RESEARCH AND DEVELOPMENT IN INDUSTRY

1 February 1957

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INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

Mr. E. Duer Reeves, Director and Executive Vice President, ESSO Research and Engineering Company, was born in New York City in 1909. He graduated from Williams College in 1930 with a B.A. degree and did graduate work at Princeton. He left Princeton in 1930 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 ESSO Research and Engineering Company (then called 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 company in New York City and has been Executive Vice President since January 1949. Mr. Reeves is president of the Industrial Research Institute and vice chairman of the National Association of Manufacturers Committee on Research.

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MR. HENKEL: General Hollis, Members of the Faculty, and Students: Undoubtedly, one of the largest contributing factors to the improvement of our economy is that of research and development. This was quite evident during World War II and has been ever since, for the reason that our standard of living has been constantly improving.

Industry derives its dynamic strength and its ability to react quickly as the result of a new technological know-how, and furthermore it finds it necessary to spend more dollars for research and development.

Fortunately, we have a speaker who has been connected with research and development for the past 25 years, and who knows how valuable research and development is to industry. This is his third lecture. Mr. Reeves is Executive Vice President and Director of Research and Development for the Esso Research and Engineering Company.

Mr. Reeves, it is a great pleasure to welcome you to this platform and to present you to this year's class.

MR. REEVES: Thank you very much, Mr. Henkel. General Hollis and Gentlemen: I would like to start off by saying that the general subject of research and development in industry is one in which I have been involved ever since I got out of school over 25 years ago. It is a subject that has always interested me intensely, and I am very happy to be here today and to have an opportunity to talk to you a little bit about industrial research as it is now carried out in the United States.

In the first place, 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 is a truly integral part of industrial activity in this country. When I first started to do research back in 1930, industry in the United States was spending about $200 million annually for its research and development. Since that time, this effort has grown tremendously, to the point where today about $4 billion

represents the current annual bill for industrial research and development work. This is a twentyfold expansion in just the last quarter-century and I think it clearly indicates the growing acceptance of research and development by American industry.

I am in the liquid energy business and I represent an industry, the petroleum industry, which 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 than my industry does, but there are also many who place even greater stress on it than we do, particularly such industries as the chemical industry, the electronics industry, etc. 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 industry, it seems to me that there are four things we should consider today. The first is the question of just what industrial research actually is and how a typical business, the energy business, has grown through it. Next I would like to cover something of how we go about organizing and managing industrial research. Thirdly, I will cover the kinds of things that can be accomplished through it. And finally, I will state the meaning of all of this, at least so far as I see it, 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. As a member of the industrial team it 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 the 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 industrial 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 of 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 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 know, 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 though this tremendous change, which was to completely alter his life, occurred almost overnight.

During these 200 years of its development, the industrial revolution started by the steam engine was to go through quite 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 time, 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 what seems to me 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 only to an annual rate of 300 tons. That's about enough to heat this building. By 1850, however, 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 great 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 own own lifetime has been six times the amount of energy consumed by all of our ancestors. Accustomed as we are to central heating, powerplants, 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 been so far 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; and 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. Whereas in 1850 almost two-thirds of our working population were still required for farming, today less than 12 percent of the workers in the United States are needed to feed the entire Nation and we still have surpluses. If we add it all up, there has been developed in the United States almost during the last 50 to 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 in reality 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 the 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 nor 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 of 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; and 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 are going to 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. So another problem of our business has been to provide all of the special lubricants, greases, etc., that are 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. It is an activity in which 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 3,500 men and women. The research and development work itself is carried out by laboratories located in Linden, New Jersey; Baton Rouge, Louisiana; Baytown, Texas; Sarnia, Canada; Port Jerome, France; and London, England. Additionally, my company is affiliated with laboratories that conduct research on new methods of finding and producing crude oil at Tulsa, Oklahoma and Houston, Texas--to round out the picture. I would also like to call your attention to the fact that, in addition to laboratories, there are a great many other activities that have to be carried out. Patent, legal, and technical and public information 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 to support our own 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 has in general to carry out all of the business activities that are part and parcel of any corporate activity.

In addition to an organization, you also have to have facilities to carry out effective research and development, and I would like to show you a few charts illustrating some of these. The next chart (chart 2, page 9) shows our Research Center at Linden, New Jersey. This laboratory houses some 1,000 people and is fully equipped with all of the modern facilities that are required to assist our technical people in carrying out their work. These charts I am going to show you illustrate some of the things that go into a modern laboratory. I know that when I was in school such things as beakers and flasks were found in laboratories. But today you can hardly find a test tube, and they are not even equipping some modern laboratories with gas. The old Bunsen burner is gone. As I said, this series of charts will illustrate some of the things that are there.

Chart 3, page 10.--This chart shows you an advanced model electron microscope, which is useful in guiding our work in developing new types of greases.

