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THERE WILL BE
ENOUGH OIL

by

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OVER THE LAST THREE YEARS public opinion in the United States has gradually come to grips with another of the "Oil-shortage" scares which have risen up to plague us periodically ever since the close of the Civil War.

The press and radio warn us that our oil supply in this country is only sufficient to meet our needs for 14 years. We are discovering fewer new oil fields than we did 15 years ago. Our leaders at Washington announce that "we are running out of oil."

Would it be strange if householders all over this nation became alarmed about a possible shortage of fuel for the oil burners which provide the clean, comfortable, automatic heat for their homes in wintertime?

This is not the first time we have become alarmed and the cry has arisen that we are running out of oil. As early as 1874, only 15 years after Colonel Drake's completion of America's first oil well, at a time when practically all of our production was confined to the State of Pennsylvania, Dr. Wrigley, the State Geologist, at that time announced that we were running out of oil. "Everything which by general acceptance can be denominated as the oil region," he said, embraced an area of only 3115 square miles. Of this total area

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of possible production, only 39.5 square miles had "actually produced oil."

A few years later Dr. Wrigley calculated the total oil producing area at 284 square miles and the total remaining reserves ("judging from the results of 20 years") at 96 million barrels. "It is only necessary to add," he commented, "that the present yearly output is over 25 million barrels. . . . Some day the cheque will come back endorsed 'no funds' and we are approaching that day very fast." And this was 62 years ago!

Subsequent warnings of oil shortage have echoed Dr. Wrigley's early forebodings down through the years. By 1908, our national production had amounted to 2 billion barrels, more than twenty times as much as Dr. Wrigley had anticipated. Nevertheless, at that time Dr. David Day, forceful Director of the United States Geological Survey, officially estimated that we were still assured of at least 8 billion barrels and might have as much as about 24.5 billion barrels yet to come. Dr. Day's optimistic estimate was greeted with skepticism by his colleagues. But since his estimate was published, 26 billion barrels of oil have been produced in this country and we still have proved reserves of some 20 billion barrels. In other words, we have already found about twice as much oil in this country as Dr. Day dared hope we might find over all time.

It would be pointless to review all the estimates of "future" oil production and warnings of impending oil shortage that have followed Dr. Day's prediction, but I wish to refer briefly to the report of the Committee of

Eleven of the American Petroleum Institute, issued in 1925, at a time when our leaders in government had again become fearful that we were running out of oil.

This study revealed that we had already produced about 8 billion barrels of oil in this country and that a group of competent geologists and engineers estimated our proved reserves, that is, the oil remaining in reserve in the fields we had already found and developed at the end of 1924, at somewhat more than 5 billion barrels. But the report showed also that the area actually producing oil in the United States had already grown from the 284 square miles, recorded by Dr. Wrigley in 1882, to 3300 square miles; and it demonstrated that our proved petroleum reserves at that time were still only a minor fraction of our total petroleum resources in this country.

In the first place, the Committee of Eleven emphasized the fact, still not generally appreciated, that our estimates of proved reserves, as we issue them from time to time, include only "recoverable oil." In the early days, we recovered only 30 percent, or less, of the total oil in place. Even today, with improved methods of production, we rarely recover more than one-half of the original oil in place in the underground reservoirs. The report of the Committee of Eleven showed, therefore, that after the estimated 5 billion barrels of proved recoverable reserves had been withdrawn there would still remain in all the depleted oil fields of the United States some 26 billion barrels out of the total original oil in place. Our proved reserves are only the

estimated amount of oil to come from the presently known fields through ordinary methods of production. Additional oil may be produced from the same fields in the future by secondary recovery methods, which are already being applied successfully in old depleted fields where primary recovery has ceased.

An even more significant conclusion of the Committee of Eleven was that there is in the United States an area of about 1.5 million square miles (the Committee estimated the area at 1.7 million and more conservative subsequent estimates have placed it at 1.4 million square miles) within which it is reasonable to believe new oil fields may still be discovered. This incompletely explored territory, the Committee of Eleven declared, constitutes our greatest national petroleum resource. The soundness of this conclusion, which caused a furor of protest when it was announced, is shown by the fact that exploration of this territory subsequent to the date of the report has already discovered about 35 billion barrels of new oil, or more than double the total discoveries (13 billion barrels) made up to the time the report was issued.

