RESEARCH AND DEVELOPMENT WITHIN INDUSTRY

2 February 1955

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INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

Mr. E. Duer Reeves, Executive Vice President, Standard Oil Development Company, was born in New York City in 1909. He was graduated from Williams College in 1930 with a B. A. degree and did graduate work at Princeton University. He left Princeton in 1931 to join the staff of the Standard Oil Company (New Jersey) and has been with various Jersey affiliates since that time. His first assignment was with Jasco in 1935 and in 1936 transferred to the research and development laboratories of the Standard Oil Company of Louisiana. In 1937 Mr. Reeves moved to the Research Division of the Standard Oil Development Company at Bayway to take charge of its newly formed Process Development Section. In 1945 he became director of the Research Division. In 1947 he was appointed director and vice president of the Standard Oil Development Company in New York City and has been with the company as Executive Vice President since January 1949. Mr. Reeves is a member of the following organizations: The Society of Automotive Engineers, American Petroleum Institute, American Chemical Society, Directors of Industrial Research, Industrial Research Institute, Society of Chemical Industry, Armed Forces Chemical Association, Advisory Committee for Conference on the Administration of Research, National Association of Manufacturers; Advisory Council, Department of Chemical Engineering, Princeton; Advisory Committee of Research Division, New York University; Office of Defense Mobilization Committee on Specialized Personnel, Phi Beta Kappa, and Phi Delta Theta.

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GENERAL NIBLO: In our previous lectures on production, we have examined many interesting and important problems pertaining to industry. This morning we shall investigate the importance of research and development through the technological progress of commercial industry. We shall see what one industry does about the new challenges as they occur. In other words what is the interrelationship between production, research and development, and technological progress within industry?

Our speaker this morning is Mr. E. D. Reeves, Executive Vice President of the Standard Oil Development Company of New Jersey. Mr. Reeves has spent almost 25 years with this company, most of which has been in the field of research and development. Today, however, is his last day with that firm. Effective at midnight tonight they are going to change the name of Arkansas, and tomorrow morning Mr. Reeves will be Executive Vice President of the Esso Research and Engineering Company, with the same job, the same pay, and the same responsibilities.

Mr. Reeves, it is a pleasure to welcome you back to the Industrial College and to present you to this year's class.

MR. REEVES: Thank you very much, General Niblo. The general subject of research and development within industry is one in which I have been involved ever since I got out of school over 24 years ago. It is a subject that has always interested me and I am very happy to be here today and to have an opportunity to talk to you about it.

First, I would like to say that industrial research as we know it today is not something that is supported by industrial concerns or carried out as a separate activity just in the hope that something good will come of it; but it is a truly integral part of industrial activity in this country. When I started to do research in 1930, industry in the United States was spending about 160 million dollars annually for its research and development. Since that time this effort has grown tremendously, to the point where today the sum of 2.4 billion dollars represents the current annual bill for industrial research and development work. This is a fifteen-fold expansion in just the last two decades and clearly indicates the growing acceptance of research and development by American industry.

I am in the liquid energy business and represent an industry that has steadily grown because of research and is typical today of the interdependence of industrial growth and a closely coordinated research and development effort. You should also know that the industry I represent is by no means exceptional on this account; in fact we are about average. There are quite a few industries in this country that put less emphasis on research and development, but there are also many who place even greater stress on it, than we have--such as the chemical industry, the electronics industry, and so on.

In talking to you today about research and development within industry, I hope you will look on my own as a typical industry and will understand that as I talk about it I am also talking about a relationship between industry and research and development that spreads all through industry in America.

As we examine the broad subject of research and development in history, it seems to me that there are four things we should consider today:

1. The first is the question of just what industrial research actually is and how a typical business, the energy business, has grown through it.

2. Next I would like to cover something of how we go about organizing and managing industrial research.

3. Third, the kinds of things that can be accomplished through it.

4. And, finally, the meaning of all of this in terms of national security.

Coming to the first question of industrial research and what it is, I would like to start by saying that it is not the glamorous activity a lot of people seem to think it is. Industrial research is a business activity and is carried on by modern industrial corporations to improve their competitive position. Industrial research is just as integral a part of what an industrial concern does as sales, manufacturing, or purchasing. Industrial research has to participate in the day-to-day decisions of the company of which it is a part and as a member of the industrial team has very definite objectives and responsibilities.

One responsibility of a research group is to find out just what its company needs in the way of research results. It has to understand the problems of the people who use the products of its particular industry; it has to find out what kinds of products would suit their purposes best and what kinds of products they are likely to want in the future. It must also study carefully the manufacturing operations themselves to discover where these need to be improved and where work must be concentrated to match similar activities on the part of competitors.

Research has to go even further and study the raw-materials situation in view of the demands for new types of products, the possibility of lower costs, alternate raw materials, and the like. At the other end of the scale, there are numerous marketing problems that need to be looked at and possibly improved. In other words every phase of a company's business has to be studied objectively and imaginatively to see where the raw-materials situation can be strengthened, manufacturing operations improved, products tailored to fit the needs of the people who buy them, and new products and markets developed to replace old ones and to help the business in its growth.

After all of this has been done and the research organization has a pretty good idea of just what is needed in the way of research results, its next responsibility is to produce the results indicated. This part of a research department's activity is what most people think of when they think about research. It is obviously a very important part, because it does no good to know all about what is needed if methods cannot be developed to meet the needs indicated.

The third objective and responsibility of industrial research is to help other units in the company in putting research results to work. The real test of industrial research lies in its usefulness, and again I would like to emphasize that finding out that a company needs a particular product and then developing that product in the laboratories is not going to do the company much good unless all of this effort results in that product's being made and sold so that the company can maintain its business and make a profit. I mention all of these things because we in industrial research have learned that if we are to do effective work, we must spend a lot more effort than most people realize on the coordination of research with other activities and in doing all we possibly can to help the rest of the company in putting the results of research to work.

I think it is clear from what I have said that the real key to successful industrial research is the day-to-day participation of the research group in the formulation of a company's major policy decisions. Technology in industry is not a thing apart, but is more a point of view or a way of doing business. In an effective industrial effort, you cannot really separate technology from other phases of the business.

When carried out in this way, industrial research can be an extremely powerful tool for industry and for all of us. The energy business is a striking example of what can be accomplished through industrial research and of how even in a short period of time the results of research can affect our whole way of living. The energy business was really born in 1760 when James Watt invented the steam engine. This, as you realize, was also about the time the Government of the United States was being formed. This was less than 200 years ago and, in comparison with all of the years that man has been on this earth and struggling to improve his existence, it is as if you woke up one morning and suddenly realized that last night something had happened that was to completely alter your life.

During these 200 years, the industrial revolution started by the steam engine was to go through a long period of incubation. For the first 90 years, the use of mechanical energy went through a sort of demonstration period. Steam locomotives were built during this period, some houses were heated with natural gas, and, on a small scale, people were learning about the new type of servant they had just invented--the mechanical servant.

The limited use of this type of energy in the United States at that time is best illustrated by the almost incredible fact that in 1814 only 22 tons of anthracite coal were mined, and even in 1820 the bituminous coal industry had progressed to only an annual rate of 300 tons. By 1850 the industrial revolution was beginning to have a real impact. By then over 2 million tons of coal were being mined each year, and in 1859 the oil industry, with its liquid and gaseous forms of energy, began its development with the Drake-discovery well in Pennsylvania. By this time people had begun to realize the tremendous potentials in using mechanical energy instead of horses and men to perform work, and there was a really rapid development over the next 50 years.

As rapid as it was, however, it pales to insignificance when compared with events of the last half century.

It has been calculated that, of all the mechanical energy developed in the world from fossil fuels, such as coal and oil, almost 85 percent has been generated since 1900. In other words our use of energy almost during our own lifetime has been six times the amount of energy consumed by all our ancestors. Accustomed as we are to central heating, power plants, automobiles, electricity, and all other forms of mechanical energy, it is hard to realize that the energy story is in reality the story of an amazing turn of events that have taken place only within the last 50 or 60 years.

As we look back over what has so far been accomplished, we must be continually amazed at the rapidity with which these changes have taken place. The facts are, however, that, in the United States in 1850, only 6 percent of the energy used by man came from machines operating on fossil fuels. The rest was supplied by man himself, horses, and other animals. By 1900, 38 percent of the work being done came from various fuels; today coal, gas, and oil, with an assist from wood and waterpower, supply 95 percent of the energy that supports our civilization. Among other things, this has increased man's productivity some sixfold over what it was in 1850.

In 1850 almost two-thirds of our working population were still required for farming; today less than 15 percent of the workers in the United States are needed to feed the entire Nation. If we add it all up, there has been developed in the United States almost during the last 50 or 60 years an economy based on the energy supplied by coal, gas, and oil operating through all sorts of machines that day in and day out let each one of us do as much work as 200 men could do before man learned to harness these mechanical horses. Each one of us today has 200 mechanical men at his beck and call 24 hours a day and enjoys a standard of living in many ways superior to that of even princes of the past.

I hope that as you listen to my remarks on the energy story you will understand that I am not claiming everything that has happened over the last 50 years for the energy business or for its research and development activities. I am sure it is perfectly obvious to you that the people concerned with the development of our energy resources did not also design the steamships, automobiles, and airplanes, nor did they invent all of the appliances and products pouring from our factories throughout the Nation.

All these things I have mentioned, however, do depend on the availability of energy--energy produced from fossil fuels such as coal, gas, and oil. So I think we can say that the energy business, although only a part of the overall effort, is the keystone and that, without the availability of mechanical energy, very few of the things that we regard as a normal part of our daily life would exist and be the commonplace characteristics of life in the United States that they are today.

