WORLD PETROLEUM SITUATION

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CAPTAIN ALEXANDER: Gentlemen: The Wright Field trip we have been talking about this morning will depend for power on petroleum resources. It may well be that in the long span the use of petroleum as an energy source will be only a flash in the pan of time. However, we all realize that right now petroleum is of crucial importance to both our domestic economy and the national security. In order to give you a picture of the world petroleum situation, we turn to another well-qualified member of the faculty, Lieutenant Colonel Marcus R. King, United States Air Force. Colonel King has had experience as a civilian in the petroleum business. He was with the Skelly Oil Company as division manager for Chicago. While there he was instrumental in developing the liquefied petroleum gas business which is now so important. During the war he came into the Air Force and has had both logistic and operation experience while he was with the S-4 of the 93d Bombardment Group. After the war he was with the Army and Navy Petroleum Board and with the Armed Services Petroleum Board. In addition to that he was also a graduate of this college, Class of 1948. I take great pleasure in presenting to you Colonel Marcus King, who will discuss the "World Petroleum Situation."

COLONEL KING: Thank you. General Holman and students: I am glad you did not classify me as an expert. Being in my home town and having no brief case leaves only one category to put me in. I think the most important fuel and source of energy for both peacetime and military economy is petroleum. More than 50 percent of our present energy comes from petroleum and natural gas. Some 40 percent of the United States chemical industry is based upon petroleum and about 50 percent of our explosives come from petrochemicals.

Because of the limited areas in which petroleum can be found and because it is used primarily in areas other than those in which it is found, with the exception of the United States in general--and probably California is the best example anywhere in the world where you have supply and demand somewhat in balance--you must consider it on a world basis. It is an item equally essential to military and civilian economy. Both demands run into millions of barrels a day of some 500-1,100 products, plus a good many base stocks for the pharmaceutical and chemical industries.

From your crude oil comes not only the fuel and lubricants to keep vehicles and planes running, but the rubber they ride on, the toluene base for explosives, the wax to keep food packages air and moisture free, and--as an oil man I hate to admit it, but I am inclined to think--the canned butter we gagged on in the tropics.

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I have a few slides here which I must apologize for before I show them. I use the original charts on the road. They are rather beautiful pieces of work, but in photographing them to make the slides, the colors did not become as contrasting as I would like.

The first chart indicates the world reserves--the sources of petroleum. These darker areas through the center here are where the proven petroleum reserves lie. They generally follow the eastern slopes of the mountain areas in the United States, down to South America; some on the Gulf Coast; up to the northern tip of Alaska; over into the European continent, where it is very very limited; and scattered all over Russia. These are the reserve areas where it is considered probable and possible that you will find petroleum as you explore the areas. (Charts were not reproduced.)

There are some areas where, it seems to me, at least under present knowledge, and probably true all the time, due to the rock structure, petroleum never will be found.

The United States for many many years has been producing roughly about two-thirds of the petroleum used in the world, from about one-third of the proven reserves. The Middle East development in recent years and other places have changed the percentage ratio; so at the present time we are producing a little better than 50 percent, from less than one-third of the proven reserves of the world.

The proven reserves of the Middle East are regarded as the greatest known. South America falls between the United States and the Middle East in production. The black-red area here shows there is still, by far, very much more demand in the United States compared to the other areas.

The bars on the chart will indicate the relationship between these areas of North America, South America, Europe, which is very small; USSR, and the Middle East countries, divided here, with these areas generally stretching clear up to the top of the chart, somewhere in the neighborhood of 45 to 50 billion barrels reserve, the total world reserves approaching 100 billion barrels.

Of course these proven reserves on the chart are an educated guess, based on the knowledge of individual producing fields which have been obtained from drilling and exploratory work and a study of pressures and flow. In areas where such information does not exist, the probable reserves are estimated by comparison with similar known areas. The amount of reserve is constantly changing, being revised as additional facts become available. Here in this country we operate on a very conservative basis in proving reserves. The initial year figures are worked out, and each year additional reserves may be added, based on what has been learned during that year.

It is sometimes said that we would find we had considerable amounts of reserves just by pushing a pencil every year. It is true, original estimates are figured on a conservative basis. The Russians have followed a different method in figuring their probable and potential reserves. Some of their figures come out in multiple boxcar numbers.

The reserves problem is open to a great many opinions, no two authorities coming up with the same result. The figures are always subject to revision as more knowledge becomes available in any specific field. We have had a couple of developments in this country in the Scurry County Canyon Reef and Spaberry Trend, both in the vicinity of Midland, Texas. Both of them have had the oil man's enthusiastic and optimistic reserve guesses running from 1 billion to 10 billion barrels. Some of the old lease holders in that area who were not without knowledge in the petroleum business have very red faces after having let their leases go to find out that a great potential existed there. The oil business has always been like that. Oil is still where you find it.

In this connection you have heard sometimes in hearings on the Hill that the United States has oil only for 10 or 14 years. That is another of those statistics that are unrealistic and is derived from dividing a reserve figure by annual consumption. Since the oil business has been in operation in this country, this figure has remained somewhere between 13 and 14 years. We are continually adding by exploratory work and new developments in old reserves, and still the demand has doubled and tripled over the years. In fact we are using now more than twice as much oil in the United States as we did just prior to going into World War II. We still maintain the 13 or 14 to 1 ratio. A petroleum well on discovery will probably produce for a short time at rather a high level and then settle down to a steady flow which declines from year to year, depending on what kind of a drive you have in the field that is pushing the oil toward the well.

