NUCLEAR POWER IN INDUSTRY

14 February 1955

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INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

Mr. Walker Lee Cisler, President and Director of the Detroit Edison Company, was born in Marietta, Ohio, 8 October 1897. He has spent his entire business career in the electric power industry. Following his graduation from Cornell University in 1922 with an M. E. degree, he became associated with the Public Service Electric and Gas Company, advancing to the position of assistant general manager of the Electric Department. In 1943 he resigned to become chief engineer of power plants for the Detroit Edison Company. He was elected a Director in September 1951 and President in December 1951. As an executive of the Detroit Edison Company he has been actively engaged in the atomic energy development since shortly after World War II. He served as executive secretary of the Atomic Energy Commission Industrial Advisory Group, 1947-48, and has been responsible for the company's participation in the Nuclear Power Development Project undertaken in cooperation with the Dow Chemical Company in 1951. Currently he is Chairman of the Nuclear Energy Application Committee of the American Society of Mechanical Engineers. During the war Mr. Cisler held many responsible assignments in the War Production Board and with the Armed Forces in Europe. He served as lieutenant colonel and then colonel, USA; Chief Public Utilities Section, Supreme Headquarters, AEF, and Office of Military Government for Germany. Since the war he has served on many Government committees and as a consultant to the Army, State Department, Atomic Energy Commission, and other agencies; and as chief consultant on electric power to the Economic Cooperation Administration and its successors since 1948. Mr. Cisler is a Fellow of the American Institute of Electrical Engineers and a member of various other societies; he is also a Trustee of Cornell University.

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ADMIRAL HAGUE: One of the great eternal paradoxes is the way we human beings will take the devices and methods we develop for warfare and put them to really more important use in our civilian economies in times of peace. I am told that one of the examples that illustrates is the profession of civil engineering. According to my informants, civil engineering became a profession because the military engineer in times of peace had to have something to keep his mind and his hands busy. Probably more to the point would be cellophane. The process of manufacturing cellophane was known as early as 1900, but it got its great impetus as a result of the Du Pont Company's having a tremendous amount of guncotton on its hands at the end of World War I.

But, of course, the thing that intrigues us, that absorbs all of our interests is the question of what is going to be the effect on our civilian economy of the application of atomic energy. On one hand, some of us visualize a small cube being cemented into the foundation of a home or building from which the householder can tap off any amount of power he wants indefinitely, long after the materials of the house have molded; or perhaps of automobiles coming out of Detroit with an everlasting supply of fuel in the tank in the form of an atomic pile under the hood. But there are others who seem to think none of that will happen, that we will still have to depend on the local public utility for the power that comes from atomic energy and we will still have to pay the electric bill.

Now to discuss this problem for us, naturally we turn to the electric power industry--because our electric power industry was so essential in the first place in the development of fissionable material, and in the second place, because none of us, so far as I have been able to determine, has visualized the application of energy from atomic power in any other way except electrical.

I am sure you will agree with me when you look over the printed biography of our speaker this morning, Mr. Walker Cisler, that we could have asked no one in the power industry to deliver this lecture who is a greater authority from actual experience, both throughout his long career and in his present position as President of the Detroit

Edison Company, and the fact--I am sure you will have noted--that for many years he has been one of the stalwart, public-spirited citizens who has pitched in to help the Government, and particularly to help the Government on the atòmic energy question. This is not his first visit to the Industrial College. He has been here many times before.

Mr. Cisler, it is an honor and a great privilege to welcome you back to this platform.

MR. CISLER: Admiral Hague, General Niblo, members of the Industrial College, ladies, and gentlemen: It has always been a very great pleasure for me to meet with members of the Industrial College of the Armed Forces, and I am especially glad to have the opportunity to meet with you today to discuss atomic power in industry for four reasons:

1. I know of your deep and intense interest.

2. I very strongly believe that electricity is one of the most vital factors in the great strength of our industry and our country.

3. I am confident that atomic energy, at some time in the future, will be a most important factor in the matter of supplying power to meet our country's increasing needs.

4. We must deal with the development of nuclear power in a rational manner, with proper regard for costs. Otherwise it becomes an economic burden rather than a most valuable economic asset.

Before getting into the subject of atomic power, I would like to review briefly the matter of electric power and its uses in the years ahead. I know that my friend, Don Marquis, discussed this in detail with you just a few weeks ago, but there are certain thoughts which we should keep in mind when thinking of the future of atomic energy.

Chart 1, page 3.--We are aware, of course, that for a long time past the use of electricity in this country has been increasing very rapidly. This is illustrated clearly by this chart, which shows the growth in peak load of our country's power systems. The data are from Edison Electric Institute statistics and include both investor- and government-owned systems supplying power for public consumption.

CHART 1

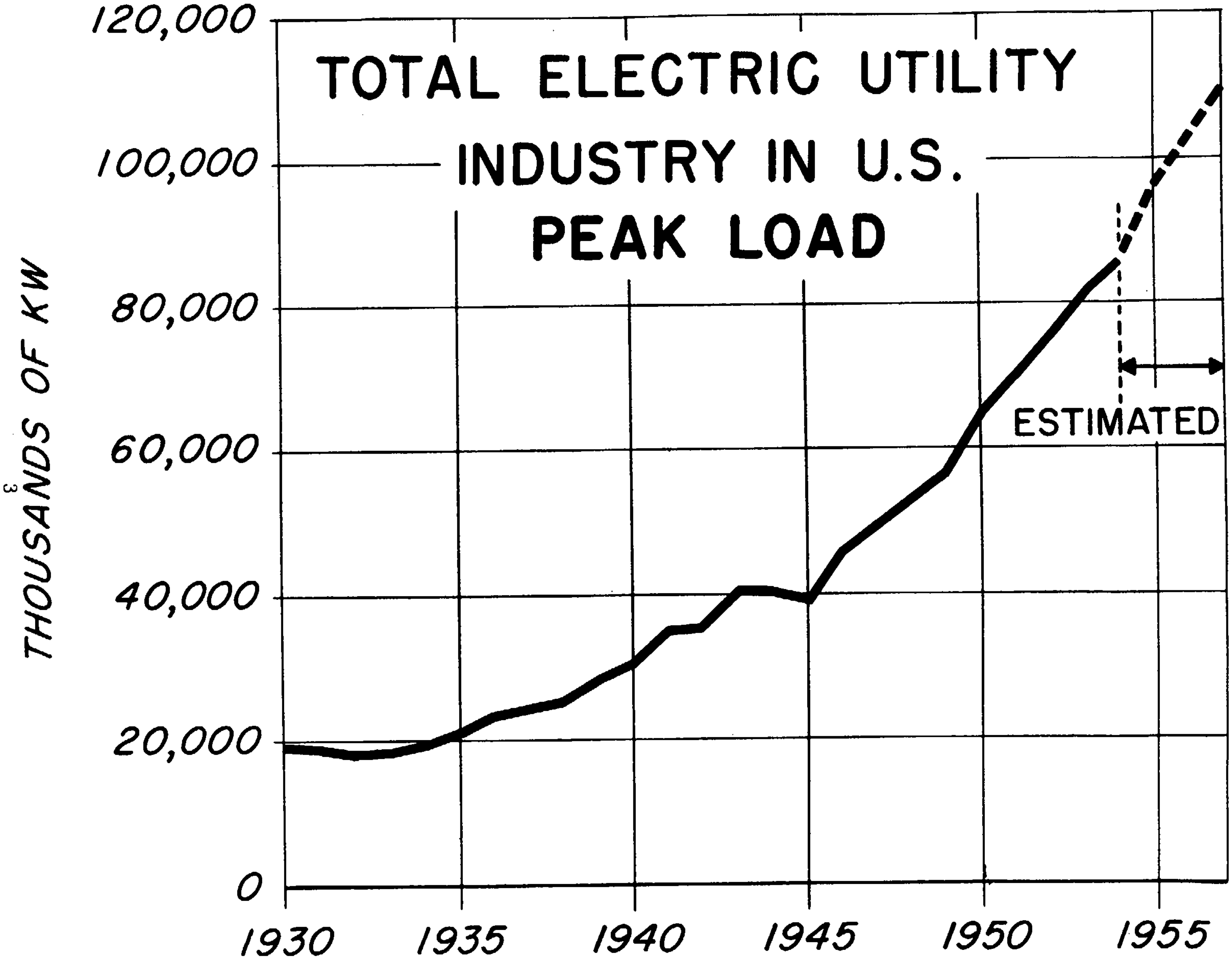

TOTAL ELECTRIC UTILITY
INDUSTRY IN U.S.
PEAK LOAD
THOUSANDS OF KW
120,000
100,000
80,000
60,000
40,000
20,000
0
1930
1935
1940
1945
1950
1955
ESTIMATED

Chart 2, page 5.--Similarly, the generation of energy--or the kilowatts of electricity--as shown by the second chart, has grown continuously at a faster rate then the peak load. Last year the generation was 472.2 billion kilowatt-hours. This year it may easily exceed 500 billion kilowatt-hours. People are using more and more electricity and for longer hours each day, particularly in the very heavy power-consuming industries and areas.