The most vigorous phase of our energy business has been the development of what we call liquid energy. These are the petroleum products--gasoline for automobiles and airplanes; diesel fuels for railroads, ships, and trucks; and heavy fuels for the power industry that furnishes light and electrical energy. The liquid energy business has from the beginning relied on research, and its growth is characteristic of a coordinated blending of an aggressive research program and business initiative. This is an important example of research and development within industry. I think you will be interested in knowing something about what is involved in carrying out research on liquid energy and in hearing of some of the things that are being accomplished.

The liquid energy business is about as complex a business as you can get into. It involves an unceasing search for crude oil wherever it may be hidden--thousands of feet or even miles under the ground all over the world. Once it is found, we must then solve the problem of getting it out of the ground, transporting it to the refining centers, converting crude oil into the kinds of liquid energy we want, and then distributing these products to those who use them. Furthermore, as the machines that use energy are constantly developed and improved, the liquid energy business has had to develop new products of its own so that each new machine can get the most possible benefit out of the liquid energy poured into it.

These machines must also be lubricated to cut down on friction and wear. Another problem of our business has been to provide all of the special lubricants, greases, and so forth, needed to do this job. Finally, this same industry has recently found that the raw materials that are so useful in providing energy can be put to other uses, and we are rapidly developing a new phase of our business in which petroleum products come out of our refineries as all sorts of chemicals, plastics, synthetic rubber, solvents, and other specialty products. This, briefly, is the field in which we do research and development.

The organization of a research and development group to meet the various objectives I have outlined, and to deal with all of the problems encountered in an industry such as ours, is not a simple one when it is also realized that research and development work itself is a complex activity. In this work it is necessary to carry out fundamental research on the physical and chemical characteristics of the materials with which we deal, applied research on the application of these principles to the development of products, and pilot-plant and engineering work required to translate all of this information into practical operations. I think you can see that the proper organization and coordination of this effort is a critical factor in its success.

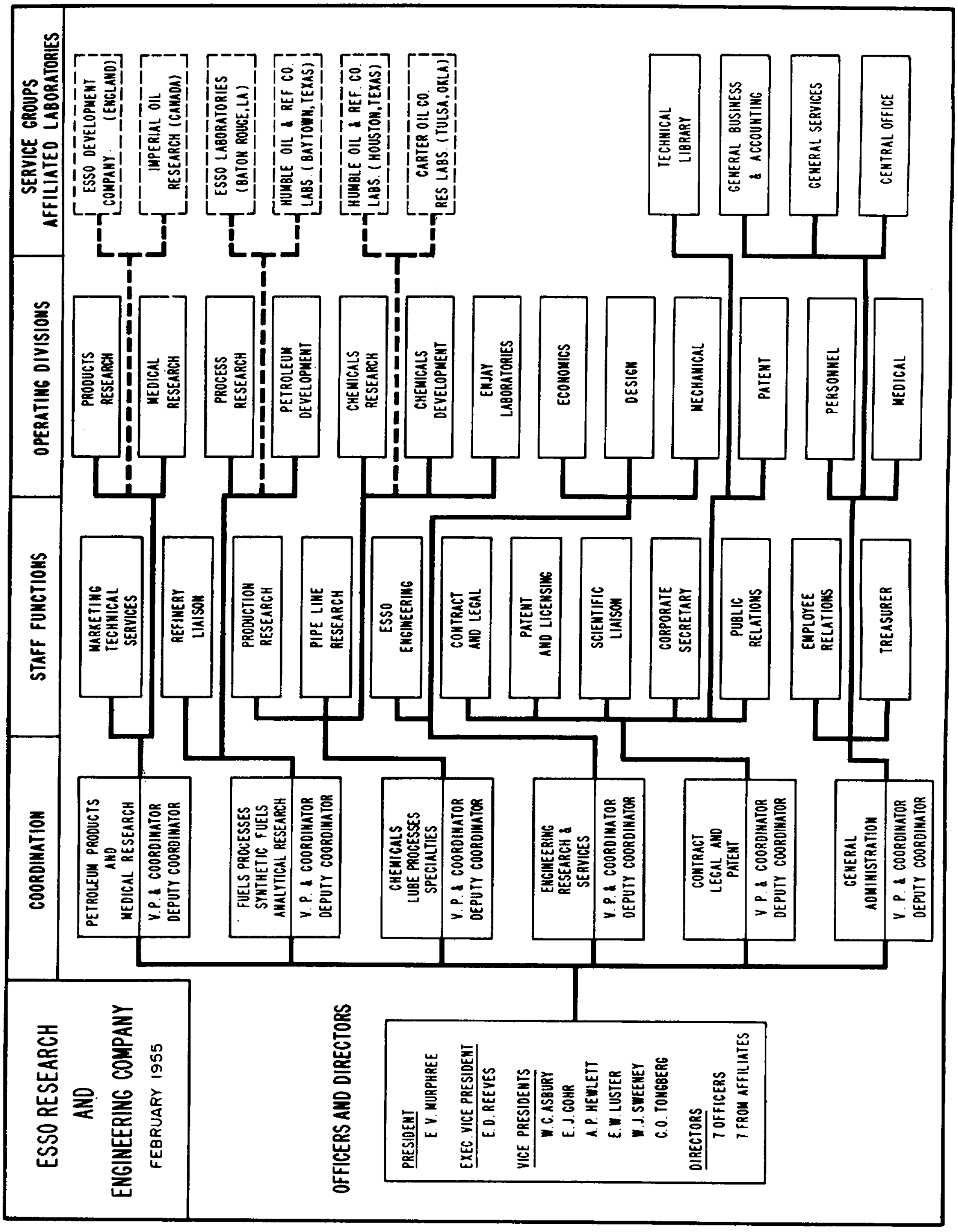
Research and development in my own company is carried out by a separate corporate organization which does the work for the Standard Oil Company (New Jersey) operating affiliates all over the world. In order to illustrate some of the things that are involved here, I would like to show you our organization chart.

Chart 1, page 8.--I do not intend to go into this in any detail, but just want you to see that a research organization today is made up of a great many different kinds of activities and a great many different kinds of people. This chart represents an organization of over 3,000 men and women. The research and development work itself is carried out by laboratories located in Linden, New Jersey; Baton Rouge, Louisiana; Houston and Baytown, Texas; Tulsa, Oklahoma; Sarnia, Canada; and London, England.

You will note that in addition to laboratories there are a great many other activities that have to be carried out. Contract, legal, and patent work, for example, is extremely important to us since it is necessary to protect our operations from suit by others and to collect royalties, which help support our research. I would also like to call your attention to the fact that a large research organization has to maintain its own library, its own business offices, a medical department, a personnel department, a public relations department, and in general carries out all of the business activities that are part and parcel of any corporate activity.

In addition to an organization, you also must have facilities to carry out effective research and development. I would like to show you a few charts illustrating some of these. The next chart shows our Research Center at Linden, New Jersey.

CHART 1


ESSO RESEARCH AND ENGINEERING COMPANY
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DEPUTY COORDINATOR
FUELS PROCESSES
SYNTHETIC FUELS
ANALYTICAL RESEARCH
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CHEMICALS
LUBE PROCESSES
SPECIALTIES
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DEPUTY COORDINATOR
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MEDICAL RESEARCH
PROCESS RESEARCH
PETROLEUM DEVELOPMENT
CHEMICALS RESEARCH
CHEMICALS DEVELOPMENT
ENJAY LABORATORIES
ECONOMICS
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Chart 2, page 10.--This laboratory houses over 600 people and is fully equipped with all the most modern facilities to assist our technical people in carrying out their work. The next chart gives you some idea of the kind of equipment in one of the laboratories.

Chart 3, page 11.--The evaluation of products we develop is extremely important since these have to perform satisfactorily if our affiliates are to retain their business. Our products are evaluated in all sorts of consumers' equipment in the field, but before this they are given exhaustive laboratory tests. The next chart shows one of the test engines in our motor laboratory.

Chart 4, page 12.--This engine is fully instrumented so that we know exactly what it is doing and how the product is performing, and all that the man in the background has to do is write down what the instruments say. In the same way, new processes have to be very carefully worked out and engineered before we can recommend that our affiliates spend many millions of dollars on a new plant. This is done in what we call pilot plants, and the next chart shows a typical large-scale pilot plant at our Baton Rouge laboratories.

Chart 5, page 13.--To give you some idea of scale, I might mention that this pilot plant is nine stories high and must be equipped with an elevator so that operators and materials can get up and down quickly. It is in pilot plants such as these that we give the final tests to processes like Fluid Catalytic Cracking that are so important in the manufacture of aviation gasoline, synthetic rubber raw materials, and the like.

In addition to an organization plan and facilities, you also must have people to do research. This is the most difficult problem of all, because modern industrial research is so complex, and must concern itself with so many different problems, that individuals acting by themselves cannot do it at all. If industrial research is to be effective, it must be carried out by teams of people in which various individuals bring specialized knowledge in a great many fields together for a coordinated attack on all phases of the problem confronting them. I would like to illustrate this by showing you a simplified chart of our organization and by describing what was involved in the development of the Fluid Catalytic Cracking Process.

