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PETROLEUM--TODAY AND TOMORROW

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The petroleum industry of the United States was 88 years of age on 27 August 1947. Military science, I suppose, dates back to that prehistoric day when some primitive Alexander conceived and executed the first ambush. It would seem theoretically easier, therefore, to tell the story of the petroleum industry in an hour than to epitomize the whole history of military science and tactics in the same time. I believe, however, that such an advantage in my favor is less real than would appear. I suspect that much of importance in military science dates back less than a century and that the last century would probably require and receive as much time in a lecture as all of the prior history of warfare.

Everyone of us today receives so many impacts of knowledge from all sources that it is utterly futile to attempt to absorb them all. It is equally futile to try to resist all these impacts for that only breeds bewilderment. A surgeon friend of mine who specializes in a very limited field tells me that it would take half of his waking hours just to keep up with the literature on his particular specialty. So it is to a greater or lesser degree with all of us. Rather than blanket you with a heavy barrage of facts about an industry that I am sure you all realize from personal experience is both vast and complex, I shall confine myself to a discussion of some of the basic fundamentals of this truly amazing resource that has contributed so much to making and maintaining our great Nation.

The petroleum industry has witnessed during its 88 years the advent and development of other inventions and industries that have likewise contributed to our national progress. Many of these are as closely linked as the hen and the egg so that any comment on relative importance has no point. It may be mentioned, however, that when the internal combustion engine was perfected it had a cheap and plentiful supply of fuel awaiting it; when the automobile was invented it had not only a practical power plant but an ample supply of gasoline awaiting it. Later on the airplane and countless other items of everyday use ranging from battleships to bombs and from explosives to perfumes became possible in their present form because of the products of petroleum. Even the production of aluminum, another of these modern miracles is linked to petroleum coke, while names like 100-octane, jellgas, butadiene, TNT and others have become almost household words. Enough of

petroleum products, however. Some 5,400 different ones are available for your selection and use.

Before getting down to some of the basic fundamentals which have made petroleum what it is today, it may be well to orient ourselves as to its relative stature in comparison with other commodities. The unit of measurement of crude oil and heavy fuel oil is the barrel, which was originally a container holding 42 U.S. gallons or 35 imperial gallons, an arrangement which made conversion very easy. Very few people living today have ever seen a barrel of crude or fuel oil but the unit of measure continues unchanged.

For that matter, a very high percentage of petroleum is produced, processed, transported and consumed without ever having been seen by human eye. It travels in walls of steel from the bottom of the deepest well to the gasoline tank on your car, or the oil tank in your basement. Practically all of the oil the average person sees today is the occasional glimpse of lubricating oil at the service station; the trickle that comes from the home oil or kerosene can and the asphalt in the highway that flows smoothly past beneath his car. All of the rest is taken for granted until there is some interruption in the supply and it is one of the proudest achievements of our petroleum industry that the people of this country have been able to take their supplies of petroleum for granted except for those special times or particular areas affected by war or shortages of material and transportation.

In no other country can the average citizen take an ample supply of oil for granted. Lack of development, lack of facilities, lack of competition and government restrictions all contribute to the lack of petroleum progress. Many things contributed to the development of our petroleum supplies but the principal elements have been recognized as being a large, well-distributed and easily available natural supply; our system of land ownership; the venturesome spirit of initiative which is more prevalent here than elsewhere; and a public that has been quick to try to adopt new and better things.

These and other factors operating for 88 years have brought us to the point where our 425,000 oil wells produced last week five and one-quarter million barrels of crude oil daily. Two and one-third million barrels daily came from Texas and more than nine hundred thousand barrels daily from California, these two states accounting for 62 percent of the Nation's oil. This is approximately a half million barrels more crude oil than the then record amount produced during the closing months of World War II.

For comparative purposes it is necessary to convert this flood of oil to more common units of measurement, so we say that crude oil production last week averaged 220 million gallons or 738,900 tons daily.

This is more than a gallon and a half of crude oil daily for every one of our 143 million population and is required for their comfort, transportation, industry, security and a score of other items of their daily life. For the year 1947, U.S. crude oil production will closely approximate 273 million tons. Five billion bushels of corn and wheat together will amount to about 146 million tons; steel production may amount to 80 million tons and total U.S. coal production may amount to 600 million tons. However, the tonnage of crude oil is only about 60 percent of the total petroleum tonnage which, of course, includes natural gas so that the total petroleum production this year will amount to about 455 million tons.