All of your oil cannot be taken out on the ground; under present known methods somewhere between 40 and 80 percent still remains in the ground, varying from field to field. That percentage is being decreased quite remarkably in recent years as better techniques are developed. One old field down in southern Illinois was practically out of operation. The operators had been using water to push the oil out; they used gas and in less than 18 months they produced a million barrels that they originally thought they would never get. Probably with development of better techniques we will have reserves that in future years may produce more for us than new discoveries will.

Some of the original Pennsylvania wells are still producing after 91 or 92 years, but generally we have declined in the United States about 7.5 percent a year. For this reason we must drill new wells

continually to equalize this decline and to maintain a constant rate of production. If we want more, we have to drill new wells. We have been drilling them since 1948 at a terrific pace and have reached over 40,000 a year. In August 1951 we drilled 4,000 wells. The goal for the year is 43,843 to maintain our production and increase it as much as possible to meet current demands which are 20 percent more than they were a year ago. To produce four times the increased demand industry has had over a period of years, we are having to go deeper and deeper to find new weels. Those 4,000 wells drilled in August represent about 16.5 million feet of pipe put into the ground.

For the eight months so far we have drilled nearly 30,000 wells. You have the situation that you don't always hit oil. It still is where you find it. In August we drilled about 1,500 dry wells. That percentage is generally true through all of this activity. In Wyoming one well has been drilled to over 20,000 feet but the average depth in the United States is 4,000 feet.

I think it is evident that we will not run out of oil in 10 or 20 years, but demands will have to be met from different sources. Responsible authorities are of the opinion that we will probably reach a peak production of between 6 to 7 million barrels daily and then decline slowly. Our immediate production is over the 6 million barrel figure, running 6.2 million barrels a day. The estimates might be wrong.

To illustrate briefly the situation in the United States: Every 12 minutes a new well is drilled somewhere in the United States. Every 23 minutes a new producing well is proved. For every 100 wells we drill we put 48 on pump and abandon 52. Every time your watch ticks, every second, we are using well over 3,000 gallons of oil. That is about three tank cars of oil gone down the drain as I made that statement.

The world demand is indicated on the charts. As I said earlier, estimates can go very high in the petroleum industry. Whenever anybody is talking about petroleum, he should put a date line on any chart or set of photographs and probably the hour as well. I don't know of any industry that has gone through more fluctuation over the years. Back at the time of the First World War we felt we were running out of oil. We did everything in the world to get production back. Then East Texas was discovered and we had an abundant supply. It has gone up and down, up and down. The industry felt there would be a decline in demand after World War II and found that the demand did not decline but increased at a great rate. For two years or so it looked as if we had plenty of oil. Right now we are being pushed to meet the situation which the demand has caused in the United States.

The bars on the chart show the relative positions--I don't want to give a lot of figures, because before I am through they will be different. The black bar on the chart of World Demand is 1947. It was running

about 5 million barrels a day. In 1951 in the early part of the year we used in the United States a little under 7 million barrels a day. The Bureau of Mines' last figures for this quarter show we are using over 7.5 million barrels a day; for the first quarter of next year, we will use well over 8 million barrels a day.

Other countries of the world, of course, do not spproach our demands. Western Europe, other than the satellite areas, has a considerably smaller demand, as you can see. The Marshall countries of Europe for 1947 used comparatively little; in 1951 they will use 1.5 million barrels a day. The Far Eastern Hemisphere does not have the increase that they are expected to have in the western European Marshall countries, due to the economic situation.

In making estimates there must be a good many assumptions. They are not always assumptions borne out as time goes on. But with the tremendous demand, the question arises, of course: Where can it be obtained for the world, and for us in particular?

Venezuela has always been the best traditional source for us, after the United States. Our production is considerably different from the demand, as I said earlier. California is probably the only very nice example of where we have production and demand somewhere in balance. The United States was for many years fairly well in balance. Now we are running about a million barrels a day greater demand than we have production.

The world production in July was a little bit over 12 million barrels a day. This production rate was not expected to be reached until about 1952; but things have gone haywire for the estimates and calculations and demand has jumped away ahead of what anybody figured. We find the United States running to 7 million barrels when we include the condensates and natural gasoline. The western European countries approach a sizable figure, running better than 2 million barrels a day. Venezuela, being the largest producer in South America, approaches 1.7 million barrels a day.

The production of the European Marshall countries is spread as follows: some of it on the German-Holland Border, a little more in Germany, and a little bit in France. Then, Canada has about 900,000 barrels a day production. The Eastern Hemisphere countries produce about 3 million barrels a day. Mexico, for a number of years was a good source, particularly for heavy crudes, but after the expropriation in 1938 its production declined. The Mexicans got it back after quite a few years to approaching what they did before the expropriation. They have a couple of contracts that were agreed upon between some American drilling contractors and the Mexican Government, which controls the industry, and they have made some new discoveries in the last year; so production is increasing there.

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Canada has probably the brightest future in the Western Hemisphere for the next few years. A great deal of production goes on in the Alberta area and, like the Scurry County setups, its potentials are fantastic, estimates from 1 billion to 20 billion barrels. I think the Canadian Government gives its estimate of proven reserves as a little over a billion barrels.