Chart 6, page 14.--This process was developed by the almost simultaneous efforts of people in six major divisions, and in general, during its development, a force of about 200 people were working on

CHART 2

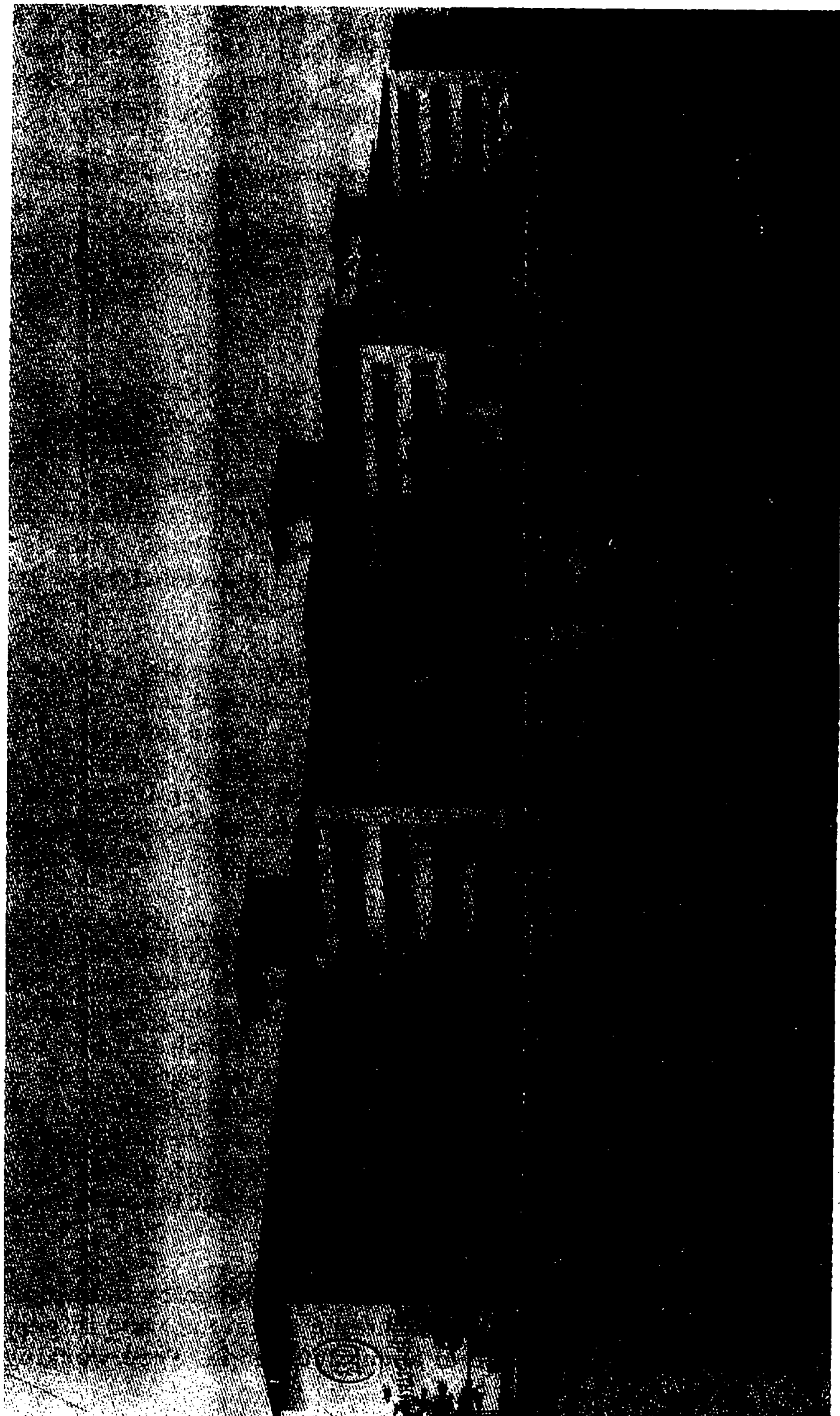
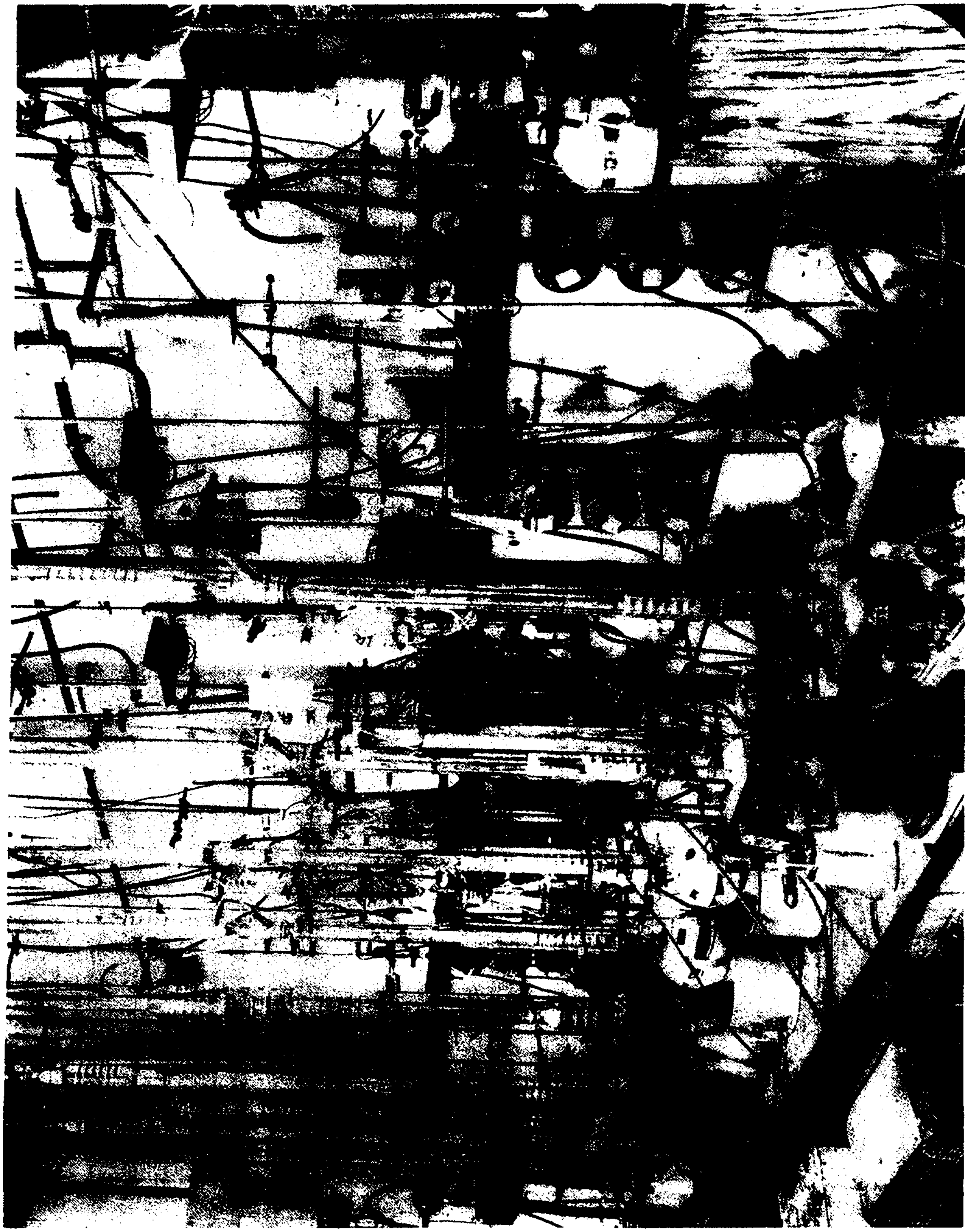


