MICHIGAN
O & A ELECTRIC COOPERATIVE	NEWAYGO,	MICHIGAN
TRI-COUNTY ELECTRIC COOPERATIVE	PORTLAND,	MICHIGAN

TRANSMISSION SYSTEM DATA

Code No. ***	Identification	KVA	MBR Coop.	Points	Dist. Miles	ACSR Cond.Size	KV
1	Tustin	750	40	1-2	7.57	3/0	44
3	Hartwick	1000	40	2-3	9.72	1/0	44
4	Hersey	2000	40-26	2-4	14.29	3/0	44
4	Hersey Plant	2500					
		2500					
		2500					
		1165					
		700					
		700					
5	Baldwin	1000	40	4-5	19.39	4/0	44
6	Walkerville	1000	41	5-6	19.48	3/0	44
7	Hart	1000	41	6-7	9.45	3/0	44
7A	Hart	1000	(Auto-Transformer)				44/33
8	Shelby	1500	41	7-8	12.75	3/0	44
				7-7A	1.28	1/0	33
9*	Scottville	1500	42	7A-9	19.10	.4	33
*	Scottville Plant	340					
		340					
		340					
		1100					
		1100					
*				9-10*	2.10	2 cu.	33
11*	Victory	1000	42	10-11*	3.45	1/0 ACSR	33
12*	Lake County	1500	42	10-12*	13.12	1/0	33
13	White Cloud	1500	40	4-13	26.24	1/0	44
14	Weidman	2000	26	4-14	22.72	3/0	44
15	Altoona	1500	26	4-15	23.97	4/0	44
16	Pierson	2000	40-26	15-16	15.64	3/0	44
17	Vestaburg	2250	26	15-17	19.48	3/0	44
	Vestaburg Plant	413					
		413					
		413					
		700					
		700					
18	Fowler	1500	26	17-18	27.84	3/0	44
19	Portland	1500	26	18-19	18.76	3/0	44
	Portland Plant	493					
		493					
		1000					
		1100					
		1100					
20	Odessa	1500	26	19-20	8.28	3/0	44
21	Chester	1000	26	19-21	15.52	3/0	44
22	Eaton Rapids	750	26	21-22	18.33	1/0	44
22	Miller Plant	(Parallel Interconnection)					
23	Burnips	600	40				
	Burnips Plant	380					
		400					
		380					
		645					
24	Wayland	1500	40	23-24	17.75	1/0	44
25	Montague**	1000	41	8-25	6.0	3/0	44
				20-24	30.61	3/0	44
26	Consumers Power Co.	Proposed 5000-10000 KVA Interconnection.					

* Owned by Michigan 42. **Proposed for near future.

*** Code numbers correspond to numbers on map, Page 7

WOLVERINE ELECTRIC COOPERATIVE INC.
Monthly Operating Report Summary
Financial Statement

MICHIGAN 46 NEWAYGO — MONTH OF December 1955

SCHEDULE A. BALANCE SHEET

ASSETS & OTHER DEBITS		LIABILITIES & OTHER CREDITS	
1. Electric Plant	$6,294,523.92	25. Membership Fees	$ 300.00
2. Construction Work in Progress	112,930.11	26. Patronage Capital Credits	
3. Electric Plant Acqui. Adj.	311,293.64	27. TOTAL PATRONS' CAPITAL	$ 300.00
4. Other Utility Plant	-	28. REA Construction Obligation	6,447,411.66
5. TOTAL ELECTRIC PLANT	$6,718,747.67	29. Other Long Term Debt	-
6. Less Reserves (From B-26)	1,031,503.13	30. TOTAL LONG TERM DEBT	$6,447,411.66
7. DEP. COST OF ELEC. PLANT	$5,687,244.54	31. Accounts payable - General	2,132.43
8. General Fund - Cash	79,297.62	32. " " - REA Const.	-
9. REA Construction Fund - Cash	44,575.13	33. Patrons Capital and Div. Declared	-
10. Other Cash	-	34. Matured Principal and Interest	-
11. Restricted Funds	-	35. Accrued Taxes	334.22
12. Investments	170,412.00	36. " Interest	7,782.05
13. Temp. Cash Investments	25,000.00	37. Employees Inc. Tax Withheld	552.30
14. Notes Receivable		38. Accrued Insurance	225.92
15. Reserves for Uncollectibles	-	39. Other Cur. & Acc. Liabilities	-
16. Accounts Receivable	92,835.96	40. TOTAL CUR. & ACC. LIAB.	$ 11,026.92
17. Reserves for Uncollectibles		41. Deferred Credits	3,621.30
18. Materials and Supplies	103,324.96	42. Other Capital	(49,651.07)
19. Prepayments and Accurals	16,284.00	43. Operating Margin (Previous Yrs)	(204,593.72)
20. TOTAL CUR. & ACC. ASSETS	$ 531,729.67	44. " " " (Current Yr.)	3,835.88
21. Extraordinary Property Losses		45. Non-operating Margin (Prev. Yrs.)	2,467.26
22. Other Deferred Debits		46. " " " (Current Yr.)	4,555.98
23. TOTAL DEFERRED DEBITS		47. TOT. MARG. & OTHER EQUITIES	$ (243,385.67)
24. TOT. ASSETS & OTHER DEBITS	$6,218,974.21	48. TOT. LIAB. & OTHER CREDITS	$6,218,974.21

SCHEDULE B. ELECTRIC PLANT

1. Elec. Plant Leased to Others	$	DEPRECIATION RESERVES	
2. " " Held for Future Use		15. Res. for Depr. - Steam Plant	$
3. Intangible Plant	18,455.39	16. " " " - Hydro Plant	
4. Production Plant - Steam	-	17. " " " - Int. Comb. Plant	687,342.36
5. " " - Hydro	-	18. " " " - Trans. Plant	319,933.89
6. " " - Int. Comb.	2,961,474.32	19. " " " - Dist. Plant	-
7. Transmission Plant	3,199,200.29	20. " " " - General Plant	24,226.88
8. Distribution Plant	2,999.19	21. TOTAL DEPR. RESERVES	$1,031,503.13
9. General Plant	112,394.73	AMORTIZATION RESERVES	
10. Electric Plant Purchased		22. Res. for Amort. - Lim. Term Elec. Plt	
11. " " Sold		23. " " " -Elec. Pl. Acq. Adj.	
12. Donations in Aid of Const. (Credit)		24. TOTAL AMORT. RESERVES	$ -
13. Unclassified Plant in Service		25. Res. for Depr. & Amort. Other Property	
14. TOTAL ELECTRIC PLANT	$6,294,523.92	26. TOTAL RES. DEPR. & AMORT.	$1,031,503.13

J&GDCO
5502-16

BALANCE SHEET
December 31, 1954

ASSETS

Utility Plant		
At original cost (less reserve)	5,445,555.95	
Acquisition adjustment	322,729.64	5,768,285.59
Investments		
Stock in Wisc. Elec. Co-op	662.00	
Notes receivable	12,750.00	
U. S. Government Bonds	130,000.00	143,412.00
Current Assets		
Cash	114,961.87	
Receivables	77,311.85	
Accrued interest receivable	575.00	
Materials and supplies	107,520.42	
Prepaid insurance	18,511.13	318,880.27
Deferred Charges		
Unamortized loan expense	305.58	
Retirements in process	25.57	331.15
TOTAL ASSETS		6,230,909.01

LIABILITIES AND MEMBER EQUITIES

Long-Term Debt			
Construction obligation to REA			6,460,529.81
Current Liabilities			
Accounts payable		8,353.25	
Taxes payable		1,859.02	
Accrued interest		8,023.16	18,235.43
TOTAL LIABILITIES			6,478,765.24
Member Equities			
Membership fees		300.00	
Contributed capital		3,621.30	
Patronage capital			
Operating deficit	(204,593.72)		
Non-operating margin	2,467.26		
Capital gains & Losses	(49,651.07)	(251,777.53)	(247,856.23)
TOTAL LIABILITIES AND MEMBER EQUITIES			6,230,909.01

(Copy from Wolverine Annual Report, 1954, Audited March 1, 1955)

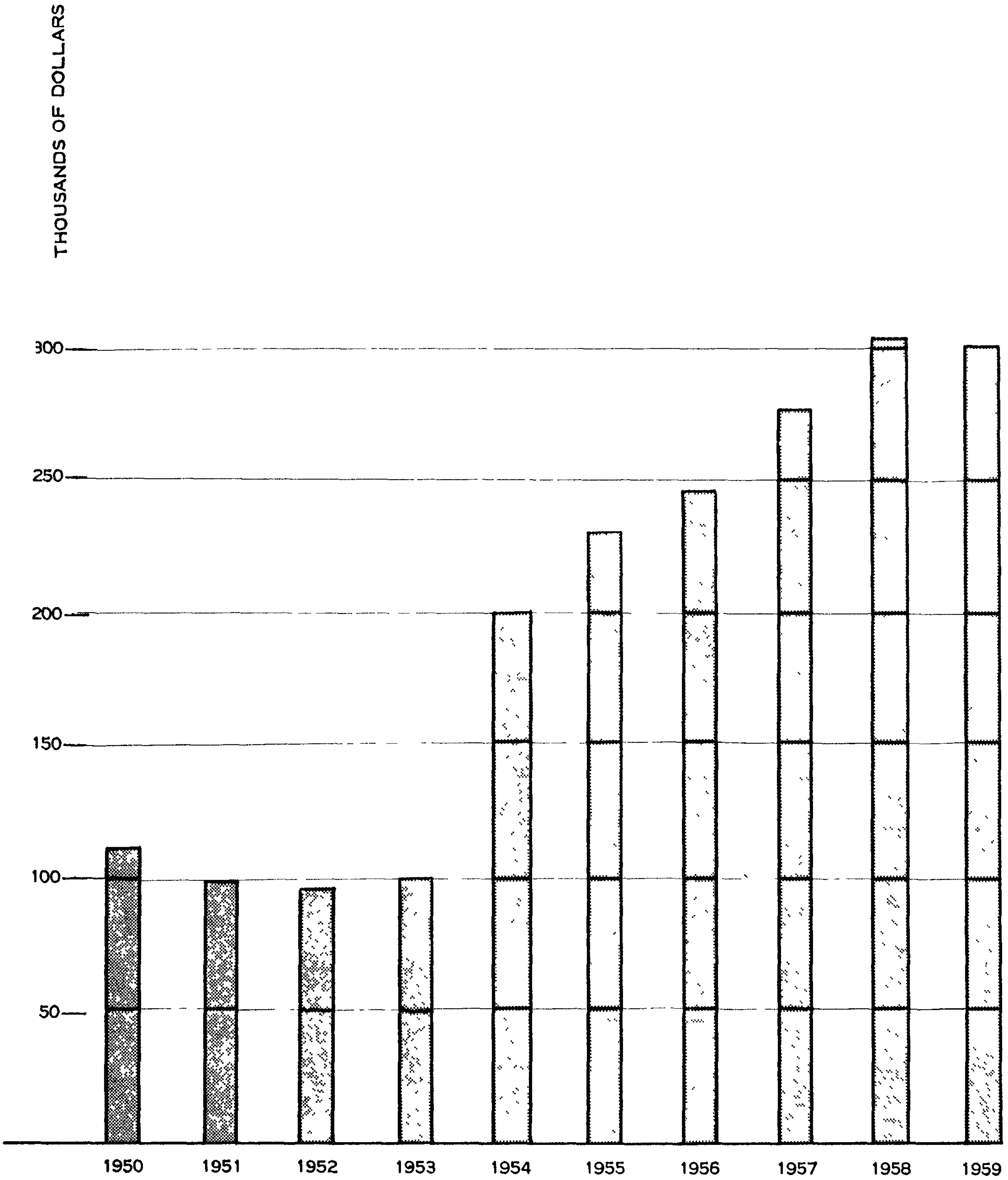
J&GDCO
5502-16

COMPARISON STATEMENT OF REVENUE & EXPENSES

Revenue	1952	1953	1954
Electric Energy Sales to Member Cooperatives	597,660.65	699,195.72	777,769.81
Electric Energy Sales to Electric Utilities	12,150.13	16,082.95	32,612.11
Miscellaneous Revenue	3,125.00	4,794.01	3,608.75
Total Revenue	612,935.78	720,072.68	813,990.67
Generation Expense			
Supervision, Engineering	6,814.21	4,976.70	1,169.00
Station labor	64,323.84	69,872.04	70,142.58
Fuel	203,302.25	214,967.00	246,519.45
Lubricants	22,116.10	19,841.61	24,764.62
Other supplies and expenses	6,262.64	5,753.26	5,182.83
Maintenance	41,853.99	18,951.37	30,533.98
Total Cost of Power Generated	344,673.03	334,361.98	378,312.46
Purchased Power	74,137.33	63,647.97	53,150.87
Total cost of Power	418,810.36	398,009.95	431,463.33
Transmission Expense			
Supervision, Engineering	1,359.77	4,715.30	792.73
Load dispatching	6,578.72	12,739.61	7,694.07
Operation of Stations	2,464.84	2,467.87	3,803.38
Operation of Lines	933.49	589.05	574.29
Maintenance	1,089.69	3,790.69	9,871.98
Rent	100.00	235.00	115.00
Total Transmission expense	12,526.51	24,537.52	22,851.45
Office & Administrative Expenses			
General office salaries	14,546.20	19,222.63	19,732.44
General office expense	8,826.07	8,521.61	4,818.99
Special services	386.63	1,715.60	1,767.33
Insurance	3,503,23	3,729.63	3,456.06
Inquiries and damages	3,016.85	3,137.39	2,895.16
Directors fees and mileage	2,231.18	2,283.32	1,964.40
Dues and donations	469.37	609.82	508.15
Miscellaneous general expenses		201.56	3,333.62
Maintenance of general property	591.79	1,028.72	1,491.08
Rent	1,885.00		
Stores expense	264.81	381.83	
Amortization of loan expense			2,198.03
Total office and administrative expense	35,721.13	40,832.11	42,165.26
Fixed Charges			
Depreciation	125,979.76	185,201.33	176,703.42
Taxes	22,356.81	31,563.89	32,610.71
Amortization of Electric Plt. Adj.	11,436.00	11,436.00	11,436.00
Interest on Long term debt-Current & Deferred	83,578.15	118,406.23	124,477.81
Total Fixed Charges	243,350.72	346,607.45	345,227.94
Total Operating Deductions	710,408.72	809,987.03	841,707.98
Net Operating Margin	(97,472.94)	(89,914.35)	(27,717.31)
Non Operating Items:			
Non operating income			2,467.26
Net Margin	(97,472.94)	(89,914.35)	(25,250.05)

DEBT SERVICE – PRINCIPAL & INTEREST

PAYMENTS TO REA 1950 – 1959



Copy from Wolverine Annual Report, 1954

FOSTER WHEELER CORPORATION
165 Broadway
New York 6, New York

Reactor Developer and Builder

FOSTER WHEELER CORPORATION

(A New York Corporation)

165 BROADWAY, NEW YORK 6, N. Y.

STOCKHOLDERS

Number as of December 31, 1954 — Common 2071.

(Capital stock is comprised of common shares listed on the New York Stock Exchange.)

DIRECTORS

WILLIAM BUCHSBAUM	OLIVER R. GRACE	CHARLES E. MCCULLOCH
HORACE K. CORBIN	IRA GUILDEN	DAVID MCCULLOCH
CHARLES A. DANA	GEORGE MACNOE	EARLE W. MILLS
MARTIN FRISCH	W. L. MARTWICK	JOHN PRIMROSE

OFFICERS

EARLE W. MILLS, *President*
PELL W. FOSTER, JR., *Vice President* — Combined Activities Division
MARTIN FRISCH, *Vice President* — Equipment Division
E. R. GOODRICH, *Vice President* — Condenser Department
GEOFFREY H. HOPEWELL, *Vice President* — London
JOHN E. KENNEY, *Vice President* — Midwest Sales
W. L. MARTWICK, *Vice President* — General Sales Division
C. E. MCCULLOCH, *Vice President* — Process Plants Division
JAMES F. MERSEREAU, *Vice President* — International Division
R. F. KOPP, *Chief Financial Officer and Controller*
VINCENT J. SCHWINGEL, *Treasurer*
ELMER HAISCH, *Secretary*

General Counsel MEYER, KISSEL, MATZ, REYNOLDS AND SEWARD, New York City

Independent Public Accountants HURDMAN AND CRANSTOUN, New York City

Transfer Agent CHEMICAL CORN EXCHANGE BANK, New York City

Registrar IRVING TRUST COMPANY, New York City

Dividend Disbursing Agent CHEMICAL CORN EXCHANGE BANK, New York City

Air, water and natural gas are converted into ammonia and urea in this chemical plant designed and constructed by Foster Wheeler Corporation.

THE YEAR IN BRIEF

	1954	1953
Earned billings	$138,597,795	$155,327,228
Net earnings	3,587,837	2,877,254
Earnings per share of common stock	6.16	5.05
Working capital	21,506,510	17,978,696
Net assets owned	31,240,863	27,449,137
Net assets per share	53.61	48.15
Unfilled orders December 31	93,860,294	145,869,924

to the stockholders of

FOSTER WHEELER CORPORATION

THE year 1954 was one of progress for your Corporation. Net earnings of $6.16 per share of common stock were $1.11 above those of 1953, although earned billings were less than those of the year before. The financial position and net worth of the Corporation improved considerably during the year with both working capital and net worth reaching new high positions. The financial statements, certified by Hurdman and Cranstoun, certified public accountants, submitted herewith, are consolidated reports covering the parent Corporation and all its subsidiaries except Société Foster Wheeler Française, the French Subsidiary, which is excluded for reasons of foreign exchange restrictions in that country.

The table on the opposite page gives the highlights for 1954 compared with 1953.

Operating Results

Our earned billings for 1954 were $138,597,795, 11% below the $155,327,228 reported for 1953. Net earnings, however, were higher at $3,587,837, equal to $6.16 per share of common stock, compared with $2,877,254, or $5.05 a common share the year before. Our unfilled orders at December 31, 1954 were $93,860,294, registering a decline from December 31, 1953.

The year 1954 was one of high activity for us, made possible by a relatively stable labor and material situation. It ended, however, with operations at a lower level than a year ago.

As we enter 1955, we look forward to augmenting our backlog of unfilled orders and to controlling our costs with increasing effectiveness. The year ahead will be one of lower earned billings for us. Plant modernization is well along but continues to have our constant attention. Good progress has been made along the lines of internal organization and controls.

Financial Position

Our financial position at December 31, 1954 in condensed form is compared below with that of a year ago.

	December 31, 1954	December 31, 1953
Cash	$10.563,714	$10,160,304
Government securities	4,540,051	6.058,626
Due us from customers and others	16,073,613	22,032,570
Funds invested in materials, supplies and uncompleted contracts	8,833,434	16,827,040
Total current assets	40,010,812	55,078,540
Less:		
Bank loans	—	13,000,000
Accounts payable	13,639,204	18,814,784
Advance payments from customers	4,865,098	5,285,060
Total current liabilities	18,504,302	37,099,844
Working capital	21,506,510	17,978,696
Land, buildings and equipment	22,446,412	21,541,556
Less accumulated depreciation	8,976,428	8,187,151
Net value	13,469,984	13,354,405
Other assets	1,283,142	1,132,479
	36,259,636	32,465,580
Less:		
Loan due Metropolitan Life Insurance Company	5,000,000	5,000,000
Minority interest in subsidiaries	18,773	16,443
	5,018,773	5,016,443
Net assets owned	$31,240,863	$27,449,137

Many important changes have taken place in the items making up the financial position of the Corporation. The year witnessed a marked liquidation in the following, $5,958,957 in amounts due us from customers and others, $7,993,606 in funds invested in materials, supplies and uncompleted contracts, $13,000,000 in bank loans and $5,175,580 in accounts payable. Working capital advanced $3,527,814, due in large measure to our good earnings, and our current asset ratio improved from 1.48 to 1.00 at December 31, 1953 to 2.16 to 1.00 at the end of last year.