In the intent to understand better what lies ahead, and to provide a basis for planning for the future, the Edison Electric Institute Electric Power Survey Committee, a little over a year ago, assembled forecasts of the peak power load for the country as a whole to 1975, as shown by the third chart.

Chart 3, page 6.--Because of the realization that it is not possible to estimate specifically for long periods ahead, the forecasts were made as the maximum and minimum limits of the peak load.

You will observe that last December a peak load of approximately 86 million kilowatts was experienced. For 1965 to the peak load is forecast as more than 157 and perhaps as much as 190 million kilowatts. For 1975 the forecast is that the load will be somewhere between 262 and 367 million kilowatts.

From a practical standpoint it is expected that the peak load of the power systems of the country will double every 10 or 12 years.

Experience has shown that our power systems, for the country as a whole, must have about 15 percent more peak generating capability than the loads to be served. This margin is necessary to provide for:

1. Scheduled and unscheduled equipment outage.

2. Leeway to permit system control.

3. Unforeseen loads.

Chart 4, page 7.--Applying this value of 15 percent to the peak-load forecasts, the required capability can be estimated as shown by this chart.

You will note that during 1954 the installed generating capability of the country's power systems passed the 100 million kilowatt mark.

CHART 2

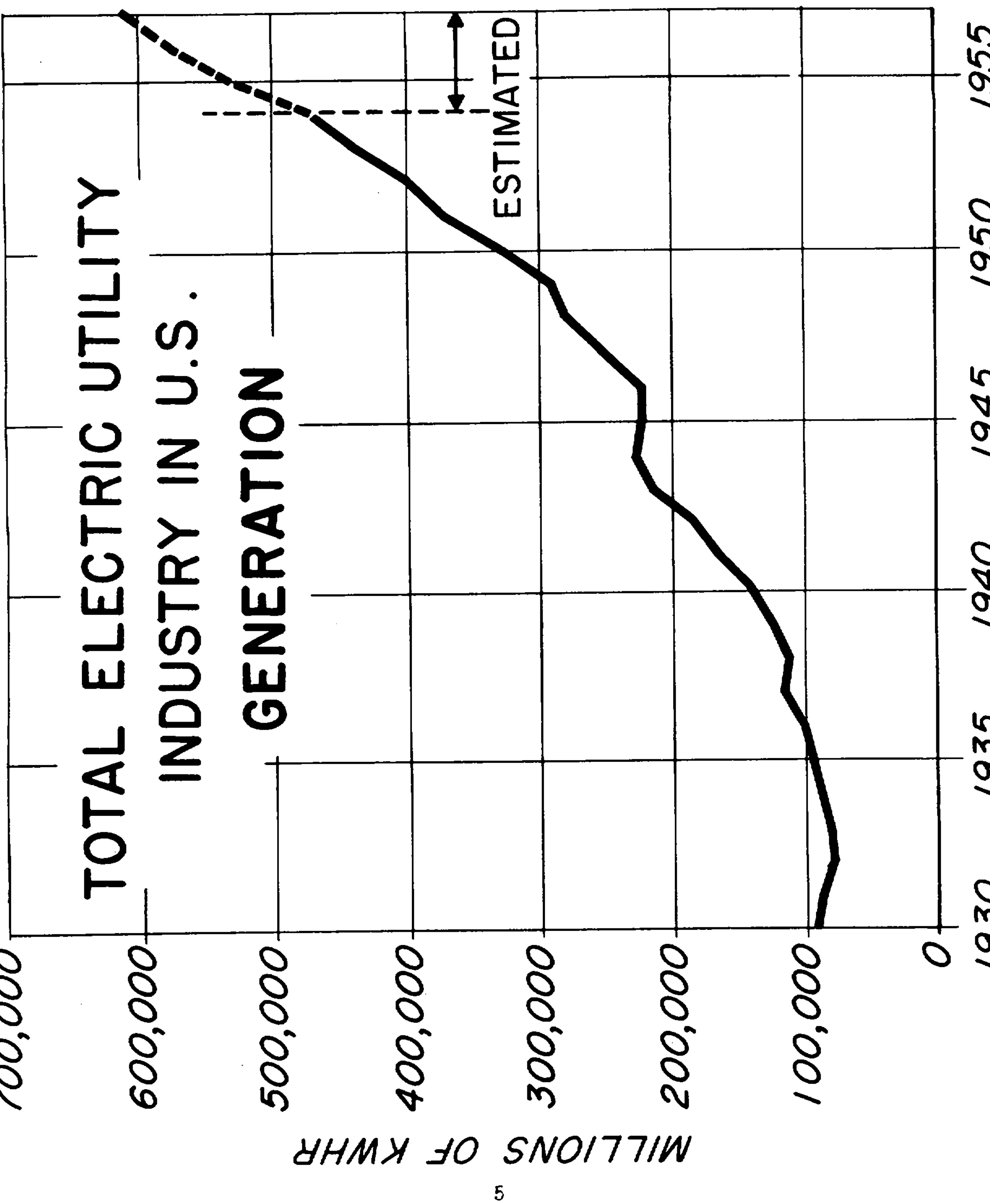
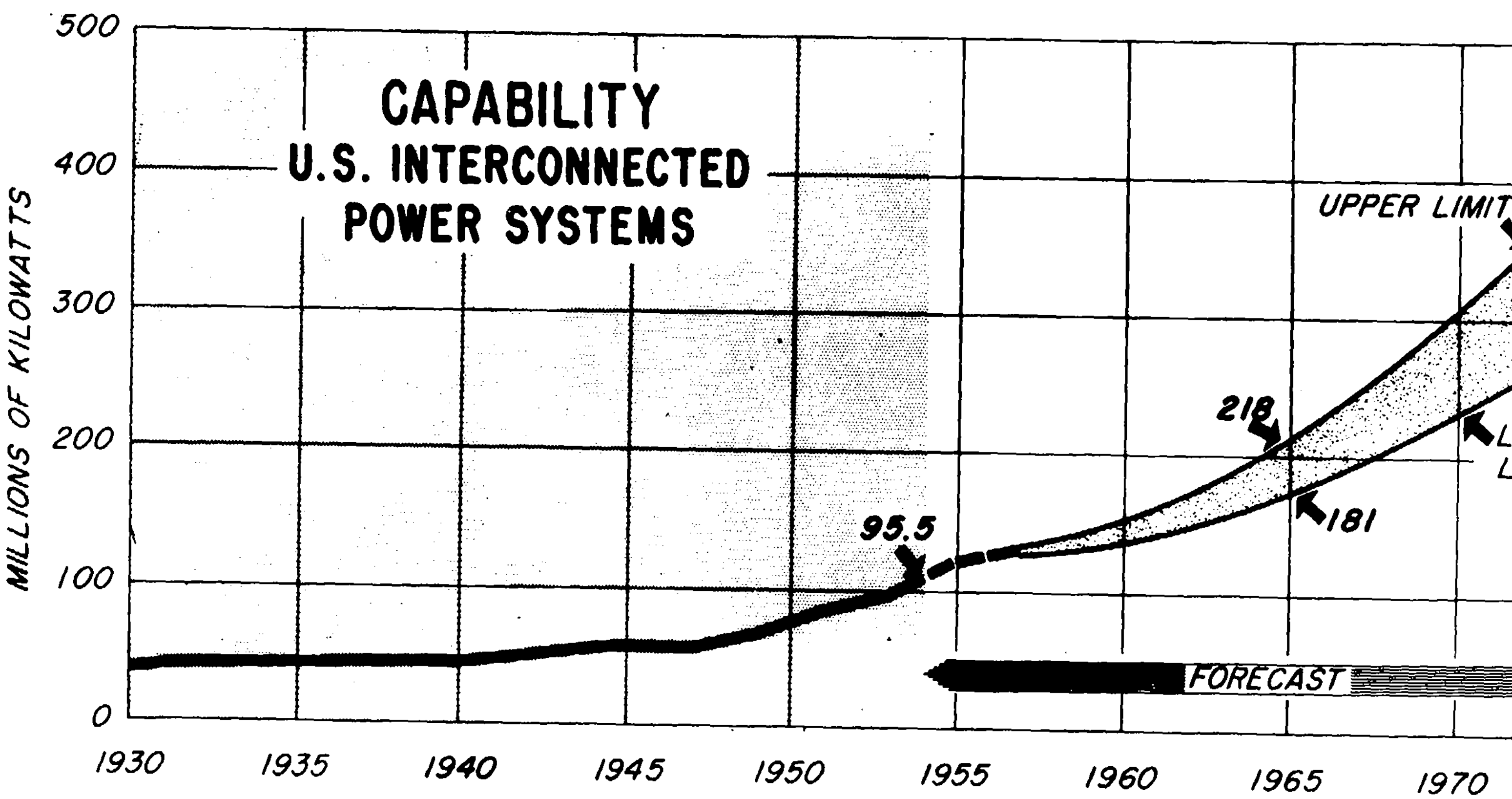