A few items worthy of note in the production of crude oil include such facts as: The daily production of crude oil averages only about 12 barrels per well. It requires practically three-fourths of all the wells to yield only one-fourth of the Nation's oil so the average daily production of these marginal wells amounts to only 4 barrels while the best one-fourth, or about 105,000 wells average about 40 barrels each, daily.

Oil wells are becoming steadily deeper as the search for oil goes downward as well as to the four points of the compass. The 425,000 wells of the country have a total depth of about 295,000 miles, a distance greater than that to the moon. Every well is lined with from one to four thicknesses of heavy steel pipe so that not less than 25 million tons of steel have been reburied in the earth to produce oil. Other millions of tons have gone into the pipe lines, tankers, barges, tank cars, trucks, refineries, terminals and service stations of the industry.

Many wells in Louisiana and California are producing steadily from depths greater than 13,000 feet. The deepest hole drilled in search of oil was recently abandoned at 17,323 feet in Caddo County, Oklahoma, an expensive item in the search for oil, that showed only where not to drill another well.

Approximately 35,000 new wells will be drilled in this country this year at a cost of well over a billion dollars. Many of these will be failures, many more will never repay their cost, less than 100 will discover important new fields and perhaps 30,000 of them will contribute substantially to maintaining our supply of oil.

From the day of its completion, an oil well is a wasting asset with its ultimate yield largely dependent on its current rate of production. Under usual conditions the daily rate of production declines steadily and inexorably due to the gradual exhaustion of reservoir pressure. Even

the largest reservoir eventually runs dry. The average decline rate of all the wells of the country is about 7 percent a year, so that at the present rate of production, new wells capable of producing not less than a total of 375,000 barrels daily through the year must be drilled to compensate for the decline of the old wells. If the average production of the new wells is the same as that of the old wells, it will be seen that at least 30,000 new wells will be required.

Looking at it another way we can say that an individual, a company, a state or a nation must find and make available at least as much oil as it produces if it expects to stay in the oil business. Since it is particularly essential that our country remain in the oil business, we must face the hard requirement that we must now find every month the equivalent of one large oilfield having recoverable reserves of at least 150 million barrels or ten 15-million barrel fields. Not only must we find that much new oil but we must also drill enough new wells to produce that amount of oil every month. The greater our production and consumption of petroleum the greater and more onerous the obligation of the petroleum industry to keep up with that demand. Long and serious studies have been made of this subject and one of the evident results is the intense interest in foreign petroleum that is now manifest not only in the industry but in many sections of business and government.

The production of oil is only a part of the American petroleum industry which is characterized by the exceeding diversity of its operations--both technological and corporate. The industry comprises four principal divisions, namely, production, transportation, conversion and distribution. The latter two are commonly called refining and marketing, but they have become such complex operations that the older names are no longer adequate. Similarly, the production division actually consists of exploration, development and production.

Transportation, too, is a multiphase operation consisting as it does of moving oil by pipelines, railroad tank cars, highway tank trucks, river barges and ocean and lake tankers. Even distribution has its phases including terminal operations, jobbing operations and retail operations. Every customer from the U. S. Government down to the purchaser of kerosene by the quart has to be served and there is some agency of the industry to serve him.

The petroleum transportation system takes crude oil from the well to the refinery and takes refined products from the refinery to the consumer. Natural gas is delivered from the well to consumer entirely by pipe line but may pass through one or more processing plants en route. A typical example of petroleum transportation is the New Hampshire, Vermont or Massachusetts village that uses petroleum products, products derived in part from oil wells on the high plains of

West Texas. The crude oil moves direct by pipe line to tidewater at Houston or Port Arthur. Depending on conditions, it may be processed at the huge refineries there or shipped directly in huge fast tankers to the New York harbor district where it is refined and some of the refined products, principally gasoline and domestic fuel, are carried in river barges to large tank terminals near Albany, where transportation ends and distribution begins. Thence the products may be shipped by tank car or tank truck to what are called bulk stations located at appropriate centers in or near the larger towns. From these bulk stations the products are delivered to retail service stations and direct to consumers, although in some cases there may be still another distributor between the bulk station and the consumer. This is the retail peddler whose operating equipment may consist entirely of one small tank truck. Small though he may be, this petroleum retailer is one of the 34,000 separate firms and businesses that go to make up the petroleum industry.