Net assets increased $3,791,726 for the year, equal to $5.46 per share of common stock, so that at year-end they were $53.61 per share.

In May of 1954 the last of the bank loans outstanding in the original amount of $16,000,000 were paid off, and no borrowing has been made since. In view of the strong financial position of the Corporation, the revolving credit agreement dated December 1, 1952 with five banks for $10,000,000 was terminated by us as of January 10, 1955 to effect the saving of the commitment fee involved.

During the year, 12,635 shares of common stock were issued to officers and employees as a result of the exercise by them of options granted under the Stock Option Plan approved by the stockholders on March 26, 1951. The plan reserved 30,032 shares for sale to officers and employees, of which 12,735 shares have been issued to December 31, 1954 to persons exercising their options.

Dividends

Upon the liquidation of our bank debt, dividends on our common stock were resumed in July 1954 with the declaration of $.30 a share, followed by $.40 a share in October 1954 and $.40 a share in January 1955. The parent Corporation's net income (which includes dividends from the Subsidiaries) is the source from which stockholder dividend payments can be made. This income was $2,254,423 in 1954. At the quarterly rate of $.40, the annual dividend payments amount to $932,325, or about 41% of the available income. The difference of $1,333,414 between consolidated and parent Corporation net incomes represents the earnings ploughed back into our English and Canadian Subsidiaries to strengthen them in their expansion of activities. Prospects and results in both areas indicate the wisdom of this action.

Directors and Officers

At the Annual Meeting of Stockholders held on March 22, 1954, the number of Directors for the ensuing year was fixed at thirteen (13), the same as for 1953, and all of the Directors in office were re-elected. Late in the year, Mr. John J. Bergen tendered his resignation to the Board of Directors and this resignation was accepted by the Board on December 27, 1954.

On July 1, 1954 Mr. Vincent J. Schwingel was elected Treasurer of the Corporation to replace Mr. Thomas G. Hoffman, retired.

At a meeting of the Board of Directors held September 27, 1954, Mr. James F. Mersereau was elected a Vice President of the Corporation.

At the regular meeting of the Board of Directors held on February 21, 1955 the resignation of Mr. John Primrose as a Director was presented and accepted with regrets.

INTERNATIONAL DIVISION

The International Division has continued to expand its activities in consolidating and coordinating the functions and procedures of the subsidiary Companies with those of the parent Corporation and in the development, expansion and effectuation of the foreign business of the Corporation which constitutes a substantial part of the total volume. Licensing arrangements with foreign companies, providing adequate manufacturing facilities abroad, have made it possible for the Corporation to furnish equipment and services in almost any currency. By this means the business of the Corporation has been improved and expanded in areas where dollar exchange is not available.

Active operating subsidiaries consist of Foster Wheeler Limited (England); Foster Wheeler Limited (Canada); Société Foster Wheeler Française (France). Deutsche Foster Wheeler Gesellschaft, the German company, has not been activated up to the present time, although it continues in good standing and is ready when conditions warrant.

SUBSIDIARY COMPANIES

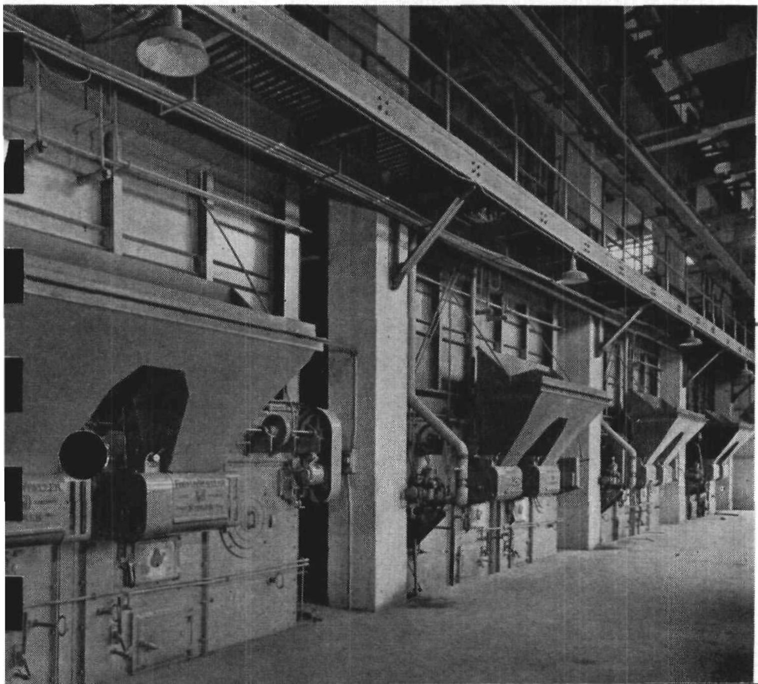
Foster Wheeler Limited (England)

Foster Wheeler Limited (England) enjoyed the best year of its history in 1954. Refinery or chemical units have been completed in the United Kingdom, Argentine, Assam and elsewhere. Work is progressing for refinery units in England, Bahrain and other locations, and new contracts have been concluded for installations at Fawley (England) and Burma. Satisfactory licensing agreements have been made with important shipyards in France, Italy, and other countries, for marine boilers. The business of the Company in stationary boilers is growing.

The Company continues to expand its manufacturing facilities at Egham and prospects for business for the coming year are good.

Foster Wheeler Limited (Canada)

The volume of business handled by Foster Wheeler Limited (Canada) continued at a good rate during 1954. This came principally from stationary steam generating units, heat exchangers, and auxiliary steam equipment. The lag in new petroleum refinery projects in Canada, which was evident in 1953, changed for the better in the third quarter of 1954 when the Company was awarded a contract for a large complete petroleum refinery to be installed near Halifax, Nova Scotia. The design and engineering work will be divided between the parent Corporation and Foster Wheeler Limited (Canada) utilizing process engineering facilities of the latter to maximum capacity. Business prospects for 1955 appear good.



Foster Wheeler Ltd. (Canada) has furnished more than 40 S.A. steam generators for air force bases in Canada.

Société Foster Wheeler Française (France)

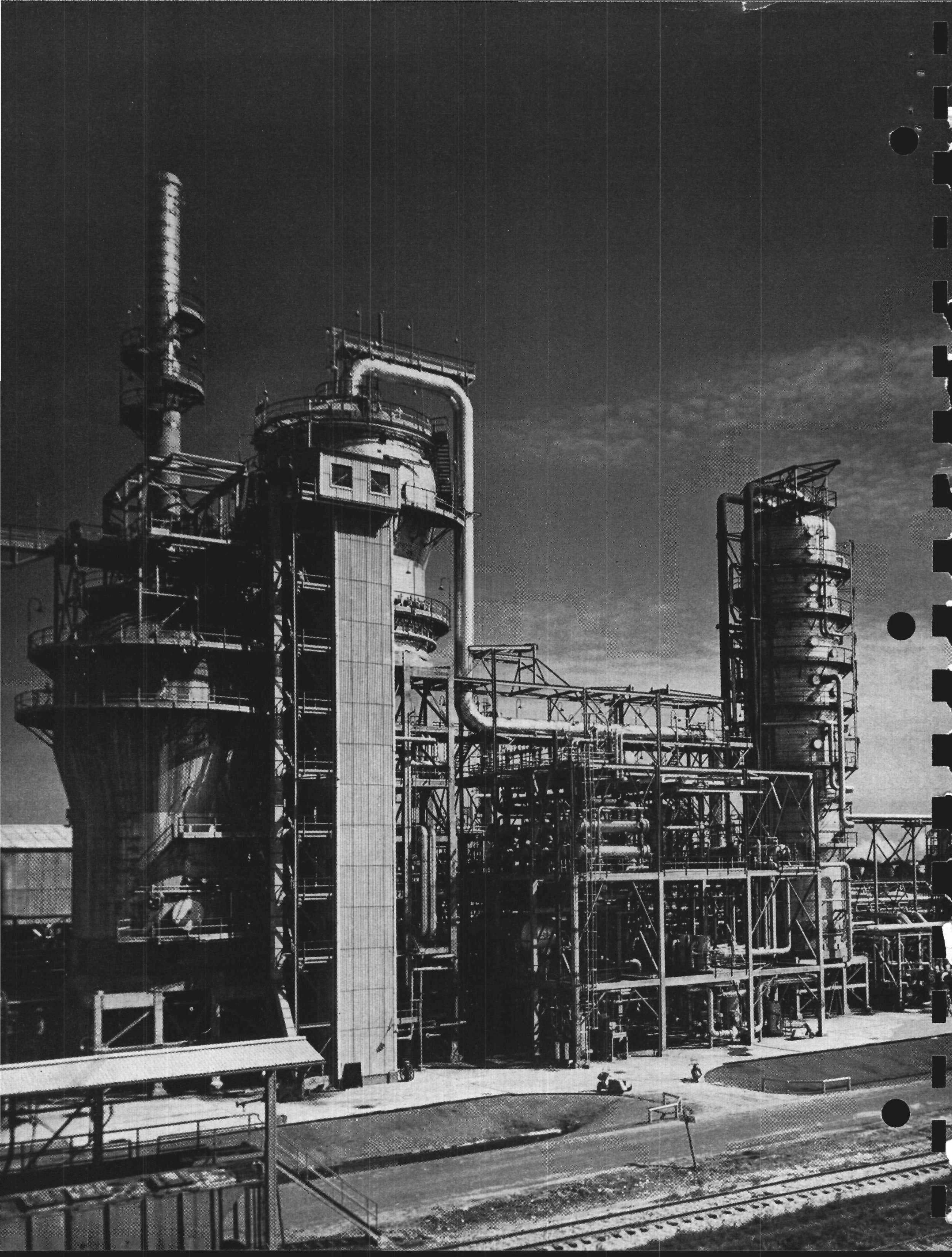
During 1954 some new contracts were received for chemical and refinery installations in France and neighboring countries. Pipeline studies and engineering work resulted in the award of a contract to the Company for an architect-engineer survey and inspection program. Increased inquiries for chemical and refinery installations in France and neighboring countries should result in additional contracts.

This Subsidiary has strengthened its technical staff and is well qualified to perform engineering work in France in conformity with the standards of the parent Corporation. It has made constructive contributions in the development of European and foreign sales for the Corporation and its other subsidiaries and it is hoped that the scope of these operations will be gradually expanded.

General Regulator Corporation

The sales of General Regulator combustion control systems and desuperheaters have been maintained as the performance and dependability of this equipment have been recognized. General Regulator control systems for marine use have been sold during 1954 for ships being built in West Germany, Sweden, Japan, France, Northern Ireland, and the United States.

General Regulator has obtained several contracts for high-speed hydraulic control systems combined with sensitive electronic controls for aircraft testing facilities. Inquiries for this type of equipment received toward the end of the year indicate that some increased business should be obtained in this field during 1955. General Regulator obtained, in addition, several contracts during 1954 for a newly developed pneumatic control system.



PROCESS PLANTS DIVISION

The Process Plants Division of the Corporation has progressed in the design and construction of processing units and complete plants for the petroleum refining and chemical industries. During 1954 the Division completed a large number of installations and successfully operated several new processes pioneered by your Corporation. In this period the parent Corporation and its subsidiaries completed engineering and construction work valued at $88,000,000.

A highly competitive market for construction of new plants developed during 1954, resulting in a lower volume of new orders for the first half of the year. There was an upturn in new orders in the last half, and prospects for 1955 are encouraging. Contracts taken by this Division require considerable time in execution so that substantial billings are not realized promptly.

Petroleum Refinery Department

Plants completed and placed in successful operation during 1954 include complete new petroleum refineries in South Africa, the Philippines, and Texas, and a major refinery modernization program in Colombia, South America. Several large processing units were completed in this country. Among them were the largest crude distillation unit in the world and the highest capacity fluid catalytic cracking unit. At the end of the year, work was continuing on projects in Brazil, Venezuela, England, France, Spain, India, Bahrain, Canada and the United States. An increasing number of new petroleum projects are being handled jointly with our subsidiary companies in Canada, England and France, thus providing our customers with the most modern American refinery technology while at the same time permitting them to pay for a portion of the service in European currencies. Expert technical personnel from the New York office are located in London and Paris to coordinate and assist in these joint projects.

The fourth and largest Foster Wheeler catalytic cracking unit for a major refiner has a daily throughput of 72,000 barrels.

During 1954 steps were taken to strengthen the Department to meet the current highly competitive market. By arrangement with process licensors, we are now able to offer several new processes to our clients in the refinery field.

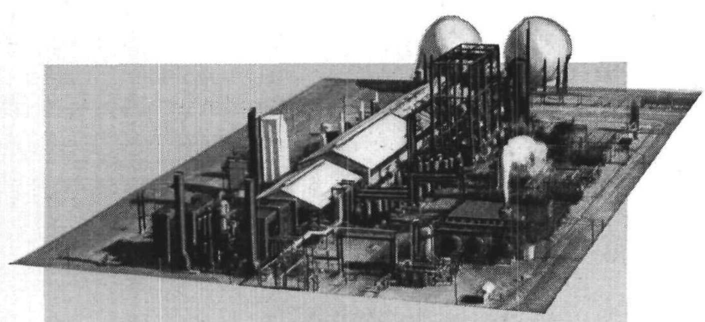
Chemical Plants Department

Three more Foster Wheeler-Casale ammonia plants, with a total annual capacity in excess of 200,000 tons, were commissioned in 1954. The success of this process substantiates your Corporation's belief that it will have industry-wide acceptance.

In addition, the first Pechiney urea plant built in the United States was completed by Foster Wheeler and has synthesized urea successfully. This process makes use of a novel oil recirculation system. Because of the continuing increase in the demand for nitrogen fertilizers, the Corporation looks with confidence to increased business in this field.

During 1954 there were four plants operating which reform natural gas by the use of the noncatalytic partial oxidation process to produce hydrogen for synthesis. These plants, all built by your Corporation, were the first of their type to be placed in successful commercial service. Their versatility permits the use of fuel oil in place of natural gas for the production of synthesis gas.

The Chemical Plants Department is actively investigating possibilities for participation in chemical fields other than nitrogen.



Chemical plants are an important part of Process Plants' activity.

EQUIPMENT DIVISION

The Equipment Division comprises the Condenser, Cooling Tower, Marine, Nuclear Energy and Steam Departments, known as commercial departments, and the Manufacturing, Repair Order and Service Departments, known as contract service departments.

Condenser Department

During the first half of 1954 the Condenser Department backlog of business was reduced. Since that time there has been a gradual increase in new business. Activity in the public utilities power industry and general recognition of improved designs point to the availability of new business.

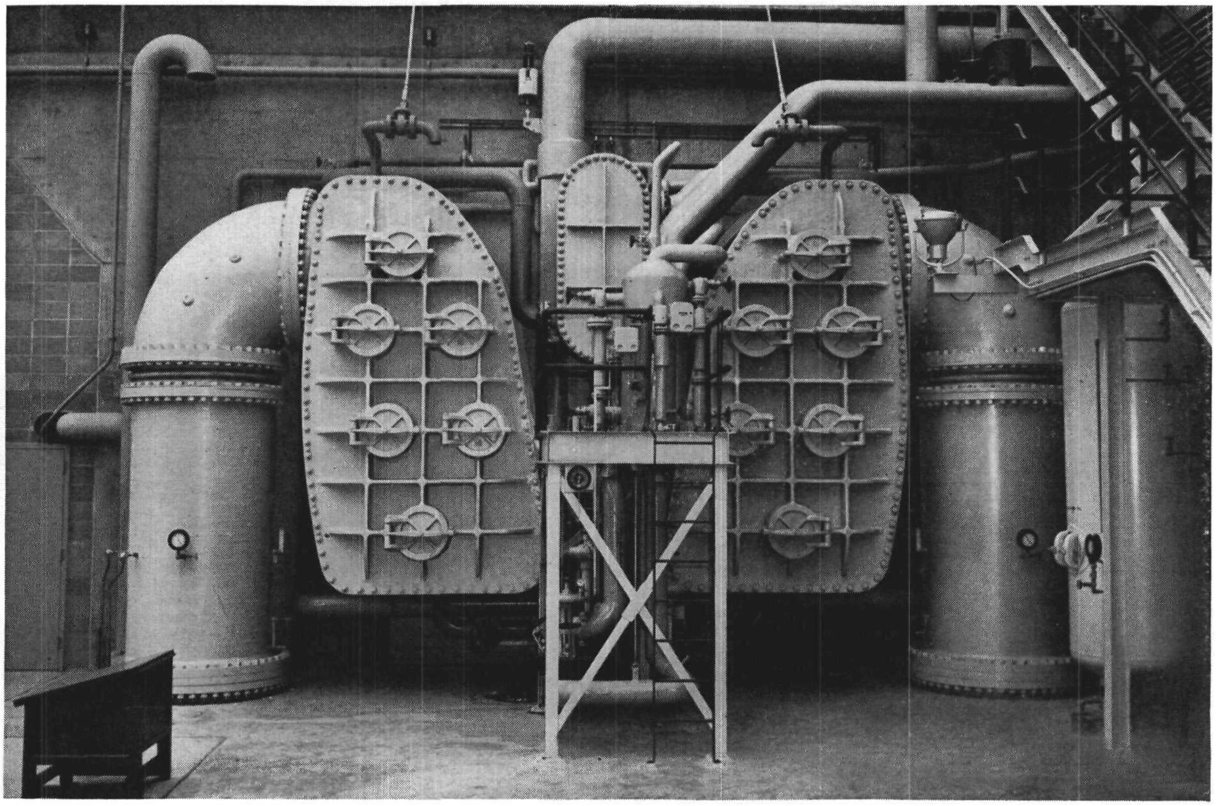
Practically all of the equipment supplied through the Condenser Department is fabricated in our own shops. The close relationship between the Condenser and Manufacturing Departments was improved during the year by the creation of the Special Products Section in the Condenser Department. It is the primary objective of this Section to develop the sale of services of heavy metal forming, welding and machining equipment to realize the best distribution of work on all tools essential to flexible and economical plant operation.

Cooling Tower Department

During 1954 the Cooling Tower Department was formed for the effective integration, organization and operation of our cooling tower business. This Department is a combination of the Cooling Tower Section of the Condenser Department, California Fabricators, previously part of the Manufacturing Department, and certain personnel formerly in the Construction and Contract Design Departments.

With a view toward improved coordination, many functions of this Department have now been located in California, where your Corporation owns a redwood lumber fabrication plant. By early 1955 the entire Department will be operated from the West Coast.

Surface condensers, such as this 65,000 sq. ft. unit, are manufactured in our Carteret Plant. This is one of 20 condensers installed in several plants of a single West Coast power company.