CHART 1

ESSO RESEARCH AND ENGINEERING COMPANY

JANUARY 1957

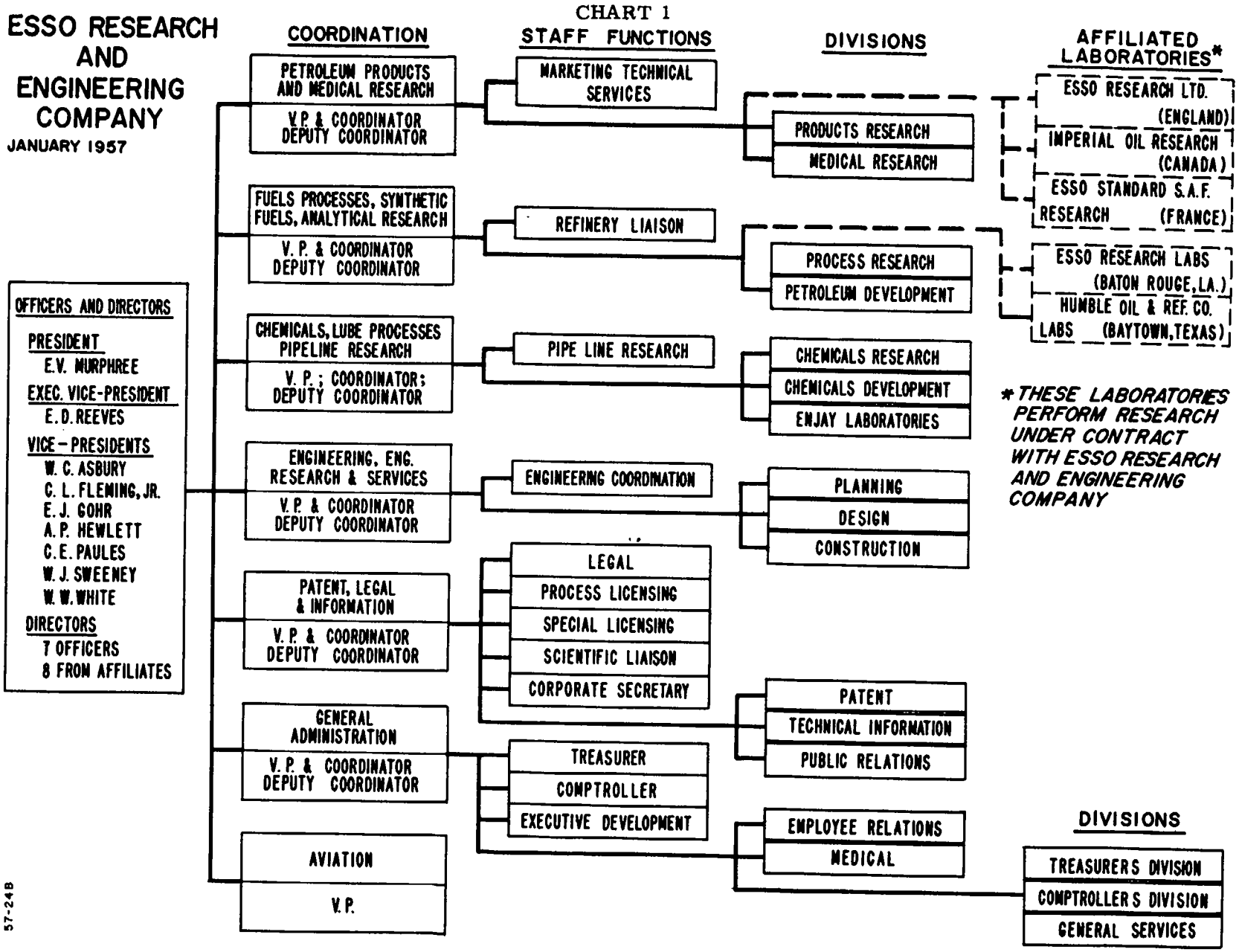

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CHART 2

CHART 3

The next illustration (page 12) is a picture of an advanced model mass spectrometer, an electronic instrument specially designed for continuous analysis of gas streams from pilot plants. It provides accurate information on operating variables and gives precise data on the quality of products under study. There are now quite a few of these instruments used in a variety of ways in research to study the fundamental properties of petroleum compounds.

Another example of the kinds of equipment required in modern research is shown in this photo (page 13). This is an X-ray diffraction device, used to study the physical make-up of the countless forms of catalysts presently required in refining and to analyze new catalysts which are under study for use in the future.

I have here two pictorial illustrations of the application of radioactive materials in today's petroleum research. Chart 6 (page 14), shows a team of scientists using radioisotopes to measure wear in auto engine parts and thus help in our work toward the development of new and improved lubricating oils. Here is a scene in our radiation laboratory (page 15) which houses a powerful radioactive cobalt-60 source. In this laboratory, we have been running experiments, day and night, from which we are learning the effects of gamma radiation on oil materials. One phase of these tests involves the use of a small pilot plant set up inside the "cave" in which the actual experiments are conducted. The purpose is to determine the possible applications for gamma radiation in refining. This is a sort of fourth force now, in addition to the usual forces of heat, pressure, and catalytic action.

Page 16 is a photo depicting development work in the field of new types of plastics derived from petroleum products. In this case, a new granule material is fed into one end of the machine on the right and it emerges from this screw extruder in the form of a plastic material which holds promises for a wide range of applications such as in packaging.

In addition to this, evaluation of the 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 photo (page 17) shows one of the test engines in our motor laboratory. This engine is fully instrumented, as you can see, so that we know exactly what it is doing and how the product is performing. All that the man in the background has to do is write down on paper what the instruments say; and he doesn't always have to do that.