CHART 3



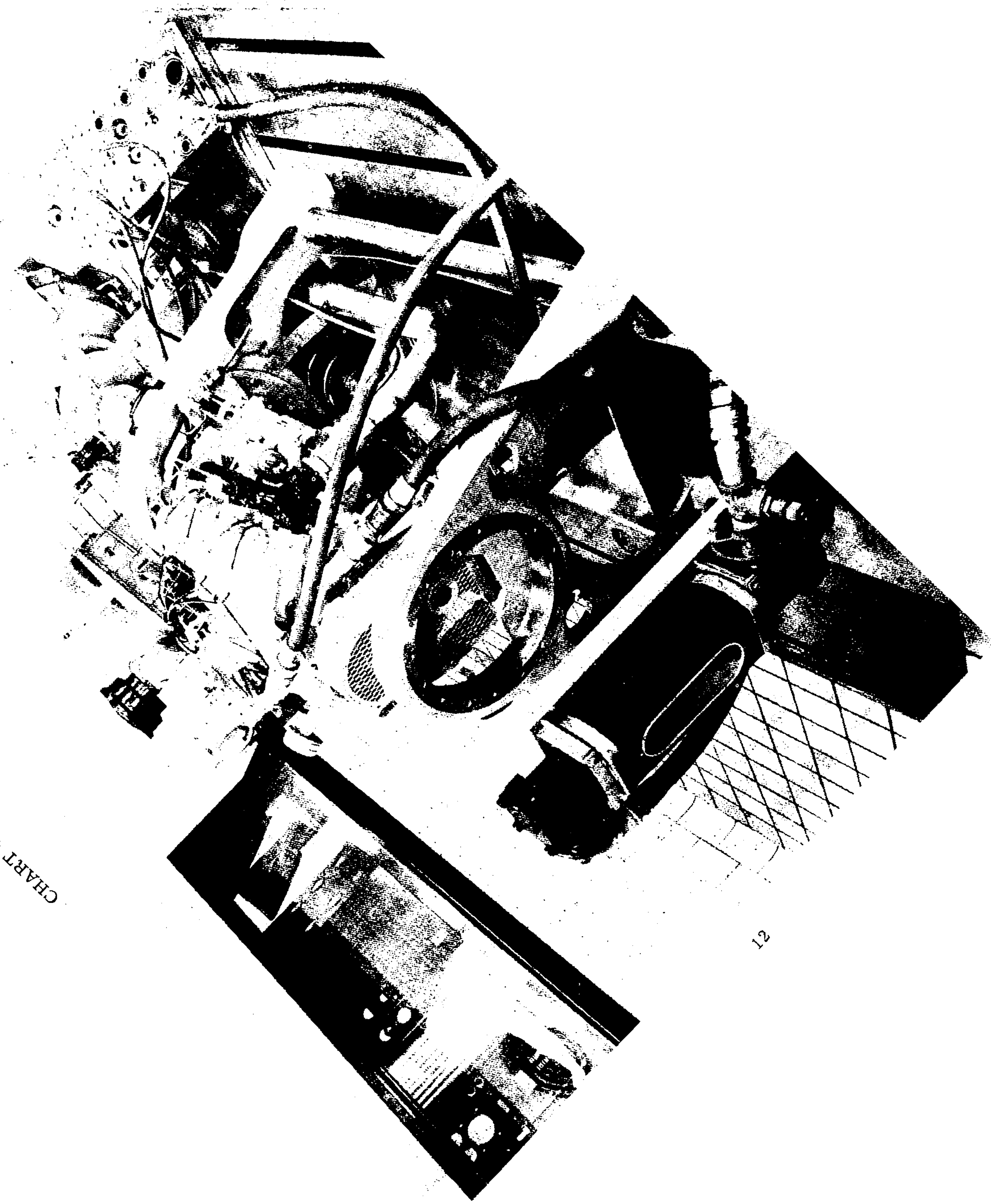


CHART 4

CHART 5

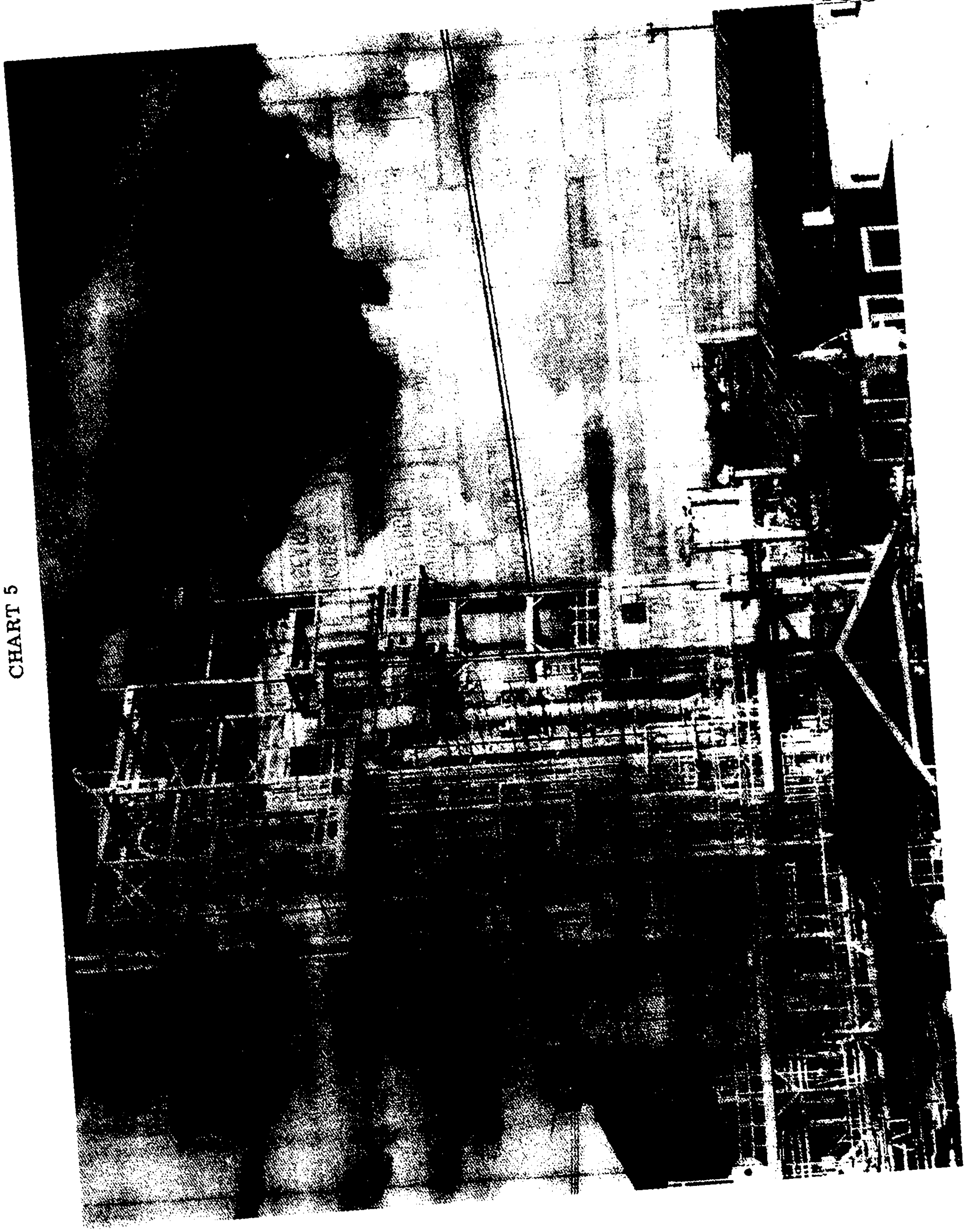
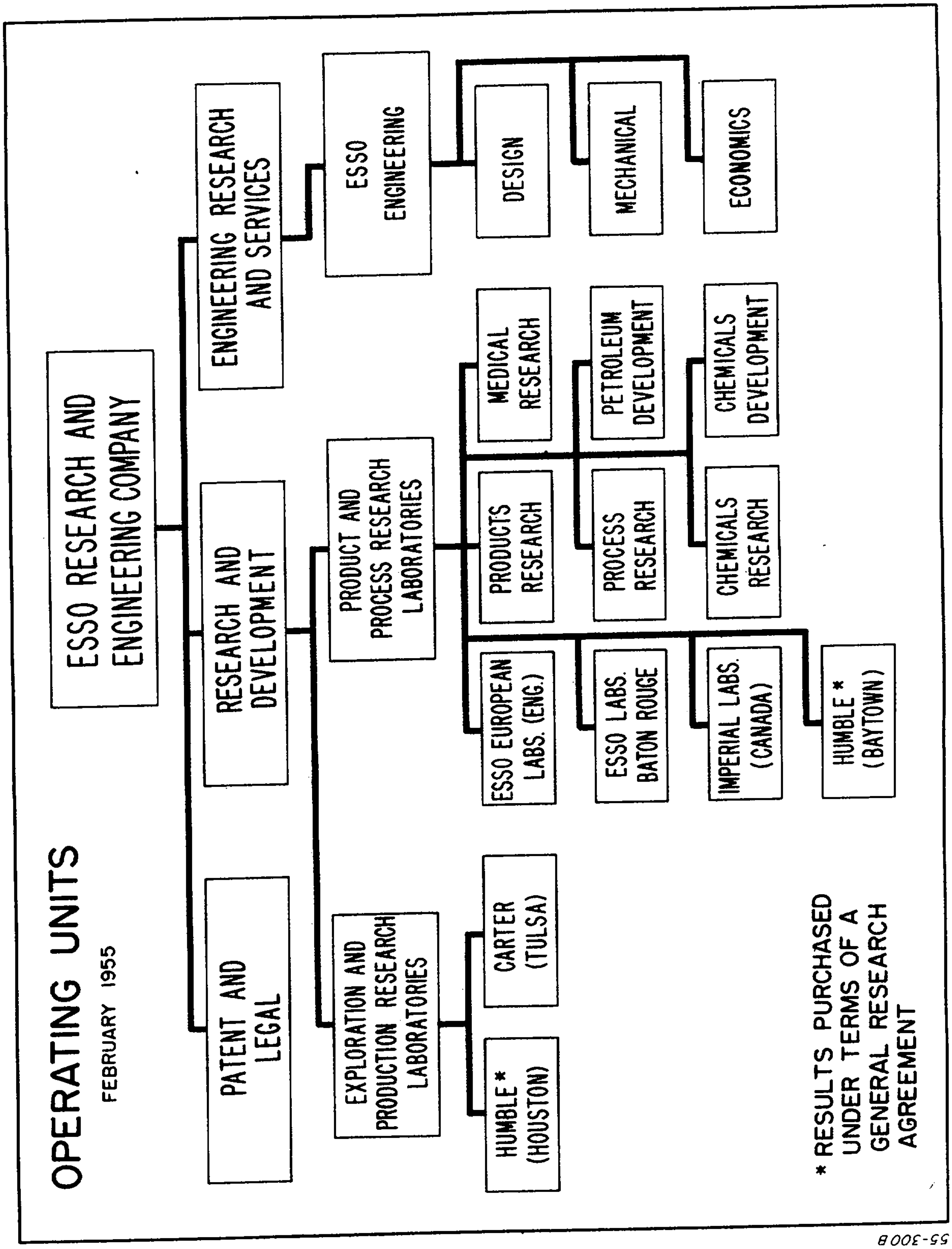


CHART 6


OPERATING UNITS
FEBRUARY 1955
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ESSO EUROPEAN LABS. (ENG.)
ESSO LABS. BATON ROUGE
IMPERIAL LABS. (CANADA)
HUMBLE * (BAYTOWN)
PRODUCTS RESEARCH
PROCESS RESEARCH
CHEMICALS RESEARCH
MEDICAL RESEARCH
PETROLEUM DEVELOPMENT
CHEMICALS DEVELOPMENT
DESIGN
MECHANICAL
ECONOMICS
* RESULTS PURCHASED UNDER TERMS OF A GENERAL RESEARCH AGREEMENT
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different phases of it. The Products Research Division had the responsibility for determining the types of products that we needed and for evaluating the experimental products developed during the course of the work. The fundamental research and basic development of the process was carried out in the Process Research Division, while the Baton Rouge laboratories developed the engineering information in their large-scale pilot plants.