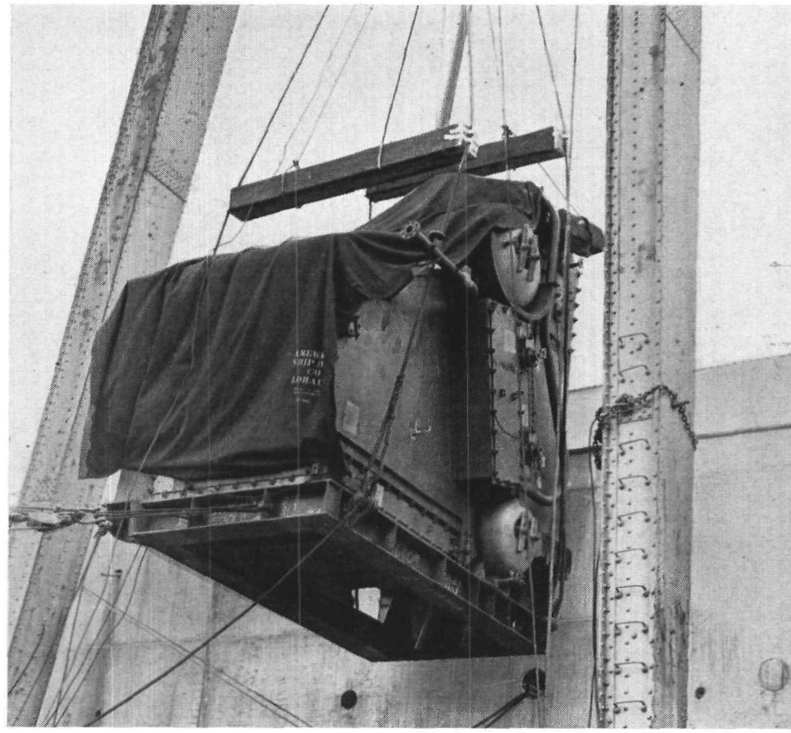


Design improvements are being developed to reduce field erection costs, and the use of plastics is being studied closely. An expanded research and development program will be undertaken during 1955.

Marine Department

Unfilled Marine Department orders were greater at the end of the year than at the beginning. This backlog of business was built up even though ship construction in this country declined in 1954 to a lower level than in the last several years. These orders were for equipment for Naval vessels and, to a lesser extent, for vessels under construction in foreign shipyards. In addition, the U. S. Navy has placed a contract with Foster Wheeler for the development and construction of a new type of steam generator which should be applicable to land as well as to marine use.

Many ships equipped with Foster Wheeler marine steam generators, economizers, condensers and auxiliaries were placed in service during the year. The supply of spare parts essential to keeping ships in economical operation, is an important part of our business.



A preassembled marine steam generator is lifted aboard a Great Lakes ore carrier for installation in the boiler room.

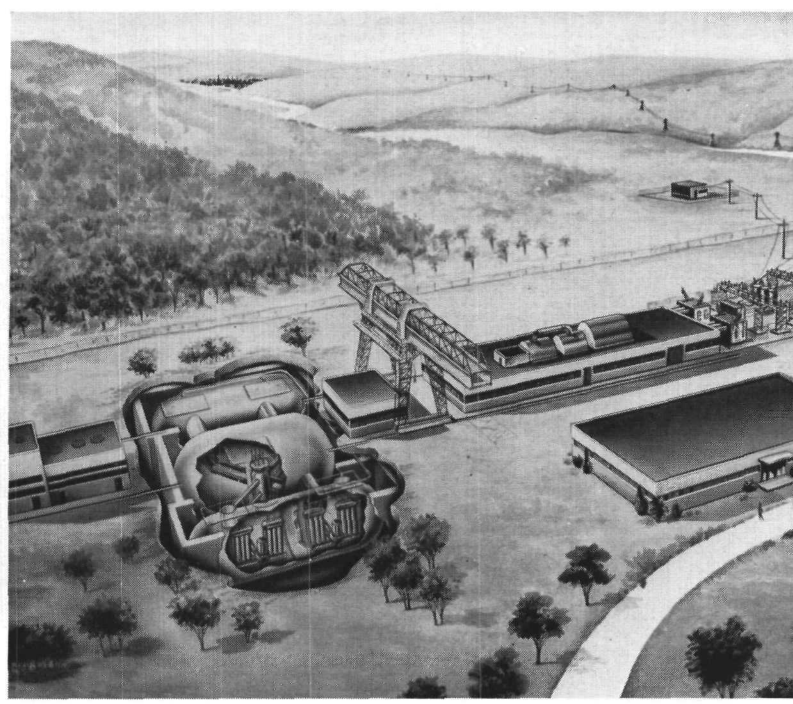
Nuclear Energy Department

The business potential in the field of nuclear engineering increased during the early part of 1954 to the point that it was decided to form a new Department which would devote its efforts exclusively to this field. Experienced personnel from the Marine Department and the Research and Development Department, including personnel trained in reactor technology, formed this new group.

New bookings during the year have been at an encouraging rate. The Department was awarded the contract for one-half of the steam generator heat exchangers required for the Duquesne Light Company Atomic Power Plant which will be built at Shippingport, Pennsylvania. This will be the first commerically-operated nuclear power plant in this country.

It is hoped that within a few years the Nuclear Energy Department's contribution to the overall business of the Corporation will be significant.

Artist's sketch of the first nuclear-fired steam electric station, for which Foster Wheeler Corporation is supplying one-half of the steam generator heat exchangers.



The first of two Foster Wheeler 1,300,000 pound per hour steam generators was started up in this Eastern Pennsylvania outdoor power plant in the summer of 1954.

Steam Department

In 1954 the bookings for the Steam Department were at a slightly higher rate than in 1953. There has been a marked increase in the volume of inquiries, particularly from public utilities, and it is expected that a larger market for Steam Department products will be available in 1955. These contracts are also of a long-term nature which delay the build-up of substantial billings.

Completed installations included packaged boilers and large central station steam generators, as well as individual components.

An outstanding accomplishment in 1954 was the receipt by your Corporation of an order for the largest steam generating unit under construction in this country. This is a reheat-type unit to supply 2,000,000 pounds of steam per hour (at a pressure of 2450 psig, primary steam temperature of 1050 F, and reheat steam temperature of 1000 F) to a turbine generator which will have a capacity greater than 300,000 kilowatts.

The Industrial Section placed into service equipment for airplane jet engine test facilities including test chambers, exhaust gas coolers, combustion air heaters and steam accumulators for serving vacuum equipment. On one contract the accumulators are supplying steam at a design rate of 2,000,000 pounds per hour.

Manufacturing Department

The new plant located at Mountaintop, near Wilkes-Barre, Pa., which was placed in operation in November of 1953, is being increasingly utilized.

Improved manufacturing techniques have been developed and new tooling has been added to our plants during the past year. Some of the more important improvements involve the application of twin-arc submerged arc welding, development of new techniques on the two-million volt x-ray equipment, installation of a new condensate pump testing facility, and acquisition of turret lathes, a large external shaft grinder, and a specially-designed inside pipe welder.

PROCESS PLANTS DIVISION

The Process Plants Division of the Corporation has progressed in the design and construction of processing units and complete plants for the petroleum refining and chemical industries. During 1954 the Division completed a large number of installations and successfully operated several new processes pioneered by your Corporation. In this period the parent Corporation and its subsidiaries completed engineering and construction work valued at $88,000,000.

A highly competitive market for construction of new plants developed during 1954, resulting in a lower volume of new orders for the first half of the year. There was an upturn in new orders in the last half, and prospects for 1955 are encouraging. Contracts taken by this Division require considerable time in execution so that substantial billings are not realized promptly.

Petroleum Refinery Department

Plants completed and placed in successful operation during 1954 include complete new petroleum refineries in South Africa, the Philippines, and Texas, and a major refinery modernization program in Colombia, South America. Several large processing units were completed in this country. Among them were the largest crude distillation unit in the world and the highest capacity fluid catalytic cracking unit. At the end of the year, work was continuing on projects in Brazil, Venezuela, England, France, Spain, India, Bahrain, Canada and the United States. An increasing number of new petroleum projects are being handled jointly with our subsidiary companies in Canada, England and France, thus providing our customers with the most modern American refinery technology while at the same time permitting them to pay for a portion of the service in European currencies. Expert technical personnel from the New York office are located in London and Paris to coordinate and assist in these joint projects.

The fourth and largest Foster Wheeler catalytic cracking unit for a major refiner has a daily throughput of 72,000 barrels.

During 1954 steps were taken to strengthen the Department to meet the current highly competitive market. By arrangement with process licensors, we are now able to offer several new processes to our clients in the refinery field.

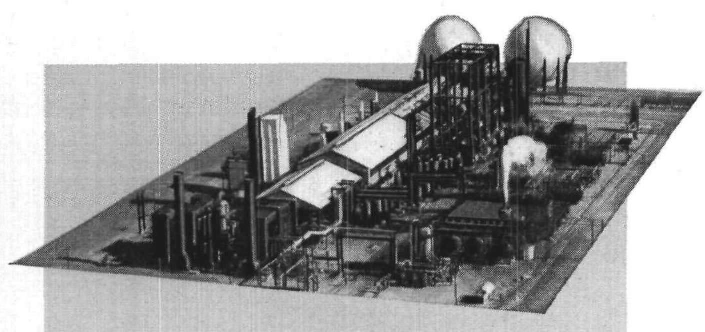
Chemical Plants Department

Three more Foster Wheeler-Casale ammonia plants, with a total annual capacity in excess of 200,000 tons, were commissioned in 1954. The success of this process substantiates your Corporation's belief that it will have industry-wide acceptance.

In addition, the first Pechiney urea plant built in the United States was completed by Foster Wheeler and has synthesized urea successfully. This process makes use of a novel oil recirculation system. Because of the continuing increase in the demand for nitrogen fertilizers, the Corporation looks with confidence to increased business in this field.

During 1954 there were four plants operating which reform natural gas by the use of the non-catalytic partial oxidation process to produce hydrogen for synthesis. These plants, all built by your Corporation, were the first of their type to be placed in successful commercial service. Their versatility permits the use of fuel oil in place of natural gas for the production of synthesis gas.

The Chemical Plants Department is actively investigating possibilities for participation in chemical fields other than nitrogen.



Chemical plants are an important part of Process Plants' activity.

EMPLOYEE RELATIONS

The relationship between management and employees was harmonious during 1954. Agreements with all organized groups, involving five different unions at our permanent locations, continued in effect during the year. There was a strike of two weeks' duration at the Mountaintop plant as the result of a disagreement on the terms of wage increases. The strike was settled on an amicable basis. Some interruptions of a minor nature occurred at field construction sites; but on the whole conditions were satisfactory.

Group insurance policies for coverage in case of death or accident and health have been continued. Total payments to beneficiaries under group policies were as follows for the last two years.

	1954	1953
Death	$107,400	$160,600
Accident and Health	65,320	82,200
TOTAL	$172,720	$242,800

These policies have remained unchanged during the year except where state laws have been adopted or revised requiring modification in our coverages. The basic group life policy is provided by the Corporation for all personnel and additional coverage may be obtained by employees under a contributory plan. During the year the coverage of hospitalization and medical-surgical insurance was changed and the Corporation now pays the full cost of this insurance for the employee and eligible dependents.

The manufacturing plants have continued the employee suggestion system with rewards for suggestions adopted. As the result of an aggressive safety program, the lost time accident record continues good.

The pension plans previously adopted and authorized continue in effect. As of December 31, 1954, 191 retired employees were receiving benefits from the non-contributory retirement plan. There were 35 individuals receiving benefits under the non-contributory discretionary directors' plan which

Each year student engineers are given an intensive nine months training course in the New York office and in the manufacturing plants before assignment to a department.

makes provision for certain individuals who were too old to qualify for the contributory plan, which was adopted April 1, 1946. The contributory plan had 717 employees enrolled as participants with three retired employees receiving benefits.

The extensive participation of Foster Wheeler employees in activities of professional engineering and other technical societies is evidence of the interest and qualifications of the individuals who carry on many of the activities involved in the conduct of our business. The number of professions represented in the Foster Wheeler organization has increased steadily during recent years, as the range of services has widened.

ACKNOWLEDGMENT

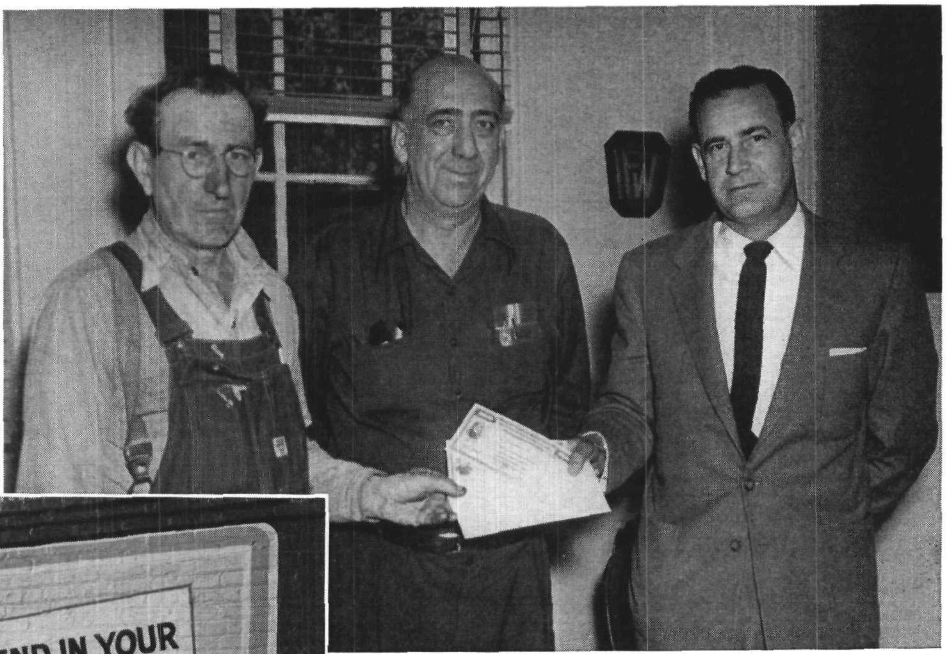
Without the loyal support and untiring efforts of the large body of faithful employees in our many lines of work at home and abroad, the accomplishments of your Corporation in 1954 could not have been possible. Your Board of Directors and your Officers acknowledge and thank the employees for this devotion to duty. They are not unaware of the skill and hard work which makes the term "Yankee Ingenuity" fit with "Foster Wheeler".

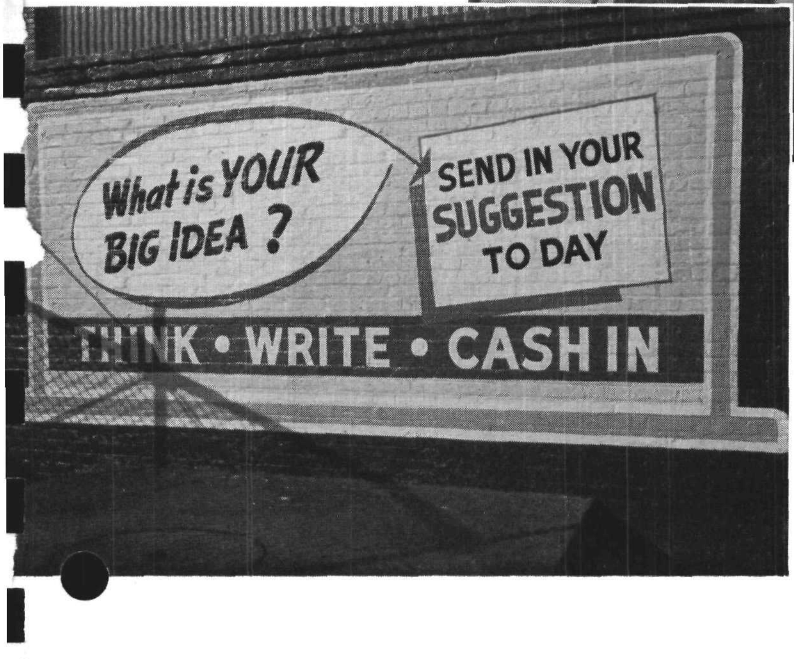
By Order of the Board of Directors,

Earle W. Mills

February 26, 1955. *President.*

A Dansville employee is rewarded for a suggestion which led to an improvement in the manufacturing process of cast iron gill rings.





Plant personnel are urged to suggest methods for job simplifications, improved machine operations, and safety measures.

Consolidated Balance Sheet —

Assets

	1954	1953
CURRENT ASSETS		
Cash	$ 10,563,714	$ 10,160,304
United States and British Government securities	4,540,051	6,058,626
Accounts receivable		
Trade (less reserve)	15,506,737	21,400,776
Other	566,876	631,794
Inventories		
Work in process		
Cost of uncompleted contracts plus accrued profit	163,700,069	167,537,960
Less earned billings on uncompleted contracts	158,170,320	155,031,913
	5,529,749	12,506,047
Material and supplies (at average cost, not in excess of market)	3,303,685	4,320,993
	8,833,434	16,827,040
TOTAL CURRENT ASSETS	40,010,812	55,078,540
LAND, BUILDINGS AND EQUIPMENT (at cost)	22,446,412	21,541,556
LESS ACCUMULATED DEPRECIATION	8,976,428	8,187,151
NET BOOK VALUE	13,469,984	13,354,405
TRADE NOTES RECEIVABLE DUE AFTER ONE YEAR	180,745	—
INVESTMENTS (at cost, less reserve)	201,676	193,385
DEPOSITS WITH MUTUAL FIRE INSURANCE COMPANIES	134,964	156,879
DEFERRED CHARGES TO OPERATIONS	765,756	782,214
GOODWILL AND DEVELOPED PATENTS	1	1
	$ 54,763,938	$ 69,565,424

Notes 1 to 6 will be found on page 17.

ATION AND SUBSIDIARIES

December 31, 1954 and 1953

Liabilities, Capital Stock and Surplus

			1954	1953
CURRENT LIABILITIES				
Loans payable to banks			$ —	$ 13,000,000
Accounts payable			4,405,929	9,650,631
Withheld from employees (taxes and sundries)			401,775	758,516
Commissions, taxes, wages and expenses accrued			2,200,212	1,953,263
Costs accrued on contracts substantially complete			2,434,565	2,609,292
Advance payments by customers			4,865,098	5,285,060
United States, British and Canadian taxes on income			4,196,723	3,843,082
TOTAL CURRENT LIABILITIES			18,504,302	37,099,844
4¼% UNSECURED PROMISSORY NOTES, maturing $425,000 on August 1 in each year from 1956 to 1966, inclusive, and $325,000 on August 1, 1967			5,000,000	5,000,000
MINORITY INTERESTS			18,773	16,443
CAPITAL STOCK, RESERVE AND SURPLUS				
Common stock, par value $10	1954	1953		
Issued and outstanding	582,703	570,068	5,827,030	5,700,680
Reserved for officers and employees under stock option plan (note 3)	17,297	29,932		
Unissued	400,000	400,000		
	1,000,000	1,000,000		
Reserve for deferred income tax in connection with accelerated amortization of emergency facilities (note 2)			500,000	120,000
Capital surplus (note 4)			578,109	274,818
Earned surplus (note 5)			24,335,724	21,353,639
			$ 54,763,938	$ 69,565,424

Notes 1 to 6 will be found on page 17.