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CHART 4

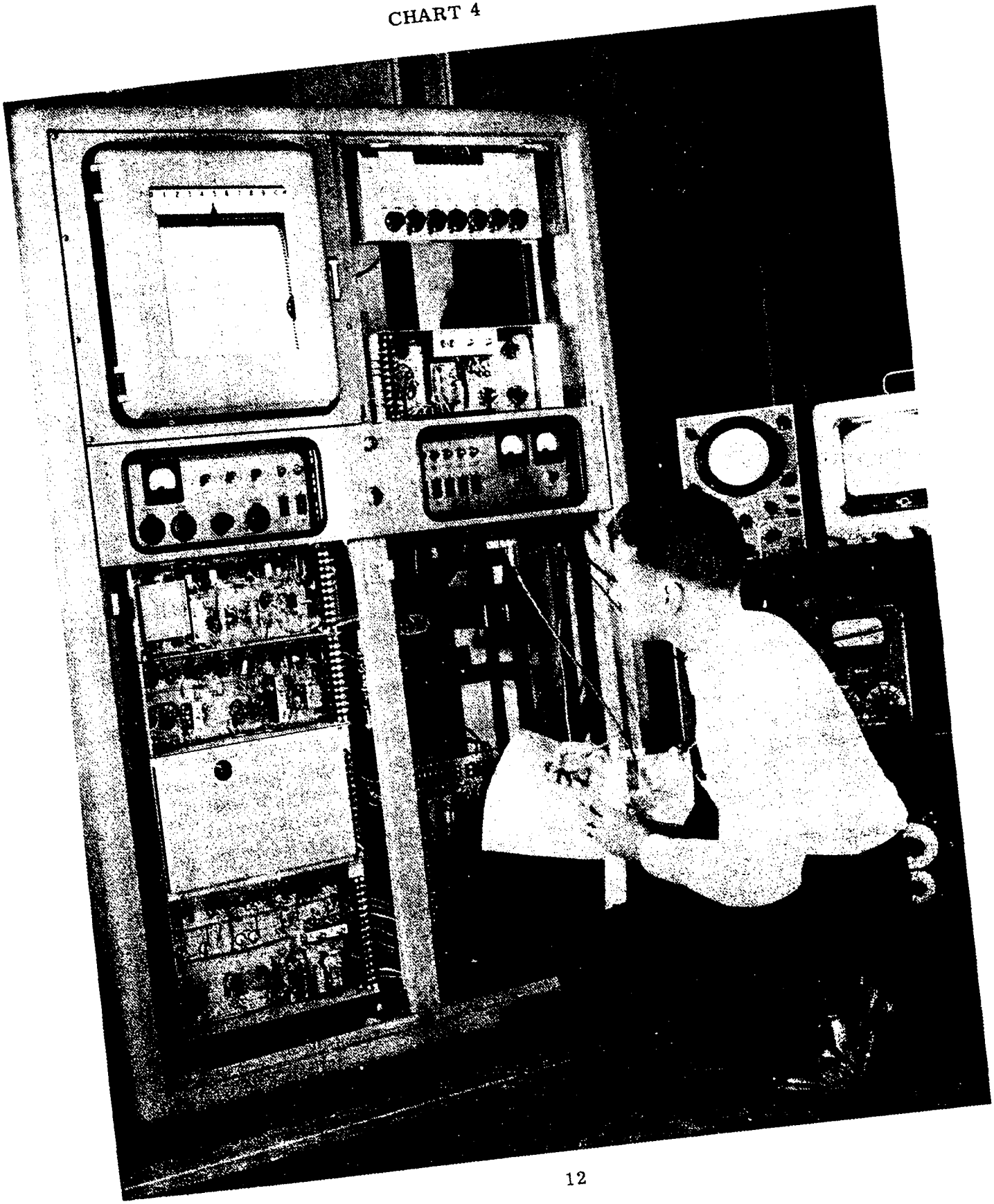

CHART 5

CHART 6

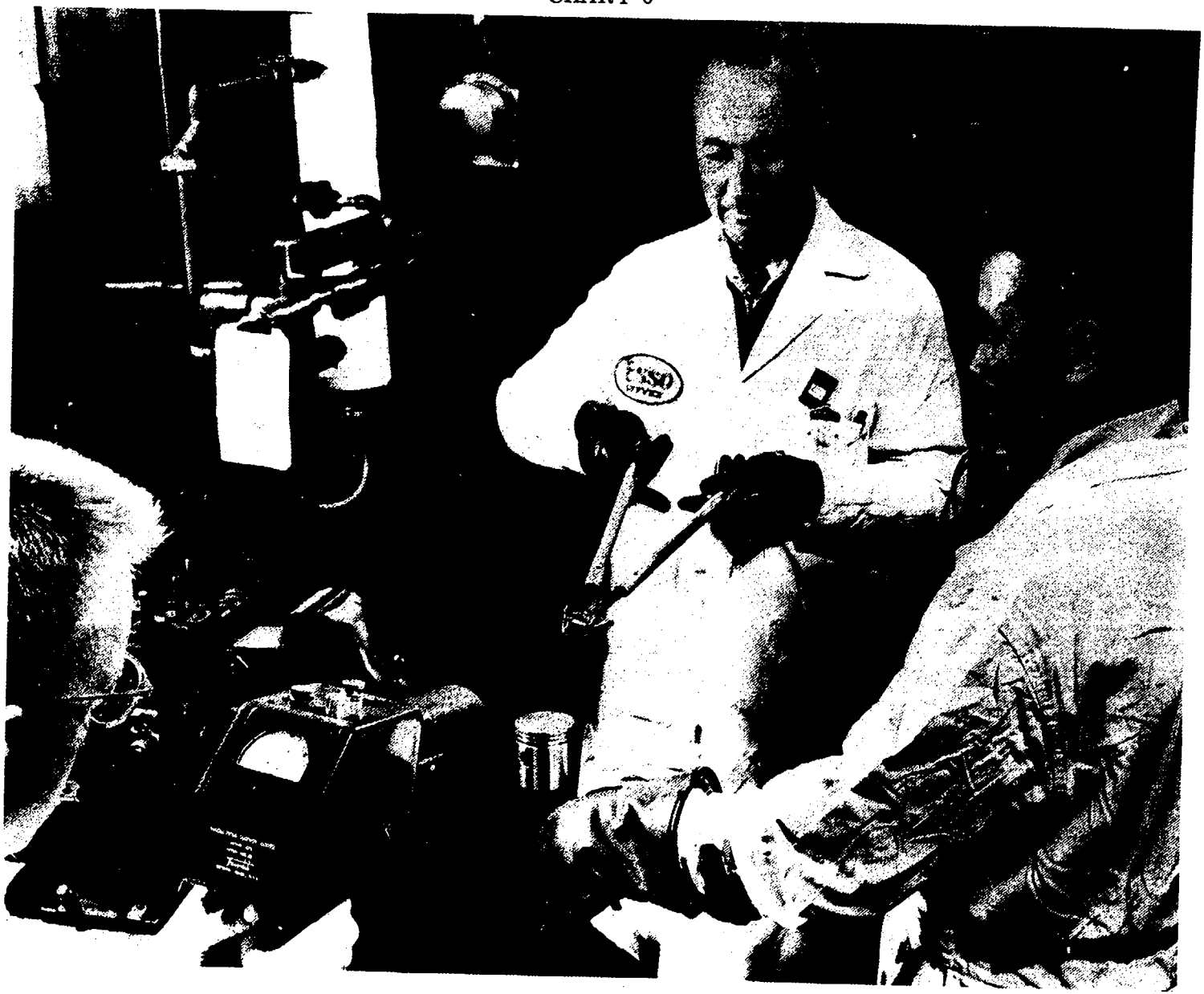

CHART 7

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CHART 8

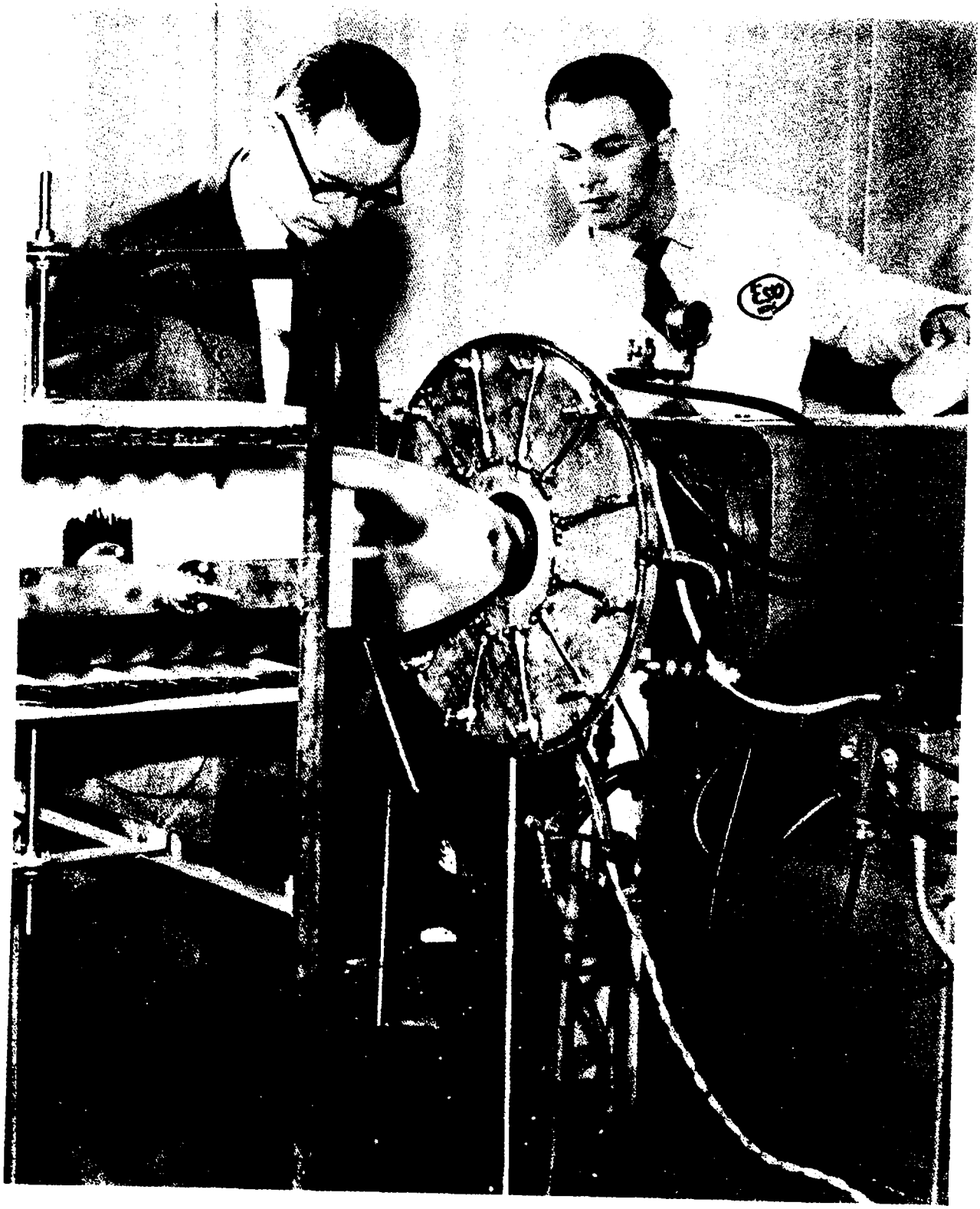


CHART 9

In very much 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 photo (page 20) shows a typical large-scale pilot plant at our Baton Rouge laboratories. To give you some idea of scale, I might mention that this pilot plant is 11 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 have to have people to do research. This is obviously the most difficult part of the problem, 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 and skill 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 another chart (chart 11, page 21), which is a simplified chart of our organization, and by describing what was involved in the development of the fluid catalytic cracking process. 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 different phases of it at all times. The products research division, which you can see there, 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 the 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 division, which had the responsibility of designing catalytic cracking units and working with the refineries on their construction and initial operation. At the same time, the patent, legal, and information 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, mechanical, and electrical engineers; lawyers; laboratory analysis; 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. And 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 has not only the responsibility 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 it 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 is 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 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 that arise 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. So proper analysis of all of these various problems and a willingness to take calculated risks in deciding what should and should not be done are the real test of research management.