The laboratory and pilot-plant work was closely followed by the Petroleum Development Division in an effort to steer the research along lines that would produce an economic process and at the same time give the engineering information required for large-scale plant designs. All of this information was then fed into the Engineering Divisions, who had the responsibility of designing catalytic cracking units and working with the refineries on their construction and initial operation. At the same time the Contract, Legal, and Patent Department was closely following the work to be sure that the process was adequately covered by patents and that we would be free to operate it without infringement of patents held by others.

The people involved in this unified effort were organic, inorganic, and physical chemists, physicists, chemical and mechanical engineers, lawyers, laboratory analysts, pilot-plant and engine operators, and specialized mechanics of all sorts. Not one of these individuals would have been able to do this job himself, even were he to live for several hundred years. I would like to emphasize again that in carrying out industrial research, it is essential that we have the coordinated efforts of a carefully balanced team having the facilities and background to cope with all phases of these complex problems.

Another phase of modern industrial research that is important and that I think you should know about is concerned with its management. The management of industrial research does not only have the responsiblity of broadly meeting the objectives I have already mentioned, that is, finding out what needs to be done, getting it done, and seeing that it is used; but must also concern itself with the important internal problem of trying to decide just how much research its particular company really needs and how this effort should be distributed among particular problems.

The basic thing to consider here is that research is only successful if it is useful and is definitely unsuccessful if processes and products that the company needs are not developed on time. I think it is now clearly recognized that various industries and companies within an industry require a fairly definite research effort if they are to be most effective. This effort, however, varies widely and depends upon the type of industry involved and the capacity of individual companies to utilize the results of research.

In a given company it is easy enough, for example, to tell whether production is running ahead of sales or vice versa. Products either pile up in warehouses or the warehouses are empty and the salesmen are calling for products. The same sort of balance has to be achieved in carrying out research; it is the responsibility of research management to sense when research is building up and not being used successfully, or when a company really needs research and the results are not there.

Another type of balance that must be achieved is that between various areas in which the company needs research--such as between raw materials, manufacturing operations, and product development. Still another balance must be achieved between long-range and short-range research. If a research organization concentrates all of its efforts on problems facing its company today, it will not have the answers that are going to be needed to solve the problems of tomorrow. If, on the other hand, a research organization concentrates on solving future problems, the company may not survive to take advantage of the long-range research results. The proper analysis of all of these various problems and a willingness to take calculated risks in deciding what should and should not be done is the real test of research management.

With this background on what an industrial research organization is like, I would like to illustrate the close relationship between the growth of an industry and its research and development by a few examples of how this works out. The oil industry, as with almost any other industry, is dependent on adequate raw material reserves to keep going. From time to time almost everybody in the country has been concerned about the possible depletion of our oil reserves and the consequent failure of our industry to supply the liquid energy that is now so important a part of this country's strength in both peace and war.

It has been pointed out fairly recently, and quite often in the past, that we are on the verge of using up all of our raw materials; figures have been cited, showing the ratio of our reserves to annual consumption to prove this point. The basis for this is illustrated by the next chart, which plots the ratio of our proved reserves to consumption in the United States over the last 25 years.

Chart 7, page 18.--According to this chart, you can see that in 1927 we had less than a 12-year supply of oil left. This same situation existed in 1936 and again as recently as 1948. Actually we have produced and sold many times the amount of oil indicated to be left to us when some of these earlier predictions were made. There has been a great deal of confusion among the general public as to what was going on. The difficulty is that the term "proved reserves" has a special meaning in the oil industry and is not at all what most people think it is. I might explain this by saying that all over the world there are many areas that we feel sure contain large quantities of oil beneath the surface. In portions of these areas we have actually drilled wells into the oil reservoirs and know that they exist. In still more limited areas, we have drilled enough holes to clearly define the extent and thickness of the oil reservoir and know fairly accurately just how much oil is in that particular reservoir; this is known as proving up a reserve. When the oil industry talks about its proved reserves, it is only talking about those reservoirs that have actually been measured and from which we are certain we can withdraw the calculated amounts of oil.

If you look at the chart, you will see that the ratio of these measured quantities of oil to production fluctuates around 13 to 1 in the United States. In order to understand these fluctuations, it must be realized that it costs a great deal of money to prove up a particular oil reservoir, so that a proved reserve represents a considerable capital investment. From the standpoint of the petroleum industry, this is very similar to what in other industries are called working inventories of raw materials.

Any industry, to operate efficiently, must determine its most desirable raw-material inventory. Obviously, if too low a raw-material inventory is maintained, there is considerable danger of temporarily running out of raw materials due to shipping difficulties, and the like. On the other hand if too large an inventory is maintained, it ties up too much of the company's money and keeps it from doing other worthwhile things. Industries vary a great deal in how large an inventory is considered suitable. In some industries this might be as low as a 30-day supply, but, in the oil industry in the United States, we have normally operated with about a 13-year raw-material inventory. When this gets below about that level, there is increased

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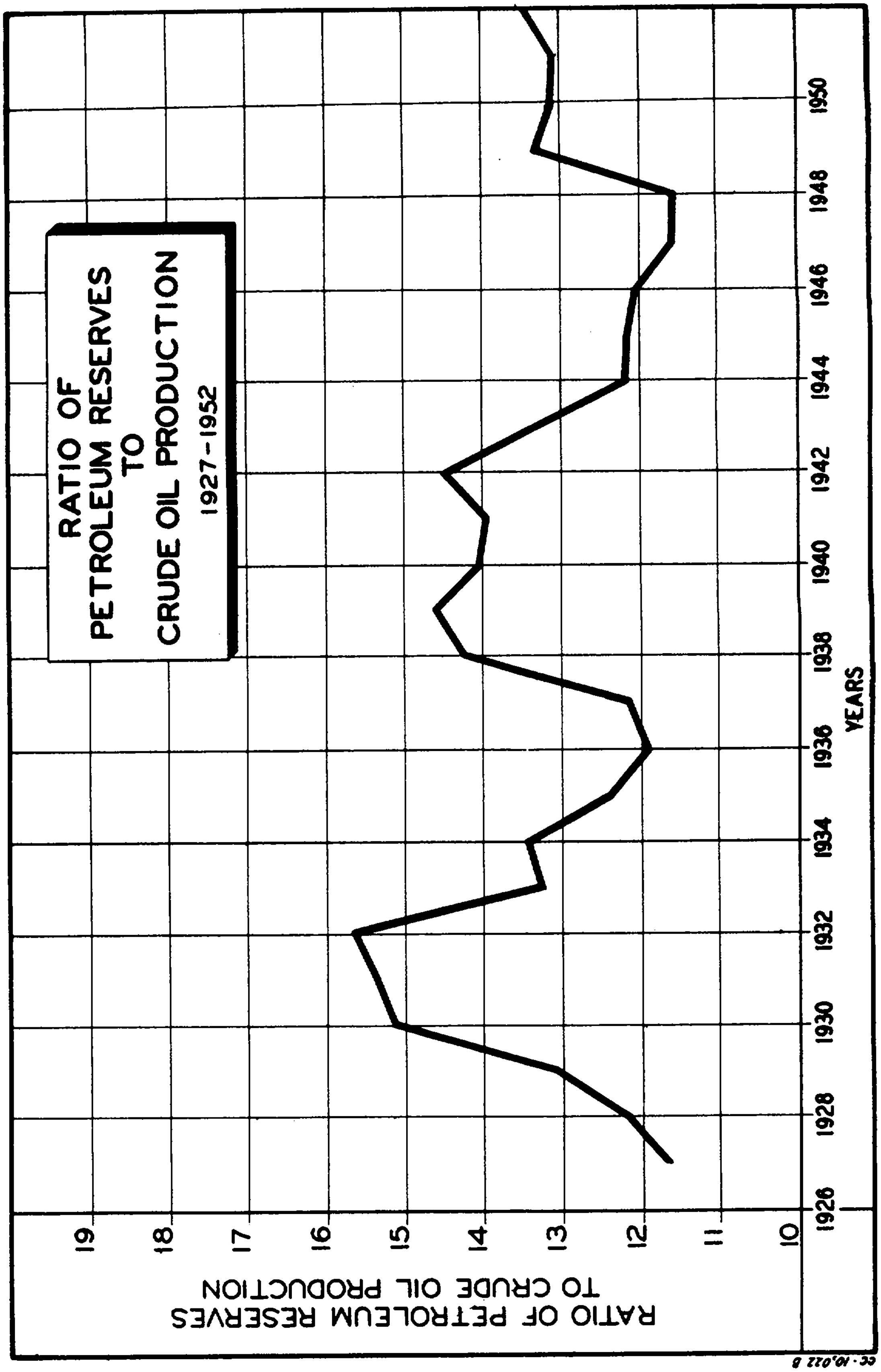
CHART 7


RATIO OF
PETROLEUM RESERVES
TO
CRUDE OIL PRODUCTION
1927-1952
RATIO OF PETROLEUM RESERVES
TO CRUDE OIL PRODUCTION
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activity in proving up reserves and in locating new reservoirs. When the supply is much greater than this, the search for oil slacks off and the ratio starts downward as proved reserves are consumed.

Now I will show you another chart which gives the same information in a little different fashion.