The Middle East is a petroleum area of a promise fulfilled beyond the dreams of Aladdin when he rubbed his oil lamp. There they have wells producing 10,000 barrels a day. It seems to me it would be well to compare that with the production here in the United States where we had 450,000 wells last year, with an average production per well of just a shade over 12 barrels a day. In the Middle East, all of the wells there, of which there were about 343 at the first of the year, the average production of all of them was over 5 million barrels a day. In Venezuela where there are about 7,000 wells, production averages about 240 barrels a day.

It brings up a rather interesting problem for a planner in a national emergency--things you are right up against such as shortages of steel and manpower. If you desire to get the maximum barrels of new production throughout the world in terms of wells, here is what you are up against: The United States in order to get a barrel a day in new production takes almost five tons of steel; in South America, a little less than one ton of steel; in Venezuela, specifically, about one-third of a ton; in Saudi Arabia it takes .021 tons of steel. There are many other problems to consider, but from that angle alone it makes the Middle East very attractive in terms of steel. There are a great many factors that help it. One is sole ownership of concession which makes it possible to make developments which allow them to operate on maximum efficiency. They don't have to worry about the fact that individual leaseholders want to do this or that. That is of interest in the long-range pull.

The Middle East area is quite the bone of contention. In the Arabian Peninsula, the major oil interests operating at the present time are settled in this area in Saudi Arabia and Bahrein Island, which are American Concessions. The oil is shipped out by means of tankers and by a new pipeline which opened last December. The line runs a little over 1,000 miles to the Mediterranean. This pipeline has a capacity of 300,000 barrels a day; this capacity can be increased with some additional pump equipment to 500,000 barrels a day.

To the north, is the largest development in terms of pipelines, particularly, in the Iraq area at Kirkuk and surrounding that particular area, where oil is piped out to the Mediterranean about the same distance as it would be to pipe it to the Persian Gulf. It then goes out by tanker shipment to Western Europe and the United States. It was estimated that

the "tap line" from Saudi Arabia resulted in a saving of 62 tankers on this route through the Persian Gulf and around the Arabian Peninsula and through the Red Sea and Suez Canal.

In World War II when there was considerable difficulty near the Suez Canal and the Mediterranean was closed, oil had to be brought around the African South Cape, which route increased the time and the number of tankers necessary to about double the number needed when using the Suez Canal route. There were two lines from Kirkuk originally put in, of small diameters, running one through Syria and the other down through Palestine. At that time the British protectorate was in at Palestine, so the situation seemed secure and they built a refinery at Haifa, which handled 90,000 barrels a day. This has been out of operation since the Arabian-Israeli conflict has been going on. You could draw a few tankers in there from Venezuela, but it is an expensive operation running a tanker from Venezuela over to that area. The Egyptians have put an embargo on any tankers calling at Haifa, so that the southern line has been closed for a number of months. Two lines of larger diameter, paralleling the two original lines have been built, one of which is in operation to the coast in Syria. The other one stops at the Palestinian border. A large diameter pipeline is being built from Kirkuk to the Mediterranean and should be finished the latter part of next year.

The operation in Iraq is owned by four major groups. You have the British, Dutch, French, and United States companies in there, and a 5 percent interest held by a gentleman by the name of Gulbenkian, who originally obtained the concession rights from the Turkish Government. I would love to have a 5 percent interest in his 5 percent. He is reputed to be the wealthiest man in the world. A few months ago he had some of his art collection exhibited here at the National Gallery.

Iran has been under development for a number of years. The development was started by an Australian named D'Arcy, a number of years ago. Then in 1908 or 1909 the largest part of the development was started. It has the world's largest refinery with an output of about 500,000 barrels a day, almost twice as large as any we have in the United States. It has unfortunately been shut down for the last few weeks, since the nationalization of oil by the Iranian Government.

There are other developments--one is Kuwait, a small sheikdom at the head of the Persian Gulf. It has the largest known petroleum pool in the world. The Texas boys are disputing that, using as a comparison their Canyon Reef and Spaberry Trend. Maybe they're right. There are two other pipelines planned in that area; one from Kuwait, another from Abadan. These are out of the picture until the present situation is settled.

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In any study of petroleum, you must consider the balancing of supply and demand or so-called world flow. In this chart the upper part of it shows the situation which existed in 1938, and the lower part shows what is estimated will exist about 1953. The Iranian situation has put a few crimps in it at the moment, although we were approaching some figures, indicated on the chart for 1953, this year. In 1938 western Europe got the major portion of its petroleum from the United States, Venezuela, and other points in the Caribbean area. The volume is indicated by the thickness of the lines. I won't give you a lot of figures; they are pretty well upset at the moment. They are not too important to us unless we understand the relative position. The Middle East was in fair production. A reasonable amount from here, not quite comparable with what was coming from the United States, went to Europe and other points in the Far West.

In 1953 your picture will be changed. There is considerable tension with the Iranian situation. If there is no more upset in that area, you will find the Middle East supplying western Europe something better than 2.5 million barrels a day in petroleum. The Middle East also will be supplying the United States a fair amount, which it has been doing for several years. The flow from the Caribbean to western Europe will be comparatively the same. The flow from the United States to Europe will be very much less, with Venezuela petroleum finding a larger market in the United States, also other places in South America where they have to compete with the Middle East. They lost a couple of sales in that operation in recent years.

Review in your mind what we have seen in the last few months. If you consider that all of this Middle East oil might be cut off overnight or in a very short period, what would happen to your world situation? If we want to maintain western Europe, which we do, I think it would mean that the Western Hemisphere, that is, the United States and Venezuela, primarily, at the moment, would be forced to try to supply the loss from the Middle East. We have had to do it in some degree at the moment, but we would be in a very tight and difficult situation.