CHART 10

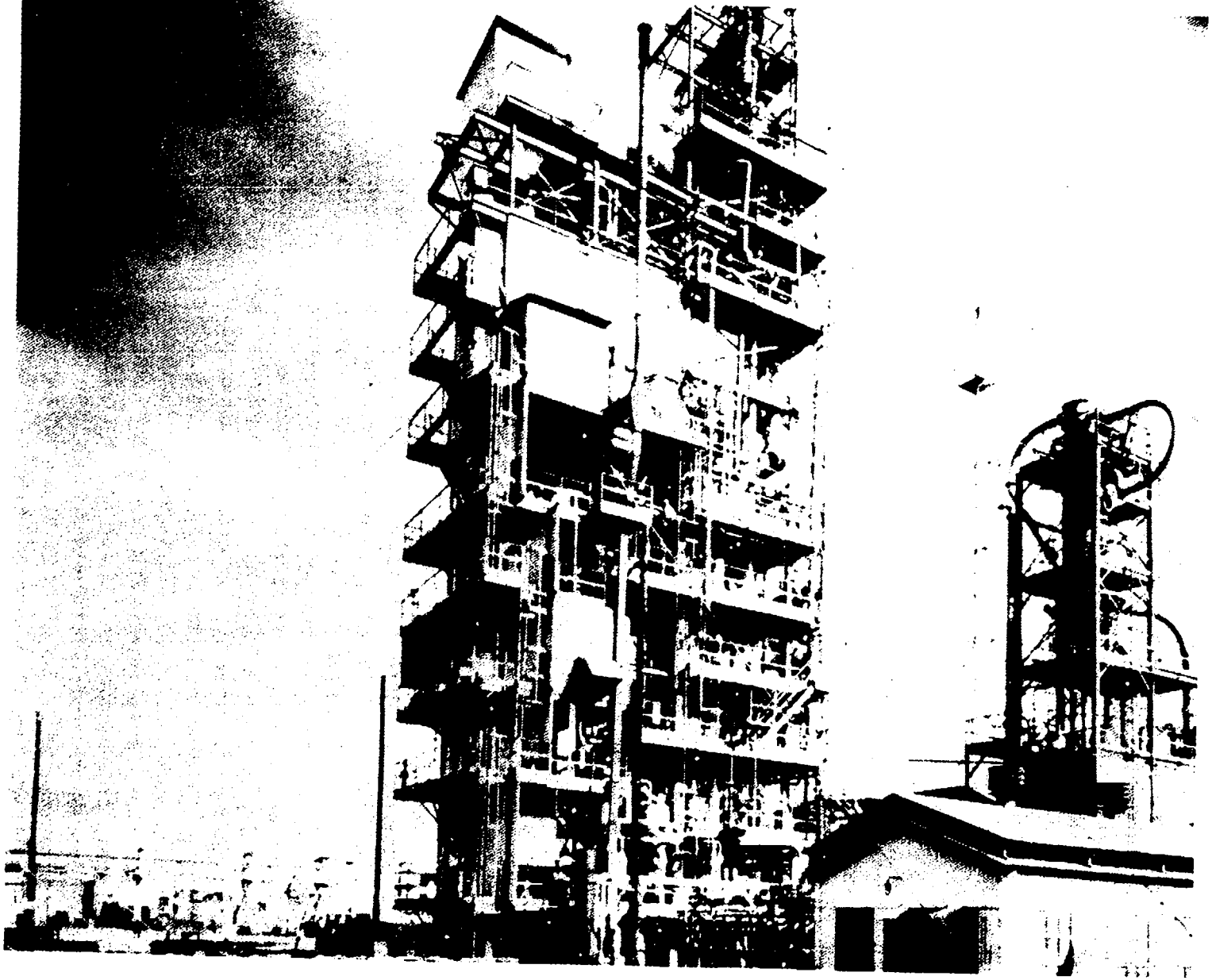
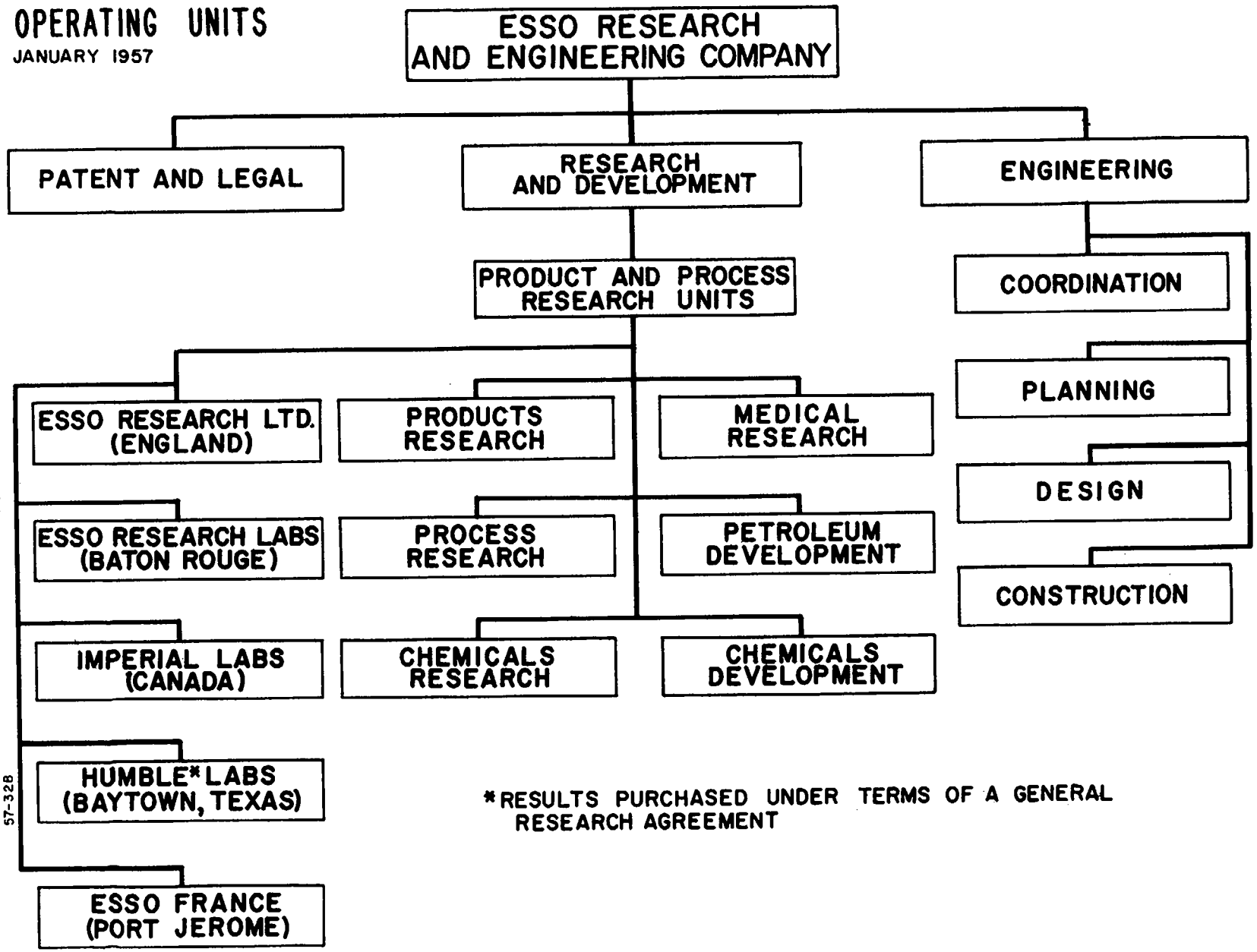


CHART 11

OPERATING UNITS

JANUARY 1957



*RESULTS PURCHASED UNDER TERMS OF A GENERAL RESEARCH AGREEMENT

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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 really works out. The oil industry, as 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 were on the verge of using up all of our raw materials, and to prove this point figures have been cited showing the ratio of our reserves to annual consumption. The basis for this is illustrated by chart 12 (page 25), which plots the ratio of our proved reserves to consumption in the United States over the last 28 years.