FOSTER WHEELER CORPORATION AND SUBSIDIARIES

Consolidated Statement of Earnings and Earned Surplus
Years Ended December 31, 1954 and 1953

	1954	1953
EARNED BILLINGS	$138,597,795	$155,327,228
GROSS EARNINGS FROM OPERATIONS	$ 17,554,259	$ 14,769,530
SELLING, GENERAL AND ADMINISTRATIVE EXPENSES	8,175,014	6,735,816
PROVISION FOR DEPRECIATION AND AMORTIZATION OF LEASEHOLD IMPROVEMENTS	1,106,530	871,181
	9,281,544	7,606,997
NET EARNINGS FROM OPERATIONS	8,272,715	7,162,533
OTHER INCOME	276,512	489,708
	8,549,227	7,652,241
OTHER DEDUCTIONS (including interest of $398,671 and $900,798 respectively)	439,546	912,321
NET EARNINGS BEFORE PROVISION FOR TAXES ON INCOME	8,109,681	6,739,920
PROVISION FOR TAXES ON INCOME		
United States, British and Canadian (note 2)	4,521,844	3,979,475
Less refunds and adjustments — prior years	—	116,809
	4,521,844	3,862,666
NET EARNINGS FOR YEAR	3,587,837	2,877,254
EARNED SURPLUS — BEGINNING OF YEAR	21,353,639	18,476,385
	24,941,476	21,353,639
Deduct		
Dividends on common stock	405,752	—
Amount transferred to capital surplus (note 4)	200,000	—
	605,752	—
EARNED SURPLUS — END OF YEAR (note 5)	$ 24,335,724	$ 21,353,639

Notes 1 to 6 will be found on page 17.

Notes to Financial Statements

NOTE 1

The consolidated statements include the accounts of Foster Wheeler Corporation, Foster Wheeler Limited (Canada), Foster Wheeler Limited (England) and domestic subsidiaries but do not include accounts of two foreign subsidiaries which are not significant in relation to the consolidated companies.

Net assets and earnings of foreign subsidiaries included in the consolidated financial statements are summarized as follows:

	1954	1953
CANADIAN SUBSIDIARY		
Working capital	$1,465,376	$1,515,222
Net assets	2,160,883	2,002,483
Net income	234,251	250,483
ENGLISH SUBSIDIARY		
Working capital	2,576,005	1,500,093
Net assets	3,164,662	2,050,609
Net income	1,568,339	596,672

Transfers of funds from England are subject to exchange controls.

The annual report of the Corporation for the year ended December 31, 1953 may be referred to for additional information with respect to 1953 figures which are shown in the accompanying statements for comparative purposes.

The accompanying balance sheet as of December 31, 1954 reflects certain reclassifications of accounts of the English subsidiary as compared with prior years. Accordingly, the 1953 figures shown for comparative purposes have been restated to give effect to such changes, the result of which is a decrease of $2,796,419 in total current assets and a decrease of like amount in total current liabilities as of December 31, 1953, as compared with previously published reports as of that date.

NOTE 2

The accompanying statements reflect depreciation of emergency facilities, acquired during the period 1950 through 1954, based upon the estimated useful life of such assets. For purposes of computing Federal taxes currently payable on income, the Corporation is amortizing the facilities over a shorter period than useful life. Accordingly, a provision for deferred income tax has been included in provision for taxes on income for the year ended December 31, 1954 in the amount of $380,000 for additional taxes in those future years which will not have the benefit of a tax deduction for emergency facilities still in use.

NOTE 3

Of the 30,032 shares of common stock reserved for sale to officers and employees under the Stock Option Plan, 14,338 shares are covered by options issued and outstanding, 272 shares are reserved for options exercised, full payment for which has not yet been made, and 12,735 shares were issued in full exercise of options.

NOTE 4

The increase in capital surplus during 1954 is explained as follows:

Excess of amounts paid for common stock over the par value of such shares	$103,291
Transfer by the Canadian subsidiary from earned surplus to comply with statutory requirements of the Dominion of Canada	200,000
Total increase	$303,291

NOTE 5

Earned surplus is the net accumulation since January 1, 1938.

The agreement relating to the 4¼% unsecured long-term promissory notes states that the Corporation may not pay dividends in excess of 75% of net income (as defined) earned subsequent to December 31, 1951, and further provides that after payment of such dividends net current assets (as defined) shall exceed $10,000,000. Applicable amounts at December 31, 1954 were:

75% of net income earned subsequent to December 31, 1951 less dividends paid	$ 2,830,317
Net current assets	17,446,355

NOTE 6

The unpaid past service cost of employees retirement plans as of December 31, 1954 is estimated to be approximately $2,940,000, which the companies plan to pay in future years.

Accountants' Opinion

HURDMAN AND CRANSTOUN
CERTIFIED PUBLIC ACCOUNTANTS
43 BROAD STREET
NEW YORK 4, N. Y.

To the Stockholders,

FOSTER WHEELER CORPORATION:

We have examined the consolidated balance sheet of Foster Wheeler Corporation and subsidiaries as of December 31. 1954, and the related consolidated statement of earnings and earned surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards and, accordingly, included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances. We made a similar examination for the year 1953.

In our opinion, the accompanying consolidated balance sheet and consolidated statement of earnings and earned surplus present fairly the financial position of Foster Wheeler Corporation and subsidiaries at December 31, 1954, and the results of their operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

HURDMAN AND CRANSTOUN
Certified Public Accountants

February 15, 1955

FOSTER WHEELER CORPORATION
165 BROADWAY
New York 6, New York

EARLE W. MILLS
PRESIDENT

REWOP
CABLE ADDRESS

27 January 1956

Mr. John M. Keen, Manager,
Wolverine Electric Corporation,
302 South Warren Avenue,
Big Rapids, Michigan.

Dear Mr. Keen:

I take this occasion to thank you for the opportunity which you have given our Equipment Division and Nuclear Energy Department to work with you in developing designs and estimates of the cost of a 5-10 MW aqueous homogeneous nuclear power plant, including chemical reprocessing facilities.

We have endeavored to provide you with an advanced but conservative design concept at a cost which we consider quite advantageous to you in view of the financial contribution which our quotation represents. We look forward to the privilege of working with you in the execution of this project when it is finally authorized. You may count on us to do our utmost to make the installation an outstanding one, with which all of us would be proud to be associated.

Yours sincerely,

E. W. Mills
President

II. THE FOSTER WHEELER CORPORATION

A. Nuclear Energy Activities Completed or in Progress

1. Consultant to the Oak Ridge National Laboratory in their investigation of helium cooled power reactors.

2. Consultant to the Westinghouse Atomic Power Division on heat transfer and fluid flow problems involved in the design of the Submarine Thermal Reactor.

3. Consultant, designer, and fabricator to the Knolls Atomic Power Laboratory on the liquid metal heat exchanger test loops for the Submarine Intermediate Reactor.

4. Designer and fabricator of a liquid metal heat exchanger for the Mine Safety Appliance test loops.

5. Designer and fabricator of six steam generating units under contract to the Westinghouse Atomic Power Division for the Bettis Mockup, the Mark I at the National Reactor Testing Station in Arco, Idaho, and the Nautilus.

6. Architect-engineer for the Idaho Chemical Processing Plant. As architect-engineer, Foster Wheeler supplied the process design, engineering, and inspection services.

7. Designer and fabricator of large cooling towers for the gaseous diffusion plant at Oak Ridge under contract to the W. L. Maxson Corporation.

8. Designer and fabricator of two of the four boilers required for the Pressurized Water Reactor, under contract to the Westinghouse Atomic Power Division.

9. Nuclear Power Project Program

   Foster Wheeler, since 1952, has been actively engaged in a study of nuclear power generation under contract with the Atomic Energy Commission. Full partners in the effort are the Pioneer Service & Engineering Co. of Chicago, Illinois, and the Diamond Alkali Company of Cleveland, Ohio. Project consultant is Dr. T.H.Pigford of the Massachusetts Institute of Technology.

The first year was spent by the group in reviewing existing and proposed reactor designs suitable for power propulsion.

In the second year, the group investigated the feasibility of a fluidized solids reactor. Several experiments, conducted in both the Foster Wheeler and Diamond Alkali Laboratories, showed that this system did not have the desirable nuclear and mechanical characteristics that stable nuclear power reactors requires.

At present the group is engaged in completing a reference design for a homogeneous power breeder. Various nuclear parameter studies were completed with the aid of the ORACLE at ORNL, and meetings with possible vendors are underway to determine costs. This homogeneous power system is now being offered to utilities.

10. Fabricator of fifty large heat exchangers for the Savannah River Project under contract to E. I. duPont deNemours & Company.

11. Developer of designs and manufacturing techniques for steam generators for the Homogeneous Reactor Program at Oak Ridge under contract with Carbide and Carbon Chemicals Company. The contract includes the design, construction, and operation of a thermal shock test loop.

12. Fabricator of two steam generators for the Homogeneous Reactor Test at Oak Ridge.

13. Designer and fabricator of a model steam generator and pressurizer for the Homogeneous Reactor Test mockup at Oak Ridge.

14. Fabricators of chemical processing plant components for Hanford under contract with the General Electric Company.

15. Designer, fabricator, and operator of a thermal shock test loop for the Westinghouse Atomic Power Division.

16. Designer, fabricator, andoperator of the Livermore Pool Type Reactor for the U. S. Atomic Energy Commission.

17. Designer and fabricator of the pressurizer for the Pressurized Water Reactor, under contract to the Westinghouse Atomic Power Division.

18. Designer and fabricator of the steam generators and reactor vessel for the Large Ship Reactor, under contract to the Westinghouse Atomic Power Division.

19. Designer, fabricator and erector of a large liquid metal heater for the Pratt & Whitney Corporation.

B. Nuclear Design Activities

1. Conceptual design of a fast reactor type nuclear powerplant utilizing pyro-metallurgical processing techniques. Personnel undertook control and parameter studies.

2. Feasibility study of a MTR type power plant for a remote location. Personnel participated in the nuclear parameter studies.

3. Fused salt package feasibility study for use at a remote location. Personnel undertook heat transfer and transient assignments.

4. Various transient studies for a submarine reactor project.

5. Massachusetts Institute of Technology "Project Separations", 1954. This project entails a study of chemical processing techniques suitable for nuclear reactor fuels. Personnel participated in the engineering and economic evaluation section.

WORTHINGTON CORPORATION
Harrison, New Jersey

Secondary Loop Designer & Builder

WORTHINGTON CORPORATION

99 PARK AVENUE
NEW YORK 16, N.Y.

OFFICE OF THE PRESIDENT

January 23, 1956

Mr. John N. Keen, Manager
Wolverine Electric Cooperative
302 - South Warren Ave.
Big Rapids, Michigan

Dear Mr. Keen:

We are very pleased to learn that you have selected Worthington to be one of your associates in your proposals to the Atomic Energy Commission.

We, at Worthington, are convinced of the bright future for Nuclear Energy in the generation of power. The Atomic Energy Commission's Demonstration Programs will do much to insure this future and we are proud to be a part of such programs. As expressed to you personally, we are glad to furnish our Secondary Cycle equipment at our cost and to contribute our experience, background and engineering know-how, as part of an overall team whose objective is to design and build the best possible Nuclear Power Plant of this size.

We again wish to express our extreme interest in this project and we sincerely hope that your proposal to the Atomic Energy Commission will receive favorable action.

Sincerely,

WORTHINGTON CORPORATION

E. J. Schwanhausser,
President

EJS:GJ

CC: Mr. R. J. Daverman
J.& G. Daverman Co.
924 Grandville Ave. S.W.
Grand Rapids, 9, Michigan

III. A BRIEF STATEMENT ON WORTHINGTON CORPORATION'S QUALIFICATION AND BACKGROUND IN THE FIELD OF STEAM POWER AND NUCLEAR ENERGY

For more than a century, the name of Worthington has been significant in the engineering and manufacture of Steam Power Plant equipment. In the evolution of the present day Steam Power Plant, Worthington has contributed greatly to the development of the equipment required for modern performance, incorporating the basic engineering knowledge and experience accumulated during its one-hundred and sixteen years of existence.

The Worthington background is an intimate part of the development of modern Steam Power Plant practice. Such a background is impressive. Worthington has been building Boiler Feed Pumps since 1840, Surface Condensers since 1854, Feedwater Heaters since 1895, Centrifugal Pumps since 1898, Air Compressors since 1873, Steam Jet Ejectors since 1918, Steam Turbines since 1918, and Electric Generators and Motors since 1902. Many principles of design now considered as conventional in such equipment were first developed and pioneered by Worthington.

Many of the features of the modern condenser plant which are now considered conventional design were developed by Worthington. Among such features we can point to:

The counter-flow principle of steam and circulating water through a multi-pass condenser, the internal air cooler in the lower and colder section, the application of the single-pass circulating water system to large units, spring supports and hydrostatic jacks, special provisions for longitudinal flow of steam, inlet steam laning for greater contact with tubes and minimum pressure drop, exit air lanes for direct and more effective removal of air, upward bowing of tubes for drainage and expansion.

More than half a century experience in the design and manufacture of heaters and heat transfer equipment has enabled Worthington to produce deaerating feedwater heaters which are efficient, accessible for maintenance and adaptable to the most exacting service conditions and limiting space requirements.

III. WORTHINGTON CORPORATION. (continued)

The Worthington Corporation has further made most notable contributions in the development of centrifugal pumping equipment for steam power plant applications. Among our developments we can point to the construction of the packingless stuffing box with cold water injection for high pressure boiler feed pumps, high pressure, high power, boiler feed pumps operating at speeds as high as 9,000 RPM, development of designs and research tests of boiler circulating pumps, and research on high speed water lubricated bearings and high pressure breakdowns, development of new high speed, high pressure boiler feed pumps for U. S. Navy Destroyers and U. S. Navy Aircraft Carriers.

Worthington's Three Quarters of a Century in the manufacture of air and gas compression equipment had facilitated the development of the Feather Valve, which is the simplest, lightest, most durable and most effective ever developed for compressor service. Our compressors can be found in power plants through out the world supplying plant air, instrument air, and performing other power plant services.

Our experience in the production of Turbo-Generator equipment of 50 years is supplemented by the experience and engineering resources of over a century of recognized leadership in the Power Plant field.

The Package Power Plant is not new to Worthington. During World War II, together with the Peter F. Loftus Corp. of Pittsburgh, Worthington designed, manufactured, and sold nearly 600 plants of capacities from 500 KW to 2000 KW. These Package Plants were made up of several component packages, which could be easily transported and readily erected.

In addition to our many years experience in the design, construction, and application of Power Plant auxiliaries to Steam Power Plants, Worthington for almost 10 years have been actively engaged in the application of its products in Atomic Energy Plants. We have designed, developed, and furnished the Condenser Circulating Pumps and other equipment for the Navy's first Atomic Powered Submarine, the "Nautilus", and have also furnished similar equipment for the second

III. WORTHINGTON CORPORATION (Continued)

such vessel, the "Sea Wolf". Under development contracts, Worthington continues to assist in the engineering studies and design of machinery for Nuclear Powered Aircraft and Aircraft Carriers.

It may be interesting to note that the first Turbo-Generator unit to develop electric power successfully from nuclear heat, in significant amounts, was of Worthington manufacture.

Worthington, because of its long background in fluid dynamics, has worked closely with others in the design of Reactor Coolant Circulators and special bearings.

Presently we have within our organization a division which is devoted almost exclusively to the application of our products for projects in the realm of Nuclear Energy. The Worthington Corporation, fully realizing the future role of Atomic Energy and its boundless possibilities, has avowed, as a matter of policy, to maintain itself abreast of all developments and to grow with this new industry.

J. & G. DAVERMAN COMPANY
Architects and Engineers
924 Grandville Avenue
Grand Rapids, Michigan

Consulting Engineer

I. J. & G. DAVERMAN COMPANY

A. History and Background

This firm, a four man partnership, was established in 1905 and has functioned in both the architectural and engineering fields since 1939. A staff of approximately sixty architects, engineers, draftsmen, construction supervisors and surveyors is now engaged on over 100 currently active projects. Included in this group are 18 men holding degrees in chemical, civil, electrical, mechanical and structural engineering with a combined total of approximately 200 years experience in their respective fields. The 12 men who hold architectural degrees have a combined experience record in excess of 160 years.

B. Partners

Joseph T. Daverman	Architect Calvin College A. B., 1934; University of Michigan B. S., 1937; B. Arch. 1937. Certificate No. 3685 Michigan; No. 1631 - Ohio.
Experience:	Ryerson Fellow, winner of competition in design that permitted nine months travel fellowship in Europe. 1 year Thomas S. Tanner, Architect and Engineer, Ann Arbor, Michigan - architectural design and layout of industrial plants, hospitals, schools, churches, office buildings, numerous houses and miscellaneous structures. Since 1938, Partner, J. & G. Daverman Company, in charge of design, planning and production of Architectural work including commercial, industrial and institutional projects.

I. J. & G. DAVERMAN COMPANY (Continued)

Robert J. Daverman — Engineer
B. S. (Ch. E.) and M. S. (Ch. E.) University of Michigan, 1936. Certificate No. 3995 - Michigan; No. 15950 - Ohio.

Experience: 2 years Michigan Bell Telephone Co. - Construction Dept; 2 years DuPont Company, Grasselli Chemicals Division - Muriatic and Sulfuric Acid; 1 year Roy A. White, Consulting Engineer - Michigan REA distribution line projects; since 1939 partner J. & G. Daverman Co., in charge of all mechanical and electrical engineering relating to architectural projects and a power program including 5,000 miles distribution line construction, 675 miles of 33, 44 and 69 KV transmission line and approximately 50 related substations and 25,000 KW diesel generating capacity in nine different power plants.

Military Service: Lt. Comdr., U.S.N.R. 20 months Ass't Officer in charge of Power Generation and Distribution and construction supervision of 20,000 KW bomb proof steam generating plant, Pearl Harbor Navy Yard; 10 months coordination of construction of communications and power facilities, Guam; 10 months miscellaneous duties.

Herbert G. Daverman — Architectural Engineer
A.B. Calvin College, 1935; University of Michigan B.S.-B.A. Eng. 1937. Certificate No. 3834 - Michigan.

Experience: 1 year Cuthbert and Cuthbert, Architects and Engineers, Ann Arbor, Michigan - steel and concrete design, detail and working drawings; since 1938 partner J. & G. Daverman Company, structural design and detail work including complete structural drawings, steel shop drawings, reinforced concrete for hospitals, steel skeleton school construction & industrial plants, superv. of structural work for schools, hospitals, churches. Airport design for Michigan Dept. of Aeronautics.

I. J. & G. DAVERMAN COMPANY (Continued)

Edward H. Daverman	Engineer B. S. (Ch. E.) University of Michigan, 1940 P. E. Certificate (C. E.) No. 7921 Michigan, No. 20140 Ohio, No. 7036 Indiana.
Experience:	2 years Roy A. White, Consulting Engineer as field and office engineer on numerous power projects. Three years with J. & G. Daverman Company as Resident Engineer on 1500 miles of power line construction. Partner since 1949 in charge of transmission line and distribution line field activities, line design, planning and construction.
Military Service:	Lt. Comdr. U. S. N. R. 3 years Ordnance Repair Superintendent, New York Navy Yard; 1 year Ordnance New Construction Superintendent battleships, carriers, destroyers, in charge of electrical and mechanical equipment and controls for ordnance installations.

C. Facilities and Partial List of Major Projects

The J. & G. Daverman Company is presently producing at an annual rate the Architectural and Engineering service including design, working drawings and supervision on approximately $10,000,000.00 of architectural and engineering construction. Projects include industrial, commercial and institutional type facilities, power plants, power distribution and transmission systems, water and sewerage works, airports, shopping centers, along with various engineering and economic studies. Listed below are a partial list of the more important projects completed or in progress since 1950.