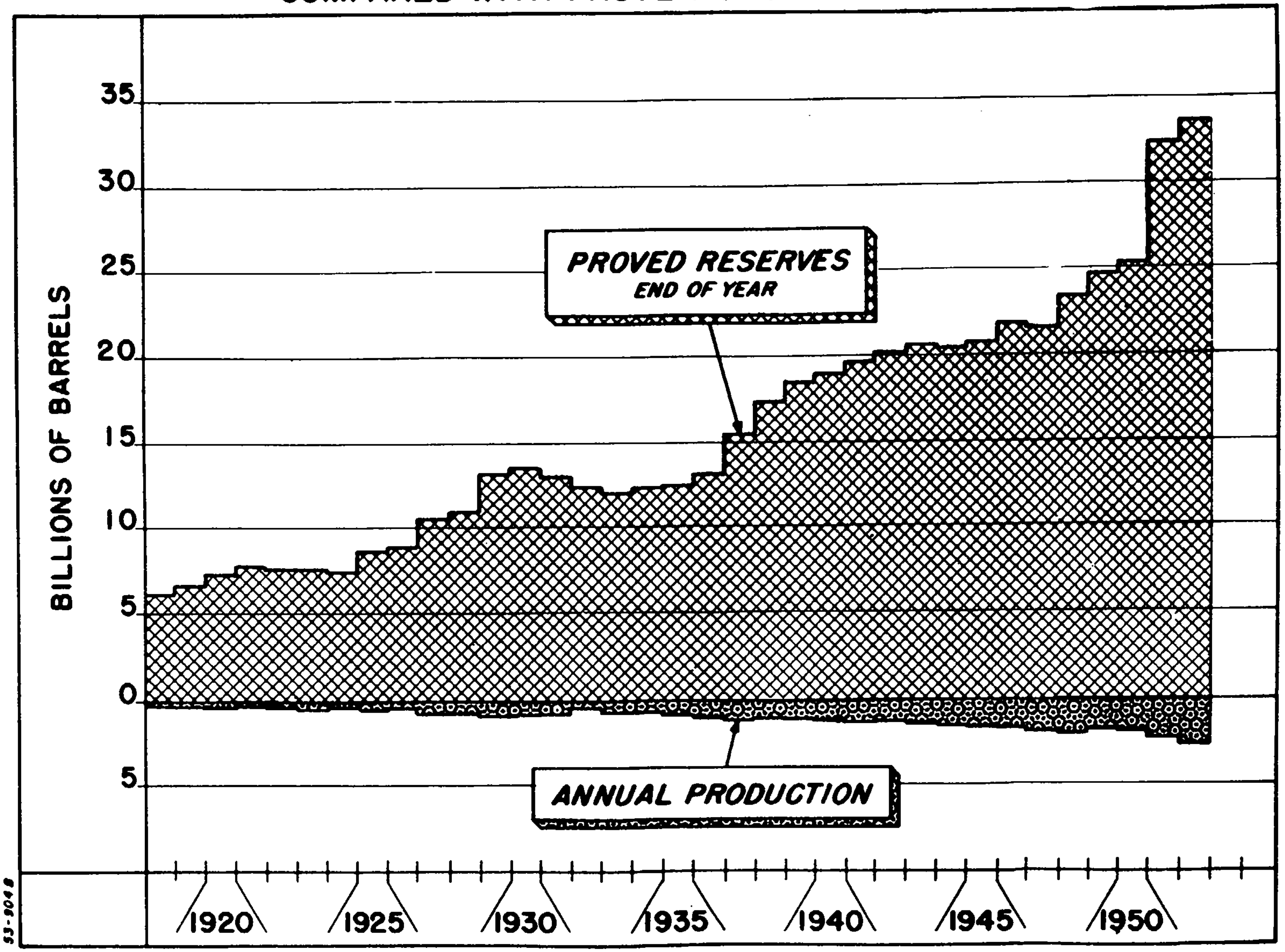
Chart 8, page 20.--You can see here that, though we are taking more and more oil out of the ground each year, our proved reserves are steadily increasing. One of the reasons we have been able to do this has been because of a great deal of research in this field. Methods of locating oil are available today that represent a great improvement over the tools that were used by industry in its early days. Oil wells are deeper today than they used to be, but at the same time our techniques for drilling wells are improved and we have learned a great deal more about how to get more and more of the oil in a given reservoir up to the surface. And so, as the search for oil goes on, it is each year more difficult to find, but also each year we have better methods of finding it; in this way we are able to keep in balance. In other words research and development within the industry have compensated for the fact that we are using up our old reservoirs and have enabled the industry to find new ones about as readily today as in the past.

Another thing that the industry has done is to develop alternate sources of raw material. We regard ourselves as suppliers of liquid energy and would just as soon make the liquid energy from sea water if we could do it and at a reasonable cost. While sea water does not seem to be a very promising source of the kind of energy we are selling, there are in this country and throughout the world very large deposits of coal, oil shale, and tar sands that can be used in place of crude oil. The industry has done a great deal of research and development on these alternate sources of raw materials and has technically developed processes which can make products from all of these fully equal in quality to those produced from crude oil.

These processes are not being used right now because we have not been able to bring the costs down below that of our present operations. In some instances, however, it is getting quite close and, if the industry had to swing over from crude oil to some of the other raw materials, this could be started tomorrow and the cost of gasoline, while higher than at present, would not be exorbitant. The point I am trying to make here is that we are as much concerned as anyone else

CHART 8

UNITED STATES CRUDE OIL PRODUCTION COMPARED WITH PROVEN CRUDE RESERVES



about our raw-material situation. We do not intend to go out of business because of it, and have taken steps that will permit us to supply liquid energy from either petroleum or other raw materials for many, many years to come.

Another important phase of the industry's research is concerned with what might be termed the efficiency of its operations. The oil industry has, from the start, been extremely cost-conscious and has constantly carried out research and installed new equipment to reduce the costs of its products. As a result of all this, gasoline today, ex taxes, is not much different in cost from what it was in 1925 or 1926, in spite of all the inflation that has taken place since then.

Furthermore, the quality of gasoline and other products is much better than in those earlier days. This quality improvement is very important, because through better-quality gasoline more efficient engines can be developed, with the net result that about 50 percent more useful work is obtained from a gallon of gasoline today than was possible in 1925 or 1926.

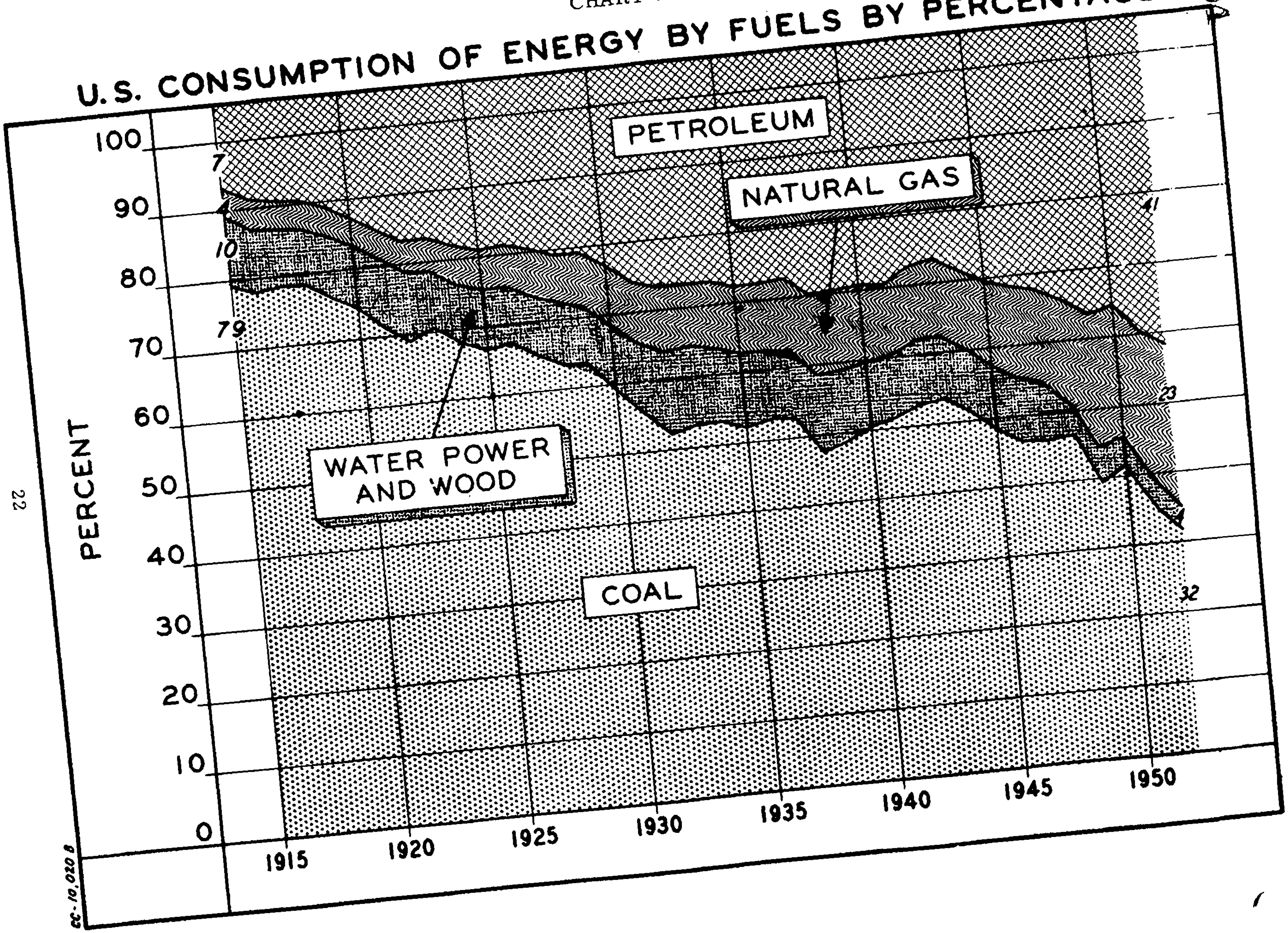
A classic example of how research along these lines can affect an industry is illustrated by the next chart.

Chart 9, page 22.--This shows the sources of energy in the United States since 1915. In 1915 almost four-fifths of the energy used was derived from coal. Today, less than one-third is derived from coal, which is gradually giving way to petroleum and natural gas. It is interesting to reflect that during this period the oil industry has been carrying out an aggressive research program and has continually tried to keep its costs down and improve the quality of its products. This has not been done by the coal industry, with the result that it has not shared at all in the rapid development of our country as a consumer of mechanical energy.