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; and there has been a great deal of confusion among the general public as to just what was going on.

The difficulty is that the term "proved reserves" has a very 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 we 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 to 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 talking about only 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 12/1 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, strikes, 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 many 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 that level, there is increased 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 want to show you another chart (chart 13, page 26) which shows the same information in a little bit different fashion. You can see here that the top of the chart shows the proved reserves, compared with the annual production indicated on the bottom. You can see 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 a great deal of research has been carried out 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 and in this way are pretty much 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 just 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 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 petroleum 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 that are 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 those of our present operations. In some instances, however, we are getting quite close, and, if the industry had to swing over from crude oil to some of the other raw materials, we could start 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 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 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 of this, gasoline today, ex taxes, is not much different in cost from what it was in 1925 or 1926 in spite of all of the inflation that has taken place since then. Furthermore, the quality of gasoline and other products is much better than it was in those earlier days. This quality improvement is very important, because through better quality gasoline more efficient engines can be developed. The net result is that about 50 percent more useful work is obtained from a gallon of gasoline today than was possible in 1925 or 1926, which incidentally, of course, is the same thing as increasing our reserves, if we can convert it so it will work more efficiently.

A classic example of how research on product improvement can affect an industry is illustrated by the next chart (chart 14, page 27). This shows the sources of energy in the United States since 1915. In 1915 you can see that four-fifths of the energy used was derived from coal. Today barely one-fourth is derived from coal, which is gradually giving way to petroleum and natural gas. It is interesting, to me at least, 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 to 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. Now, it may not be due to research, but certainly that's an important factor.

CHART 12

RATIO OF PETROLEUM RESERVES TO CRUDE OIL PRODUCTION 1927 - 1955

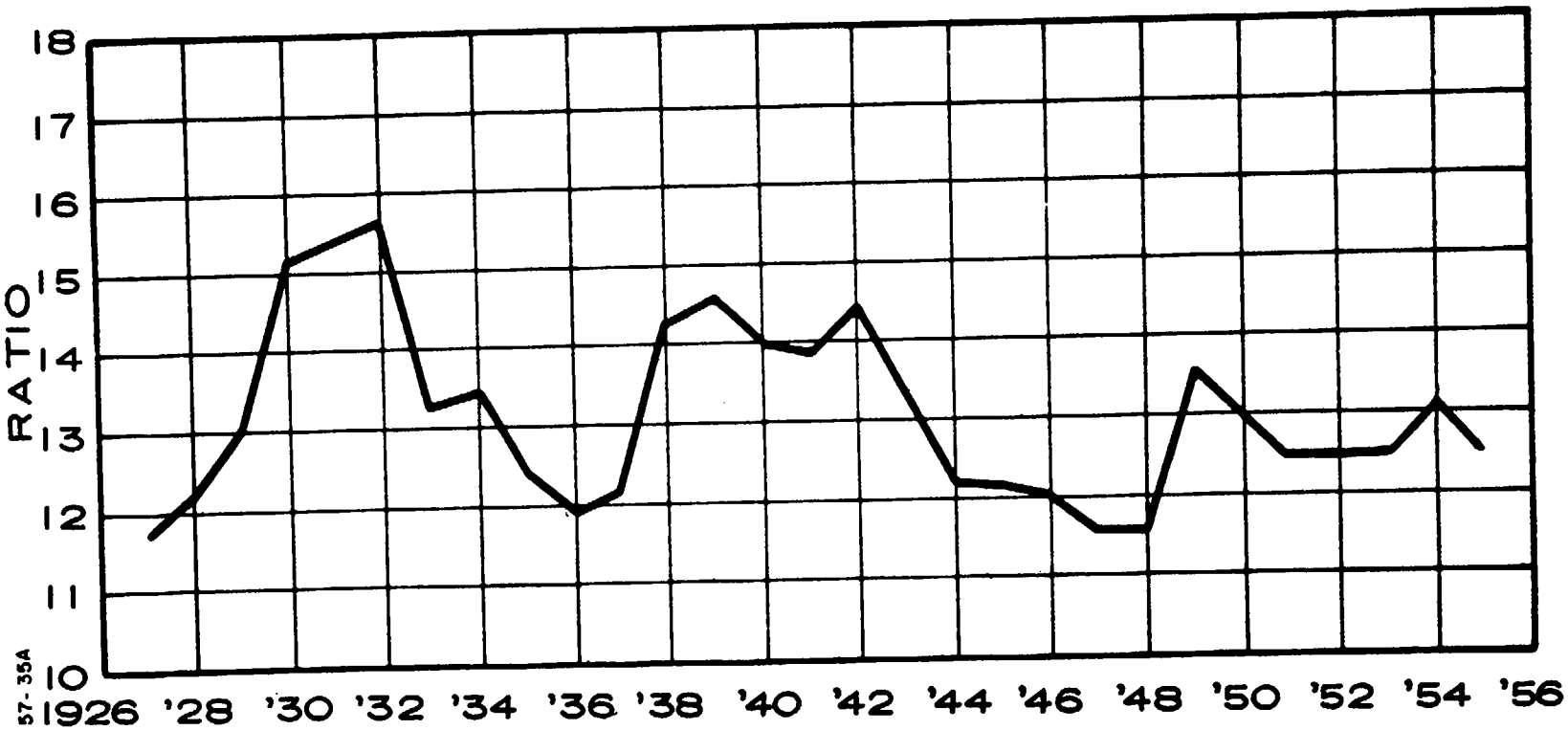
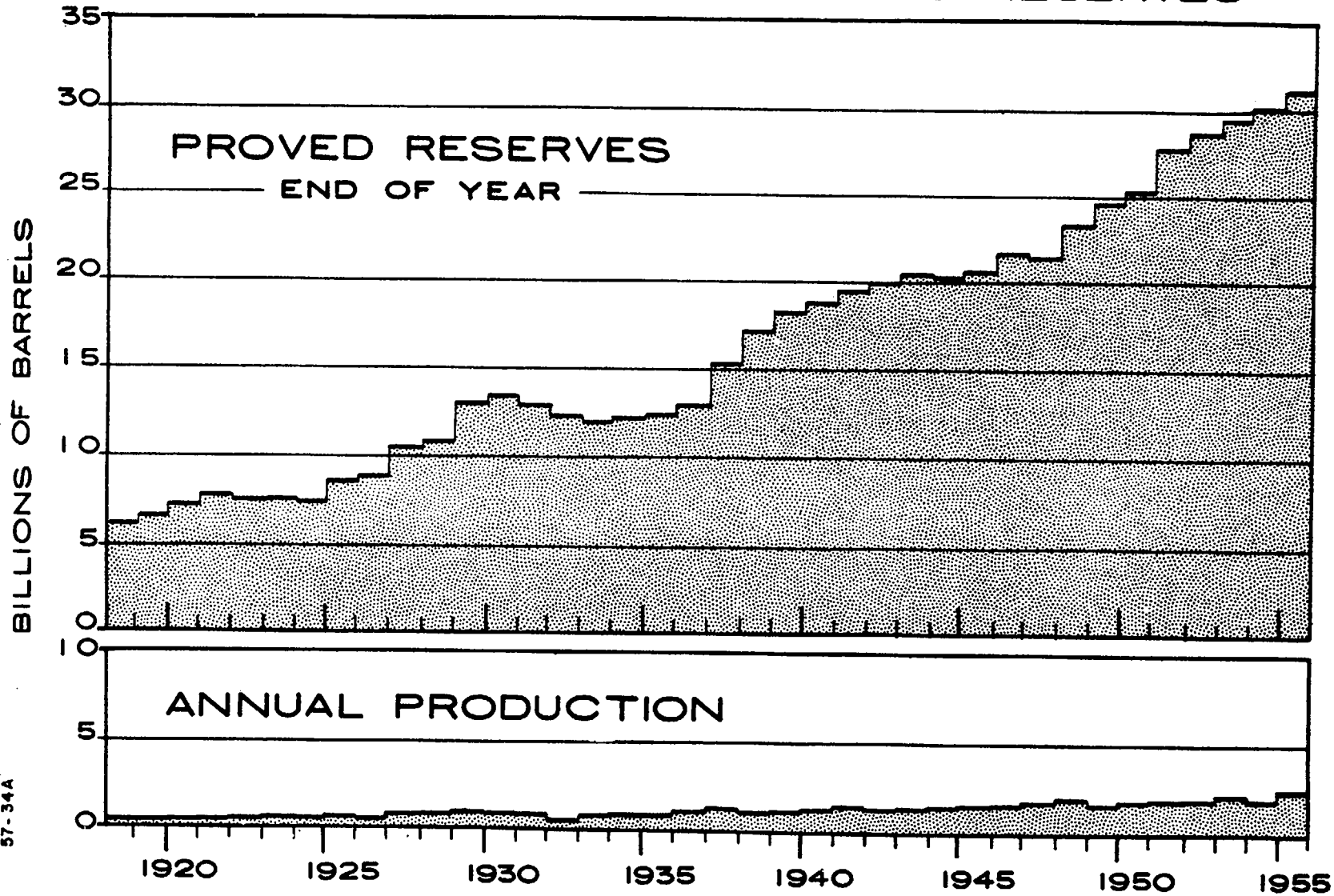