I. J. & G. DAVERMAN COMPANY (Continued)

Major Projects - partial list 1950 - 1955

Wolverine Electric Cooperative, Big Rapids, Michigan 9500 KW Diesel Power Plant, 300 miles 44KV transmission line, 18 substations and switching stations and diesel plant additions	$3,800,000
Northern Michigan Electric Cooperative, Boyne City, Michigan - 320 miles 69 KV transmission line, 20 - 69 KV substations, power plant additions	$2,750,000
Parke-Davis Company, Holland, Michigan Steam Power Plant, chemical process equipment and piping and remodeling	$1,700,000
Thumb Electric Cooperative, Ubly, Michigan Diesel generating plant, 44 KV substations, switching stations, transmission system	$1,320,000
Kent County Airport, Grand Rapids, Michigan Runways, lighting, expansion	$1,500,000
Cloverland Electric Cooperative, Sault Ste. Marie, Michigan - 2200 KW generating plant, 100 miles 69 KV transmission system and 300 miles rural distribution line	$1,800,000
American Motors (Nash-Kelvinator), Grand Rapids, Michigan - Plant addition and remodeling	$1,200,000
State of Michigan, 600-man Medium Security Correctional Institution, Ionia, Michigan - Site development, administration building, housing, hospital, dining and recreational facilities	$7,200,000
The Center, Omaha, Nebraska Shopping Center, economic study, plans and specifications and supervision	$3,000,000

I. J. & G. DAVERMAN COMPANY (Continued)

General Motors Corporation, Grand Rapids, Michigan - Addition to compressor station, Fisher Body Plant No. 1	$ 500,000
Steelcase Incorporated, Grand Rapids, Michigan Steel office furniture manufacturing plant and office	$1,800,000
City of Grand Rapids, Grand Rapids, Michigan Rehabilitation of Water Pumping Station, Filtration Plant and Water Distribution System	$2,100,000

APPENDIX B

I. Description of Plant Site

II. Existing Hersey Generating Plant Facilities

I. DESCRIPTION OF PLANT SITE

A. Location

The Plant Site is located in the NE 1/4 of Section 30, T17N, R9W, Hersey Township, Osceola County as shown on Dwg. 5502-16A. It is a 93 acre tract of relatively flat, open land, with good drainage, located adjacent to and 40 feet above the Muskegon River. An aerial photograph of the vicinity is included as Exhibit 1 of this appendix.

The site is in relatively sparsely populated country, approximately 1/2 mile from the very small town of Hersey (population 239) and 4 miles from the small town of Reed City (population 2241).

The site is well drained and is located on an improved secondary road which is maintained and kept open throughout the year by the County Road Commission. The roads to the plant are adequate for hauling any contemplated loads imposed by the equipment to be installed.

B. Geology

The sub-soil at the plant is gravel and sand to a depth of 50 feet below the surface, beneath which lies glacial drift to a depth of several hundred feet. The Vicinity Map, Dwg. 5502-16A, shows the location of oil well drilling in the area of the plant. Logs of three of the drillings are shown on Exhibits 2 and 3, this appendix. The soil conditions at the plant provide satisfactory bearing for the loads to be imposed by the contemplated construction.

C. Water

The Muskegon River is the source for cooling water in the Plant. The River at this point has a minimum recorded flow of 164 cfs and a maximum flow of 7,000 cfs, with an average twenty year flow of 968 cfs. The stream is clean and clear, except during flood times, and has a maximum summer temperature of 75 deg. F.

The existing plant has two wells, used for drinking and sanitary purposes only. Well water is available at the site in large quantities at a depth of approximately 100 feet and is of good quality.

I. DESCRIPTION OF PLANT SITE (continued)

D. Meteorology

The winds in the plant area are prevailing westerly. There are no records available at or near the site. Dwg. 5502-16A shows wind roses for Grand Rapids (approximately 58 miles south) and Cadillac (approximately 25 miles north) of the plant. The roses were compiled from C. A. A. data taken at the respective airports.

There are no records available for any point in the lower peninsula of Michigan on temperature inversions. Temperature inversion or fogs and smogs caused by inversion are extremely rare in the Central Michigan area. The occasional fogs which do occur are normally of short duration, occuring during night and early morning hours following a drop in temperature, and clearing up during the day. Exhibit 4, this appendix, is a record of fogs, taken from data compiled by the Grand Rapids Weather Station.

E. Seismology

Earthquakes or earth disturbances are, as far as is known, nonexistant in the Central Michigan region. As evidenced by Exhibit 5, the Seismology Department of the University of Michigan has no record or data on any such occurences during recorded times.

APPENDIX B-I
EXHIBIT I

AERIAL PHOTOGRAPH OF HERSEY PLANT AND VICINITY

APPENDIX B
Exhibit 2

DRILLING LOGS

[illegible] Twp., (Osceola County)

D. E. Hughes and A. Hansen

M. Bor or et al #1

Drilling Contractor: McC[illegible]han Oil Company

Permit #4934

Location: SE¼ SW¼ SW¼ section 35, T.17N., R.10W.
330' from the south and 990' from the west line of quarter section

Elevation: 995 feet above sea level

Record by: L. [illegible]le from driller's log and samples 615-3716.

	Thickness (feet)	Depth (feet)
PLEISTOCENE:		
Drift:		
Drift	83	83
Sand	29	112
Gravel	3	115
Sand	4	119
Drift	39	158
Sand	7	165
Mud	22	187
Mud, red	16	203
Mud, red; sand; and gravel	18	221
Mud, red	39	260
Heaving sand	55	315
Shale, sandy	20	335
Mud	10	345
Mud, red	40	385
Mud, red and gravel	32	417
Mud	19	436
Mud and gravel	20	456
PERMO-CARBONIFEROUS (?):		
"Red-Beds":		
Mud, red mud; and gypsum	29	485
Mud, red	28	513
Gypsum shell	19	532
Mud	20	552
Mud, red and sand	18	570
PENNSYLVANIAN:		
Saginaw:		
Shale, dark	20	590
Shale, blue	25	615
Sandstone, gray, well cemented; gray, flaky and micaceous shale; a little brown shale; a little dolomite	14	629
Shale, dark gray, hard, flaky; some sandy shale	5	634
Shale, black, carbonaceous	14	648
Shale, light gray, muddy; and hard black shale	15	663
Shale, gray, flaky; some micaceous shale	9	672
Shale, gray, flaky; and some hard brown shale	18	690
Shale, brown, hard; a little gray shale; some pyritized fossil wood fragments (?)	6	696
Shale, light gray, soft and muddy	14	710

Page 2 - Richmond Twp., (Osceola County)
D. E. Hughes and A. Hansen
M. Berger et al #1

	Thickness (feet)	Depth (feet)
Shale, gray, splintery with some organic matter; a little gray well cemented sandstone	6	716
Shale, gray, micaceous; some well cemented sandstone; some hard brown shale; a little dolomite	29	745
No samples - driller's log - Shale, gray	10	755
Sandstone, gray, fine to medium grained; and gray shale	10	765
Shale, black, platy	5	770
No samples - driller's log - Shale, gray	7	777
Shale, gray, muddy	8	785
Sandstone, gray, very fine grained, both friable and cemented; and some gray, flaky shale	11	796
Shale, light gray, muddy; a little sandstone	34	830
MISSISSIPPIAN:		
Bayport:		
Limestone, brown, dense; some sandy limestone	12	842
Limestone, brown, dense; gray fine to medium grained sandstone - some frosted grains	5	847
Sandstone, fine to medium grained - some frosted grains; a little limestone and shale	23	870
Limestone, brown, dense; and gray fine grained sandstone	20	890
Dolomite, brown, finely crystalline; and fine grained sandstone	27	917
Shale, dark gray, muddy	5	922
Dolomite, light brown and brown dense; and gray, fine-grained sandstone	13	935
Sandstone, gray, fine to medium grained, angular & little stone; a little gypsum	5	940
Gypsum, white; some dense dolomite; some grained fine sandstone	7	947
Dolomite, brown, dense; some gypsum; a little sandstone	3	950
Sandstone, gray, medium to fine grained sub-angular frosted; a little limestone	5	955
Sandstone, gray, fine grained, some medium grained, rounded, frosted grains; some gypsum; a little shale	5	960
Michigan:		
Shale, grayish-green, muddy	17	977
Gypsum, pink and white; a little shale; a little dolomite	6	983
Dolomite, light brown, dense; pink and white gypsum with some gray shale	182	1165
Dolomite, brown, finely crystalline	25	1190
Dolomite, brown, finely crystalline; some gypsum; a little shale	45	1235
Gypsum white and pink; gray shale; a little dolomite	45	1280
Napoleon (Upper Marshall):		
Sandstone, gray and reddish-gray, partially cemented with dolomite; some gray shale	15	1295
Sandstone, red and gray, medium grained angular (Water at 1295)	35	1330

Page 3 - Richmond Twp., (Os[illegible] County)
D. E. Hughes and A. [illegible]n
M. Berger et al #1

	Thickness (feet)	Depth (feet)
Sandstone, red and gray, fine to coarse grained, angular; a little mica; a little shale	10	1340
Sandstone, red, fine grained, angular; some mica	39	1379
No samples - driller's log - Shale, gray	6	1385
Driller's log - Lime	5	1390
Sandstone, gray, fine to medium grained, angular	50	1440
Sandstone, gray, fine-grained, angular; some mica	12	1452
Lower Marshall:		
Sandstone, red, fine-grained, some mica	75	1527
No samples - driller's log - Red rock	5	1532
Coldwater:		
Shale, gray, soft and muddy	18	1550
Shale, gray, dolomitic, micaceous	4	1554
Shale, grey, soft and muddy	32	1586
Shale, grey, flaky and splintery; some hard brown shale; some dense to crystalline dolomite	349	1935
Dolomite, gray-brown, fossiliferous; some dolomite; some gray shale	39	1974
Shale, gray, fossiliferous dolomite; a little hard brown shale	201	2175
Shale, dark gray and light gray; some light gray dolomite; occasional fossils	40	2215
No samples - driller's log - Shale, gray	7	2222
Driller's log - Shale, gray and shells	8	2230
Shale, gray, hard, flaky	12	2242
Dolomite, gray-brown, partly crystalline, shaly; some dark gray shale	8	2250
Sunbury:		
Shale, dark gray to brown, hard	30	2280
Bedford:		
Shale, gray, flaky, hard; a little dolomite	60	2340
Shale, gray, flaky; and gray, shaly dolomite	10	2350
Shale, gray, flaky; some gray shaly dolomite, hard	132	2482
Dolomite, light gray hard, shaly; and light gray shale	105	2587
Shale, greenish-gray and gray brown; a little dolomite	65	2652
MISSISSIPPIAN-DEVONIAN:		
Antrim:		
Shale, black to brown, hard; occasional greenish-gray shale	210	2862
Shale, dark gray and some brownish-gray limy shale	8	2870
Shale, brown and dark gray, hard	55	2925
Shale, dark gray and brown, hard; some limestone	25	2950
DEVONIAN:		
Traverse: (Preliminary Report - Top of Traverse at 2930)		
Shale, gray, limy; occasional fossils	9	2959
No samples - driller's log - Lime, brown	9	2968
Limestone, brown, dense to crystalline	2	2970
Limestone, light brown and buff; a little shale; a little chert (Water 2970-3009)	39	3009
Limestone, buff and brown, dense; a little shale	16	3025

Page 4 - Richmond Twp., (Osceola County)
D. E. Hughes and A. [illegible]sen
M. Berger et al #1

	Thickness (feet)	Depth (feet)
Limestone, buff and brown, dense to crystalline	65	3090
Limestone, buff - drills up as fine particles	42	3132
Limestone, dark brown, dense; a little light brown limestone	18	3150
Limestone, brown, dense	21	3171
No samples; driller's log - Traverse lime	24	3195
Limestone, light brown and buff, dense	37	3232
Limestone, brown and light brown, dense	18	3250
Limestone, gray-brown, dense	68	3318
Limestone, dark brown, dense; some white dense limestone	49	3367
Shale, gray, limy	13	3380
Limestone, gray-brown, dense; a little shale	67	3447
Limestone, gray-brown to buff, dense; a little secondary quartz; a little shale	13	3460
Shale, gray, and some limestone	15	3475
Shale, gray, hard, flaky	40	3515
Dundee:		
Limestone, gray-brown, brown and buff, dense; a little shale; some fossils	6	3521
Limestone, brown, dense to finely crystalline; drills up as fine particles; a little secondary dolomite	59	3580
Limestone, brown - drills up very fine	10	3590
Detroit River (Upper Monroe):		
Dolomite, brown to buff finely crystalline; some crystals of gypsum (?)(Water 3607-3622)	26	3616
Dolomite, brown, crystalline; some gray, dense dolomite	45	3661
Dolomite, dark brown, finely crystalline; a little limestone (Black water 3675-81)	27	3688
Limestone, dark brown, dense; a little dolomite (Water at 3710)	28	3716
No samples - driller's log - Lime	104	3820
Driller's log - Salt	43	3863
TOTAL DEPTH		3863

Casing record:
14" 485'
10" 586'
8¼" 961'
6-5/8" 1556'

Commenced: 4-22-38
Completed: 6-16-38
Initial Production: Dry Hole
Plugged and Abandoned: 7-16-38

DRILLING LOGS

Hersey (Osceola County)

Taggart Bros. Company

King #1 — Permit #8633

Drilling Contractor: Company Tools

Location: SW¼ SW¼ SW¼ section 33, T.17N., R.9W.
330 feet from south and 330 feet from west line of quarter section

Elevation: 1078.9 feet above sea level

Record by: G. R. Gaige from drillers log

	Thickness (feet)	Depth (feet)
PLEISTOCENE:		
Drift:		
Clay, sandy and boulders	285	285
Clay and small boulders	62	347
Clay	203	550
PERMO-CARBONIFEROUS:		
"Red-Beds":		
Clay, red	90	640
PENNSYLVANIAN:		
Saginaw:		
Sand	65	705
Shale	133	838
Shale and streaks of lime	122	960
Sandy lime	45	1005
Parma:		
Sand	90	1095
MISSISSIPPIAN:		
Bayport:		
Lime, gray	20	115
Lime	93	1208
Michigan:		
Lime, brown and shale	26	1234
Lime, anhydrite and shale	60	1294
Lime	11	1305
Anhydrite	40	1345
Shale	35	1380
Lime, brown	25	1405
Lime and shale	8	1413
Sand	2	1415
Cored lime	15	1430
Lime and shale	39	1469
Lime	15	1484
Sand, Michigan "Stray"	16	1500
TOTAL DEPTH		1500

Casing record:
10" 270'

Commenced: 5/23/41
Completed: 5/27/41
Initial Production: Dry Hole
Plugged & Abandoned 5/27/41

25-17N-10W
Richmond Twp., (Osceola County) — TD 1363 in "Stray" (Dry)

The Pure Oil Co.

L. C. Haist #A-1 — Permit #11282

Drilling Contractor: Taggart Bros. Co. (Rotary 0-1350
Cable 1350-1363)

Location: C N½ SE¼ SW¼ section 25, T.17N., R.10W.
990' from south and 660' from east line of quarter section.

Elevation: 1071.8 feet above sea level.

Record by: D. Myers from driller's log & Partial sample log submitted by the Company.

	Thickness (feet)	Depth (feet)
PLEISTOCENE:		
Drift:		
Drift	550	550
Geological Log:		
PERMO-CARBONIFEROUS (?)		
"Red Beds":		
Gypsum and red clay	90	640
PENNSYLVANIAN:		
Saginaw:		
Sandstone, light, medium, stained red by hematite and gypsum	20	660
Shale, dark gray to black	20	680
Shale, dark gray	70	750
Drillers Log:		
Shale and shells	10	760
Shale, blue	30	790
Geological Log:		
Shale, dark gray to black	30	820
Shale, gray	60	880
Sandstone, white, medium to coarse; abundant pyrite; gray shale	90	970
MISSISSIPPIAN:		
Bayport:		
Lime, gray, dense, sandy	20	990
Dolomite, brown, dense to very finely crystalline, sandy; small amount tan, dolomitic sand	30	1020
Michigan:		
Sandstone, white, medium, cemented with gypsum	5	1025
Shale, gray and gypsum	225	1250
Lime, gray dense (Preliminary Report Brown limestone 1250)	20	1270
Shale, gray; gypsum	20	1290
Shale, gray; gray, fine, tight, slightly glauconitic shale; gypsum	6	1296
Shale, gray and gypsum	54	1350
Driller's Log:		
Shale and lime	6	1356
Stray - Marshall:		
"Stray" sand (water 1356-63)	8	1363
TOTAL DEPTH		1363

13-17N-9W
Hersey Twp., (Osceola Co.) — TD 1769 in Coldwater — Exploratory Dry

McClure Oil Company & I. W. Hartman

James Alexander No. 1 — Permit No. 19134

Drilling Contractor: McClure Drilling Company (Rotary 0-542)
(Cable 542-1769)

Location: SW¼ NE¼ SW¼ section 13, T 17N, R 9W
990' from north and 890' from east line of quarter section

Elevation: 1038.4 feet above sea level

Record by: B. L. Champion from driller's log

	Thickness (Feet)	Depth (Feet)
PLEISTOCENE:		
Drift:		
Drift	485	485
PERMO-CARBONIFEROUS(?):		
"Red-Beds":		
Mud, red & gypsum	120	605
PENNSYLVANIAN-MISSISSIPPIAN:		
Saginaw-Parma(?)-Bayport-Michigan:		
Mud, ,ray	20	625
Shale	27	652
Sand	18	670
Shale	63	733
Sand	8	741
Shale	59	800
Shale & lime shells	67	867
Sand & shale	43	910
Lime & gypsum	25	935
Shale & gypsum	16	951
Sand	38	989
Shale & gypsum	28	1017
Sand	35	[illegible]
Lime & gypsum	53	1105
Lime & shale	15	1120
Shale & gypsum	204	1324
Lime, brown (Pre. Report-top brown lime 1326 Schj.)	16	1340
Shale & gypsum	79	1419
Sand	7	1426
Shale & gypsum	2	1428
Sand (Pre. Report-top stray 1426 Schj.)	98	1526
Shale	12	1538
	(933)	
MISSISSIPPIAN:		
Marshall: (Pre. Report-top Marshall 1540 Schj.; base 1735 Schj.)		
Sand	195	1733
Coldwater:		
Shale	36 ([illegible]+)	1769
TOTAL DEPTH		1769

16-17N-9W
Hersey Twp., (Osceola County) — TD 3764 in Detroit River (Dry)

Union Drilling & Producing Co. & Americrude Oil Co.

Leo Cody, et al No. 1 — Permit No. 12665

Drilling Contractor: Union Drilling & Producing Co. (Rotary 0-1660
Cable 1660-3764)

Location: NE¼ SW¼ SE¼ section 16, T.17N., R.9W.
990' from south and 990' from west line of quarter section.

Elevation: 978.8 feet above sea level.

Record by: D. R. Cain from driller's log.