Transportation needs of the petroleum industry change continually as sources of crude oil supply change and as the consuming habits of an area change. New pipe lines are constantly being laid and old ones are being dug up and relaid. Tankers, barges, tank cars and trucks, not being tied to fixed terminals, are shifted about as occasion requires. The basic objective of all petroleum transportation is to move the products from well to consumer at the least cost. As in every other division of the industry, the operating units range from the very small to the very large--from the one truck operator who hauls crude oil from the well to the railroad, up to the new owners of the two Big Inch Pipe Lines from Texas to New York that were of such vital service during the war.

In its original meaning, refining was the removal of impurities from crude oil so that the desired product, kerosene, would be of higher quality and more reliable. The "impurities," gasoline and heavy residues, were disposed of by burning or running into the river. Although considered a dangerous nuisance by early refiners, gasoline, together with naphtha, was studied to the degree that made it readily available in quantity when the horseless carriage came along.

The processing of petroleum has come a long way since those early days. For a long time and even today in many refineries the process of refining consisted of boiling the crude oil and the separation of the condensates by fractionation methods. Various blends of several hydrocarbons of nearly the same boiling point were collected in different tanks, further purified by acid treatment and filtration and then sent on to market.

The results of this practice were the development of a great many commercial products having physical rather than chemical specifications and being commingled solutions of hydrocarbons. With the average barrel of crude oil containing 200 or more readily identifiable hydrocarbons, it is not surprising that our motor fuels contain a dozen or more, and our heavier petroleum products progressively greater numbers of simple and complex hydrocarbons. A blended gasoline is just what the name implies, but the straight run gasoline that may constitute a component is already a natural blend.

Beginning just before the First World War, petroleum refining began to include some chemical conversion. Some of the original hydrocarbons in the lighter fractions were found to be susceptible to disassembly and rearrangement under high temperatures and pressures with the result that better gasolines were soon being produced by what was known as the cracking process. Steady improvement in motor fuel quality has resulted from continued development of the cracking technique and the result has been not only the production of the vast quantities of 100-octane plus gasoline that were required by military aviation during the war but likewise the supplying of the highest grade civilian gasoline ever available at rates of more than 100 million gallons daily during midsummer.

These improved motor fuels result in higher efficiency and better performance in whatever craft or vehicle they may propel, and the end is by no means yet for the petroleum industry still remains ahead of public demand and the motors available for the consumption of the better motor fuels. As further progress is made in motor design it may be expected that wherever needed, reconstructed synthetic fuels will replace the high-grade, conversion products now available in ever increasing amounts. The synthetic super-fuels of the future will tend to be more nearly pure hydrocarbons than are today's blends because they will be built to specification.

What once was a distillation process called refining has become a complex chemical industry on a vast scale. No other chemical industry approaches the tonnage of petroleum products produced and no other chemical industry requires such enormous and expensive equipment as do the great modern cracking units that dominate the landscape in refining areas. However, there are still many small refineries operating in special areas and under special conditions that make them competitive and economical. It is worthy of note that some of the larger refineries are so flexible and economical as to permit operation at 146 percent of capacity for weeks on end. Had this not been so, the supply problem would have been even more acute in some parts of the country than it was during the past summer; also it would not have been possible to make the record refinery run of 5,318,000 barrels daily reported last week.

The distribution of petroleum to virtually every family in America is on a par with the distribution of food. In fact, petroleum products go many places where food does not, air-lane beacons being an example. Supplies of gasoline and motor oil are to be found in lonely mountain passes that are open only a few weeks yearly; it is also cached along shores of remote lakes and emergency airports for the use of the occasional airplane that puts down at such places. Kerosene for lamps is packed and portaged to even more remote places. A remote desert outpost offered beer, kerosene and good drinking water at the same price, a quarter a bottle, but in most of our cities kerosene is the cheapest of the three.