TOTAL ELECTRIC UTILITY
INDUSTRY IN U.S.
GENERATION
ESTIMATED
MILLIONS OF KWHR
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1930
1935
1940
1945
1950
1955

CHART 4


CAPABILITY
U.S. INTERCONNECTED
POWER SYSTEMS
MILLIONS OF KILOWATTS
500
400
300
200
100
0
1930
1935
1940
1945
1950
1955
1960
1965
1970
95.5
218
181
UPPER LIMIT
FORECAST

For 1965 we will require between 181 and 218 million kilowatts, while for 1975 a generating capability somewhere between 301 and 423 million kilowatts is estimated.

Chart 5, page 9.--The installation of new generating equipment to provide the capacities foreseen is a tremendous undertaking. This chart shows the generating capacity additions required for 5-year periods in order to meet the expected load growth. During 1954 the power systems of our country actually brought nearly 12 million kilowatts of new capacity into commercial operation. We should find it possible to meet the increases which may be as much as 23.9 million kilowatts a year if we plan sufficiently far in advance. The generating capacity additions as tabulated, it should be noted, include no allowance for retirement of existing facilities, some of which surely will occur.

These forecasts of future power loads and generating capacity requirements were made without any specific considerations of the use of atomic fuels. The new power loads which have resulted from atomic energy activities over the past 10 years are included in the peak-load data shown in chart 1 and in this way, atomic energy unquestionably has influenced the forecasts of loads for future years. Those who study our industrial and economic advances believe that this is reasonable. It is highly probable that the very large uses of power for atomic facilities which have come into being during the past 10 years are portents of things to come.

The point I wish to make is that we believe we have a reasonably good idea of the power requirements in the United States for the next 20 years. I do not believe that the coming use of atomic fuels will greatly change those requirements. We are fortunate, in this country, in having very large fuel reserves and substantial amounts of undeveloped hydro in the Far West. We can use those reserves to meet any power requirement now foreseen. Admittedly, we would begin to deplete the easily recoverable part of those reserves quite rapidly, but I seriously doubt whether the cost of power would increase to the point where it would become a prohibitive factor in our industrial economy.

The important point about atomic energy is that it very likely can be used to supplement conventional fuels in meeting the power loads which I have just indicated. There is even the possibilit that it may provide some economies in the cost of generation, and

CHART 5

ESTIMATED REQUIRED CAPACITY ADDITIO

MILLIONS OF KILOWATTS

5 YEAR PERIOD	REQUIRED CAPABILITY ADDITION MINIMUM	REQUIRED CAPABILITY ADDITION MAXIMUM	AVERAGE YE ADDITION MINIMUM	AVERAGE YE ADDITION MA
1955-1960	33.1	43.5	6.6	
1960-1965	42.0	61.2	8.4	1
1965-1970	53.0	84.9	10.6	1
1970-1975	67.0	119.5	13.4	2

perhaps that it may greatly simplify the power supply problems in some areas remote from sources of fuel.

We in Detroit have been active in the study of how to utilize atomic fuels for the generation of electric power for about four and one-half years. As we see the situation, the use of atomic materials for the generation of electricity is primarily a power problem. The electric power produced will be no different from electricity produced by the present conventional methods. In all likelihood it will be made available to industry, homes, farms, and other consumers over the existing power networks and distribution systems. The electric power industry, therefore, is the key central factor in the ultimate use of atomic fuels for power generation. It must assume a leading part in the development effort and bring about the things which are needed to make the production of power by using atomic materials a practical reality.

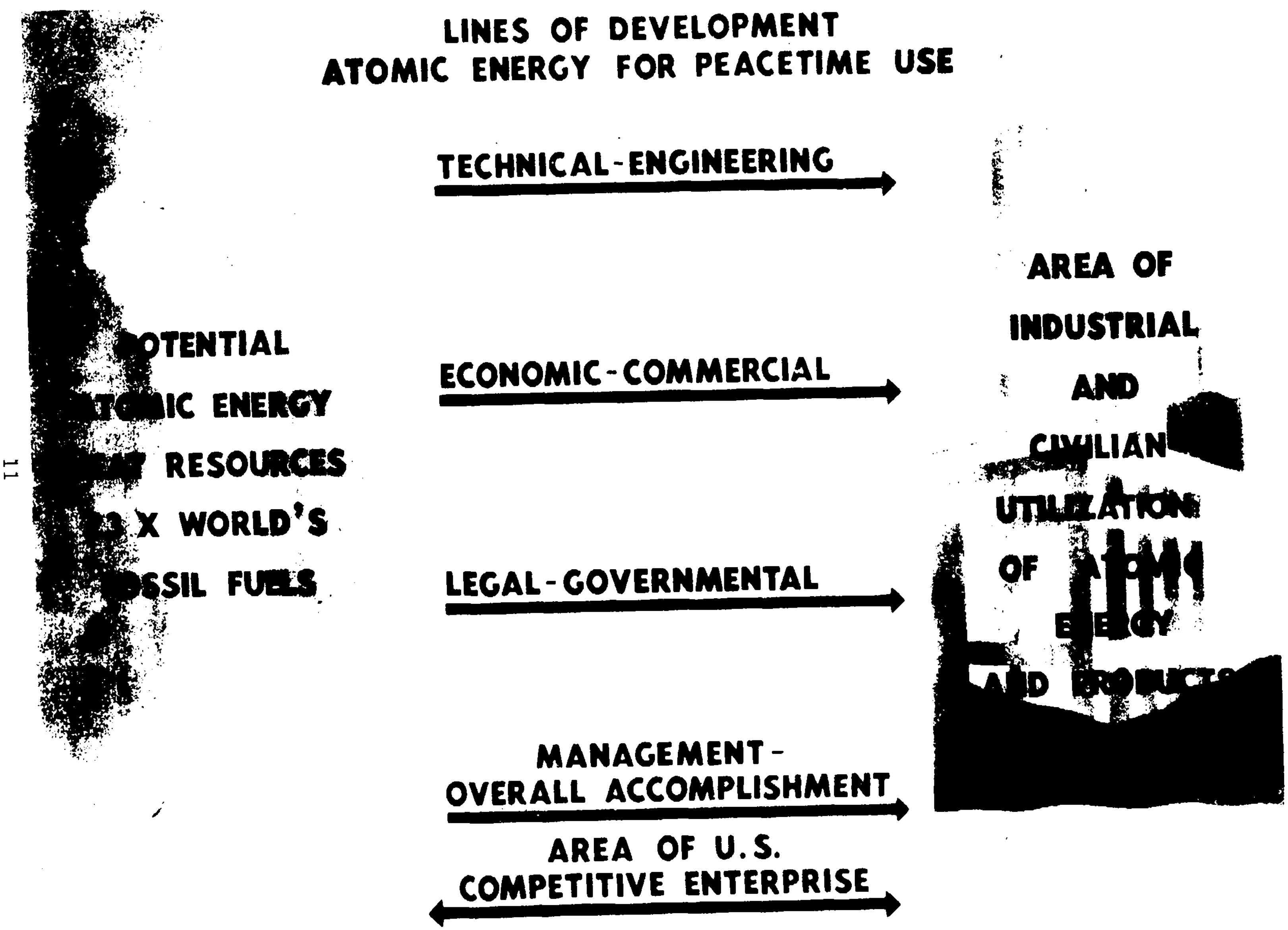
In order to carry our effort forward effectively, we have associated with others having similar interests and at present our group, known as Atomic Power Development Associates, comprises 25 electric power systems, 4 manufacturing firms, and 4 engineering organizations, a total of 33. The 25 power companies, located east of the Mississippi River, supply a little more than 35 percent of the electric power for the United States.