Our present conviction that we are running out of oil rests principally on the fact that our proved reserves amount to only about 14 years' consumption. Yet in 1925 our estimates of proved reserves amounted to only about 7 years' consumption. Let us try to realize that the term "proved reserves" has but little bearing on total petroleum resources or on possible future discoveries. The proved reserve, perhaps more clearly termed "discovered" reserve, is simply the current

underground working stock of the industry. It is continually being supplemented by new discoveries and of course drawn upon by current production. The industry is constantly finding new reserves. When the search is active and discoveries exceed current production, the reserve increases—conversely when discoveries decline the reserve may decrease.

Today our proved reserves are estimated at about 20 billion barrels. Our past production amounts to 28 billion barrels of recoverable oil. The sum of these quantities is the portion recoverable by ordinary methods from a total quantity of about 120 billion barrels of oil originally in place in the underground reservoirs already developed in this country. The oil which will remain in the ground when the present estimated amount of the proved reserves has been fully recovered is set by most engineers at about 70 billion barrels. Some of this oil that remains in the ground after our wells cease to flow and to pump will be brought to the surface in the future by methods of secondary recovery.

It is clear from this resume that our proved reserves in this country are still only a minor fraction of our total petroleum resources in even the presently blocked out fields. But we have not yet considered the most important single item in the list of our petroleum resources; namely, the oil still to be discovered in the United States by further exploration.

We have observed that the total area actually productive of oil in the United States grew from 39.5 square miles in 1874 to 284 square miles in 1882, and

to 3300 square miles in 1925. By 1943 the productive area had expanded to about 8000 square miles. And from our accumulated experience in exploring for petroleum over the last 80 years we have learned that where exploration is conclusive, that is, where we test thoroughly by drilling closely spaced wells through the entire thickness of the petroleum-bearing rocks, we can depend upon a minimum of about one percent of the territory we test actually to produce oil. In territory of first-class promise the proportion of productive to non-productive territory is higher; often it runs up to two or three percent.

On the basis of our experience, therefore, we should eventually find not less than about 15,000 square miles (one percent) of oil-producing lands out of the 1.5 million square miles of territory in the United States in which oil fields may be expected. So far we have proved only 8000 square miles. In other words, we appear to be not more than about half way through with this job of finding the oil of the United States.

Over the last 20 years more than 50 percent of all our discoveries of new oil reserves have been made in Texas. Over the same period nearly 35 percent of all the oil we have produced in this country has come from Texas. About 60 percent of our present proved reserves are situated in Texas. And nearly 50 percent of the current production of American oil fields comes from Texas. Yet the area which has so far been proven productive in Texas is less than one percent of the total area in Texas in which it is reasonable to expect oil fields to be found. Out of about 285,000 square miles

of territory promising for oil in Texas only 2660 square miles are yet productive. The area already productive of oil in Texas contains nearly two-thirds of the total proved reserves in the United States although it constitutes only one-third of the total productive area in the United States. Clearly the search for oil in Texas is far from complete and clearly also most of our oil-finding effort in the United States in the past has been devoted to territory which has yielded far smaller reward than may be expected from Texas and adjacent parts of the Gulf Coast region when these areas shall have been thoroughly explored.

Reputable geologists and engineers are almost invariably conservative in their estimates. Those who have issued estimates of petroleum reserves in the past have uniformly underestimated these reserves. In 1922, the United States Geological Survey, acting jointly with the American Association of Petroleum Geologists, estimated our remaining proved reserves at 5 billion barrels. Looking back at the fields they dealt with today, in the light of hindsight, which permits us to calculate almost exactly the total output which will finally come from these old fields, now largely depleted, we find that the reserves in 1922 really were 8.4 billion, instead of 5 billion. In other words, the actual reserve was 168 percent of the estimated reserve.

When the Committee of Eleven in 1925 estimated the proved reserve at 5.3 billion barrels, we actually had 8.3 billion barrels in the reserve as is proved by the producing history of the fields in question since the estimate was made. In this case the true reserve

exceeded the estimate by more than 50 percent. Yet the estimate of the Committee of Eleven was received with strong disapproval. It was branded as an attempt by the petroleum industry to allay the fears of imminent shortage by inflating its estimate of our proved reserves. Accordingly the Federal Oil Conservation Board, established by President Coolidge, reviewed the facts and in 1926 issued their own estimate, which reduced the proved reserve to 4.5 billion barrels. Actually as we can now determine precisely, the proved reserves in 1926 had increased to 10.7 billion barrels, so that the official estimate was only 40 percent of the actual reserve.