The petroleum terminal, where hundreds of thousands of barrels of petroleum products may be temporarily stored, is usually considered to be an adjunct of the petroleum transportation system because working storage at terminals and en route is necessary to provide the elasticity and flexibility that is required to avoid unbalanced operations. The principal terminals are usually located close to one or more of the cheapest transportation facilities, namely, tankers, pipe lines and barge lines, but many terminals are supplied only by tank cars and tank trucks.

From the terminal, which may or may not be owned or controlled by the same company that refined the products, the process of distribution begins. Every step in the process deals with smaller and smaller lots of petroleum products, until the eventual retail customer, who may buy only a quart of kerosene, a bottle of household lubricant or fly spray, a cake of paraffin or a tube of petroleum jelly, is reached. The distribution system is composed principally of primary suppliers, secondary suppliers, tertiary suppliers and retailers, and every possible combination of any two or more of these.

From the facility standpoint, the next unit beyond the terminal is the bulk station which usually consists of enough tanks and other equipment to hold a week's supply or more for the area it serves. Some bulk plants are so large as to be called subterminals or district plants. These bulk plants can be and are operated by anyone who is assured of a supply of petroleum products and who can economically and competitively dispose of the products to his customers. They may be owned by the same company that produced, refined and transported the petroleum or they may be owned by retailers who have enough business to warrant their buying in bulk. Or they may be owned by individual jobbers having no other part in the petroleum industry than the jobbing of petroleum products to retailers. Or there may be any combination of this group. Whatever the organization may be, it adjusts itself to the competitive trade practices of the area it serves and succeeds or fails according to the effectiveness of its adjustment.

One of the difficulties faced by the petroleum distribution is the wide differential between refinery prices of gasoline and the service station cost to the consumer. A very large part of this spread is, of course, the combined State and Federal tax on gasoline which makes it second only to cigarettes as the highest taxed widely used commodity. An example of this consumer cost is worth attention.

Last week, in the midwest, the average price of regular 73-75 octane gasoline in tank car lots was about 8.7 cents a gallon. This is the highest priced volume product recovered by the refiner from crude oil that costs him between five and six cents a gallon at the refinery. His lowest priced product, residual fuel, brings him only about 2.2 cents a gallon. After paying State and Federal taxes of 5.5 cents on 63 percent of the cost per gallon and all transportation and handling charges on this gasoline it is finally delivered by tank trucks to retail dealers for an average of 17.3 cents a gallon, representing an increase of 8.6 cents over the refinery cost. Of this increase 5.5 cents or 64 percent was tax and 4.1 cents or 36 percent was to cover transportation costs and handling charges all the way from the refinery to the service station and provide a small margin for those who handled it. After receiving the gasoline from the tank truck, the retail dealer adds whatever is competitively necessary to his delivered cost to pay the numerous costs of operating his service station--including rent, taxes, utilities, supplies, labor, occupational tax, repairs and maintenance. What is left over, after paying for the gasoline and other products and all other expenses, is available for him and his family. With regular grade gasoline retailing at 23 cents a gallon in the Chicago district, it is perfectly obvious that the average service station operator can hardly be classed as a tycoon.

By way of comparison it is interesting to observe that No. 2 fuel oil for home heating, which is handled less and in larger quantities and pays no State or Federal gallonage tax, is now selling for an average of 6.8 cents a gallon at refineries. It is transported, handled and delivered to consumers tanks in 400-gallon lots at only 10.5 cents a gallon including 2 percent occupational tax. The great difference between the cost of gasoline to the consumer and the cost of furnace oil is obviously due principally to high taxes and to consumer buying habits. There is only a two-cent difference at the refinery but a 9.5-cent difference to the consumer. However, to the consumer, who buys his gasoline at 19.3 cents in 400-gallon lots, the difference is only 8.8 cents. Of this difference 5.5 cents go to the tax collector. As with all other commodities, unit costs of gasoline must be higher when small deliveries are made in nice packages accompanied by accessory service.

As is the case in other industries, many oil companies are vertically integrated, but the overwhelming majority of companies operate in only one division of the industry. The production and distribution divisions include over 90 percent of the 34,000 firms engaged in the petroleum industry. The integrated companies range from the very small to the very large. The smallest integrated company at present known produces about 80 barrels daily from a few of its own wells and purchases about an equal amount. The oil flows by gravity through a small pipe line to a tiny refinery which supplies the two service stations owned by the company and turns out fuel oil and road oil used by the community.