A third interesting field of research has been concerned with products, and there are countless examples of how this work has led to new uses for our products and has helped the industry to grow. It was not too long ago, for example, that automobiles were put up on wooden blocks in the fall and left there until the spring. This was partly because the roads were no good in the wintertime and partly because people did not particularly want to go anywhere in the winter. It was also because the cars would not operate well in cold weather. With improved roads and the increased desire of people to drive around

CHART 9

U.S. CONSUMPTION OF ENERGY BY FUELS BY PERCENTAGE



as much in the wintertime as in the summer, the oil and motor industries toegther have done a great deal of work directed toward making cars run just as well in the winter as in the summer.

For the oil industry, this has meant careful control of gasoline volatility and the development of new types of lubricating oils and greases, with the result that a new season has been created in which gasoline can be sold. We have also cooperated with oil-burner manufacturers in the development of systems for household heating, to the extent that today the sale of heating oil for this purpose is a very important part of our business. In the same way we have worked with the manufacturers of diesel engines to supply just the right fuels and lubricants so that diesels can operate satisfactorily, and we now sell a great deal of liquid energy to railroads, which at one time operated entirely on coal.

In addition to what we call our normal petroleum business, the oil industry is actively entering a new field known as petrochemicals. In this field organic chemicals, which can be derived from petroleum, are rapidly being made available, principally as raw material intermediates for the chemical industry. For example, the oil industry today produces large quantities of synthetic ethyl alcohol. Although technically this would be suitable for making alcoholic beverages, the synthetic alcohols are used for various industrial purposes and are converted into solvents and the like. We also manufacture large quantities of materials that go into the manufacture of plastics, and supply some of the raw materials for the synthetic fibers such as nylon, dacron, and so on. Synthetic rubber is another product of oil research.

Practically all the automobile tires used in this country have now joined gasoline and oil in being derived from petroleum. We now have hopes that plastic automobile bodies will likewise use petroleum products, and the day may come when the oil industry will not only supply the fuels and lubricants for your cars but will also supply most of the raw materials from which they are made.

In what I have said so far I have tried to emphasize the intimate relationship that exists today in industry between its operations and its technology. The technology of an industry is not just research people in laboratories, it is not an engineering staff in a separate building, but it is technically trained people throughout the organization, and is as much as other operations a part of the industrial effort. Furthermore, the research and development of an industry are not provided solely by the formal technical knowledge of those associated with it. They are even more dependent on the knowledge and understanding on the part of the technical people of the problems of their particular company and their ability to work closely with each other as a team to meet problems as they arise.

When we come to the question of technology and national security, I am convinced that our greatest strength lies in the existence in this country of industries and organizations which have the flexibility and capacity to meet new challenges as they arise. During peacetime, no company or industry can insist that its competitors use techniques with which it is accustomed to dealing, nor do I think that in war we can depend on others to stand still or to fight according to rules that we might set up for them. This was dramatically demonstrated during the last war by the capacity of my own industry to produce synthetic rubber to replace natural rubber supplies that were unexpectedly lost to us and by its ability to create sources of aviation gasoline and all of the other petroleum products required by our fighting forces. This has also been true of many other industries. I am certain that our future security will depend as much as anything else on the continued development in this country of industrial organizations which have the technological know-how and the capacity to react quickly when our security is challenged.

I would like to close by summarizing what seems to me the important points to remember as we think about research and development within industry and their bearing on our national security. Within recent years we have built up in this country an industrial capacity which derives its strength from continued research and development and technological know-how. Whereas in the not too distant past, industry could survive by taking or leaving technical developments as it saw fit; today this is no longer the case.

The rapidity with which industry has had to meet new challenges in both peace and war has given rise to a new relationship in which research and development extend throughout our entire industrial effort and are actually a part of it. This combination of business initiative and aggressive research and development has brought about tremendous changes in our standard of living and capacity to produce even during the last 50 years. In this same capacity to produce and meet challenges resides our future security.

Thank you very much.

COLONEL BENEDICT: Gentlemen, Mr. Reeves is ready for your questions.

QUESTION: Sir, now that the Government is getting out of the rubber business, I would like your comment about the probability of future research and development by industry and how that will compare with what has been done in the past.

MR. REEVES: Well, it is not out of it yet. I can speak for ourselves on the potential purchase of a butyl rubber plant. We intend to do a lot more research and development in the future. We have spent 14 million dollars in research on butyl. We think it has a lot of possibilities. We are going to give the Government rubber styrene (GRS) people a battle. I would say they will do the same thing we do. There will be a great deal of development on synthetic rubber when it is in the hands of private industry, because of the competitive situation. There will be a lot more activity in the field than there was under the way it was set up in the past.

QUESTION: Mr. Reeves, you spoke of striking a balance and establishing a program. Is this a fluctuating program from the point of view of the dollar-level support, or can you count on a fairly consistent level? Do you have to depend on operating conditions in the company? Does it tell you how much money it will give you to spend for this or that, or can you determine the research and development?

MR. REEVES: It is a long story. It may be interesting to you. Since we are a separate company, and since Jersey operates on the principle of decentralization, we don't get money from the parent company at all. We get it from the various operating affiliates all over the world. Contracts with them require that we carry out research and development in fields of interest to them. They are required to make us payments, based on their use of research and development. In other words the contract has schedules for various types of processes we develop as well as products and other items. The contract results in each affiliate's having what we call a maximum liability, depending on how much use it makes of our developments. We add up the liabilities for each one and get our maximum liability from all the contract affiliates. That is the maximum amount of money we can spend each year on research and development.

Those contracts are 10-year contracts. Unless the companies fold up, we have a fairly assured income for the future. We try to stay within two-thirds of our liability. You can't tell what is going to come up in research programs. It is done on a program basis. We set up a program each year outlining at that moment what we plan to do during the year. We recognize that two weeks or two months later we might want to change the program. We are at liberty to make changes without consulting anybody else.

Obviously, on a major change we would want to consult the affiliates. That is part of a program for getting the best results out of research. Whenever we start to work on a new product or process, we try right away to get our affiliates interested in what we are doing. We think this is an important part of getting our results used. Ideally they are continually watching us and asking us what we are doing and when will we be finished so that they can build a new plant. It is very desirable to have them prepared to use something when it is ready to be used.

QUESTION: Mr. Reeves, you probably read the article, I believe it was months ago, on gasoline and the advertisements. I think it said that Shell got ahead of Standard, or something like that, by about nine months worth of sales--something like the tricresylphosphate (TCP) advertisement. Do you get things like that pinned on you in your organization?

MR. REEVES: Yes; we don't mind that. We steal a march on other people, and every now and then we get caught. The Shell development was a very interesting one. I don't want to get into the technical angles of it. We have written a lot of technical papers to the effect that we don't think TCP is much good. The way the thing was put to the public intrigued everybody. It was tremendous; there's no question about it. They got a lot of public interest in what they were doing. They have always had the reputation with the public of being progressive in research.

It is true they got a lot of business by an aggressive advertising and marketing program. People came to us after that and said, "Why didn't you give us something like that before Shell?" I think the fact of the matter is that this represented a new era in petroleum advertising. I think that six months before Shell did it, if we had something like that, our company would not have done anything about it--the oil industry being conservative in advertising, would not have done it. Everybody does it now. Somebody has to break the ice.

QUESTION: Would you carry that further? You say you cooperate with the enginemakers. They can't make an engine with a high compression agent until they have your basic research. You can't give your basic research until you know what engine they are making. How do you get together? Do you tell each other your secrets?

MR. REEVES: No. We go around to the different engine manufacturers by ourselves and try to find out what they are going to do. If they don't tell us, we tell them what we think we can do. The thing has to be considered like being on a seesaw. If we tell the engine manufacturers we are going to put out 97 octane gasoline in two years, they will try to have a car that will make use of it. If one manufacturer does that and another does not, he is stuck when the gasoline is available. If nobody does anything about it and we put 97 octane gasoline out, we are stuck; nobody needs it.

What you depend on is the natural interplay of competitive forces to bring things together. We try to tell the automobile industry what the general capability of the oil industry is in improving its products. They develop an engine along those lines with enough leeway so that they can make minor adjustments of the engine, so that minor mistakes can be corrected. Major mistakes can't be corrected. You remember before the war when Buick had a high-compression engine--it turned out that no suitable gasoline could be purchased for it. It was so far out of line it could not be adjusted properly without losing a lot of power. That was a mistake on Buick's part in making too great a model change in one year. The level is pushing up steadily all the time. The difficulty is, there are a lot of problems. We have processes today that let us go up quite a bit on the quality. Unless we have plants, we can't go that far. You can't junk a lot of equipment and make a change in quality unless the change is worthwhile, but as plants wear out, you can replace old equipment. The rate of improvement depends on the need for it and our ability to finance it.

QUESTION: How free is the interchange of information within the industry, differentiating between the fundamental research which you said the companies are performing and the applied research which they are performing? Is there a difference? Is there any interchange?

MR. REEVES: There is quite a bit of difference. We like to make contributions to technical literature. We feel we have an obligation to do this. We put things we do into three categories. We have analytic techniques; we have things that are of general interest to everybody; and we have things that are of particular competitive advantage to everybody. The analytic techniques are published the minute they are developed. Also, on long-range work we tend to be fairly liberal on the publication of what we call fundamental information. If somebody makes a study of the thermal properties of a particular product, that is usually published. Maybe it would be better for us not to publish it. On the other hand we feel an obligation to make that contribution to technical literature.

In applying research to new processes, we depend on the patent system. The minute we think we have something, we apply for a patent. As soon as we have our application in, we publish our information. On things of very important competitive value, we have to be sure we register ownership of them with the Patent Office before we get too free telling other people about them.