	Thickness (feet)	Depth (feet)
PLEISTOCENE:		
Drift:		
"Drift"	465	465
PENNSYLVANIAN:		
Saginaw:		
Clay and gyp	75	540
Shale, gyp and lime	145	685
Shale, gray	85	770
Sand and shale	45	815
MISSISSIPPIAN:		
Bayport-Michigan:		
Lime and shale	10	825
Lime	20	845
Lime and sand	15	860
Shale, s nd and lime	143	1003
Sand	22	1025
Lime and shale	30	1055
Lime	38	1093
Shale, gyp and lime	122	1215
Lime, brown	21	1236
Shale, shells	76	1312
Sand, "Stray"	56	1368
Shale and lime	69	1437
M rshall:		
Sand, "Marshall" (Preliminary Report - Base Red Rock 1591)	208	1645
Coldwater:		
Shale, gray	660	2305
Sunbury:		
Shale, brown	63	2368
Ellsworth:		
Shale, gray	325	2713

APPENDIX - B
Exhibit 4

FOG DATA
FOR GRAND RAPIDS, MICHIGAN
AVERAGE FOR 20 YEAR INTERVAL

MONTH	AVERAGE DAYS PER MONTH	
	DENSE FOG	LIGHT FOG
JANUARY	1.0	2.3
FEBRUARY	.6	2.8
MARCH	.8	2.1
APRIL	.3	1.0
MAY	.1	.5
JUNE	.1	.6
JULY	.2	.4
AUGUST	.3	2.0
SEPTEMBER	1.1	3.6
OCTOBER	1.5	5.1
NOVEMBER	1.0	3.2
DECEMBER	.9	2.9

No data available for any point closer to the proposed plant site.

Data obtained from Weather Records Processing Center Room 864, Federal Office Building, Kansas City, Missouri.

APPENDIX B
Exhibit 5

UNIVERSITY OF MICHIGAN
ANN ARBOR
DEPARTMENT OF GEOLOGY

RECEIVED J. & G. Daverman Co. JAN 9 1956 File To Noted G.I.D. H.G.D. I.T.D. R.I.D. E.H.D.

January 1956

Mr. Edmund P. Gibson
J. & G. Daverman Co.
921 Grandville Ave., S.W.
Grand Rapids 9, Michigan

Dear Mr. Gibson:

I am writing in reply to your letter of December 29 addressed to the Observatory here inquiring about earthquakes in the area of Osceola County.

No earthquakes large enough (or certain enough) to be listed in any of the standard earthquake catalogs have occurred in this area in historic times. An earthquake is supposed to have centered near Kalamazoo in 1883 but I have made quite a study of the newspaper accounts and as a consequence it has been removed from the recent lists. It was apparently an explosion that was erroneously reported as an earthquake in the Chicago papers. The 1906 (May 26) earthquake in the Houghton region was felt in Osceola County. The 1811 shock was probably felt as far north as Osceola County but it would have been at the very fringe and I know of no reports from that area. The small earthquake that centered in Branch County in southern Michigan in 1947 (August 9) was felt weakly in Osceola County. Some of the large Canadian shocks such as the Timiskaming shock in 1935 have been felt generally in the Lower Peninsula.

I know of no earthquake damage that has ever occurred in Osceola County.

I am interested in your statement " there have been three (3) in recent years, of no particular importance." We have not recorded any here and I have missed any newspaper notice. If there have been any I feel they must be extremely small. I get reports of earthquakes in Detroit every year or so and they always turn out to be explosions, passing trucks, jet planes, etc. However, there may well have been small shocks in the Osceola area. I would appreciate any information you might have.

In general Michigan is about as free of earthquakes as any comparable area in the world.

If I can give you any mor information please write me.

Very truly yours,

James T. Wilson

JTW/s James T. Wilson

II. EXISTING HERSEY GENERATING PLANT FACILITIES

A. Building

The generating plant building is a steel frame and masonry walled structure with basement and main operating floor. A traveling crane runs the length of the building. There is a space in the building for an additional generating unit and auxiliaries, more than adequate for the proposed steam turbo-generating unit. Dwg. 5502-16C shows the floor plan of this plant.

B. Generating Equipment

Existing generating equipment consists of six dual fuel diesel electric generating units as follows:

2 Cooper-Bessemer - 700 KW
1 Cooper-Bessemer - 1160 KW
3 Fairbanks-Morse - 2500 KW

All are equipped with complete auxiliaries, controls, metering and relaying to provide reliable central station service. The fuel oil handling system is arranged to heat and handle a medium heavy fuel oil and storage capacity of 100,000 gallons is available. There is also a lube oil storage and purification system connected to all units, a water softening system to supply soft water to the jacket cooling system of the engines, and a complete compressed air system for starting and plant purposes.

C. Electrical

The plant is set up on a unit basis, with each machine being connected directly to its own transformer. The high side of the transformer is then connected to the bus through an oil circuit breaker. The three small machines are connected to a 7.2/12.5 KV bus, the three larger machines to a 43.8 KV bus. There is a 2500 KVA, LRC transformer connecting the two busses. Distribution lines are fed directly from the 7.2/12.5 KV bus while the 44 KV bus serves five transmission lines. Two of the transmission lines are interconnected with other generating plants.

The Plant is equipped with complete differential relay protection for busses and equipment and with high speed relays for line protection.

II. EXISTING HERSEY GENERATING PLANT FACILITIES (Continued)

House service is obtained from banks connected to both busses. Machines #1 and #2 are arranged for starting and picking up station service with dead busses.

Control power is obtained from two banks of storage batteries coupled with suitable charging equipment.

D. Cooling Water

The plant cooling system as shown on Dwg. 5502-16B consists of:

1. An intake canal dug from the intake house located at the bottom of the river, to the main bed of the river.
2. An intake house containing a self-cleaning traveling screen and an intake header.
3. Four pumps having a total capacity of 2400 gpm connected to a 24" discharge header.
4. Room in the dry intake house pit for several more pumps of 3500 gpm capacity each.
5. A twenty inch supply line of mechanical cast iron pipe running below grade to the power plant building and a similar discharge line running from the plant and ending below water level in the river.

E. Gas Supply

There is a 4", 500 psi, gas supply line running from the west, crossing the river and terminating in a gas regulator house located west of the power plant building. This is also shown on Dwg. 5502-16B

Gas is reduced to 50 psi at the regulator station and fed to a 12" underground header running along the south side of the plant with valved runouts to the machines inside.

The Gas supply is a mixture of natural gas and processed casing head gas obtained from local fields within a fifteen mile radius of the plant.

APPENDIX C

I. Description of the Reactor Plant

II. Reactor Plant Operation

III. Special Testing Facility

IV. Remote Maintenance

V. Steam Electric Plant

I. DESCRIPTION OF THE REACTOR PLANT

A. Reactor Type

The nuclear reactor is a one region aqueous homogeneous reactor employing uranyl sulfate in heavy water for the fuel solution. The nuclear fuel is highly rich with the uranium isotope 235. No conversion or breeding occurs in the system. New uranium must be continually added to the reactor as make-up since the original charge is continually depleted by the fission reaction.

Fluid fuel is circulated from the reactor to a heat exchanger where all the heat generated by the fission process is removed. The fuel is circulated by one of two canned motor type pumps. Pump submergence is maintained by pressurizing the system.

The steam generated in the heat exchanger is superheated in a superheater, fired with a fossilized fuel. The superheated steam drives a conventional turbine for the production of electricity.

B. Design Specifications

All design specifications outlined in this proposal are the result of preliminary engineering and therefore all designs and specifications are subject to change dependent on the outcome of final engineering calculations and test results.

C. Primary Loop Description

1. General Description

The nuclear reactor plant is designed for an equivalent electrical generating capacity of 10,000 KW. Initially the reactor plant will supply steam to a 5,000 KW steam-electric plant. After a period of initial operation a second 5,000 KW steam-electric plant may be added to the station for an eventual capacity of 10,000 KW. During initial operation the reactor plant will be operating at one-half load. Doubling the electrical capacity can be accomplished without making any changes to the reactor plant.

The primary loop flow diagram is illustrated by Dwg. ND-561-5A. Heat is generated in the nuclear reactor at the rate of 31,000 KW.

I. DESCRIPTION OF THE REACTOR PLANT (Continued)

The average temperature of the fuel solution in the reactor which is equivalent to the reactor outlet temperature remains constant at 570° F. The hot fuel solution is circulated from the reactor at a rate of 340 lbs. per second to a vertical U-bend heat exchanger with an integral steam drum. Heat generated in the reactor is transferred to boiling water producing steam at 600 psi at a rate of 116,000 lbs. per hour. Cool fuel solution leaves the heat exchanger at 500° F. Circulation then proceeds to one of two constant speed canned motor type pumps operating at 2,750 gpm with a head of 65 ft. The pump overcomes the friction losses of the fuel circulating in the closed loop. The fuel solution circulates from the pump through a checked valve on the pump discharge and back into the reactor. The pumps are so inter-locked that one is in operation and the other in stand-by. If one pump should trip out of operation the auxiliary pump will automatically switch on.

A pressurizer is connected to the outlet from the reactor. Its function is to pressurize the system to an average pressure of 1900 psi. The over-pressure guarantees submergence on the pumps at all times and maintains the fuel solution subcooled for nuclear stability. The system is pressurized with oxygen. A small percentage of the primary loop flow is continually circulated through the pressurizer to maintain the fuel solution saturated with oxygen at all times.

2. Reactor Vessel

The reactor vessel is illustrated by diagram ND-552-223. The reactor is a 5 ft. diameter sphere approximately 3 inches thick. It is fabricated from two hemispherical heads of type 347 stainless steel. The design pressure of the reactor vessel is 2,000 psi. A fuel solution inlet nozzle is located in the bottom of the reactor vessel and an outlet nozzle at the top. A small bleed line is located in the bottom half of the reactor vessel for chemical processing.

3. Primary Loop Heat Exchanger

The primary loop heat exchanger is illustrated by Dwg. ND-551-228.

I. DESCRIPTION OF THE REACTOR PLANT (Continued)

It is a vertical U-bend heat exchanger with an integral steam drum containing 1,768-3/8 inch OD-tubes of .058 inch wall. The tube material is stainless steel 347. The two legs of the heat exchanger are of unequal length to evenly distribute the generation of steam and minimize fuel solution hold-up in the primary loop piping. Fuel solution is circulated on the tube side of the heat exchanger. Steam produced on the shell side of the heat exchanger is removed by natural circulation. Internal risers and down-comers are provided. Feedwater is introduced into the liquid region of the steam drum. Vertical centrifugal separators and steam dryers are provided to separate the liquid boiler water from the steam.

4. Canned Motor Pumps

Two constant speed canned motor type pumps are provided to maintain circulation in the primary loop. The second pump is maintained in stand-by while the first pump is operating. Each pump is designed to handle 2,750 gpm of fuel solution at 500° F. and develop a head of 65 ft. A swing check valve is located on the discharge of each pump. Therefore, circulation will not be by-passed through the shut-down pump. If for any reason the operating pump is tripped off the line the second pump will automatically cut in. In the event of failure of both pumps the reactor will shut down and the decay heat will be removed by natural circulation. The canned pumps are made of 347 stainless steel. Titanium is employed in regions of high velocity and for the pump impeller.

5. Pressurizer

The pressurizer is illustrated in Dwg. ND-551-229. Its function is to pressurize the primary loop to an average pressure of 1900 psi using oxygen. A small percentage of the primary loop flow is by-passed through the pressurizer. The four inch inlet line directs the fuel solution into the pressurizer where it spills into a distribution header and drips down through the oxygen environment to the liquid reservoir in the bottom of the vessel. Fission product gases are stripped out of the fuel solution in the pressurizer and the fuel is maintained saturated with oxygen at all times. This is desirable for corrosion protection. The level in the pressurizer will fluctuate

I. DESCRIPTION OF THE REACTOR PLANT (Continued)

with load. At full load the liquid will be at its lowest level because the average density of the fluid in the primary loop is high. At no load conditions the average density of the fuel solution corresponds to 570° F. and at this condition the level will be the highest. The level will fluctuate approximately 6 inches from full load to no load conditions.

During normal operation the primary loop is completely isolated. Oxygen is added to the pressurizer in a batch-wise operation. As fission product gases build up in the pressurizer they are vented in a batch-wise operation. Therefore, since the loop is a closed system the changing liquid level characteristic of a changing load will change the pressure on the system. From no load to full load conditions the pressure will fluctuate from 1750 to 1950 psi in the extreme conditions. The average pressure in the pressurizer at full load is 1900 psi.

An observation access nozzle is provided at the top of the vessel for internal inspection. The vessel is made of 347 stainless steel and the design pressure is 2,000 psi.

6. Primary Loop Piping

The primary loop piping is 10" schedule 120 stainless steel 347 pipe. It is arranged to minimize fuel solution inventory and for piping flexibility. Each component in the primary loop may be rigidly supported. The resultant stresses induced in the piping are within design limits. The maximum fluid velocity in the piping is 15 ft. per second.

7. Fuel Solution Make-up

Two 2.8 gph pulsafeeder type pumps are used for the make-up of concentrated fuel solution to the primary loop. During full load operation only one pump is required for about 30 minutes per day to make up the uranium which has been depleted in the fuel solution. The second pump is for stand-by operation only.

8. Primary Loop Arrangement

The primary loop arrangement is illustrated in Dwg. ND-551-232.

I. DESCRIPTION OF THE REACTOR PLANT (Continued)

The components of the primary loop are arranged inside a containment vessel which is 15 ft. in diameter and 32 ft. 6 inches high. The components are arranged to minimize the fuel solution inventory and allow accessability for maintenance from above. A partial radiation shield of high density concrete aggregate is located around the reactor vessel to minimize radiation from the reactor vessel during maintenance operations.

9. Steam Generation

The steam drum pressure of the primary loop heat exchanger will vary with load due to the heat exchanger characteristics. At full load, steam will be generated at 600 psi and the pressure will increase to 1225 psi as the load is decreased to zero. At half load the steam pressure will be approximately 850 psi. At all loads the boiler steam is flashed to 600 psi by a pressure reducing valve in the main steam line. Flashing the steam from a high pressure to 600 psi will produce wet steam which will be completely evaporated and superheated in the superheater.

A quick acting stop valve is located in the main steam line. If a leak develops in the heat exchanger permitting activity to pass into the steam, a leak detector will sense the leak and immediately close this main steam line stop valve. The primary loop is then completely isolated and all the activity is contained inside the shield. As the steam pressure builds up in the steam drum due to the generation of steam from decay heat, a safety valve set at 1500 psi will open allowing steam to blow off to a shielded condenser in the waste disposal system. During normal shutting down operations, steam from the heat exchanger is vented into the main turbine condenser to remove decay heat and cool down the primary loop.

The feedwater control valve is actuated by a four element control from boiler level, steam flow, feedwater flow, and boiler pressure.

10. Dump Tanks

The dump arrangement is illustrated in Dwg. ND-562-34. The dump tanks are three identical units fabricated from 12 inch schedule 100 stainless steel pipes and fittings. Any two units will completely contain the fuel solution inventory of the reactor plant. The third

I. DESCRIPTION OF THE REACTOR PLANT (Continued)

unit is provided as a spare dump tank unit or it may be employed as a heavy water storage tank. Each dump tank unit is provided with a platinized alumina catalytic recombiner to recombine gases formed from the decomposition of heavy water. The three units are designed to maintain subcritical geometry of the fuel solution while it is in storage. The units are located in a containment vessel 8 ft. 6 inches in diameter and 23 ft. 4 inches high which is completely filled with dowtherm. Four 24 inch cylinders are also located inside the containment vessel to minimize the dowtherm inventory. The dowtherm bath can be employed as a heat sink to remove decay heat during a dump or it can be maintained at an elevated temperature to keep the fuel solution hot during a start-up operation. Employing dowtherm facilities control of the fuel solution temperature over a wide range while it is stored in the dump tank.

D. Oxygen Pressurization and Off-Gas System

The oxygen pressurization and off-gas system is illustrated in Dwg. ND-561-12. Oxygen is required in the primary loop to minimize the corrosive attack on stainless by the fuel solution. Oxygen will be continually depleted from the fuel solution by the oxidation of corrosion and fission products in the primary loop. At convenient intervals, oxygen can be added to the loop from a high pressure oxygen storage tank. Also, the gases and vapors collected in the gas space of the pressurizer are vented in convenient batches to the dump tanks. Any uncombined deterium and oxygen present in the gases will be recombined by the catalytic recombiners on the dump tanks. Also, much of the D_20 vapor will be condensed out of the gases. The dump tanks in turn can be vented to an off-gas condenser where the D_20 vapor is almost completely removed from the gases. The condensed D_20 will be returned to the heavy water storage tank. The remaining gases, which are essentially oxygen and fission product gases, will be vented from the condenser to a low pressure oxygen storage tank. They are held up in this tank for a length of time sufficient to allow much of the activity of the fission product gases to decay. A compressor transfers the gases from the low pressure tank to the high pressure tank. Again the gases are held up allowing more time for the activity of the fission product gases to decay

I. DESCRIPTION OF THE REACTOR PLANT (Continued)

away. A small fraction of the gases held up in this tank are vented to a charcoal bed which preferentially extracts the remaining fission product gases from the gas stream. The resultant gases are vented to the atmosphere through a stack. The discharged gases are diluted with air from the building and shield ventilation system. New oxygen is added to the system from standard oxygen supply tanks. The oxygen system is made of stainless steel and it is designed for a pressure of 2000 psi. Oxygen may also be supplied to other areas of the plant from the high pressure oxygen storage tank.

E. Chemical Considerations and Fuel Processing

(This section is included in a classified supplement submitted independently and directly to the AEC by Foster Wheeler.)

F. Instrumentation

1. Nuclear Instrumentation

Neutron flux instrumentation will be provided in the partial shield adjacent to the reactor vessel. The neutron level will be recorded from the source range on into the power range. Period meters will be provided in the start-up range.

2. Reactor Plant Instrumentation

Instrumentation including temperature, pressure, liquid level, and flow indicating instruments and recorders will be provided through out the plant to insure proper plant operation at all times.

3. Reactor Dump Signals

The primary loop dump valve will be actuated to flash hot fuel solution into the dump tanks from the following signals.

a. High reactor outlet temperature
b. High pressurizer pressure
c. High dump tank pressure
d. Fast reactor period in start-up range
e. High reactor power from neutron level indicating instruments.

I. DESCRIPTION OF THE REACTOR PLANT (Continued)

4. Radiation Monitoring

Radiation monitoring equipment will be provided in all areas of the plant and surrounding areas to insure rapid detection of high levels of radioactivity. The monitoring system will be furnished with visible and audible alarms.

5. Control Room

All instrumentation necessary for the satisfactory and safe operation of the nuclear reactor plant will be controlled from a centralized control room. An instrument panel and console will be provided with indicating and recording instrumentation and annunciators.

G. Containment

1. High Pressure Components

The components of the primary loop, oxygen system and dump tanks are all contained within separate pressure containing vessels. Each containment vessel is a stainless steel lined carbon steel vessel designed for the maximum equilibrium pressure resulting from a major rupture in a pressure part. Each vessel is interconnected with the other vessels by a rupture disk. In the event of a major rupture of a component in the primary loop, while the plant is operating at full load conditions, the maximum equilibrium pressure developed inside the containment vessels should be approximately 160 psi. The partial shield located around the reactor vessel will act as a missile degradation medium in the event of a brittle failure of the reactor vessel.

2. Chemical Processing Plant

The chemical processing plant is contained in a vapor tight stainless steel lined cell. The structual strength of the concrete cell should be sufficient to contain the resultant pressure developed from any major failure of components in the chemical processing system.

I. DESCRIPTION OF THE REACTOR PLANT (Continued)

3. Dowtherm Heating and Water Cooling System

The components in the dowtherm heating and water cooling cell will never be subjected to the high pressure fluid of the primary loop and, therefore, need not be contained. The cell will be lined with stainless steel along the walls and floor to facilitate decontamination of the cell after a radioactive spill.