In a little more detail: What is happening as a result of the Iranian situation? Historically Iran has been exporting about 150,000 barrels a day of crude oil to all places around the world. A great deal of its business went to western Europe; a portion of it went to India and other places in the Far East area. This has been replaced by increasing the production in Saudi Arabia, Kuwait, and the Caribbean. These areas have been able today to pick up practically all of the crude losses in the last couple of months.

Crude in the amount of 230,000 barrels a day was coming to the United States and Canada from the Middle East and Caribbean areas.

During August, when the pinch began to get tight, 75,000 barrels a day of this which we had been getting was diverted to Europe and was replaced by an increase in production of our own domestic crude. European refineries have a capacity to take another 190,000 barrels a day. There is considerable refinery construction now being developed in Canada and western Europe. Some of it is "on stream," and more will be brought "on stream" within the next few months.

The refinery at Abadan normally exported 460,000 barrels a day of refined product. This is now stopped. The major difficulty has been that 18,000 barrels a day of aviation gasoline which they produced went--some to western Europe, some to India, and some to Southeast Asia. This created a very tight situation with no supplies and tight rationing in many areas, even as far off as Norway and Sweden.

During August 21,000 barrels a day of refined product was acquired in the United States and about 25,000 barrels a day above normal production were acquired from refineries in the Eastern Hemisphere and Caribbean. This leaves a deficit of 150,000 barrels a day in products; part of which is being made up by withdrawal from stocks.

If Abadan went back into operation tomorrow, it would take four to six weeks to put it back "on stream." Crudes could be shipped as fast as tankers were made available. But as time goes on day by day, the period of getting the refinery back "on stream" will increase.

If means of agreement are reached, and if products continue to be purchased in the United States at the rate of 210,000 barrels a day, it will be necessary to increase diversion of the Middle East crude from the United States and Canadian refineries by 115,000 barrels a day above the August diversion of 75,000 barrels a day. It may be possible to supply this additional crude from domestic refineries by a reduction in crude stocks, if the United States companies will be willing to dip into their stocks when we are getting into the maximum demand for fuel oil, and the demand for tanker oil for shipping and Diesel oils for industrial use. If the United States companies will sell some of their surplus stock, the situation will be tight but workable.

If agreement is reached by the first of November, the supply situation will be more serious; it will be difficult to acquire products in the United States for export because of increased domestic requirements. It will require an increase in production and in refinery runs.

If agreement is not consummated until 1 December 1951 it will be difficult to meet the domestic requirements and make up the deficit created by the Iranian shutdown. At that time maximum crude and refining operations in the United States would be required to supply sufficient products to meet world demands.

If agreement is not completed until the end of 1951 or later, it will be impossible to supply the world demand at maximum production.

Just to give you an indication, the Asiatic Petroleum Company, buying agent for the British Government, has purchased for delivery from August through the end of this year, some 47 million barrels of petroleum--both crude and refined. For this month they are planning to have shipped from the United States 471,000 barrels of aviation gasoline, about 1.5 million barrels of motor gasoline, smaller amounts of kerosene, gas, oils, and heavy fuels, a total of almost 6 million barrels. Last month their liftings were 7.5 million barrels, requiring United States companies, with a great deal of reluctance, to dip into their stocks. Of the total purchases out of the 47 million barrels, a little better than 25 million barrels were in the United States.

Look at the situation so far as the military angle is concerned. prior to the Korean outbreak, the military demands were a little less than 300,000 barrels a day, about 3.5 percent of our domestic demand. Wartime military demands are a matter of constant study, based on current strategic concepts. During wartime they have run from 11 percent to as high as 21 percent.

It was said we were short 2 million barrels a day in the event of an all-out emergency. This figure is not too realistic. It was worked out on the basis that the continental United States would have the obligation of supplying petroleum to ourselves and allies regardless of where we were fighting. If we were fighting in the Persian Gulf area, we would have to supply oil from the United States. It is an academic figure. Maybe we will be short, but that figure depends a great deal upon the situation and what producing territories are open to us, denied to us, or overrun by the enemy, what lines of communications are available, and when and where the active theaters of combat would be, and so on. The military planner must of necessity look at the darkest situation in an attempt to cover himself in all eventualities. A surplus of crude oil is no good unless it is turned into the products we want to use.

On the first of January 1950, the world refining capacity was slightly in excess of 11 million barrels daily, of which 6.5 million barrels were in the continental United States. This has been increased to about 6.8 million in the United States and almost to 12 million in the world picture. This United States capacity, however, is concentrated in five areas: East coast, near Philadelphia and New York; near Chicago; near St. Louis; down on the Gulf Coast; and on the west coast, at Los Angeles and San Francisco; which is somewhat of a matter of concern from a defense standpoint. As you know when you get into the refining areas, you have one refinery next door, almost, or across the road from the other.

We have been obtaining both crude and refined products from the Venezuela area. It was the petroleum from this area and the petroleum shipped by tanker from the Gulf Coast that proved vulnerable to submarine attack in the last war and required the Big and Little Inch pipelines from Texas and Louisiana to the east coast to counteract the loss. These lines are in gas service at the present time. The contract calls for their recapture by the Government in case of emergency; but I doubt if they could be barred from supplying natural gas to war industries which are adapted for natural gas for their operating and which are not in a position to substitute other fuels rapidly. If you change to burning oil or coal, you are in trouble trying to meet any increased demands; so I think the lines will continue carrying natural gas. If we get into a similar situation we were in during the last war and we have the same submarine casualty results we had before, we have the right of way and some storage available along the lines; we could lay new lines if the steel could be obtained in a very short period of time.