Our objective, as stated many times, is to develop the means by which atomic fuels may be utilized on a commercially competitive basis. I would like to point out to you some of the many complex problems that are involved.

Chart 6, page 11.--In our effort we have considered that there are four lines of developmental work, as illustrated by this chart, which must be carried on simultaneously in order to reach our ultimate result.

The first line of development, technical and engineering, is usually reasonably well understood. We must bring about the technical and engineering advancements necessary to make it possible to build safe, reliable nuclear reactors which can be used to produce heat energy for the generation of power. Many people, however, fail to realize that very severe difficulties lie between the origination of an idea and its translation into a workable and accepted industrial application.

CHART 6


LINES OF DEVELOPMENT
ATOMIC ENERGY FOR PEACETIME USE
OTENTIAL
IC ENERGY
RESOURCES
X WORLD'S
SSIL FUELS
TECHNICAL-ENGINEERING
ECONOMIC-COMMERCIAL
LEGAL-GOVERNMENTAL
MANAGEMENT-
OVERALL ACCOMPLISHMENT
AREA OF U.S.
COMPETITIVE ENTERPRISE
AREA OF
INDUSTRIAL
AND
CIVILIAN
UTILIZATION
OF

The second line of development has to do with economic and commercial matters. We may succeed in building reactors which can be used for the generation of electricity but, from a business standpoint, we likely would not be justified in doing so unless the power could be produced at lower costs than with conventional methods. There are many matters of judgment which enter into this consideration.

The third line of development has to do with legal and Government matters. If we are to substitute atomic fuels for conventional fuels, we become involved in a whole new area of legal matters. There is the Atomic Energy Law, which provides a whole new set of rules under which those wishing to use atomic energy must operate. New and detailed working relations must be established with the Commission. And because we will be working with new materials and processes, there are problems with State and local governments.

Finally, there is the matter of management and actual accomplishment. Over the years we have become accustomed and skilled in doing our jobs and managing our present power systems. We know what is involved in financing, building, and operating our present-day power plants and systems. Atomic-fueled plants bring many new and different problems. There is much to be done in the area of management in anticipation of the commercial use of atomic fuels.

Power Reactor Development

Let us return now to the technical and engineering problems. Many reactors for electric power generation have been proposed and studied in considerable detail, and there is a large amount of scientific and technical information available concerning them. Only a very few have been carried through to the point where construction of either pilot or full-sized units has been completed or definitely undertaken. Much of the very large task of translating this technical information into safe, practical reactors which can produce electric power efficiently enough for industrial use on a commercially competitive basis still remains to be accomplished. This is something which cannot be done by building one or two reactors. Rather, this will require perhaps 10 or more years of experimentation and development, out of which will come the engineering practices, skill, and experience which are needed.

We are beginning to move into the field of actual experience. The submarine "Nautilus" has the largest power reactor built and operated to date in the United States, and probably in the world. You in the armed services must be well aware of the success which has been achieved. It is an accomplishment of which we should all be proud. It is generally believed, however, that because of the cost of the materials which must be used as fuel and the comparatively poor utilization of the fuel, a reactor similar to that used in the "Nautilus" cannot be economically justified for the production of electricity on a commercial basis--except perhaps in very high fuel-cost locations and under other very unusual circumstances.

There is also the "PWR" reactor under construction. This installation, as you know, is a joint venture of the Atomic Energy Commission, Westinghouse Electric Corporation, Duquesne Light Company, and Stone & Webster Engineering Corporation, at Shippingport, Pennsylvania. The reactor is similar in many respects to the "Nautilus" unit. It is much larger, however, presumably incorporates many technical and engineering improvements, and will bring a definite step forward toward the ultimate goal.

The Atomic Energy Commission has undertaken a 5-year reactor development program which includes four promising types of reactors, but of smaller size. These are intended to provide technical information from which larger and perhaps economic reactors can be built.

Only last Thursday,10, February, the Consolidated Edison Company of New York, Inc., announced that it intended to enter into an agreement to purchase an advanced type of pressurized water reactor having a capacity of 100,000 to 200,000 kilowatts.

It is certain that other projects of a similar nature will be undertaken in the near future. Thus, it is evident that much progress is being made in technical and engineering development.

Before leaving the subject of technical and engineering development, I would like to point out a few basic facts concerning the way in which different types of power reactors utilize atomic materials. Many ways of classifying the reactors which are now being studied have been suggested; and for our purposes in analyzing the use of atomic fuels for power generation, it is convenient to use the following three groups:

1. Utilization--or nonregenerative--reactors.
2. Converter--or partial regenerative--reactors.
3. Breeder--or producing--reactors.

These classifications are based upon the effectiveness of utilizing the neutrons which are given off in the fission process. In this discussion I am assuming that you have at least some understanding of the atomic materials--uranium, plutonium, and thorium--which are involved. Uranium, a natural metal more than 1.5 times as heavy as lead, is found in rather small concentrations. It is composed of two isotopes: U-235, which is naturally fissionable, and U-238, which is not fissionable; but U-238 can be changed to plutonium, which is fissionable through a complicated process called transmutation. These isotopes in natural uranium always occur in the ratio of 1 part U-235 to 139 parts of U-238.

Plutonium (PU-239) is not a natural material but can be produced by the transmutation of the fertile U-238.

Thorium, a very heavy natural metal, is not fissionable but it can be transmuted to U-233, which is fissionable.

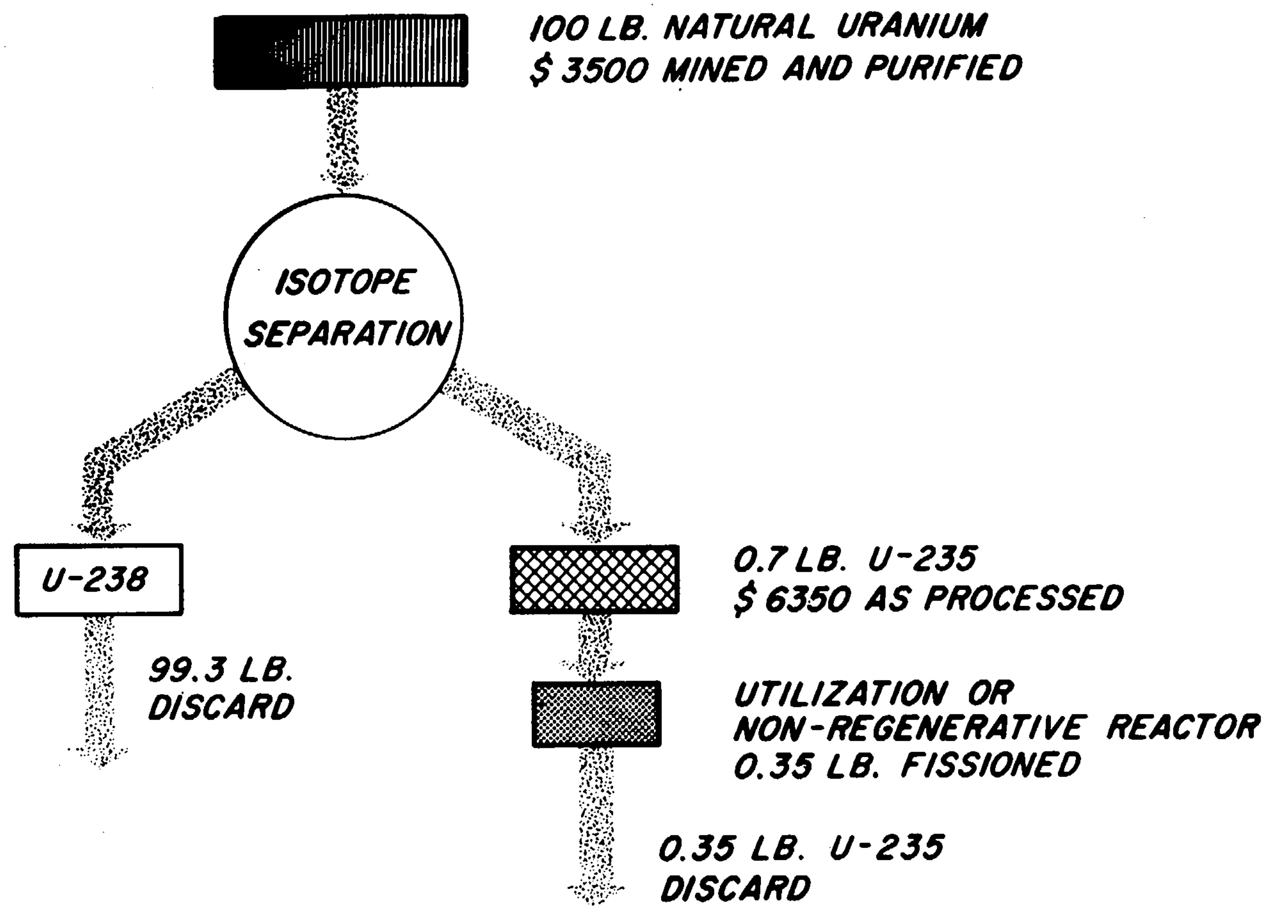
Thus, three materials, U-233, U-235, and PU-239, can be used as atomic fuels. U-235 at best is found in small quantities and its separation from U-238 is extremely difficult, as indicated by the extensive and costly gaseous diffusion plants. U-233 and PU-239 must be produced by complicated processes in nuclear reactors. U-235 seems to be more readily available than the other two and its technology is the most advanced. U-233 and plutonium, at the present time, seem to be too important as weapons materials to use as fuels.