There is not much interchange of information on a personal basis between the various companies. We do what everybody else does. You think somebody else has information that you want, so you feed him a little unpublished information, and he will feed you something back. It is a give-and-take proposition. We try to be competitive. We give information only if we think we are going to get more back than we give.

QUESTION: Mr. Reeves, your first organization chart had something on it which I think the services could benefit by very much. You had, for example, your vice presidents and coordinators in between your top executives and your various staff groups. Is this a fairly recent innovation in your organization? Would you mind telling us how it works?

MR. REEVES: I am sorry I don't have all the names on there. The vice presidents constitute the executive committee. The vice presidents have dual responsibilities. They are directors of the company and members of the executive committee. They have overall responsibilities. We divide our fields of responsibility for the whole research and engineering company into six different fields. Each vice president is assigned one particular field. He sort of runs that as a separate operation and, in his capacity as a member of the executive committee, he tries to tie it in with the other fields.

I don't know whether that answers your question or not. Does it?

STUDENT: Well, partially. The way you portray it, set up as vice president and coordinator, is not commonly seen on organization charts. We do not see it on ours. I notice you have cut across the board with your various vice presidents and coordinators. There seems to be no chain, no link.

MR. REEVES: That chart had lines that went like this (indicating). Actually, when it spreads out more, each vice president has under him the operating divisions he needs to do his work. He has the staff groups under him that he needs to do his work. There is very little cross play between what his responsibility is and where he has to get his work done. There's a certain amount, but not too much.

On the other hand we try to decentralize even further within the company. We look on operating divisions as major administrative units. In other words we depend on the directors of each division to take the administrative burden. So even though the vice presidents have administrative responsibility for the people under them, their major responsibility is technical coordination. Their responsibility is to be sure they are doing everything required in the field assigned to them; that they understand what kind of problems are to be solved; and that the work is done. Their responsibility is to know what needs to be done, to see that it gets done, and to get it used.

STUDENT: It has been said on this platform several times that an engineer is a poor administrator and a poor manager, and that a manager is a poor research man or engineer. Do you run into this problem in your company? If so, do you have any trouble bringing in people who may be engineers to be managers?

MR. REEVES: It is always a problem. We feel it is important in a company such as ours that administrative people should also be able to take technical responsibility over research and development and engineering groups. So we draw our administrative people from, you might say, younger technical ranks. We usually try, when we employ people, to employ people who are going to be able to work effectively in teams.

When you employ people you think will be effective in teamwork, you employ people who have administrative potential. We try to take young people, through the first four or five years with us, and see what kind of work they are going to be best suited for. We spend a lot of time trying to put round pegs in round holes and square pegs in square holes. We always have a need for administrative people. If we have technical people who have an administrative flair, we train them for administrative work. We put them in charge of groups where they have only technical supervision. They also have special assignments and special courses. We send them to Harvard, Columbia, or North Western, where they pick up the administrative background.

We also gradually put them in as section heads. Section heads in our organization have personnel responsibility as well as work responsibility. We see how they work out there. We also use a pyramid system of organization, where each person is always working with someone on the next level. This is the Hopkins theory of education. This is a very good way to train and educate people. It is a system we use continuously.

In direct answer to your question, what we try to do is this-- we try to locate technical people with administrative potential. We try to analyze their strengths and weaknesses, and we try to give them training and special assignments to develop those weaknesses into strengths. We try to put them in jobs where they will make full use of their abilities.

QUESTION: Mr. Reeves, on the basis of a comparative volume of production of liquid fuels from both shale and crude petroleum, what is your best estimate of the cost differential per gallon of the fuel products?

MR. REEVES: It is hard to say. It might be a nickel. In other words gasoline in New Jersey is 28 or 29 cents a gallon. I suppose if it were made from shale, it might be 33 or 35 cents, or something like that. It is not a big percentage increase. Since year by year there is also a steady increase in the efficiency of gasoline engines, in the long run you won't pay any more per mile than you do today.

QUESTION: In connection with this question just posed regarding your selection of administrators, do you have pretty much the same problem that we have in evaluating those people as they come up? Would you care to briefly tell us what means you use to evaluate those people and what record you keep on them?

MR. REEVES: Yes. We try to do everything we can. We use lots of ways in doing it. Of course one way that is always used is casual observation. This can be formalized into what is known as the critical incident system. You put down what good things a man does and what bad things a man does and you get an idea of what his effectiveness is and what his faults are.

We spend a lot of time evaluating people. We do that for two reasons. We want to understand their potentialities of both strength and weakness. We use it also for salary administration. We feel it important, where a man is doing a good job, that he should be rewarded, and where he is not doing a good job to see that he is not rewarded anyway.

Our division directors and assistants work together with people quite intimately. They get together with the section heads at least once a year, and usually every six months, and make a complete revision of the ratings of all the technical people in their division. In other words they give an individual rating for every individual and they also rate each by number. They take the best one and say he is number 1; they take the worst one and say he is number 100. By following the changes in ratings, they can get a good idea of how people are progressing. This is done mostly by people who are familiar with their work, deliberately sitting down and trying to put down in black and white what they think of people's ability. They try to talk with people to see if they can correct their faults. They are anxious to do something about it. You find a lot of people who, after being studied, are told they don't have administrative talent. They say they don't want to be administrators anyway.

We try to do everything we can for those people. For instance, we feel that technical contributions are very important to us. The people who don't have administrative talents don't lose prestige and salary becuase of that. We pay our strictly technical people as much money as we pay our administrative people and try to give them comparable prestige in the size of their office and in their parking privileges, and things like that.

QUESTION: Mr. Reeves, this new company of yours that you mention is separately financed. Do you not lose the 27 percent depletion allowance by drifting away from the mother company?

MR. REEVES: We don't produce any oil. We don't get any depletion allowance anyway.

STUDENT: If you stayed under the mother company, would you get a depletion allowance?

MR. REEVES: No. We changed our name. We are called the Standard Oil Development Company, a separate organization. Tomorrow we will be the Esso Research and Engineering Company. The only difference is the different name. The corporate relationship is not changed at all. There is just a change in the name. Actually we are what is called in consolidation with other Jersey companies. From a tax standpoint if you own 80 percent of the company, you can go into tax consolidation with the parent company. We have always been in tax consolidation. We will remain that way.

QUESTION: Can you tell us what uses you are planning for atomic energy at the present time, for possible or probable future uses in research and development?

MR. REEVES: Yes. Our interest in atomic energy is twofold. One, we look on it as a threat to our competitive position. If it gets to be too cheap, we will not sell as much residual fuel--things like that. We have analyzed the whole situation very carefully from a competitive standpoint. We have reached certain conclusions from this standpoint. For 20 years we do not think it is going to be a serious competitive threat. Those things can change. We are going to follow it.

The other thing is, it may be useful in our own operation. We already do use isotopes to help us analyze problems. We do things like other companies do. We put isotopes in engines to determine where the piston rings are faulty. We put isotopes in engines to find out where the oil leaks out. It is also good in production problems. In the secondary recovery of oil, we often put water into the oil formation to try to flush the oil in the formation out of the ground. Sometimes when we put the water down there and it doesn't show up where we think it should, it is necessary to add radioactive substances to it and run around with Geiger counters to find out where the water went.

We do the same thing with gas. There are wells all around the country, where gas leaks. We don't know where our own gas is coming out. By putting in radioactive material, you can find the hole where your own gas is coming out.

We have lots of uses for atomic energy. We are constructing an atomic energy laboratory. We have a pipe of cobalt 60. We intend to study gamma radiation for chemical reactions, cracking reactions, and other reactions. We intend to make a study of atomic reactor radiation on various cracking and other processes we are interested in. We want to follow atomic energy very closely as an operational tool and also as a potential competitor for our products.

QUESTION: Mr. Reeves, I would like to pursue the question about the battles between basic and applied research. I think the industrial laboratory is similar to the Government laboratory, except possibly for the salaries paid to the people who work there. There seems to be a feeling that primary emphasis must necessarily be put on applied research, but, in order to retain good scientists, it is felt that we must do a certain amount of basic or fundamental research.

How do you achieve the balance, in order to keep the good people? Is it productwise or how? Do you set up an arbitrary percentage or how do you do it?

MR. REEVES: We distinguish between fundamental and basic research on the one hand, and long-range research on the other. Long-range research we class as uncommitted research. That is research that is not directed toward solving a particular problem. We try in the laboratory to set up a separate group, which constitutes about 10 percent of the laboratory, to do long-range research. The people in the group are the ones who have previously indicated an aptitude and a liking for that type of work. They are left pretty much alone, from the standpoint that we don't tell them what to do. We do spend a lot of time telling them about things we think would be interesting for them to think about. People make inventions which are in fields of their own interests. If we identify their interests with our interests, they will make the kind of inventions that are useful in our work.

Basic research or fundamental work is required on any problem. Some of our most routine problems require a great deal of basic research for their solution. We might have trouble with a catalyst. We have to find out what is wrong. We might have to know how many layers of cobalt are necessary for maximum activity. There are all kinds of needs for a basic or fundamental research. In order to improve the quality of alkylate aviation gasoline, we first had to study the basic mechanism of the reaction, develop analytical techniques to identify isomeric mixtures, and study the thermodynamic properties of the system so that we could determine the best conditions for plant operation.

Basic research is the fundamental study we think needs to go into solving problems that we are working on. Long-range research is the work we think has to be done so that we can create a backlog of scientific data for the future.

COLONEL BENEDICT: Mr. Reeves, the way you have covered this discussion of industrial research has rounded out a production problem we are all interested in. I think the most sincere compliment is the interest which was shown in the question period. On behalf of the Commandant, the student body, and the faculty, I thank you.

MR. REEVES: Thank you. It has been very pleasant being here.

(11 Mar 1955--750)S/gmh