In addition to the Caribbean sources, we have been importing some crude from the Middle East to both the east and west coasts and products to military points of demand in the Far East. A large portion of Navy Special Fuel Oil has been coming out of the Persian Gulf. Most of the British Navy fuel was coming out of Iran. It is cut off now.

In balancing the supply of crude with the refining capacities, you get into the question of products. The major ones we are concerned with are aviation gasoline, motor gasoline, Diesel oils, fuel oils, and lubricants. In peacetime the major emphasis on refinery runs in the United States is the production of motor gasoline, which is in greatest demand. In other countries it is Diesel and fuel oils. For many products there is little difference between the normal product supplied for the civilian economy and that needed by the military.

Aviation gasoline and jet fuels have little demand in the civilian economy. Before the Korean situation built up the aviation production, we had made about 91,000 barrels a day of 100 or better octane gasoline with the military using about 51,000 barrels a day.

Navy Diesel is a special product of a higher cetane rating than commercial Diesels. Navy Special Fuel Oil is not too far different from commercial fuel oils to present a great problem, except in the quantity required. The situation is very tight in this product at the moment. The requirement is about 2 million barrels in this quarter, and it has been necessary for the Petroleum Administration to order companies to supply this demand. The order is not due to any particular reluctance on the part of the companies to supply it, but they would have to increase their output to such a degree they would have to cancel large contracts and face damage claims. Other refineries were ordered to supply fuel oils to the military suppliers so that they can meet the commitments.

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A barrel of crude oil will produce an infinite variety of products, but when you maximize the production of any one product you do so at the expense of other possible products. The normal United States peacetime production runs about 43 percent gasoline; 5 percent kerosene; a little under 40 percent gas and fuel oils; and the balance lubes, waxes, cokes, asphalt, and refinery fuels.

The picture has changed over the years. In 1918 we were making 25 percent gasoline and better than 50 percent fuel oil.

During World War II the major problems in the refining industry were to produce 100/130 aviation gasoline, to increase the output from about 14,000 barrels a day to nearly 550,000 barrels a day, and to maximize the fuel output for the Navy. To do this, the aviation-gasoline program was quite a task. It cost 90 billion dollars, took a million tons of steel, and time--four years. It required considerable new facility construction and high-cost production to meet our demands, which required interchange of the component parts of gasoline from one refinery to another, and shipment by tank car from the east coast to the west coast. Maximum production was not reached until the spring of 1945. At present there is a theoretical capacity of a little less than this figure which could be put into production in a little less than 18 months.

Some of that problem has been brought back since the Korean situation. Things were pretty tight. The situation was close; fortunately a tanker got in, but things were bad; and in order to increase production, more drastic measures had to be taken. There was a lot of opposition. The easiest method would have been to change the lead content of the commercial grade of aviation gasoline, but the cries of the airlines were terrific. The military was using 4.6 lead and the commercial lines were using less than that; immediately, of course, it must be assumed that the military forces were not operating efficiently in the Air Force or Navy aviation which is fallacious. So they couldn't go along with that picture at all. It was possible to meet the aviation requirements without changing the lead content of the commercial gasoline.

Now our demand has changed--instead of 130 octane, we want 115/145, which has considerable effect on the availability. The 100/130 gasoline is a blend of high quality base gasoline stocks, plus alkylates or special components, codimers, cumene, and toluene, plus lead. To produce 115/145 it is almost entirely a question of special components, plus lead. It depends on the refinery, what kind of equipment or what stocks it has. As a result, as demand is increased from 100/130 to 115/145, the availability is cut about in half. If we had a capacity for 500,000 barrels a day of 100/130 and if we want 115/145 with that same capacity, we could get half of that amount.

The problem the military planner is faced with is: Shall we have higher quality and less gallons or more gallons and lower quality. As soon as we go into that, we set ourselves up for a lot of problems of equipment, storage, and transportation facilities.

Jet fuel is a new and difficult problem. The conventional type of jet fuel is essentially kerosene, virgin kerosene. Kerosene is 5 to 6 percent of normal production of crude or about 400,000 barrels a day. The civilian or domestic demand for this is pretty tight. It would be extremely difficult to cut off this or ration it deeply. Most of it goes to the New England areas where people use it for heating and cooking; people don't like to be cold or hungry. That caused the development of JP-3 and 4; taking part of the gasoline and part of the Diesel in the barrel of crude, producers came up with a product of which they can make considerable quantities. I don't mean we always get higher quality fuels. We have again the availability question; we have the problem of availability versus quality, and who can best be pinched and where. When we talk about a particular product in terms of a million or two million barrels a day, we must remember the facts of life; what we can or cannot do. That is true, and it is a problem which is studied constantly by the petroleum refiners. It is a problem of great magnitude. What can we do anout it?