4. Decontamination and Waste Disposal System

This cell, like the dowtherm heating and water cooling cell, will never be subjected to high pressure radioactive fuel solution. It will also be lined on the walls and floor with stainless steel to facilitate decontamination of the cell after a radioactive spill.

H. Biological Shield

The reactor plant biological shield is illustrated in Dwg. ND-552-233A. The shielding dimensions indicated are for normal concrete. The reactor vessel requires approximately 10 feet of shielding at full power operation. Two feet of this shielding is provided in a partial shield located around the reactor vessel. The remaining 8 ft. is incorporated in the biological shield outside the containment vessel. During shut-down conditions approximately 2 ft. of concrete is required around the reactor vessel to attenuate the radiation emanating from the activated material in the reactor vessel.

Approximately 5 ft. of shielding is required surrounding the dump tank cell to completely attenuate activity emanating from the entire fuel solution held up in the dump tank immediately after shut-down. Approximately 3 ft. of shielding is required around the chemical processing cell, oxygen cell, dowtherm heating and water cooling cell and the decontamination and waste disposal cell. A cooling pit 6' x 10' x 26' deep is provided in the shield for storing large radioactive components such as the primary loop heat exchanger.

Two levels of maintenance galleries are provided in the biological shield adjacent to the chemical processing cell. Due to the experimental nature of the chemical processing system, the maintenance galleries will facilitate the addition and removal of equipment and

I. DESCRIPTION OF THE REACTOR PLANT (Continued)

simplify the problem of obtaining chemical samples from the process equipment.

I. Decontamination and Waste Disposal System

The decontamination and waste disposal system is illustrated in Dwg. ND-561-1A. A major maintenance operation on primary loop components may require the complete decontamination of the loop. A standard decontamination operation, which will remove the absorbed fission products from the vessel walls and heat transfer surfaces, incorporates a series of acid washes and base rinses.

Initially the loop is drained of the heavy water fuel solution. The decontamination solutions are made up from light water. The primary loop is first filled with an acid wash which is circulated for several hours. The acid wash is drained from the loop and pumped to an evaporator and high activity storage tank by a canned motor pump. Once the loop is completely drained the canned motor pump is used to fill the primary loop with a base rinse. The acid wash can be evaporated while the base rinse is being circulated in the loop. Concentrated high activity residue of the acid wash will be contained in the bottom portion of the evaporator. Steam from the evaporator will be condensed in a vertical stainless steel condenser. This condensate can then be sent to the river or circulated to a low activity water holding tank which is located underground. If there is still a considerable level of activity in the condensate it can be re-circulated by the sump pump back into the evaporator. The concentrated activity in the evaporator can be drawn off as a waste for burial.

When this cycle is complete the base rinse in the primary loop can be pumped into the evaporator as was the original acid wash. When the base rinse is completely contained in the evaporator the next acid wash can be pumped into the primary loop. This cycle of operations can be continued until the loop is completely decontaminated.

Similarly, the process vessels in all the cells are connected to the decontamination and waste disposal system. They would be decontaminated by the same procedure as described above.

I. DESCRIPTION OF THE REACTOR PLANT (Continued)

Any spillage collecting in a shielded cell can be pumped by the sump pump into the evaporator and handled as any other radioactive waste solution. If these drainings are of fairly low activity they can be directed to the low activity water holding tank.

The condenser in this system is also employed to quench steam from the primary loop heat exchanger as explained in sub-section C.

J. Heating and Cooling System

1. Intermediate Cooling Water System

The intermediate cooling water system is illustrated in Dwg. ND-561-36. It is designed to remove a total of 3,000 KW of heat. The principle source of heat is from decaying fission products in the chemical processing plant. Other areas which require cooling include: reactor partial shield, canned motor pumps, cell air and other moving components. This intermediate water cooling loop is required to contain any fission products that may leak into the cooling water from the heat transfer equipment. Since most of the equipment is stainless steel the water employed in this loop must be low in chloride ion concentration. The heat transferred into the intermediate cooling loop is removed by an intermediate heat exchanger to river cooling water. The loop is in continuous operation.

2. Dowtherm Heating and Cooling System

The dowtherm heating and cooling system is illustrated in Dwg. ND-561-36. Dowtherm is employed in a heating and cooling system because of its low vapor pressure at elevated temperatures. It is advantageously employed to heat, cool and regulate the fuel solution while it is contained in the dump tanks. Some of the heating loads on the dowtherm system are:

a. Heating the fuel solution in the dump tanks from room temperature to 500° F.

b. To evaporate decontamination wash and rinse solution in the waste disposal evaporator.

I. DESCRIPTION OF THE REACTOR PLANT (Continued)

c. Chemical processing and heavy water evaporation in chemical processing plant.

d. Source of heat to maintain the catalytic recombiners at an elevated temperature.

The principal cooling load on the dowtherm system is to remove the decay heat from the fuel solution immediately after shut-down. During a cooling operation the hot dowtherm gives up its heat to river cooling water. During a heating operation, heat is supplied by firing fossilized fuel in a dowtherm heater. A surge tank is provided in the dowtherm system to handle level surges resulting from temperature changes of the dowtherm.

K. Manufacturing and Quality Control

Pressure equipment supplied in the reactor plant will be designed, fabricated and inspected in accordance with the 1952 ASME Unfired Boiler and Pressure Vessel Code. Tube sheets will be designed in accordance with the latest TEMA standards. The minimum manufacturing and quality control requirements will be those necessary to conform to the ASME code referenced above. In addition, certain special procedures and requirements will be applied to insure that the equipment produced will be suitable for the specialized application.

1. Materials

The materials for all pressure and strength parts will be purchased with chemical and physical certificates to demonstrate adherance to code requirements. Samples of materials from each heat employed in the manufacture will be collected and preserved for future reference. Such samples would allow physical, metallurgical and chemical tests to be conducted on the actual material employed in the manufacture after the equipment is placed in service. Heavy stainless steel forgings and plate will be ultrasonically reflectoscope tested before fabrication.

2. Welding

All welding will be done by operators qualified in accordance with

I. DESCRIPTION OF THE REACTOR PLANT (Continued)

ASME code requirements. Welding will generally be of the shielded arc type, either inert gas or coated electrode. Welding on the high pressure parts in the primary loop will employ backing rings or will be back-chipped and rewelded with stainless filler rods to provide continuity of the inside stainless surfaces.

All longitudinal and circumferential butt welds on the pressure parts in the primary loop will be radiographed. In addition, the root pass and final pass on stainless parts will be examined with zyglo. Weldments in carbon steel will be examined by magnaflux.

3. Heat Exchanger Tubing

All tubes will be ultrasonically reflectoscope and hydrostatically tested prior to bending to guard against the remote possibility of installing a defective tube. After bending, the stressed portion of the tubes will be annealed. Each tube will be checked for surface cracks by zyglo inspection on the outside.

4. Surface Finish

All surfaces exposed to the fuel solution will be finished to 125 micro inch RMS and the incidence of crevices will be kept to a minimum to minimize the possibility of primary loop corrosion. All surfaces will be machined or ground when necessary to sound metal free of all slag, scale, spatter, surface inclusions or other impurities. In the region of tube welds, where machine finish is impractical, the surfaces will be grit blasted to the equivalent of 125 RMS micro inch.

5. Cleaning and Degreasing

In order to reduce initial contamination of the primary loop to a minimum, the equipment will be thoroughly cleaned and sealed before shipment. During fabrication, all parts will be maintained in as clean a state as feasible. After final assembly, the primary side of the unit will be completely degreased, washed with distilled water and dried.

No special surface finish will be provided on the steam side. The surface will be equivalent to normal commercial practice.

I. DESCRIPTION OF THE REACTOR PLANT (Continued)

6. Tests

After assembly the primary loop will be hydrostatically tested. After the hydro-test the primary loop containment vessel will be pressurized with helium. The primary loop will be evacuated and helium leakage into the loop will be checked with a mass spectrometer at maximum sensitivity. Any detectable leaks will be corrected.

7. Inspection

The purchaser shall have the right to inspect the equipment at key inspection points during its manufacture. Such inspection shall be made in the presence of an assigned Foster Wheeler engineer. The purchaser shall have access to physical and chemical certification records.

L. Estimated Life of the Reactor Plant

The major components of the primary loop will be designed for an estimated useful life of forty years. A corrosion allowance of approximately 20 mills will be added to all materials in contact with the fuel solution. The assumed corrosion rate for out-of-pile corrosion is one half a mill per year. A conservative corrosion allowance will be provided for the reactor vessel.

The biological shield should outlive the estimated life of the plant. All mechanical components subject to wear will be arranged so they are accessible for servicing by direct or remote maintenance techniques.

II. REACTOR PLANT OPERATION

A. Normal Plant Operation

Under normal full load conditions the steam is produced at 600 psia. There is a 700 psi pressure drop in the main steam line and superheater so that the steam delivered to the turbine is at 530 psia. At lower load conditions the boiler steam pressure will tend to rise due to the heat transfer characteristics of the heat exchangers. The temperature of the fuel solution leaving the reactor is always constant at 570° F. Therefore, the inlet temperature of the fuel to the heat exchanger is also constant at 570° F. At full load conditions the fuel solution leaves the heat exchangers at 500° F. At half load fuel will leave at 535° F. and steam will be produced at a pressure corresponding to saturation conditions at this temperature. At half load the steam pressure will be about 850 psia. At no load the steampressure is 1225 psia. A pressure reducing valve is located in the main steam line to reduce the pressure to 600 psia at all load conditions. The turbine will receive steam at constant conditions at all loads.

Normal operation of the power plant requires placing the load demand on the turbine generator unit. The reactor power will follow the load demand automatically due to the large negative temperature coefficient of the reactor. When the load demand is decreased the corresponding steam flow from the reactor is decreased, tending to raise the pressure in the steam drums. Increased boiler pressure results in an increased boiler temperature. This, in turn, will increase the fuel solution temperature leaving the heat exchanger. The higher inlet temperature to the reactor will tend to raise the mean reactor temperature and shut the reactor down. For an increasing load demand the fuel returning to the reactor will be at a lower temperature and the reactor power will increase to maintain its constant mean temperature. This self regulation occurs rapidly without creating excessive power excursions.

B. Reactor Start-up

In starting up the reactor from a complete shut-down the fuel solution in the dump tank is heated to 570° F. by heat supplied

II. REACTOR PLANT OPERATION (Continued)

from the dowtherm system. When the fuel solution is at temperature and pressure it is drained into the primary loop through the dump line. The flow rate is controlled by governing the pressure differential between the loop and the dump tanks. When the fuel has been transferred a circulating pump is started establishing circulation in the loop. The loop is pressurized by injecting oxygen into the pressurizer. The reactor system is now in standby and the negative temperature coefficient of reactivity will hold the reactor at 570° F. Boiler steam can then be drawn off to heat the steam plant and get the turbine up to speed. The reactor power will automatically follow the steam demand. Load is then placed on the generator and the plant is in operation.

C. Reactor Shut-down

During the shutting-down operation the load is gradually removed from the generator until it has been reduced to about 10% of full load. At this condition the turbine throttle valves are tripped isolating the reactor plant. Steam is dumped from the steam drum into the main condenser to remove any decay heat produced in the reactor.

While the decay heat rate is decreasing, the dump tanks are pressurized to 1225 psi (saturation at 570° F.) by evaporating heavy water. The pressurizer vent is opened balancing the pressure in the dump tank and primary loop. Opening the dump valve allows the fuel solution to drain from the primary loop into the dump tank. Flow can be regulated by governing the pressure differential. The primary loop circulating pump is shut off when the dump valve is opened.

The fuel solution temperature can then be maintained at 570° F. in the dump tanks to facilitate start-up. Maintaining the fuel solution at an elevated temperature also minimizes the possibility of peroxide precipitation of uranium. Catalytic recombiners are located on each dump tank unit to recombine decomposition gases.

D. Reactor Dump

During normal operation the pressure in the dump tank is maintained

II. REACTOR PLANT OPERATION (Continued)

at about 10 psi. If an emergency signal actuates the dump valve the fuel solution will flash from the primary loop into the dump tank and shut the reactor down.

III. SPECIAL TESTING FACILITY

A complete hot cell will be provided at the plant site for the remote handling of highly radioactive materials. The cell will include remote cutting and machining equipment to analyze corrosion specimens and new test materials. The cell will serve as a remote chemical laboratory for analyzing samples of the fuel solution from the primary loop and chemical processing plant. The cell will also be equipped with tools and machines necessary to perform remote maintenance operations on small equipment.

IV. REMOTE MAINTENANCE

All the components in the reactor plant with the exception of the components in the chemical processing cell are maintained from above. Some of the components in the chemical processing cell are serviced from the maintenance galleries. The process vessels in this cell, however, must be serviced from above.

The two components in the primary loop with the greatest probability of failing are the fuel solution circulating pumps and the heat exchanger. These components are flanged into the primary loop.

Servicing a circulating pump requires opening the containment vessel flange for access from above. When the containment vessel is partially filled with water for shielding, maintenance personnel can remove the pump motor and impeller from the housing (which is welded in the piping) with long handled tools and an impact wrench. The service work on the pump can be accomplished in a specially designed area for this purpose.

In the event of a heat exchanger tube failure the heat exchanger can be removed from the loop by disconnecting the flanged connections. The heat exchanger can be stored upside down and under water in the cooling pit provided in the shield. The tube sheets will be horizontal and facing upward so that the leaky tube can be detected and plugged.

The dump tanks may be serviced by direct maintenance techniques from above after the fuel solution has been removed from the tanks and they are completely decontaminated.

Components contained in the oxygen cell, dowtherm heating and water cooling cell, and the decontamination and waste disposal cell can be serviced by direct maintenance techniques from above after the components have been completely decontaminated.

A slightly different maintenance philosophy can be employed in the chemical processing cell due to the developmental nature and the size of the equipment. Two maintenance galleries are

IV. REMOTE MAINTENANCE

located along one wall of the cell. Most of the pumps, valves and sampling equipment associated with the chemical processing system can be located behind a wall in the maintenance gallery. These components will be connected to the process vessels inside the cell by process lines running through the shields. Each component in the maintenance gallery will be inside a flanged bubble on the containment vessel of the processing cell. Master maintenance manipulators can be located on the ceiling of the galleries to open the containment bubbles and service the equipment.

V. STEAM ELECTRIC PLANT

A. Basic Design

Steam will be delivered from the reactor to the turbo-generator unit at a pressure of 600 psia. Steam will be passed through a natural gas fired economizer-superheater unit and will then go to the turbine. The condensate leaving the condenser will go to a deaerating type heater which will be heated by means of bleed steam from a single uncontrolled bleed point on the turbine. From the deaerating heater the condensate will go to the boiler feed pumps and will be pumped through the economizer section of the gas-fired superheater-economizer and to the boiler section of the reactor. The basic cycle and rated heat balance are shown on the Heat Balance Diagram, Exhibit 1, this appendix.

Boiler water will be highly demineralized water.

Power from the generator will be fed directly to the 44 KV bus, thru suitable transformation and protective equipment.

The steam electric plant components will be standard commercial equipment.

The turbo-generator unit will have a nameplate rating of 5000 KW, .8 PF, with a continuous capability of 6250 KW.

The house service requirements of the turbo-generator unit including auxiliaries and of the reactor are estimated at 275 KW. The net capability of the reactor generator plant will be 5975 KW.

B. Superheater-Economizer

The superheater-economizer is added to the cycle to perform two functions. It permits the use of highly superheated steam in the cycle, so that a standard steam turbine can be used without resorting to special measures to remove excess water from the steam in the low pressure stages of the turbine. Moreover it greatly increases the efficiency of the turbine, reducing the heat requirements on the reactor by a substantially greater amount than is required to fire the superheater. The superheater will be designed for entering steam at 600 psia, 62,500 lbs. per hour, at saturate temperature, and to deliver steam at

V. STEAM ELECTRIC PLANT (Continued)

565 lbs. psia at 825 deg. F. The economizer will increase the condensate temperature returning to the reactor from 250 to 287 deg. F. when handling a like amount of condensate.

C. Steam Turbine and Auxiliaries

The turbine will be a 5000 KW single uncontrolled extraction turbine generator, complete with a 4650 sq. ft. condenser, suitable condensate pumps, air ejectors, evacuators and necessary instruments and controls. The turbine will be designed for inlet steam at 530 psia, 825° F. with an exhaust pressure of 1.5" Hg.

The deaerating heater will be designed for 65,000 lbs. per hour to operate at 30 psia, complete with controls.

There will be two motor driven boiler feed pumps, the motors to be variable speed, to permit operating the boiler feed pumps over a wide range of discharge pressures to assure proper injection of water into the boiler section of the reactor under the widely varying pressure conditions accompanying variation in reactor loads.

A steam dump valve will be connected into the reactor side of the super heater to discharge steam into the condenser, which will absorb the after heat of the reactor during normal shutdown of the turbine.

The control panel for the turbine will be installed alongside the generator on the main operating floor and will be combined with the reactor supervisory panel.

The equipment will be installed in space available in the existing plant, as shown on Dwg. 5502-16C. The contemplated second 5000 KW turbo-generator would be installed in a building addition shown on the same drawing.

D. Electrical Equipment

The generator will be a 3Ø, 60 cycle, 5000 KW .8 PF, 2400/4160 volt Wye connected machine with the neutral grounded through a ground detection transformer. The generator will be connected to the 44 KV bus as shown on the Line Diagrams, Exhibits 2 and 3, this Appendix.

V. STEAM ELECTRIC PLANT (Continued)

A three phase 5000/6250 KVA transformer and 44 KV oil circuit breaker to connect the unit to the 44 KV bus will be installed in space available in the existing substation. Metering and relay transformers, surge protection, ground detection equipment and generator field breaker will be located in an electrical cubicle beneath the generator. Generator relays and voltage regulator will be mounted on the generator control panel to be installed at the end of the existing electrical control board. The electrical connections, relays and controls will match the existing plant installation.

E. Station Service Power

Station service power for the turbo-generator auxiliaries will be fed from the existing house service busses which are supplied from either of two station service transformer banks. The station service for the reactor plant will be fed from a special reactor service bus to be located in a reactor control house adjacent to the containment. This new bus will have dual feed, one from each of the existing house service transformers, with automatic relay equipment to provide preferential and secondary service, including automatic throw-over in case of failure to preferential service, as shown on the House Service Line Diagram, Exhibit 4. Control power for the reactor will be supplied by the existing battery banks.

F. Miscellaneous Auxiliaries

There will be two (2) 3500 GPM pumps installed in the existing pump house to furnish circulating water for the condenser, the two pumps to provide a combined capacity of 6000 GPM.

A 250 gallon per hour ion exchange demineralizer will be installed to furnish boiler feed water makeup and necessary demineralized cooling water for the reactor.