CHART 13

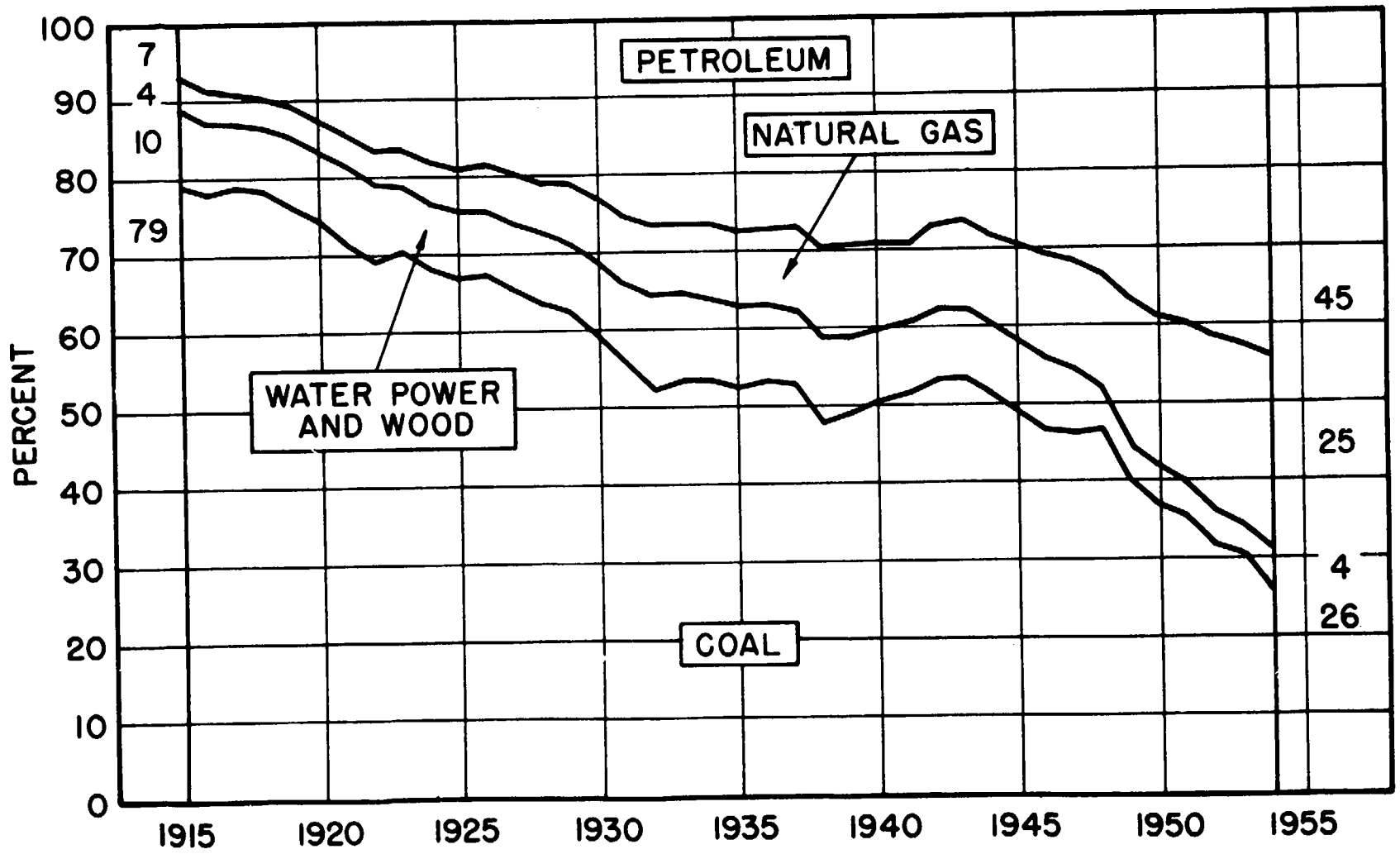
UNITED STATES CRUDE OIL PRODUCTION COMPARED WITH PROVEN CRUDE RESERVES



57-34A

CHART 14

U.S. CONSUMPTION OF ENERGY BY FUELS BY PERCENTAGE



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 in the northern part of the country. 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. But 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 as much in the wintertime as in the summer, the oil and motor industries together have done a great deal of work directed toward making it possible for automobiles to operate just as well in the cold weather as in the warm weather. 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 really new season has been created in which gasoline can be sold. So that's almost a new use for our product--winter gasoline. 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. Steps are also well under way to use oil in combination units that heat in the winter and cool in the summer--merely by throwing a switch. 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 could be suitable for making alcoholic beverages, most of the synthetic alcohols made by the petroleum industry are actually used for various industrial purposes and are converted into solvents and similar materials. We also manufacture large quantities of materials that go into the manufacture of plastics and supply some of the raw materials for new synthetic fibers such as nylon, dacron, and orlon. Synthetic rubber is another product of oil research. Practically all of the automobile tires used in this country have now joined gasoline and

oil in being derived mainly 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 it is as much as other operations a part of the industrial effort. Furthermore, the research and development strength of an industry is not provided solely by the formal technical knowledge of those associated with it. It is 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 one another 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 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, I think, 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 use, and by its ability to create sources of aviation gasoline, synthetic toluene, and all of the other petroleum products required by our fighting forces. This has also been true of many other industries, and 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 to be the important points to remember as we think about research and development in 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, in my estimation, our future security.