Utilization Reactors

For the purposes of power production, a utilization reactor is one which has, as its fuel, atoms of U-233, U-235, or PU-239. The fuel elements and reactor would be so constructed that there would be practically no transmutation of U-238 to plutonium or thorium (TH-232) to U-233.

Chart 7, page 15.--If uranium is the fuel for such a reactor, the assumed utilization might be approximately as shown schematically by this chart. Only a very small part of the total heat potential of the uranium would be utilized and consequently the cost of the uranium alone would be as much as, or more than, the total cost of generation in most of the modern conventional thermal plants in the United States using present-day fuels.

CHART 7



COAL AND ELECTRICITY EQUIVALENTS

100 LB. OF NATURAL URANIUM USED IN THIS MANNER WILL
(1) PROVIDE THE HEAT EQUIVALENT OF 455 TONS COAL
(2) GENERATE APPROXIMATELY 910,000 KWHR OF ELECTRICITY

THE COST OF URANIUM WILL BE 0.7 CENTS PER KWHR OF ELECTRICITY GENERATED

In those areas where U-235 separation processes do not exist, PU-239 or U-233 would be required as fuels. There is little experience with the use of these materials in power reactors and cost data concerning them are not available, but certainly they will be more costly than the value for U-235 assumed in the chart.

The problems of developing and constructing reactors of this type appear to be less difficult than for other reactor types. In addition, they have other characteristics which permit them to be built in compact form. Thus, as expressed earlier, the largest power reactor that has been built and operated to date in the United States--the unit for the submarine "Nautilus"--presumably comes within this classification.

Converter Reactors

Included in this group are all reactors which produce some new fissionable atoms, but not as many as are burned or fissioned in the operation of the reactor.

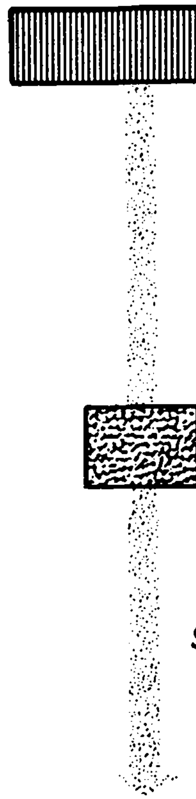
In other words, some of the neutrons given off in the fission process are actually used to transmute U-238 to PU-239 (or TH-232 to U-233).

Chart 8, page 17. --This chart shows approximately how such a reactor, utilizing natural uranium as the fuel, might operate. With natural uranium at 35 dollars per pound, the cost of fuel alone to produce electricity does not appear to be excessive. It should be remembered, however, that at present the cost of a reactor probably would be several times that of a conventional boiler to perform a similar service. Thus, the interest and operating charges may make such reactors uneconomic until further development is accomplished.

Most of the reactors now being studied for power generation are in this class, including graphite moderated water cooled reactors, pressurized water reactors, boiling water reactors, sodium graphite reactors, and so on. The development efforts now under way will lead to several different reactors which will be capable of producing power in a satisfactory manner. Whether they will be competitive depends largely upon their building cost and their fuel requirements.

Most of these reactors apparently will produce somewhere between 60 and 100 percent as much new fissionable material as is

CHART 8



100 LB. NATURAL URANIUM
$ 3500 MINED AND PURIFIED

CONVERTER OR REGENERATIVE REACTOR
1 LB. FISSIONED

99 LB. DISCARDED

COAL AND ELECTRICITY EQUIVALENTS

100 LB. OF NATURAL URANIUM USED IN THIS MANNER WILL
(1) PROVIDE THE HEAT EQUIVALENT OF 1300 TONS COAL
(2) GENERATE APPROXIMATELY 2,600,000 KWHR OF ELECTRICITY

THE COST OF URANIUM WILL BE 0.13 CENTS PER KWHR OF ELECTRICITY GENERATED

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consumed. An average of 90 percent probably is on the high side and, with this conversion rate, less than 7 percent of the total uranium could actually be utilized.

There is the belief that some of these reactors can be developed so the conversion rate is 100 percent or slightly higher, or they may be made to breed. In this event, the utilization of the fuel would be greatly improved.

Breeder Reactors

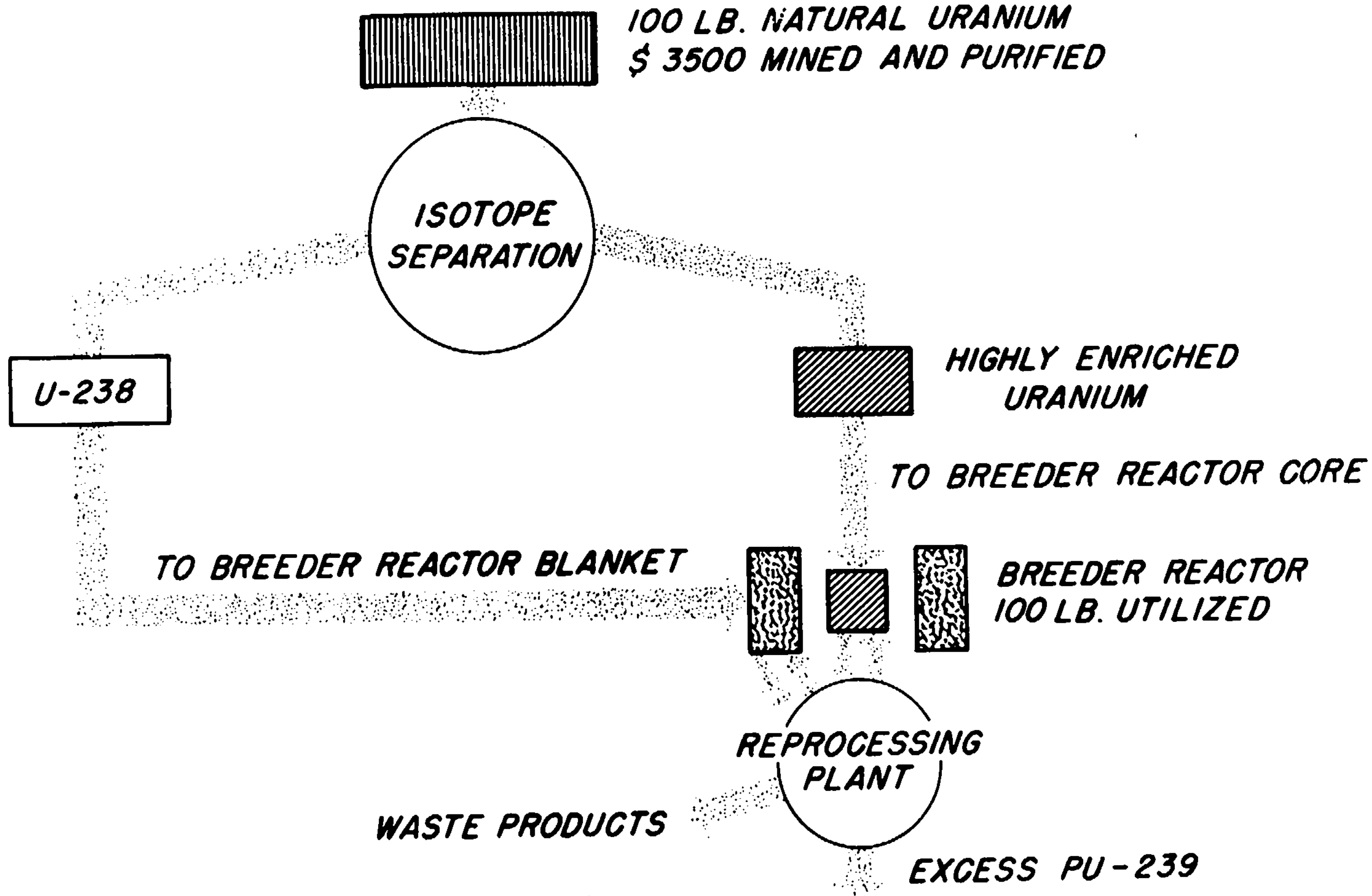
Breeder reactors produce more fissionable material than they consume. This is accomplished by making very effective use of the neutrons given off during fission. If suitable processing and reprocessing methods can be developed, they can utilize the full potentialities of uranium--or thorium--and, in addition, increase rather than deplete the world's supply of fissionable materials.