Petroleum demand in the United States is increasing very rapidly. Our own United States supplies are limited; I think our own sources within the continental limits of the United States could not support a major war of global proportion. There is petroleum, if it can be found and new refineries operated. There's a lot of it left. We have over the years, even with the increased demand, maintained just about the same reserves. There's so much in the ground. Eventually, yes, we may run out, not get enough of what we want from our own sources. A great many plans have been suggested so far as petroleum itself is concerned--getting a larger portion from the Middle East, stockpiling our United States production, making more reserves like we have Naval reserves in California, and so on. It's no easy solution. And having reserves of petroleum would not be a solution unless there is refinery capacity to take care of the demand.

I don't think anything depreciates more rapidly than a refinery; it is always being rebuilt. There is stockpiling to meet the military demand of a magnitude of 2 or 3 billion barrels a day, at a cost of 2 or 3 billion dollars for oil alone. Then you get into steel for transportation, pipelines, terminal facilities, requirements, so you can have it overnight. Many products cannot be stored for too long without deteriorating. A large stock of products in storage would have a depressing effect on the economics of industry, as the possibility

of its being dumped on the market would always exist. The situation at present, where we have practically no surplus available, has not eased the pressure that existed a couple of years ago, when we had some market shortages of petroleum during the wintertime.

The answer to the problem lies in a combination of various suggestions. There is no question but that a vigorous, alert industry is essential, above all other things. A sensible importation policy will permit us to secure some foreign oil and yet will not injure the industry. There's a balance which will meet the demands; how much I don't know. There are other facets of the situation which reflect some brighter lights. Canada within the last three years has discovered and is beginning to develop petroleum reserves that may equal those of the United States.

Venezuela is producing quite rapidly, although the Venezuelans feel that they cannot anticipate much more increase in production in the immediate future. However, there is a potential in the tidelands of the United States.

Two fields are open to supply fuels and power in the future--synthetic fuels and atomic power. We wan't go into the atomic power. You have had considerable material on that and will have in other lectures. A great deal of research work has been done on the synthesis of coal, shale, and natural gas, and practical processes are available.

Both the Bureau of Mines and the petroleum industry have spent a great deal of money. A Bureau of Mines study plans on 2 billion barrels a day of synthetic fuel, the production of which will require a tremendous quantity of steel and manpower, about seven years of time, and billions of dollars, with top priorities.

The synthesis of natural gas is the easiest of the basic materials to convert. There is a commercial plant now under construction at Brownsville, Texas, which is expected to be in operation in the near future to produce 6,000 barrels a day of gasoline, 1,000 barrels a day of distillates and fuel, and various chemicals.

There is a question as to whether it is economically sound or wise to take natural gas, which is an ideal fuel, and convert it to another fuel, losing potential energy in the process. In this operation natural gasoline is removed from the raw gas. The "dry" gas is then burned with oxygen, recovered from the air to produce synthetic gas, a mixture of carbon monoxide and hydrogen. This mixture is then reacted in the presence of a catalyst to produce synthetic liquid products, which are then subjected to normal refining operations.

The oil shale synthesis has been given great consideration and publicity inasmuch as we have great quantities of this rock in the mountain areas of Colorado, Utah, and some other places.

To secure fuel from the shale requires three basic steps. (A piece of shale was passed around among the students.) You have to get it out of the ground, which is a material handling and mining project. The Bureau of Mines developed special techniques which have pretty well solved the problems involved there. The crushed shale is charged to the retorts and is heated to 800-1,000 degrees, at which temperatures the organic material breaks down and is distilled out of the rock. This product is of poor quality, containing a large amount of sulphur, nitrogen, and oxygen compounds admixed with a high percentage of olefinic and aromatic hydrocarbons. It is subject to hydrogenation and then normal refining processes. About twice the volume you put in comes out slag. There is the problem of deciding what you are going to do with it. There have been numerous ideas offered regarding the space around Colorado, and that the slag can be used to fill up a lot of holes there.

Then there is the problem of refining. A refinery requires a considerable amount of water; and there is not too great a supply of water in that area, which means the problem of shipping the raw product to the Chicago area or to the west coast area for refining. That brings in a few complications about pipelines.

The over-all yield is about 15 gallons per ton of shale, which means that a large quantity of rock must be handled mechanically to get a given yield of liquid products. Colorado alone has enough known shale to produce 200 billion barrels of shale oil.

Coal synthesis gives great promise as a source of synthetic fuels. As you know the Germans produced carbon monoxide and hydrogen from coal for various purposes and had built a sizable liquid fuel industry, employing an expensive batch process. In order for a process to be competitive in this country, a low-cost continuous method for converting the coal into liquid fuels is necessary. Government and industry are both working on this phase with some degree of success. The over-all yield at the present time is about two barrels of synthetic liquids per ton of coal; that is, about 50 percent of the heating value of the coal that is fed into the process can be obtained from the products.

The question of costs of synthetic production has had a great deal of publicity recently. However, in most cases there is considerable difference of opinion about what can be produced. In other words we are in a competitive business here and some sources are claiming prices competitive with crude oil. The difference between what the Government figures and industry's competing figures is largely based on what they have to put up as capital investment charges.

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There was a recent study made by two Stanolind men who approached the problem in a different manner to try to estimate costs in terms of what the consumer would have to pay at the service station for gasoline; they arrived at conclusions that the cost of gasoline from various sources at the service stations would be: Wyoming crude, as your base for gasoline, which is not the best crude, at your service station, 12.2 cents; natural gas base, 15 cents; using oil shale it is 22.5 cents; using Montana subbituminous coal it is about 27.5 cents; using Indiana bituminous coal it is 22.5 cents. They also concluded that there is very little choice between coal and shale as base stocks.