Integration usually results from a need to reduce unit costs and to achieve greater security by becoming independent of sources of supply and product outlets controlled by others. Integration is still actively in process, particularly in highly competitive areas and it is not unlikely that the list of larger companies will increase by two or three in a few years.

Some integrated companies are truly international, operating in three or four continents and this trend is steadily continuing as others sense that it may be possible to find more crude oil with less money and materials in foreign fields than in the United States.

All of the foregoing constitutes a brief sketch of the American petroleum industry as it is today. It is an industry in the midst of a cycle of flux and change and the conditions of today are but a prologue of tomorrow. The future can be discerned even dimly only by delving deep into the secrets of petroleum itself.

Although the word petroleum literally means "rockoil" and gas, being a word coined to replace the cumbersome "aeriform fluid" means only gas, custom and usage have come to include both the gas and oil that so often come from the same well under the term "petroleum." Both natural gas and crude oil are simply hydrocarbon mixtures, with natural gas being only a physical segregation at normal temperatures and pressures. Because hydrocarbon gases dissolve in hydrocarbon liquids and vice versa, light liquid petroleum can be extracted from petroleum gas and petroleum gases can be removed from crude oil.

So petroleum commonly includes both crude oil and natural gas and both are composed of a great many hydrocarbons. Coal is also composed largely of many of the same hydrocarbons found in petroleum, but since it is a solid and therefore neither migratory nor fugacious in its natural state it is subject to a completely different set of laws, operations and uses. However, if a group of hydrocarbons are extracted from coal, either directly or indirectly and are used as petroleum is used, the product may be called oil, gas or petroleum, or gasoline,

kerosene or distillate, but should carry the qualifying adjective "synthetic" to distinguish it from the natural product. It is doubtful, however, whether future users of gasoline or fuel oil will care whence their fuel comes, just so they get enough of it.

The simple hydrocarbon, methane consisting of one carbon and four hydrogen atoms may be considered to be the foundation of modern transportation, power and comfort for it and its thousands of more complex relatives are the principal source of the energy yielded by coal and petroleum. None of these resources is inexhaustible, but the reserves of coal far exceed the known reserves of petroleum. We have evidence that petroleum and coal are still being slowly formed and accumulated but probably at a rate far less than that at which we are depleting the accumulations of probably half a billion years.

Next to water itself, the hydrocarbons are the world's principal source of combined hydrogen. By a long and complicated process, heat, pressure, bacterial action and infinite time, the carbohydrates, fats and proteins of primeval plant and animal life have gradually altered and evolved into the magic molecules that mean so much to us today. Truly the stored sunlight of bygone ages is serving us well today.

It may be deduced from the references to coal, that there is some reason for believing that coal will play a considerable part in the future of petroleum. This is undoubtedly true and the same is true of oil shale which exists in great quantities in the Rocky Mountain states. Oil shale, despite its name, does not contain oil as such, but only oil-forming components called kerogens that require processing with heat to yield their oil.

The petroleum gases containing relatively more hydrogen than do the liquid or solid hydrocarbons are proving to be a great source of hydrogen which is used principally in combination with nitrogen of the air as the ammonia component of fertilizers and explosives. If natural gas and coal could be combined, great quantities of liquid hydrocarbons might theoretically be evolved but known processes are by no means that simple although there is little doubt but that radically new and improved processes of synthesizing petroleum from coal will be announced within a few years. To make the best use of our coal reserves we must discover a method of almost completely converting coal to liquid hydrocarbons, for at the best known present rates of recovery the coal production of this country would have to be doubled to supply our gasoline requirements alone, and a new investment equal to the present 18 billion dollar depreciated investment of the oil industry would be required. It is virtually certain, however, that intensive research now in progress will make synthetic petroleum fully competitive with natural petroleum within the next few years. But

synthetic petroleum will simply be depleting another of our resources as the production and consumption of petroleum has depleted that resource.

Beyond coal and oil shale we can only hope that other sources of heat and power will be found. It is utterly futile to speculate on the prospect of fuel production by the crop lands of the world when they are already so taxed in producing food. Wheat and corn, when dry, make good fuel, but quadrupling our grain crop to obtain fuel to replace petroleum is not even an idle dream--for petroleum of the the future we must continue to look to the petroleum industry as we do today.

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