Chart 9, page 19.--This chart illustrates the way a breeder reactor might operate and the possible fuel costs for producing electricity. From a practical standpoint, there will be some losses of uranium in the processing and reprocessing of the fuel elements and blanket, and it is possible that not more than 50 percent of the total heat potentiality of the uranium will actually be utilized. Even with only 50 percent of the uranium actually utilized, the cost of the fuel for power generation will be very low indeed.

The project in which the Detroit Edison Company and its associates are engaged is directed primarily toward the development of a large liquid metal cooled fast neutron breeder reactor with an integrated fuel element and blanket reprocessing and fabrication system. This type was chosen because of our belief, (1) that a reactor which produces both heat and fissionable material has the greatest possibility of being economically justified and (2) that an atomic power industry should be capable of supplying its own fissionable material requirements. The integrated reprocessing and fabrication systems are required to make such a reactor practical.

While we have recognized that the technical problems involved in a fast breeder reactor may be more difficult than some other types of reactors, we have felt that it is more desirable to devote our effort to the longer range development.

CHART 9



COAL AND ELECTRICITY EQUIVALENTS

100 LB. OF NATURAL URANIUM USED IN THIS MANNER WILL
(1) PROVIDE THE HEAT EQUIVALENT OF 130,000 TONS COAL
(2) GENERATE APPROXIMATELY 260,000,000 KWHR OF ELECTRICITY

THE COST OF URANIUM WILL BE 0.0013 CENTS PER KWHR OF ELECTRICITY GENERATED

The nuclear physics of a breeder reactor are well understood, and the principle of breeding has been demonstrated by the experimental breeder reactor (EBR) near Arco, Idaho. This, as is well known, is a small unit--only 250 kilowatts of electricity--and is intended primarily for experimentation.

Chart 10, page 21.--Our research and development work involves the design of a large reactor with a capacity of 100-150 megawatts electricity. The plant we envisage would be approximately as shown here on this chart.

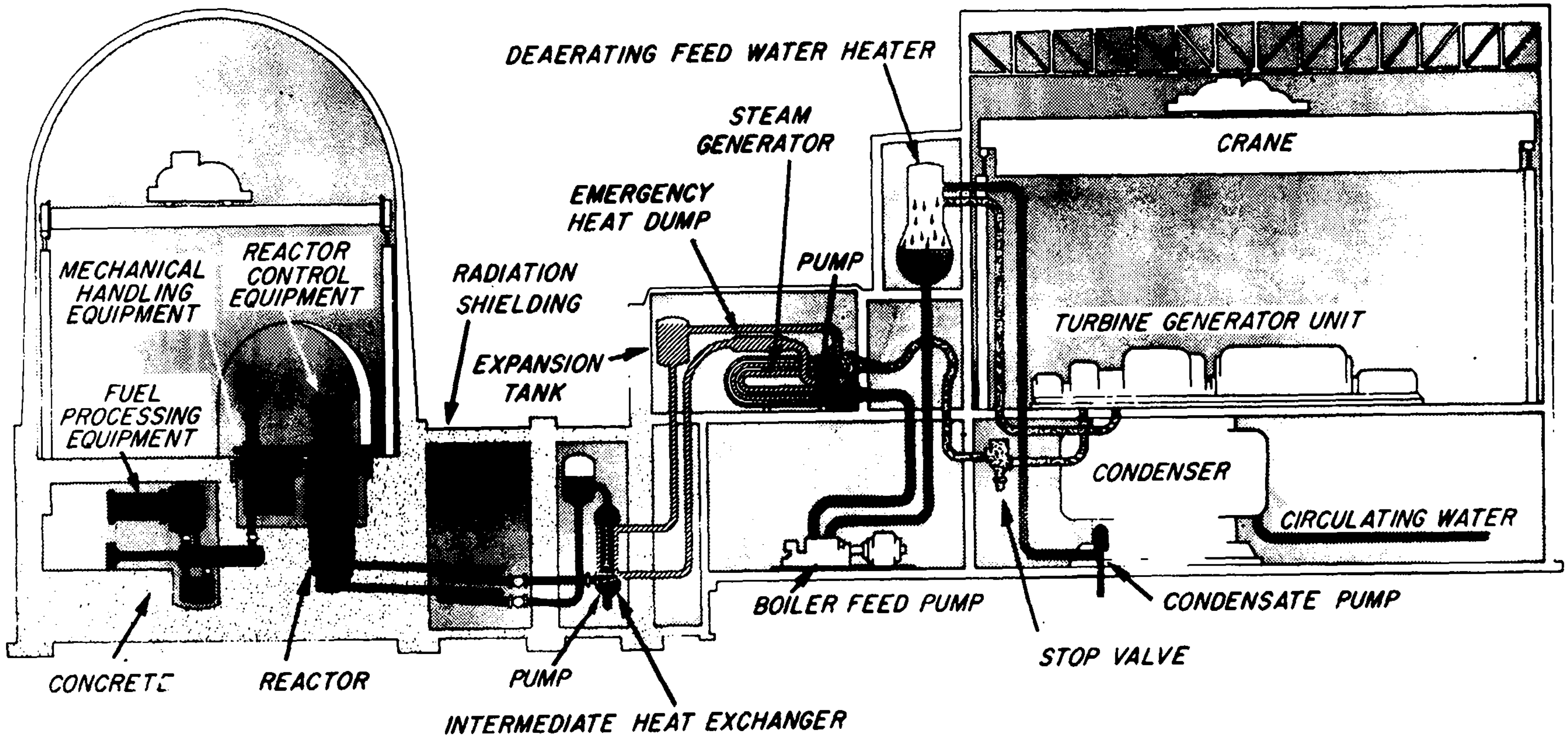
Work is under way on the fuel elements, coolant system, control system, heat cycles, and other similar factors, which are needed in a practical steam-producing installation. During 1954 our group spent approximately 1.9 million dollars in carrying forward this project.

The project work now planned for 1955 has an estimated cost of 3,815,000 dollars. Included in this is the beginning of a facility for the testing of prototypes of reactor components. The first test will involve a section of the steam generator which we propose using. It will require a small sodium loop, heating devices, and other equipment necessary to determine accurately the heat exchange rate and other characteristics. Later, we expect to test a full size reactor vessel, fuel element handling device, control equipment, and so on. The cost of this test facility and the work which will be done there will be well over 2 million dollars, one-third of which is to be spent this year.

Since last July, as the result of suggestions by the Commission, we have given a great deal of thought to the matter of undertaking the actual construction of a developmental reactor at an early date, in order to obtain operating experience which will provide the basic knowledge required for the subsequent construction of improved and perhaps economic reactors. With the announcements by the Commission on 10 January of its policies and prices, we are now in a position to make definite plans.

We have concluded that a large breeder reactor capable of producing up to 100,000 kilowatts of electricity could be undertaken at the present time but that a substantial amount of developmental work remains to be done before the complete design could be accomplished. Moreover, satisfactory reprocessing methods for the fuel and blanket

CHART 10



LEGEND

- RADIOACTIVE COMPONENTS - REACTOR AND ASSOCIATED EQUIPMENT, LIQUID SODIUM (Primary Coolant System)
- LIQUID SODIUM - POTASSIUM ALLOY (Secondary Coolant System)
- WATER
- STEAM

1795

elements have not yet been developed. Thus, for the time being at least, we would have to depend upon Commission facilities for this essential part of a breeder reactor operation.

The complete plant would cost about 50 million dollars, excluding the value of the atomic materials required for fuel and the blanket. It could not be economically justified on the basis of the value of the power and plutonium which it would produce. The construction and operation of such a reactor might well provide the information and experience needed to make atomic energy a competitive source of energy.

We are studying the possibility of financing such a project. Obviously, since it would not be economic, conventional financing methods and techniques cannot be relied upon.