Thank you very much.

COLONEL SEEDS: Mr. Reeves is ready for your questions.

QUESTION: Sir, I am curious about the corporate setup of your research work, and particularly in regard to its relationship in terms of financing its effort, and so on. Would you comment on that?

MR. REEVES: Yes. My company is called the Jersey Company. The parent company is the Standard Oil Company (NJ). It does not do any operating; it is just a holding company. It has affiliates which carry on operations all over the world. The Esso Standard Oil Company is one of them. Humble is another; Creole in Venezuela, another; Imperial in Canada, another; Esso Petroleum in England; and so forth.

Since Jersey tries to operate on a decentralized basis, it felt that it ought to set up its technical activities on a decentralized basis; so it established a separate company, which is Esso Research and Engineering Company, to do the research work and the engineering work for the Jersey affiliates. Now, in doing it, though, it felt that it should not have any control over the research, except as a stockholder. So we operate as really an independent company, but we are restricted to Jersey affiliates for clients. We have contracts with most of the Jersey operating affiliates to carry out research and development work for them in specific areas. Through those contracts they pay us for the work we do, and this is usually on a net-cost basis, except for what we call special technical services, which are on a total-cost basis. But our relationship with the affiliates I guess is the same as the relationship

of any independent company with its customers. If they want to, they can try to get their research work done someplace else, which of course is quite a spur to us, because we spend a lot of time trying to convince them that the best place to get it is through us.

QUESTION: Mr. Reeves, I have been studying the priority problem in research quite a bit, and it comes up in the military perhaps a little more than it does in industry because of the large military program. I wonder whether you in your work find a need to use priorities, or whether, say, the individual worker or team is given projects on which there is no relative priority involved. What measure do you use to establish priority?

MR. REEVES: We do have lots of priorities. We don't work on projects; we work on programs for the most part. But the first thing we try to do is to find out how much overall technical effort Jersey can justify. That of course sets our total budget and our total force. That is done by making a study of Jersey's own needs, of what we think our competitors are up to, and of what we think is going to be needed to meet competition from other industries. In other words, we do try to analyze Jersey's overall need for technology and use that as a measure of what our overall efforts should be.

Then, the next thing we have to do is to decide what distribution of effort is justified in various fields, such as producing, which is getting oil out of the ground; refining; developing new products; petrochemicals; and engineering. We then divide up our program on that basis.

Then, within each area, such as the development of new processes, we try to decide what processes would be of interest to Jersey and useful to Jersey. Those are carefully analyzed in terms of their applicability to operations, the scale in which they would be employed, and the benefits that would be derived, say, per barrel, in using them. We can calculate within categories, then, the relative desirability of the projects. We try to work up our programs so that we start off with the most desirable and work our way down the list. Since there are always many more problems to resolve than we have people to solve the problems, there is a continual reexamination of our overall effort and our effort in individual fields; and new projects are continually pushing the least desirable out the bottom.

So that I would say that our program is continually on a priority basis. Those priorities are not established and left there. They are reexamined almost from day to day.

Does that answer your question?

STUDENT: Yes, sir. I want to ask also--is there a formal list of these? Do you have to have numbers? Does the team know what numbers there are? Or does the priority exist as a management tool?

MR. REEVES: It is more a management tool. We have what we call coordinators in each field, and it is the responsibility of the coordinator and his office to continually review the programs in that field, because he is responsible for being sure that we do an effective job in his particular field. Then, there are discussions with the various divisions that do the work. He is the one who talks to them, and between them they establish the immediate priorities we use.

QUESTION: I gathered from your talk that our ability to produce petroleum products from other resources, such as coal, was a matter of economics. Could you comment further in that area by telling us, first, whether it would be possible to put out a volume of oil products comparable to that which we are putting out from the resources here in our hemisphere? Second, the magnitude of production, dollar-wise, to do it? Third, how long it would take to get to that area? In doing that, you might have to use a large crystal ball.

MR. REEVES: Well, I can try. We have thought a lot about this in terms of capacity to put out products. In the United States there is a big reserve of oil shale out in Colorado. There have been lots of estimates of how big that is and they vary quite a bit, depending on what richness we are willing to accept as being workable. If you take just the richest part of it, that's equivalent to about twice our proved reserves of oil. If you are willing to go a little farther down, it just goes up and up. So oil shale, you might say, represents a larger source of raw material than crude oil does.

There are some tar sands in the United States, and there is a very large deposit of tar sands in Canada. The coal reserves in the United States are good for many thousands of years, I think, but coal is more expensive to recover than anything else.

So I would say that from the standpoint of availability of oil materials, it is quite difficult to see how you could run out of them in a couple of hundred years.

From the standpoint of the processes themselves, I think the best way to express it is in the cost of the products. I know you asked about the capital investments. For oil shale the capital investment would be higher than for starting with crude oil. We are not certain how much higher it would be, because it is very difficult to figure the equivalent capital investments in producing operations. But certainly we think you could make gasoline for another nickel a gallon, or something like that. The result would not be too bad. We think that the capital investments are of the same order of magnitude, and it would not represent a tremendous strain on the industry to shift from crude oil to oil shale as a petroleum material. Did I answer your question?

STUDENT: Not on the time factor.

MR. REEVES: Oh, well on time, we could start today, I think, and build an oil-shale plant. Of course the Government has been running a lot of pilot plants, and I think the process is quite well demonstrated. Union Oil Company has a large demonstration plant that it is building and getting ready to run. So technically you can design plants now, and then it is a question of building them. Even if no more oil is discovered in the United States, of course we have reserves for quite some time anyway. Surely, long before you would run out of oil, you could have it replaced with shale.

QUESTION: Sir, because of the very nature of R & D work it is difficult to measure progress and rate of satisfactory completion. Would you comment on what administrative tools you found useful in measuring the progress, if you will, of your activity, and the performance?

MR. REEVES: You have certainly hit on the hardest job there is. Of course some of the things are simple. Engineering is really quite simple, because people want to build a plant and so it has to be designed. If they know exactly where they want to build it, they can pretty well tell how many man-months or man-years it is going to take to design it, and to calculate what engineering backup is going to be necessary.

I think the same thing is true to a somewhat lesser extent in development work. If we have a process that is pretty well developed

look at it and decide how long
nt where we can install it commer-
well, if we put in an effort equivalent to
three years, we will be there."

course those estimates are not always correct, but they are
not too far off, and they are not too hard to make.

The same thing applies to developing products. But when you
come to the creative part of the work itself then you are in a lot more
difficulty. You've got to play the law of averages there. In other
words, you've got to assume that if you have so many creative people
working in an area they are bound to come up with something at fairly
regular intervals. From experience, you know about how large a crew
you have to have and, if you know how much you need to have invented,
then they will make those inventions.

It's like the gas laws, I guess. I mean, you take a molecule and
nobody can tell what that is going to do, but if you take, say, a liter
of molecules, you can apply the gas laws to them.

So I think the same thing is true of creative work. If you've got a
large enough group, you can be pretty sure that, if its members are
properly stimulated, a group of a certain size is bound to be creative
to a certain degree.

That's not a very good answer, but that is the most ticklish part
of it--trying to figure out how creative a group will be. The develop-
ment part and the engineering are very simple...

QUESTION: My question is predicated on the assumption that your
company does not produce its own refineries; that is, it doesn't
build its own refineries. Knowing that the major refining building and
construction concerns also have expensive engineering projects and
development projects, can you give me a general idea of the balance
between your own engineering staff, development-wise, and that of the
major construction company employed in building a given refinery?