The Bureau of Mines estimated, not at a market center or gasoline station, a cost of 17.5 cents to 20 cents for gasoline from Wyoming bituminous coal, which price could be reduced by plant modernization to 10.1 cents to 15.6 cents.

Coming down to present standards, the price for gasoline is about 10.25 to 10.5 cents. The Bureau of Mines plan secures gasoline of 78 octane at a plant cost for a 30,000-barrels-per-day refinery--which is not too big a refinery--of 306 million dollars, taking 26 million man-hours construction time. This would make a refinery cost based on crude of about 10,000 dollars a barrel, as compared with normal refinery costs of about 2,000 dollars a barrel. There is not too much agreement between the petroleum industry and the Bureau of Mines.

Under present conditions the cost of synthetic fuel is such that it could not compete with natural petroleum. It will be probably 10 or 15 years before it is economically possible for it to enter the market, although it might play an important role as a supplementary source of fuel if we get into an emergency.

As a matter of defense, research and pilot-plant development should be pushed, and it is possible that some small commercial-sized plants can be built, gaining some operating know-how. Legislation along these lines is under consideration.

In this discussion I have exlcuded Russia from my figures because of lack of firm facts and figures on a lot of things. I believe, however, the Russians have access to sufficient barrels of petroleum and refining facilities torefine it, but will run into difficulties, particularly with aviation gasoline, What octane are they able to turn out? I have not been able to find out anything better than 92 or 93. They may be able to get something better than that but I have not been able to find it. Maybe some of you have more information on that than I have.

The Russians have large oil reserves, estimated between 5 and 8 billion barrels, and potential ones which before the war years according

to Soviet official estimates reached 60 billion barrels. Today's possible oil reserves calculated on the basis of geological data have increased considerably, inasmuch as the prewar estimates did not include the reserves of the Ukranian Salt-Dome Basin; the Taimyr oil bearing basin in the Siberian Arctic, and the basins of western and eastern Siberia and Kamchatka.

Last year Russia is estimated to have produced and refined 740,000 barrels a day, about one-tenth of the United States continental potential. This, with satellite production of 125,000 barrels a day, would be sufficient to meet most of its military needs with the exception of high-octane gasoline. The USSR figures may be conservative. You might give them another 60 to 70,000 barrels a day. Some people feel that the Russians have been shorting the official percentage figures they put out in order to cover stockpiling. That is open to argument. They have difficulties of distribution--lack of pipelines and drilling equipment--which make it difficult.

The major source is the Baku area, where they get some 60 percent of their petroleum. The Germans got down to the northern part of that area, the Grozny fields, and got them operating. Although they got little petroleum for the German war machine out of it, they had over-planned the operation.

Sakhalin Island, north of Japan, is a major source of development for oil to Siberian mainland and refiners in the Far East. They developed part of it at the end of the war, and they have been pushing production. They have pipelines to the mainland which are probably supplying a good portion of the military fuel for Korea. They have shipped some tankers of Diesel oil out of Roumania into Vladivostok. The second Baku beyond the Urals and Volga area is being developed which may take care of 50 percent of their production in the course of time. It is possible that they are hindered by the Middle East and the Far East situation, as well as the tie-up on capacity of the trans-Siberian railroad in transporting the original Baku and second Baku tank car shipments of oil. This should act as a brake for any large military operations in that area.

They have emphasized the jet aircraft, probably not only from necessity for defense, but due to their petroleum refining capacity. This refining capacity could make considerable jet fuel. That may have something to do with the emphasis on jet aircraft.

I have covered a lot of territory. I will stop now and leave some time for any questions that you may have.

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CAPTAIN ALEXANDER: Marcus is ready for your questions. Visitors are invited to join in.

QUESTION: Do you think we will have to go on gas rationing any time in the near future?

COLONEL KING: Motor gasoline, no. You are faced, I think, with what you have had in some areas, a drop in octane due to lead allotments, lead shortages, more than petroleum shortages. I think if you have oil in your house you had better keep your tank full this winter if you are on the east coast, particularly. I wish I had a larger tank than I have. I doubt if you get into any motor gasoline rationing, until sometime after we entered an all-out war.

QUESTION: What is being done about getting heavy fuels for jet use; in other words getting into something a little heavier, so that you don't get below what you have in JP-2 or 3?

COMMENT: JP 4 is standard fuel; it is JP-3 pressured with say five to seven pounds of pressure, using maximum column. There is lots of vaporization through the column. It is standard now, agreed to by the British scientists.

QUESTION: How does it compare with JP-1?

COMMENT: JP-1 is fine; it is commercial; anything standard is available right with it.

COLONEL KING: You are against the facts of life. Do you want to fly one jet plane or thousands? As I recall it, the Allied demand came in a couple of years ago, when they were figuring it for jet fuel. The demand was 2.5 times the world production. They would not listen to anything else. One JP-1 or 1,000 JP-3's--when are they going to learn facts?

QUESTION: I believe in the last war the transportation problem for petroleum products constituted actually about 50 percent of the tonnage moved overseas. Is that correct?

COLONEL KING: Quartermaster put out a figure of about 65 percent.

QUESTION: If we should deploy a comparable jet force overseas again, will we have the tankers to move the quantity of fuel required to fly the same number of hours? I don't think we will have.

COLONEL KING: You come back to the basic problem there. Do you want to or do you plan to fly as many hours with jet aircraft as with piston aircraft, since the jet as you know uses more gallons per hour? It is thinking in terms of convential type of aircraft; you draw plans; I don't know who made the original plan. Some of you probably worked on it. That came out as a strategic conflict.