G. Operations

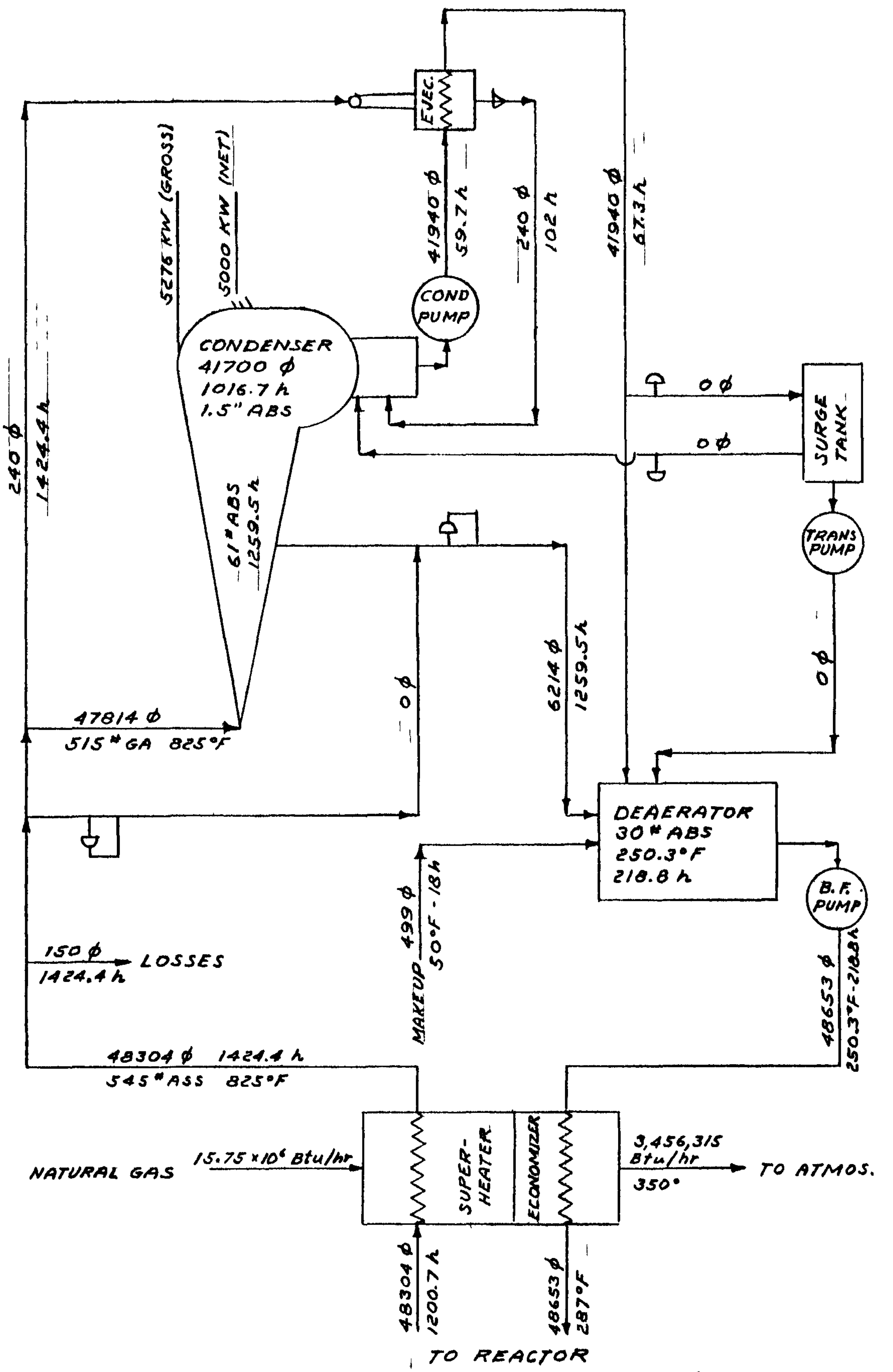
The reactor turbo-generator plant will be operated by the existing staff of the Hersey plant, augmented by a staff trained especially in the operation of the reactor. The unit will be employed as a base

V. STEAM ELECTRIC PLANT (Continued)

load unit, operating 24 hours a day with loads ranging from nameplate rating to net capability. It is estimated that the plant will operate at an annual load factor of 100% based on the nameplate rating with 90% availability. It is anticipated that after the initial testing and adjusting period the unit will be able to operate on a continuous basis except for such shutdowns as are normally required for periodic inspection.

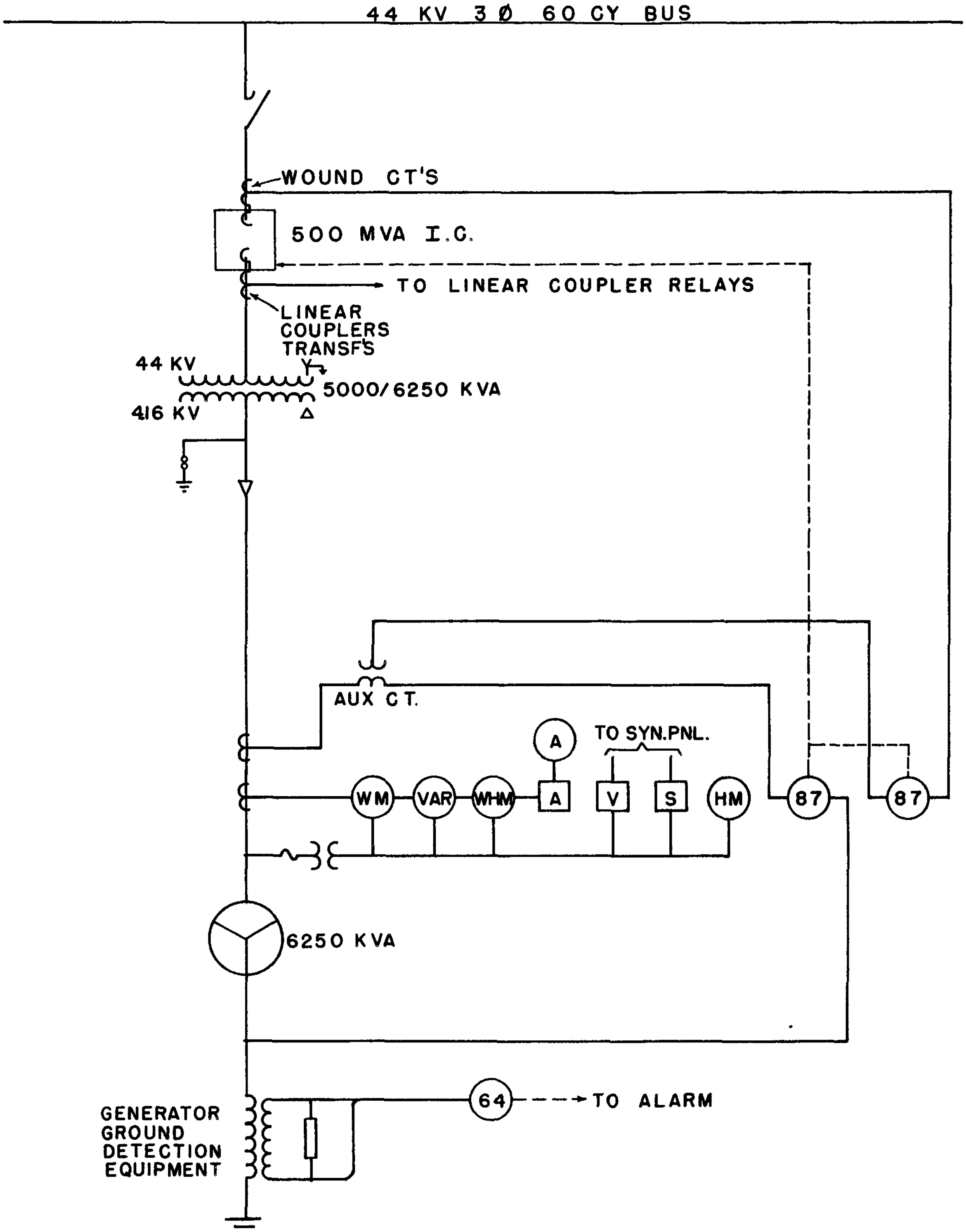
During light and medium load periods the unit will be augmented by the 10,060 KW capacity in dual-fuel diesel facilities now installed at the Hersey plant and during peak load periods by the additional diesel capacity located in three (3) other plants owned and operated by the Wolverine Electric Cooperative.

Power from the unit will be utilized by the three member distribution Cooperatives of the Wolverine Electric Cooperative.



HEAT BALANCE DIAGRAM

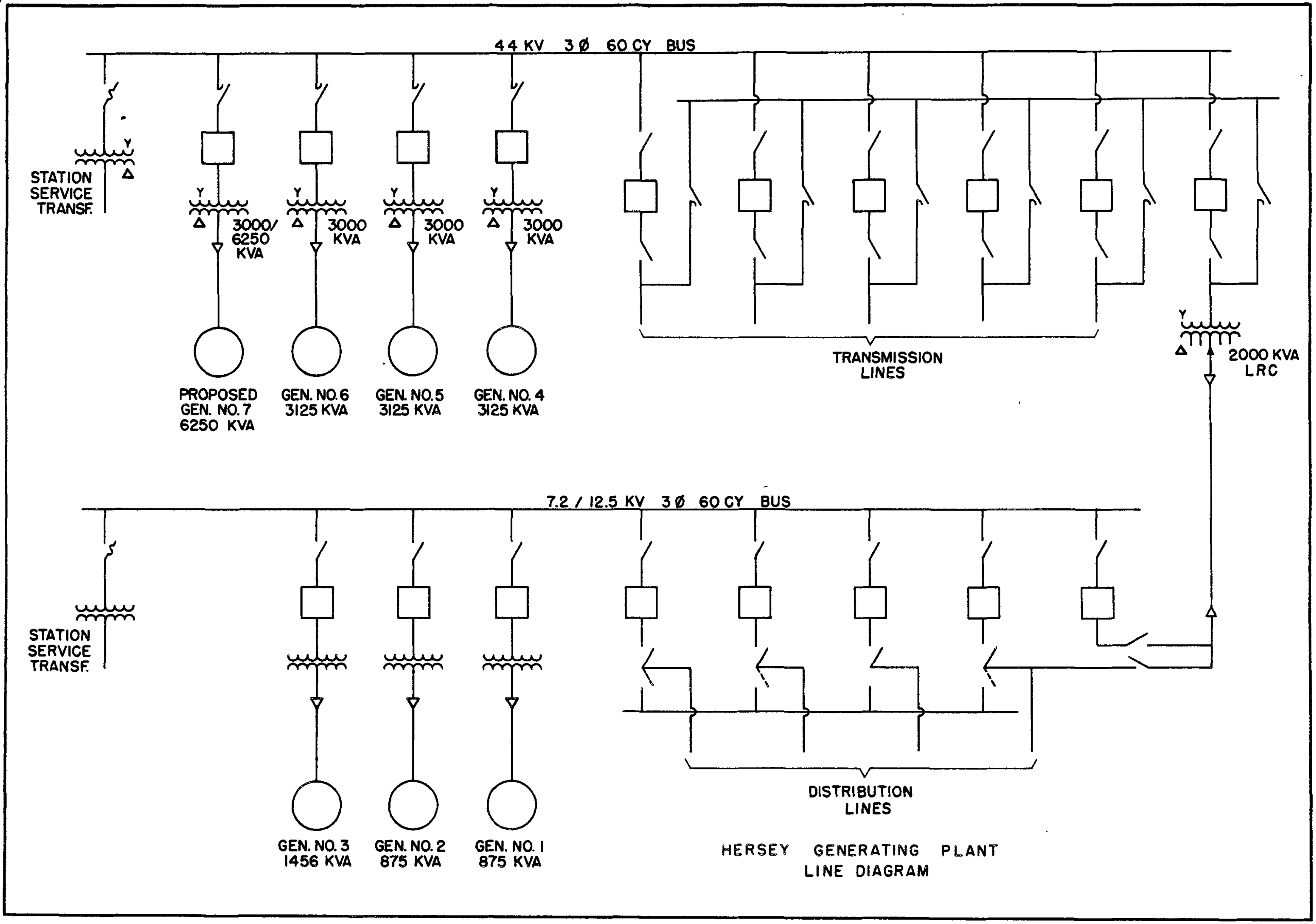
5000 KW UNIT 5000 KW LOAD



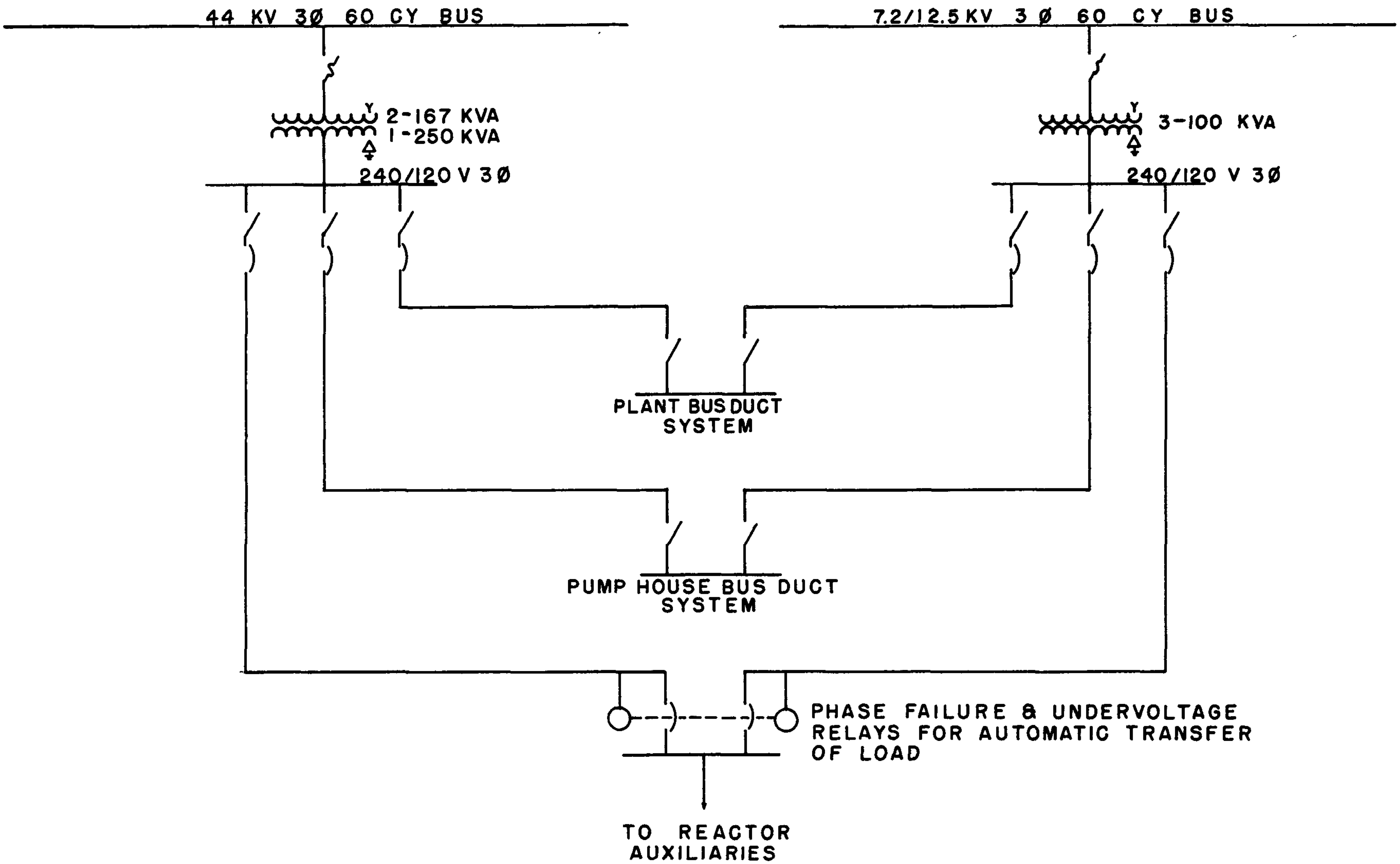
HERSEY GENERATING PLANT

PROPOSED UNIT NO. 7
LINE DIAGRAM

APPENDIX -C
Exhibit 3



HERSEY GENERATING PLANT
LINE DIAGRAM



HERSEY GENERATING PLANT
STATION SERVICE POWER
LINE DIAGRAM

APPENDIX D

Educational Interests

APPENDIX D
Exhibit 1

UNIVERSITY OF MICHIGAN
HORACE H. RACKHAM
SCHOOL OF GRADUATE STUDIES
ANN ARBOR

OFFICE OF THE DEAN

August 30, 1955

Mr. John N. Keen, Manager
Wolverine Electric Co-operative
302 South Warren Avenue
Big Rapids, Michigan

Dear Mr. Keen:

From our recent conversation I understand the Wolverine Electric Co-operative is contemplating the construction of a nuclear power plant. Both as Dean of the Graduate School and as Director of the Michigan Memorial--Phoenix Project at the University of Michigan, I am much interested in this possibility and think that it will go forward as promptly as possible.

The Graduate School has set up a program for the training of nuclear engineers. The program is of one year duration and leads to the degree of Master of Science in Engineering. It is open to engineering graduates in Chemical, Electrical, and Mechanical Engineering as well as Engineering Physics, and is intended to give a basic theoretical and practical training in reactor theory design and operation. The Michigan Memorial--Phoenix Project is now building a swimming pool type reactor of one megawatt capacity. This reactor is not intended for power development, but rather as a neutron source. It will be available for use in our training program. This program would be much enriched if our students could have access to a reactor of another type and one which is actually being used in production of heat for power development. We shall probably have access to the reactor planned by the group organized by the Detroit Edison Company in Detroit; however, their reactor, as I understand it, would be of a different type and capacity, and it would be extremely important to us if such a reactor as you plan were to be built and were to be available to our students for observation and study.

The Phoenix Project, as you know, is interested in all the peacetime applications of atomic energy. While power development is not one of our activities, we are interested in all the research applications of nuclear energy and are hoping to provide facilities and opportunities for faculty and graduate students here to do research in this field. It would then be important to us from this point of view to have available another reactor which could be used for observation and study and perhaps for some neutron experiments. These needs would not require special design of your reactor, since I am sure that the design you have in mind would be very useful for many studies which we might wish to undertake.

To conclude then, I certainly hope that you will be able to go forward with your plans, and any support which we can give we shall be glad to do.

Sincerely yours,

Ralph A. Sawyer

Ralph A. Sawyer
Dean

RAS:h

APPENDIX D
Exhibit 2

FERRIS INSTITUTE
OFFICE OF THE PRESIDENT
Big Rapids, Michigan

July 30, 1955

Mr. John N. Keen
Wolverine Electric Cooperative
302 South Warren Avenue
Big Rapids, Michigan

Dear Mr. Keen:

It is my understanding that there is a possibility that some time in the relative near future an atomic reactor might be installed in this general geographical area with which your company will be associated in use and operation.

I can well understand that for reasons of the recency of developments in this area and their relationship to national defense and other security concerns, that definiteness of program and other information cannot be made available in unrestricted fashion.

My purpose, however, in writing you is this that should there be this type of construction and should there be authorities sanctioned by the Atomic Energy Commission, that I hope such statements would be written broadly enough that in the future that they would not preclude the instructional use of these facilities by Ferris Institute at the point where our instructional program particularly in the field of physics and electronic devices might greatly benefit from this.

I should further say that our instructional program would not in any way correspond to the research development or graduate training type of program engaged in by the University of Michigan. Our relationship to such a facility as I would visualize it would be as we further develop our technicians' training programs where knowledge of the theory and principle devices associated with atomic power would be helpful in the training of sub-degree technician personnel.

APPENDIX D
Exhibit 2

Mr. John N. Keen
Page 2
July 30, 1955

This letter is written in exploratory fashion and is merely designed to make our ultimate concern in this kind of thing a matter of record.

Your consideration will be appreciated as from time to time in the future opportunities might develop for further thinking along these lines.

Sincerely yours,

Victor F. Spathelf
President

VFS:nsc