MR. REEVES: Yes, I can do that. We generally divide the engi-
neering on a new plant or a new refinery into two areas. One is what
we call the process engineering, and the other is the mechanical
engineering. The process engineering involves laying out the process
itself, determining the operating conditions, and sizing the basic

equipment, and so forth. The rest of it is involved in calculating heat exchanges, towers, piping layouts, and so on and so on.

The basic engineering normally accounts for 15 percent of the total engineering on a project. We feel that we should do the basic engineering, and that the construction company should assume responsibility for the mechanical engineering, which is the bulk of the engineering work. The reason we feel that way is that the translation of research into commercial operations involves the basic engineering. With the background that our own engineers have in terms of the research work that is going on, and with the experience of other units in the company on similar or the same processes, we feel that we can do a much better job of basic engineering than the construction company can do. But we certainly don't feel that we can do a better job of the mechanical engineering and the drafting.

STUDENT: Basic engineering, then, includes what you term process engineering?

MR. REEVES: That's right. Process engineering is what I mean by basic engineering.

QUESTION: My question is along the same line, sir. I read in an article recently that in certain areas productivity has fallen behind because industry has been reluctant to accept certain new processes because these processes were very revolutionary and they completely caused a deflation of the capital investment, the capital equipment, in the company. For example, I know any direct reduction of I & O could cut out a great part of the industry. Is there any reluctance on the part of your company to accept new processes, or is there the feeling that the period of obsolescence is too hard on your capital equipment because of new processes?

MR. REEVES: We discuss that a lot, and it is an interesting situation so far as we are concerned. So far, fortunately, it is a theoretical thing. The oil industry has been growing pretty rapidly over, I guess, the last 30 or 40 years, and it has been pretty hard put, really, to finance its expansion, much less replace everything. So all of the money that has been available to put into new capital has been put into new plants which do not replace old ones. So that question just does not come up. We keep running old ones as long as we can, because, while they are more expensive, they do put out products. The day is bound to come, I suppose, when our expansion slows down to a point where we can start

replacing plants because of technical obsolescence. But that has not occurred. We just don't tear anything down until it falls apart, because we need the capacity so much. It's an interesting problem. A lot of people are wondering about it.

QUESTION: You mentioned that your industry was interested in the fluid energies, and you mentioned sources of fossil oils. Do you in your research consider vegetable sources of it, and are there any other possibilities?

MR. REEVES: Well, of course I suppose indirectly a lot of people feel that oil comes from vegetables. I think that, if we thought we could make them into crude oil, we would be very much interested. Generally speaking, the agricultural raw materials have been far more expensive than crude oil has. I don't know whether that answers your question or not. I mean, we are willing to use any raw material so long as it is economical.

STUDENT: How about the side developments that you have, such as alcohol and products from alcohol?

MR. REEVES: Well, that's different. We are trying to integrate the chemical business and the oil business. What we find is that people in the oil business tend to look at things in a certain way. They are accustomed to large-scale continuous operations, and they just have a point of view about things that you don't find, say, in different industries. For the time being we don't want to change our main business. We feel it is necessary in developing the petrochemical business that it integrate. We have taken as a matter of principle that our petrochemical activities ought to use raw materials which are petroleum in origin. In other words, we are doing it as a by-product activity. We also restrict ourselves, in petrochemical ventures, to those operations on which we think we can take advantage of our refining background.

QUESTION: Mr. Reeves, I have two questions relative to personnel. The first concerns this thing of much disucssion in the newspapers and all, relative to the shortage of scientists, engineers, and that sort of thing. Occasionally some facts pop up that indicate that maybe this may not be as serious as it seems, that there may be some hoarding of that type of personnel, or that available personnel is not properly used. I wonder what your view of the thing is, relative to shortage or not.

The other question is relative to the management of the highly technical personnel from the point of view of management. Do you have to employ special techniques so as not to hamper their initiative?

MR. REEVES: I will be glad to tell you what I think about the shortages. I agree. I think that people talk about numbers of people all the time. The fact of the matter is that if the rest of the graduating classes were as good as the top 25 percent there would be no shortage at all. Most of the scurrying around is to get the top 25 percent of the graduating classes. From what I have found out, the bottom half of the classes all wind up with jobs, but there is certainly no great competition for them. Also I have talked to a lot of people in various research organizations and, while everybody talks about the trouble of hiring people, I haven't heard anybody say that there were things they wanted to do that they could not do because they didn't have the people.

I think the same thing applies to the Department of Defense. They talk a lot about the shortages of people to do research projects for them, but at the same time they talk about reducing their budget because they can't afford to spend so much money.

So what I think is true is that there is a tight situation existing, and people who want the best people find that the effort that is required to get them is worthwhile. In other words, a good man is worth a lot more to you than a mediocre man. We consider that it normally costs us about $60,000 a year to support a technical man. We expect him to stay with us for life, which means that we are going to spend a couple of million dollars on him before he retires. Under those circumstances you can see that you can easily justify spending 2 or 3 thousand dollars to hire a good man to spend all that money on, compared to one that is not quite so good.

I think that is the basis with most industrial companies for the competition that takes place. They all realize that the best man is better than the next best man, and they are all trying to get the best man. I think there are lots of ways of doing the kinds of things that the bottom half of the class does. They are usually the not-so-creative people. There are always exceptions, of course. For engineering work or any other technical work that does not require really creative thinking you can usually work out some sort of system for doing the work, either nontechnical people or by automation.

We can do a great deal on the design of refining equipment by using IBM machines. It takes some pretty good people to set up the whole scheme and to set up the cards and to feed the questions into the machine.

But once they do that they can do ten times as much work as a less creative person can do. So there is always going to be a shortage of really creative and good people. That's not only true in technical work; it is true in everything. I think that for the rest of them it is a question of a sort of economic balance. Undoubtedly a lot of engineers are used in jobs that you wouldn't have to have an engineer to do, but you've got to realize that a lot of these people are engineers only in the sense that they are craftsmen. They are not creative engineers, of course. So that if you replace them they would be quitting something else; not engineering.

Now, the second part of your question was concerning incentives. That's a very difficult problem, and most technical people, I think look mostly for prestige and recognition, as well as an adequate salary. What we do is, we have a philosophy of salary treatment which is based on the fact that technical contributions are the most important things that we need. We pay technical people and administrative people the same in proportion to the contributions that they are making. In other words, you can make just as much money with us if you want to stay in scientific work or if you want to get into administration.

The problem of recognizing them is something else again. We have a series of titles by which we recognize our senior scientists and engineers, but a lot of the technical people don't like titles. They say that's just like being in administration and they don't like administration, so they don't like titles. So what we try to do is give them the forms of recognition. We try to consult with them on projects and things like that. It is just a question of individual treatment of each person. You've got to figure out what kinds of things will mean something to them and what things will stimulate them, and try to apply them.

But it is not an easy question to take all these different technical people, each with a different idea of what he wants, and keep them all happy.

QUESTION: Mr. Reeves, are there any sizeable deposits of shale oil in Western Europe? Are the people in Western Europe examining those as a source of supply for gasoline?

MR. REEVES: I don't know of any. That doesn't mean that there are not any. I don't think they have really looked very hard. There's some in Scotland and there is some in Sweden that I know of. I haven't heard of any really large deposits.

COLONEL SEEDS: I think you have answered all the questions, Mr. Reeves. On behalf of the College I want to thank you for a very fine view of research and of our national economy and security.

MR. REEVES: I appreciate being here. I am glad to have had the opportunity.

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