In 1932 the Federal Oil Conservation Board estimated our proved reserves at 10 billion barrels at a time when, as we know today from subsequent developments, the reserves actually amounted to 18.4 billion barrels. The actual reserve, then, was 80 percent larger than estimated.

In view of these considerations, we should hardly conclude that we shall run out of oil in 14 years because our proved reserves are now estimated to be equal only to 14 years' requirements. Judging from past experience, it is quite likely that we have underestimated our present reserves as we have invariably done in the past. In any event, at the present state of development of our industry our proved reserves are only one item, and not the most important item, among our petroleum resources.

Another fact widely interpreted as an evidence that we are running out of oil is the decline in the rate of

finding new oil fields in recent years. We have found fewer new fields since 1938 than we did in a similar period in the 1920's. But one reason for our failure to find new oil fields is our failure to drill a sufficient number of exploratory wells. There has been too little incentive to the wildcatter. We entered the first period of national emergency with the highest proved reserve in history. Crude-oil prices were too low to afford any stimulus to the search for new oil fields and it has been impossible to raise prices under the policy of war-time controls we have adopted. War priority also has necessarily denied to the oil-finding branch of the industry adequate manpower and adequate supplies of critical materials for a vigorous campaign of test-well drilling—and we can't find oil without drilling wells in search for oil!

In the last analysis we find oil only by drilling test wells down into the oil-bearing rocks. The intensity of our search for oil is best gauged by the number of wells we drill in that search. The more energetic our search for oil, the more wells we drill that fail to find oil. These failures we call dry holes. A dry hole is a well drilled in search for oil which fails to find oil (or gas). We have kept a record since the earliest days of the industry of the results of the wells we have drilled; the total number of wells drilled; the number of successful oil wells; of gas wells; and of dry holes. This record enables us to compare the intensity of our search, year by year, over the life of the industry.

In the two years preceding the First World War, the years 1912 and 1913, we drilled 7,160 dry holes in the

United States; whereas in the two war years themselves, 1917 and 1918, we drilled 10,515 dry holes. In other words, we searched more intensively as our needs for oil increased during the war than we had searched previously. But in the two years before the present war, the years 1937 and 1938, we drilled 12,463 dry holes; whereas during the war years 1942 and 1943, we have drilled only 11,808 dry holes. In this case our effort to find oil has become less intense as our need has increased.

In 1943 we drilled all over the United States only 6,200 dry holes against a five-year average over the last half of the 1920's of 7,200 dry holes per year. In Texas, which is first-class hunting ground for new oil fields today, we drilled only 1,761 dry holes in 1943, against a five-year average of 2,800 dry holes per year for the period 1925 to 1929, inclusive. We are not putting as much effort into oil-finding today as we did 20 years ago.

Certainly the job of finding oil in the United States becomes more difficult every year. Our finding effort must be stimulated and assisted in every way possible. We need to drill a great many more exploratory wells than we did 20 years ago. Our needs are twice as large and fewer fields remain to be discovered. According to P.A.W. we only drilled 3,600 exploratory wells last year. We should have drilled three times that number. But there is no evidence in our experience that we are already at the end of the procession of new oil fields that has been a continuous spectacle in this country for eighty years. On the contrary, the evidence does indi-

cate that the job of oil-finding in the United States is far from finished. If it is true that the task becomes more difficult each successive year, it is also true that our search becomes correspondingly more efficient.

I do not contend we shall always continue to find new oil fields in this country nor that we shall always be self-sufficient in domestic supply. On the contrary, for many reasons, we may anticipate a gradually increased need for imports in years to come. Let us turn, then, to look at petroleum in the world at large.

It became apparent to the early students of the occurrence of petroleum "that the total amount of petroleum underlying the surface . . . is large beyond computation." The very processes by which the crust of the earth is formed are of a character which makes petroleum an inevitable product of their operation. Where then are the principal petroleum resources of the earth to be sought? From our knowledge of the origin of petroleum and the nature of petroleum accumulations in the earth's crust where would we go most logically in search of petroleum?

Most of us believe that petroleum has its origin in the organic remains of former marine life which became entombed in the sediments on the floors of the seas of past geologic ages. If this is true, the sedimentary rocks formed on the floors of old seas in which marine life was most abundant should be most promising for petroleum. But there are other considerations; we have found that there is but little organic matter in the sediments that reach the bottom of the deep oceanic basins; the organic matter must be preserved from oxi-

datation and decay and actually entombed in the sediments before it is devoured by marine scavengers; there must be a thick, extensive series of sedimentary beds to permit the accumulation of large volumes of petroleum.