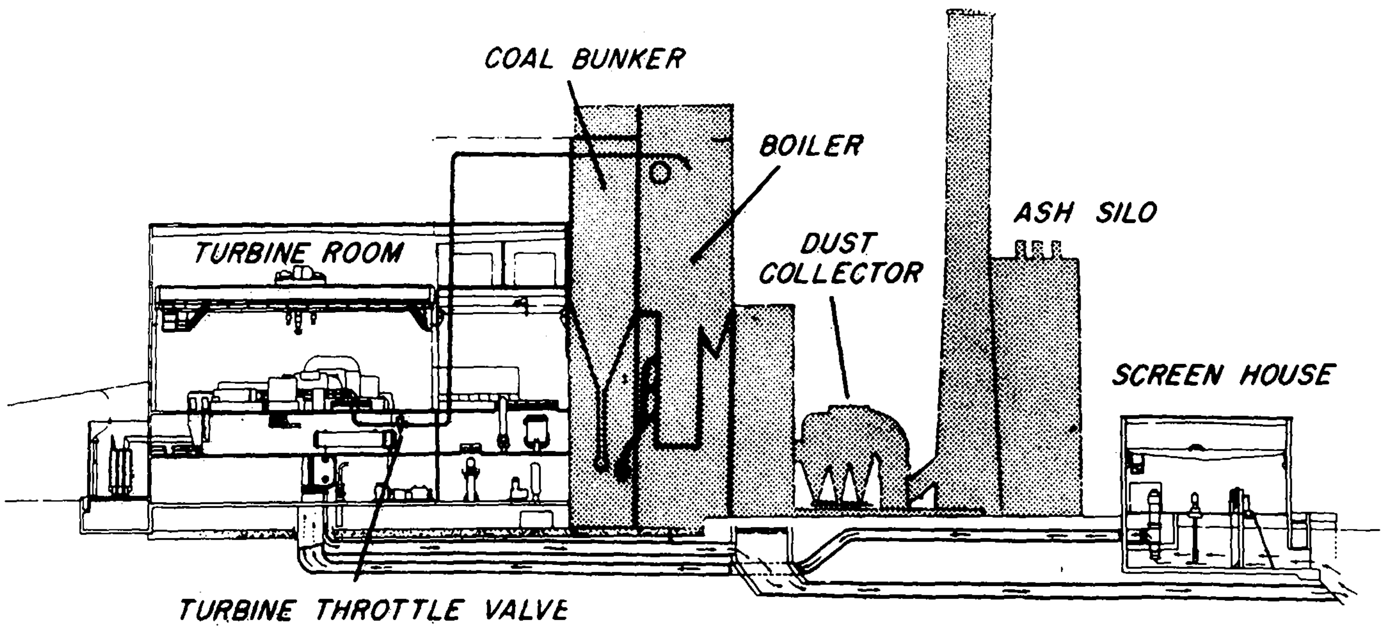
Economic Matters

In the matter of economics, we believe that, considering the use of atomic fuels by electric power systems for the generation of electricity, the basic premise should be that the power so generated must cost no more than power produced by the present conventional methods. Consumers cannot be expected to pay more for electricity simply because it is produced by using atomic fuels. A great many factors enter into this matter.

What is, or is not, economic power will be influenced greatly by the available energy resources in different areas. Because fuels for some regions must be transported quite long distances, the costs vary substantially in different parts of the country. For example, coal and oil in the New England States may cost 40 to 50 cents per million B.t.u.'s while natural gas, which at present is used extensively for power generation in the area around the Gulf of Mexico, may cost only from 10 to 15 cents per million B.t.u.'s. In both of these locations there is no question concerning the availability of fuels, but as time goes on the relative costs may change substantially.

Chart 11, page 23.--In the studies of the Detroit Edison Company, one approach to the economic situation has been a determination of what we can afford to pay for a nuclear reactor. In this we have made comparisons with the cost of conventional coal-fired boilers for our new St. Clair power plant, shown in cross section on the chart. This plant has a total capacity of 625 megawatts in four cross-compound

CHART 11



GENERATING CAPACITY

4 TURBINE GENERATORS EACH 156,000 KW CAPABILITY - TOTAL 625,000 KW

	STEAM GENERATION	ELECTRIC GENERATION	TOTAL PLANT
TOTAL COST	$ 48,293,000	$ 50,407,000	$ 98,700,000
COST PER KW CAPABILITY	$ 77.00	$ 81.00	$ 158.00
% OF TOTAL PLANT	49	51	100
% OF TOTAL CO. INVESTMENT	17 *	18 *	35 *

* THESE PERCENTAGES REPRESENT THE SUM OF THE INVESTMENTS IN STEAM GENERATION FACILITIES, ELECTRIC GENERATION FACILITIES AND POWER PLANTS RESPECTIVELY, IN THE FIVE POWER PLANTS OF THE DETROIT EDISON CO., AS OF JUNE 30, 1954.

turbine generator units, and its total cost was 98.7 million dollars. The steam generating facilities of this plant (the shaded area) cost 48 million dollars or 77 dollars per kilowatt. Approximately 1,233,000 tons of coal, costing 8,860,000 dollars will be burned in this plant each year. With the coal at 35 cents per million B.t.u.'s delivered at the plant, steam at the turbine throttle costs 57.7 cents per million B.t.u.'s, including operating and investment costs and taxes.

If a similar station to use atomic fuels were to be built, nuclear reactors would replace the conventional steam generating facilities. The remainder of the plant would not be appreciably changed except that steam conditions might be somewhat different.

In discussing reactor development, it was shown that under certain conditions, the cost of atomic fuels might be exceedingly low, and in addition, it was indicated that breeder reactors might produce plutonium which could be sold for other uses. Assuming that the commercial value of plutonium to be sold would exactly balance the operating and maintenance costs and the new fuel cost of the reactor plant, the amount which we could afford to pay for reactors to replace the boilers is 227 dollars per kilowatt of capacity. At this cost, and with the above stipulations concerning operating and fuel expense, the cost of steam at the turbine throttle would be 57.7 cents per million B.t.u.'s the same as with conventional boilers.

Obviously, there will be a substantial operating and maintenance expense for any nuclear facility, and the cost of new fuel, even if it is only natural or depleted uranium, will be appreciable. This would tend to decrease the amount which we can afford to pay for a reactor.

On the other hand, if the value of the plutonium which can be sold for use as fuel in other reactors exceeds the operating and maintenance expense, or if some commercial use for fission products can be found, then the amount which could be invested in a breeder reactor would be increased above the 227 dollars per kilowatt.

All of these are real considerations which enter into the economic determinations, and the same kind of comparison can be made for any other type of reactor. Unfortunately, because there is no actual experience with large breeder reactors, there is a lack of factual information on these problems.

One point which does seem clear is that reactors of very large capacity have the greatest possibility of producing economic power. This, as is well known, is true of conventional steam boilers. The ability to achieve an extremely high heat release in nuclear reactors makes very large units even more attractive. The problems lie in removal of the heat from the reactor, not in the ability to produce it.

Other factors which enter into the economic considerations include the safety and public liability considerations and the disposal of reactor waste products. These might involve very heavy expense and make the use of nuclear reactors uneconomic.

Summary

In this discussion I have referred chiefly to the research and development work, and economic studies in which we are engaged. There are, of course, many others engaged in similar activities, and all are contributing toward the overall advancement. At least 19 separate industrial study groups are working under agreements with the Commission. The approximately 55 power systems, both investor and publicly owned, identified with those study groups, supply about 60 percent of all the power in the United States. Many others seek to become engaged in the work. We can be sure that the development is receiving adequate attention and that it will move forward surprisingly fast. However, we should keep the following thoughts in mind:

1. A tremendous amount of research and development must be done before atomic energy can be developed to the point where it can assume its expected role in the peacetime economy of the world. The potential benefits fully justify the effort which is required.

2. Private industry has the major responsibility of bringing about the practical application of atomic energy for peacetime uses. While the Government may furnish the scientific laboratories for research, it generally is not organized to carry out the industrial operations required to bring about the development of economic installations of the kind under consideration.

3. The development of practical methods of utilizing atomic energy for power generation is primarily a responsibility of the electric power industry. Obviously, the closest cooperation of physicists, chemists, engineering profession, and many others is needed to bring about this development.

4. Because of the high cost of nuclear reactors, and the fact that the major cost of electricity does not result from expenses chargeable to generating plants, it is not probable that the successful development of atomic fuels will result in large savings to the consumers.

And now in closing, I express to you my very deep appreciation for being here with you today and I wish you well in all your own endeavors. I hope from time to time there will be an opportunity to meet with you again in connection with atomic energy development because I believe that, in the immediate years ahead, we will find astonishing progress being made.