After the war when each service came out with its own plan, we tried to wrap them up. Of course, Air Force had enough planes to block out the sky; Navy had enough ships so that you could line them up and have a bridge across the Atlantic. There wasn't enough of anything to fulfill plans. Those have been switched around. Something sound will materialize as you get a better planning setup and figures.

To come back to your specific question--tankers are too far behind, like the petroleum bases. At the moment the tanker situation is tight for the present demand, largely due to the rerouting because of the Asiatic situation. Anybody who ownes a tanker now can get any price he wants. He gets a multiple of the British rate, or the Maritime rate. Although I believe for any final effort we will be pretty well supplied with tankers, even allowing for some submarine losses comparable to the over-all losses during the last war. If we get hit on some of them like we did in those months in 1942 or 1943, it might be rough. It is not too easy, but it is not too rough a situation.

CAPTAIN ALEXANDER: Do you anticipate any large tanker construction program?

COLONEL KING: You have a fairly good-sized one under way now. The British yards now have many tankers under construction. The United States yards haven't been doing much due to differentials in cost. The British have been getting most of that business. There is a maritime-aid program to get large tankers; better than twice as big as T-2 and much faster. It is not too easy a situation.

QUESTION: In the event there was a scramble for the Middle East oil fields; they are very vulnerable to a bombing attack and could be very easily put out of commission, couldn't they?

COLONEL KING: The oil field is very rough to bomb--you have a well here but you may not have another well for a long distance. If you try to hit an oil well by bombing, it is a good trick. Sabotage, I think, is probably more of a hazard there. I have some decided ideas of holding the Middle East; they are based on an all-out attack.

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QUESTION: Haven't they gone into refining to a considerable degree over there, too, so you could put that station into commission?

COLONEL KING: Of course Abadan was the world's largest refinery. That is out of commission and probably going to stay out of commission. I don't see any solution for getting that back in the near future. You have two reasonably large refineries at Rastanova and Bahrein, at which the production is about 150,000 barrels a day each. The one at Bahrein was not completed during the war--we gave them money to set up facilities for producing aviation gasoline there. They changed over to crude distillation units. I think the figure they wanted was 12 million barrels. They were supposed to get back on aviation gasoline production; it could be done but at a high cost. However, most of the refinery output there is in these bunker fuels, kerosene, and a not too high-grade motor gasoline. In fact Abadab operators for a time were figuring on taking the light ends, out of which they get aviation gasoline, and putting them in the ground. There is no market for it. They could sell heavy stuff at the time much easier.

QUESTION: You have all the war plans built up except for petroleum. The others may be an unworthy attempt.

COMMENT: I think this is a good opportunity for me to advise this audience that petroleum is the most critical area today.

COLONEL KING: I am glad you made that remark, because I might say that in our own service there are a lot of people at the top who need some basic petroleum information. A lot of others have felt the need for it.

QUESTION: Why don't you put out some figures and educate people?

COLONEL KING: A lot of figures have been put out.

QUESTION: Colonel King, I am wondering if you have any data on the percentage of independent producers in the refinery business; that is, the little producers, the little refineries, their percentage in the over-all picture in the United States, and what role we may expect them to play in an emergency? Would they be curtailed or would we be expected to depend on them?

COLONEL KING: Reaching away back in the pigeonholes, I think somebody came in with a figure that 18 companies refine 60 percent of the petroleum. In the United States I think there are 375 operating refiners, taking in all classes. For your aviation gasoline, it takes a big refinery to make it; for jet fuels most anybody can make it, particularly going into JP-3 or 4, because that is pretty largely first-run proposition. You don't have to get into very expensive and very fancy operations to do it. But keep in mind, you have civilian demand for petroleum products, motore gasoline, heating oil, and certain grades of Diesel oil that they can make. That is going to have to be sold--whether the big refiner sells

it or the small refiner sells it, your small refiner is apt to go down. Usually they plan, like some of those out in Kansas, to produce over a course of several years, and then many of them go out of business; they move to a larger field. Producers who plan to face the economic situation build a good-sized refinery at the center of the market or at the center of the production where, like Texas, we have the case where you have a good supply for many years to justify your investment.

QUESTION: I was wondering about the economics of building such a large refinery in Abadan. It seems so far away from the market and is different from our economic principles of petroleum development.

COLONEL KING: Abadan started about in 1909 or 1910 as a limited type of plant making primarily bunker field. The market was for bunker fuel in the Aden Corridor area and near there. So they were forced--I think this is just the case--they could have made their refinery at one of these major shipping fuel supply points. The demand at any one point is not too great, so it was probably far better to build it at their source of supply rather than at their market, because the markets are so widespread that if they built at the market they would have to build small plants.

QUESTION: Have the services given any consideration to the utilization of alcohol with gasoline? Has any consideration been given to buying up all this surplus corn we have and making it into alcohol or storing it or stockpiling it?

COLONEL KING: The Bureau of Mines has been conducting experimental work in that field. There is a requirement for that in some South American Countries. There is the requirement that alcohol be used with gasoline for economic reasons. I think can be done.

CAPTAIN ALEXANDER: I think that is a good note on which to bring this discussion to a close. We have had a good example of what the CRIB teams are doing on the road and how effective they can be. Thank you very much, Marcus.

(13 May 1952--750) S/mmg