Without any attempt to sketch here the theories of origin of petroleum, it may be stated that rich petroleum resources are to be expected in the rocks formed from marine sediments deposited near shore, where marine life abounds and where great loads of sediment are poured rapidly into the sea by streams from the adjacent lands. The sites occupied by land-locked seas in the past are particularly favorable and when we look about over the earth for evidence of conditions which would best fulfill these specifications our attention is very soon drawn to those conspicuous depressions in the earth's crust, still occupied in large part by land-locked seas, which separate the continents at their points of closest approach to each other.

There are four great regions on earth characterized by these depressed segments between the continents. The best known is the Near and Middle East, the Mediterranean region of the Old World. Lying at the juncture of the continents of Europe, Asia, and Africa, much of its surface is today depressed below sea level. It is occupied in part by such land-locked bodies of water as the Persian Gulf, the Black, Red, Caspian, and Mediterranean seas. It is a region of "seas in the midst of the land" and it is the site of the greatest petroleum resources so far discovered in the earth's crust. The Union of Soviet Socialist Republics is in a

dominant position in this region and most of her developed oil fields are situated within its boundaries, but Great Britain, France and the United States all have large reserves there, also.

Next most important today among the petroleum-bearing regions of the earth is the inter-continental basin lying between the continents of North and South America, occupied by the land-locked Gulf of Mexico and Caribbean Sea. The oil fields of Trinidad, Venezuela, Colombia, Mexico and our own Gulf Coast region fall in this province.

In the Far East, the land-locked seas which occupy the shallow basin lying between the continents of Asia and Australia are studded with the large islands, Borneo, Sumatra, Java and New Guinea, which together comprise another of the great petroleum provinces of the earth. Prolific oil fields, developed many years ago by British and Dutch capital, and others, developed later by Americans in this region are now held by Japan. In the main, however, the petroleum resources of the Far East remain yet to be explored.

There is a fourth great inter-continental depression which, except by the forward-looking Russians, is not generally recognized and has so far received but little attention from the petroleum-seeking nations of the world. This basin surrounds the North Pole, is occupied by the Arctic Sea and lies between the continents of North America, Europe and Asia. We usually think of the waters covering the North Pole as an ocean but in reality they constitute a relatively shallow, land-locked sea, into which sediments have been transported by the

streams draining three great continents throughout much of geologic time.

Evidences of petroleum are conspicuous at many places along the coasts of the Arctic Sea. There are copious seepages of petroleum near Point Barrow in northernmost Alaska. A major oil field was discovered more than 20 years ago at 65° north latitude on the lower Mackenzie River in northwestern Canada and has been producing for a limited local market for more than 10 years. Seepages also occur on the islands north of the mainland of western Canada, and there are seepages of petroleum and natural gas at intervals over a distance of 3,000 miles along the northern coast of Siberia.

Several years ago I had occasion to point out that this natural distribution of the principal petroleum resources of the earth bore a fortunate relationship to the centers of population and industry of the various peoples of the earth. The greatest known resources, those of the Near and Middle East, are admirably situated to serve Europe's 350 million inhabitants, along with part of the needs of the Union of Soviet Socialist Republics, the boundaries of which include a portion of this region. This great country, the Union of Soviet Socialist Republics, which more nearly than any other nation is self-contained as to petroleum resources, shares also in the petroleum resources of the Arctic. The peoples of the Western Hemisphere, of North and South America and the West Indies naturally draw upon the centrally placed petroleum resources of the Gulf of Mexico-Caribbean Sea region. North America

will share extensively, also, in the petroleum resources of the Arctic, when these are developed. For the future needs of the teeming populations of the Orient, the rich petroleum resources of the islands lying between the continents of Asia and Australia are most conveniently placed.

Our great stake in the petroleum resources of the Arctic is the territory of Alaska. It is a remarkable circumstance that the petroleum resources of Alaska have never been developed. To be sure, Alaska appears cold and remote to most of us but it is in reality near at hand, and enjoys an equable climate, in comparison with the Middle East, to which our Government now feels obliged to turn in search of petroleum. The natural seepages near Point Barrow, as described in official Government publications many years ago, are as impressive as the famous seepages that led to the first exploration in Mexico and Venezuela in the early years of this century. Alaska has been American territory over practically the entire life span of the American petroleum industry. In our search for petroleum in that time we have drilled one well for each three square miles in the United States but in Alaska we have drilled only one well for each 10,000 square miles. Yet there are some 200,000 square miles of promising territory in Alaska marked at various places by oil seepages. Like California, Alaska first attracted the pioneer by its great wealth of gold but it will not be surprising if Alaska, again like California, eventually produces a still greater wealth of liquid gold in the form of petroleum.