I have here some copies of a paper which was given to an international group in Brussels last September. It will give you in prepared form some of the material that I have endeavored to bring to you today, and perhaps it may help you to fix some of these facts in mind.

Again, Admiral Hague, I appreciate very much the privilege and opportunity of being here with you. Thank you very much.

COLONEL WALKER: Mr. Cisler is ready for your questions.

MR. CISLER: Gentlemen, may I say at the beginning that I am not far enough away from home to be classed as an expert and I find that there are those in the audience who would be in a position to check up on me if I did attempt to do so. So I am just an ordinary fellow away from home, and if there are questions that I can answer, I will be very happy to do so.

QUESTION: Mr. Cisler, do you have any information that you could give us as of now on the kind of problem that they expect in waste disposal of these commercial type reactors?

MR. CISLER: We are hopeful, of course, that with the accomplishment of the breeder reactor we will use up much more of the potential which is in the fuel. In fact, the development that we contemplate would use depleted uranium as well as natural uranium. These fission products are highly radioactive. They are a problem.

Perhaps you noticed, in connection with the proposed design of a fast breeder, the shielding and the control equipment there and the reprocessing of the coal and blanket elements. There is a great deal of work which is necessary in connection with the fission products. For the present all industry is largely dependent on the Government facilities for that processing and reprocessing work. But it is one of the important technical and economic problems involved.

If you will recall the diagram of the four channels of development necessary, you will remember that the second channel indicated the economic and commercial aspects. We must realize that as a part of this development there must be a whole economic system coming out of the use of atomic fuels, because it may well be that in the immediate future the use and the value of the products and byproducts will play an extremely important part. As we look ahead, the use of the fission products, for one purpose or another, may bring in a commercial activity that would provide a substantial source of revenue.

In order to make these fission products available for commercial use, it will mean that very high investments will probably be necessary. Here we have the unusual situation of energy being concentrated in a relatively small volume. How do we spread it out? How do we take this tremendous amount of energy in that tiny particle of the atom and so release it, so blow it up, so spread it out that it can go from this very minute particle into the forms that can be used for all kinds of domestic, commercial, and industrial purposes?

And these byproducts have an energy factor in them, too. It may well be that by the use of fission products we can find a whole new series of products. I sometimes think back to how the silicons have come in, a whole new family of products resulting from research and development work.

Certainly, the fission products, if they are not put into usable form, will have to be stored, and that in itself is a costly process.

What we are really trying to do is to get all the squeal out of the atom the same as they do out of the pig, and to make some commercial use of all of the energy components. I liken the situation of the atom to Dr. Jekyll and Mr. Hyde. On the Mr. Hyde side is the destructive force of the atom; on the Dr. Jekyll side is the constructive force of the atom, realizing that a pound of uranium is equivalent to 1,300 tons of coal and 2,600,000 pounds of coal.

Recently, I had occasion to talk on a radio program and I said that the bar of uranium which I had in my hand, weighing 3.3 pounds, would be equivalent to all the coal that we use over an 8-hour period to supply some million customers of ours in eastern Michigan, and that 10 pounds of it would take care of a whole day's operation. And we burn a lot of coal every day, in fact, more than 5 million tons a year for the generation of power.

QUESTION: Sunday a week ago, Senator Anderson stated on "Meet the Press" that our industrial progress in atomic energy was tragically behind what it should be. He also stated or intimated that the British had made greater progress in that area than we have. Would you care to comment on that?

MR. CISLER: I heard Senator Anderson. The next afternoon I was up before his committee and that was discussed again.

It is true the British have been moving forward and they have announced their program for reactor construction. I have visited England and I have seen something of its program over there.

I think that here in the United States we are moving forward very rapidly. If you take an inventory of what we are doing and our background of knowledge, you will find we are in a very strong position. The announcement, as I said earlier, of the Consolidated Edison Company (which is one of the member companies of the Atomic Power Development Associates), that it was going to go forward with an advanced type of pressurized water reactor entirely on its own is a very significant step. Those of us who are concerned with the breeder reactor will endeavor to move that project forward. We so stated before the Joint Congressional Committee just a week ago.

A major part of the electric power industry in the United States is now engaged in atomic research and development, economic studies, and actual experimentation. American industry is endeavoring to move forward.

We now have an Atomic Energy Act, that of 1954, which permits the private ownership of facilities for utilizing atomic energy and licensing for the use of fissionable materials. In my opinion, the United States will move forward and will be a leader in atomic energy development.

We are getting up steam, so to speak. A great deal of private money is going to be expended on the research and development work. We are on that research and development team.

QUESTION: Sir, if I remember your figures, you said in the breeder type reactor you would probably produce electricity for the cost of 0.013 mills. I have two full questions: (1) Does that include amortization of the plants? and (2) Could you give us some idea of the comparative best cost you could arrive at by present generation methods?

MR. CISLER: In answer to your first question, my point was that with a breeder, a fuel cost of 0.013 mills per kilowatt-hour might be achieved theoretically. That includes no cost other than fuel and from a practical standpoint the actual cost may be two or three times that amount, which is still insignificant.

At the St. Clair plant the cost of a million B.t.u.'s at the turbine throttle is 57.7 cents. For those who are in the Navy, I like to look upon the turbine throttle as the North Star to guide us because the turbine doesn't care where the steam comes from, provided it is delivered to it in the quantity and under appropriate temperatures and pressure conditions. The turbine throttle marks the transition point where thermal energy is converted first into mechanical and then into electrical energy.

The overall cost of electric power coming from the St. Clair plant is on the order of 7 mills per kilowatt-hour including all investment charges, taxes, fuel, and operating expense.

It is not possible at the present time to build an atomic power-plant which will produce electric power at 7 mills. And, of course, entering into the cost of power produced by an atomic plant is the value of the inventory of the fuels and the possible value of the reactor products and the byproducts.

In the TV program mentioned earlier and in the questioning that occurred in the Joint Congressional Hearings a figure of 10 mills or 1 cent per kilowatt-hour was used as the estimated production cost for an advanced type of pressurized water reactor.

At the present time, it would not be economic, looking at it strictly from a competitive standpoint, to use atomic fuels if it costs one cent per kilowatt-hour to generate power. However, if we look ahead over the next 20 to 25 years, we believe that there will be an ever-increasing development of atomic energy and the construction of atomic plants. Probably by the year 1965 we will have from 1 to 2 million kilowatts of atomic generating capability in this country, and by 1975 or 1980 we will have from 40 to 65 million kilowatts of atomic generating capability. That might account for 20 to 25 percent of the total kilowatt-hours generated and utilized in this country 20 to 25 years hence.

Atomic power plants, because of their high investment cost, would be used for high load factors and that consequently a kilowatt of atomic capability would proportionately carry a higher load, a higher yearly output, than would one from a conventional plant. There again, that is all part of economics.

QUESTION: You have pointed out in your talk that the problem here, as far as the price of a kilowatt-hour to the consumer is concerned, would not be really significant, even if we solve the technology problems. Will the real role, then, of atomic energy in the power industry be one which will result in jacking up the low cost perhaps of industry?

MR. CISLER: I think the answer to this is that atomic energy should help to keep the cost of electric power low. May I just explain a little further. We have, in the Detroit Edison Company, an investment in excess of 800 million dollars, and of that amount 17 or 18 percent is in the coal handling, coal preparation, the boiler plant, and the like, that part of the investment which produces steam and takes the millions of B.t.u.'s over to the turbine throttle. Atomic powerplants will affect less than one-fifth of the total investment; all the rest remains the same.

May I remind you that, in connection with our own system, I gave you the figure of 57.7 cents per million B.t.u.'s at the turbine throttle for our St. Clair plant. At our new River Rouge powerplant, the cost per million B.t.u.'s at the turbine throttle will be down to 51 cents. Atomic plants must meet the improvement in economy in the conventional plant. Undoubtedly there will be further improvements in conventional plants, and we will have to think not of what it is costing today to build a plant, but what it is going to cost 5, 10, and 15 years hence to build a conventional plant as compared to atomic powerplants.

Atomic fuels are up against stiff competition, but competition, as is often said, is the life of trade. It has always been the responsibility of the electric power industry to give good service at the lowest economic cost. The efforts of the industry to solve the competitive aspects of atomic power are in keeping with that responsibility.

COLONEL WALKER: Mr. Cisler, it has certainly been a real pleasure for us to have you with us this morning and to enjoy your most interesting and instructive talk. On behalf of the Commandant, faculty, and all students, I sincerely thank you.

(7 Apr 1955--750)S/ibc