There has never been the same freedom for private enterprise to drill wells for oil in Alaska that we have enjoyed in the United States proper. The petroleum resources of Alaska are almost entirely in the hands of the Federal Government. For the most part, they are administered by the Secretary of the Interior, but some 35,000 square miles of the region surrounding the seepages near Point Barrow were set aside many years ago as a petroleum reserve for the United States Navy.

No wells have ever been drilled on this reserve, so that it was totally undeveloped when the Japanese attacked Alaska. Consequently, the United States Army found itself compelled to take over an adjacent oil field discovered twenty years ago by private enterprise on the lower Mackenzie River, in Canada, as a local source of gasoline supply for its operations in the Alaska sector.

The situation with respect to the petroleum resources of Alaska prevails over much of the earth's surface. The world's petroleum resources remain undeveloped. Petroleum is obviously a normal constituent of the marine rocks of the earth's crust, widely disseminated beneath the surface. The immediate problem is not any dearth of petroleum but the exploration and efficient development of the resources we have already identified and the equitable distribution of the products to potential consumers everywhere.

Within our own country we have erected, on a foundation of abundant cheap energy derived from petroleum, the highest average standard of living enjoyed

by any nation. We consume per capita more than thirty times as much petroleum as the rest of the world. The mechanical work done for us by petroleum equals the manpower of 4 billion able-bodied human slaves laboring eight hours a day, six days a week, year in and year out. No other nation has developed its petroleum resources with such great advantage to its industrial and social economy. In this achievement America is a generation ahead of other peoples; abundant petroleum distinguishes our social order from that of any other nation.

How does this fortunate state of affairs—this abundance all over our country of cheap mechanical power and fuel derived from petroleum—come about? For many years we have been asked to believe that the abundance of petroleum in our country results from our good fortune in having been blessed by nature with unusually rich petroleum resources. We know today that this is a totally mistaken view. Petroleum resources richer than any with which our own country has been blessed, for example, are just now being developed in the Near and Middle East, on the opposite side of the globe from the United States. In comparison with them our own resources appear rather meager. Yet there, at the very back door of a Europe starved for cheap petroleum products, those bountiful resources lay for more than fifty years after our own industry began to supply the world with oil, almost totally neglected by all nations except Russia.

What we in America have been blessed with is a genius and a heritage of political and social concepts

that have enabled us to explore for petroleum more effectively in our own country than any other people on earth. The prime requisite to success in oil-finding in the United States has been freedom to drill wells everywhere in search for oil. Only slightly less imperative is freedom to develop and produce the oil, once it is found. In these freedoms (as in many other freedoms) America has been blessed.

The American petroleum industry could hardly have succeeded in any European country as it has at home. If the natural resources of a nation are held by the crown, or the commonwealth, or if they are locked up inviolate under the estates of a landed aristocracy to which the average citizen is denied entry, then no enterprise of the character of the American petroleum industry can attach to them. It is to state regulation and long established social barriers, rather than to a paucity of natural resources that the failure of many nations to develop petroleum reserves within their own boundaries is to be attributed.

The current issue of "The Atlantic Monthly" carries a thoughtful essay by Joseph E. Pogue under the arresting title: "Must an Oil War Follow This War?" It is idle for a civilian to speculate on the quantities of petroleum needed for military purposes and I shall not do so. In war-time we gladly give up many of our peace-time necessities to the war effort, including petroleum. Under these circumstances, it is inevitable that shortages must develop. But in the case of petroleum it is my conviction that for peace-time use after this war we face no critical shortage nor any necessity

for an "oil war." On the contrary, I believe we can safely anticipate a growing abundance of petroleum to an increasingly large proportion of the world's inhabitants. What we need to learn is how to live at peace in a world where everybody has an abundance of petroleum and enjoys the same blessings of cheap liquid fuel that we first obtained for ourselves after the close of the last World War.

The world needs desperately to explore fully and develop its petroleum resources. This is a task the American industry is well qualified to undertake. If political and social conditions over the earth could be modified to permit everyone to go about the job of oil-finding everywhere in the same way we have followed in the United States, there should be little difficulty in establishing petroleum reserves adequate for man's needs over the long future.