Oil Prospecting Drilling *and* Extraction

BY

F. J. S. SUR, E. M.

Petroleum Geologist

Oil Prospecting, Drilling *and* Extraction

MINES BRANCH
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F. J. S. SUR, E. M.
Petroleum Geologist
CALGARY, CANADA

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PREFACE.

For the man who desires to know how oil is found, the geological formations in which it is found and the methods that are used in its development and extraction this book has been prepared.

In the mining industry for the prospector, miner, geologist and engineer many books have been written. However, the prospector for oil, the driller and the general operator have never had any book giving any classified and systematic data. In this book I have, therefore, attempted to fulfill the requirements of the last mentioned.

Especially for Canada is this now needed, where vast areas of oil formations with tremendous productive potentialities lie unprospected when wells are being drilled in large numbers in other parts of the World where infinitely fewer indications for large production existed at the initial stage of development.

If the petroleum prospector can work from the standpoint of the trained geologist his efforts will be greatly simplified and will be much more effective. This book is designed to furnish the information that will permit the prospector to work in this way.

Petroleum geology has been a specialized profession only within the last ten years. Previous to that time all oil men chose locations for wells and did all other work by chance and by guess.

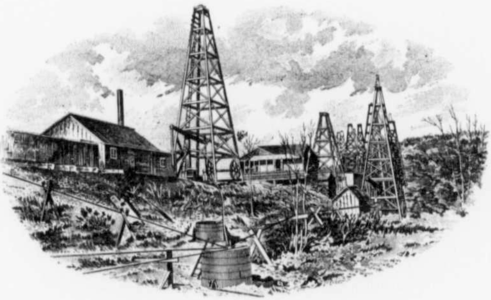
It is now for the geologist to find out the reasons why accumulations of oil occur in certain places. It is his duty to furnish classified information to the driller as to the formations which he may expect and the depth at which production should be encountered. The whole World has had to be studied in the acquisition of this data. As a result, all large oil companies have on their regular staff a geologist who chooses the sites of all wells, gives the driller information as to where to expect shifting sands, water, gas, hard and soft strata and much other data of the greatest value. No property ever passes into the hands of a successful oil operator or company without first having been passed upon by a geologist of established standing and integrity.

In this book I have used as reference all of the standard works on geology and petroleum. Such books as those by Hayes, E. H. Cunningham Craig and Beebe Thompson have proven most valuable.

For some of the plates and information I am indebted to the Oil Well Supply Company of Pittsburg and The G. S. Johnson Company of San Francisco. To my field assistant, Mr. E. H. Nichols, for data gathered in the field with me, I am also very much indebted.

If the information contained herein should reveal value in a property to some prospector who spends one weary month after another in searching out and locating Nature's hidden treasures, if it saves someone the thousands of dollars that it would cost to drill a well where there is no chance for production, if it should show a chance for production in a locality where it was thought no production could be had, or if it saves some operator from the heavy expense incidental to a fishing job or the loss of a well, I shall consider that my efforts have been well worth while.

F. J. S. Sur, E. M.,
Calgary, Canada.



OIL FORMATION.

ITS GEOLOGICAL HISTORY AND PROCESS.

From a wide range of reading of the best authorities of all the countries of the World and from a broad experience in many different countries, I have gathered much information of a valuable character.

So that chance may be eliminated, a great multitude of facts has been made available by Geologists, Chemists, Refiners and all Scientists who have unceasingly studied every phase of rock formations, action of gas, water, heat, pressure, oil; in fact, the gamut of physics applied to terrestrial and marine action.

So that the great petroleum horizons may be intelligently studied with the hope that the facts which each horizon reveals may be applied in a practical way to the many undeveloped areas, I present such information as I consider will be of practical value.

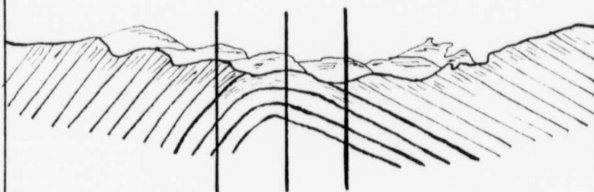
I have made no attempt to give a historical review of the means and methods used by the various authors and scientists to bring out the final result. In the evolution of the ideas of the formations of petroleum many theories have been advanced, a majority of which have been exploded and eliminated one by one until finally the theory herewith presented is now accepted by practically every authority.

There have been many theories evolved in recent years by chemists, geologists and oil men as to the formation of petroleum. Among these are: The theory of volcanic origin, the theory of animal origin, the theory of hypogene causes, the theory of vegetable origin, and many others.

The weeding out process has slowly brought the majority of the World's authorities to the conclusion favoring the theory of vegetable or organic origin of petroleum.

The natural distillation of shales and hydrocarbons found in the Earth's crust may have produced some petroleum, but it is the author's opinion that 90% of the World's supply of petroleum came from vegetable or organic origin.

The material from which the petroleum was evolved was deposited or grew in sediments in shallow water on tropical sea shores—tropical at the time of deposition—usually at the mouths of rivers or streams. At times the ocean overflowed the deposits so that strata of marine and fresh water deposits usually alternated, as proven by the fossils found in them and their materials of which they consist of the deposited



ANTICLINE WITH UNEQUAL LIMBS

ANTICLINAL FLEXURE WITH VERTICALLY INCLINED BEDS ARE OFTEN FAULTED OR DISTURBED.

organic matter over a great length of time allowing pressure, heat, gases and time to act on the sealed mass, which we now find as petroleum.

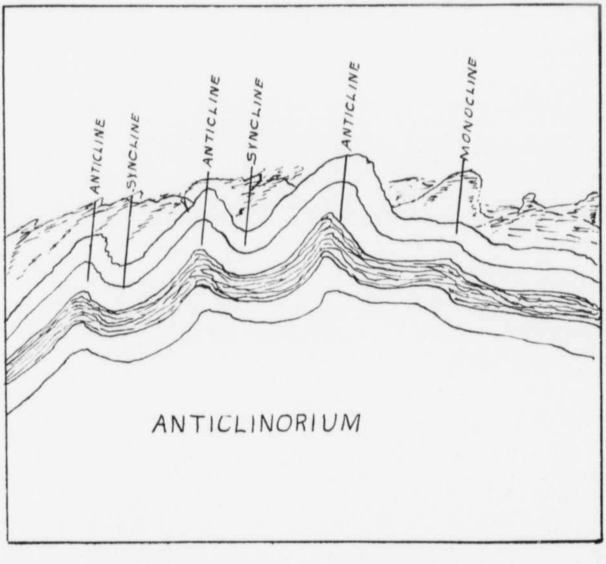
In the days when the formations, in which the petroleum is found, were deposited tropical conditions prevailed. Rapid tropical growth was necessary to produce the amount of vegetation necessary for material from which we know petroleum is derived.

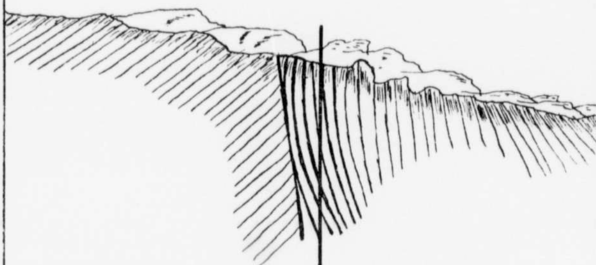
Climatic changes occurred with great frequency in those pre-historic days, when the tropics were near the poles, proof of which we find in fossil remains. The raising and sinking, building up and washing away of the lands are all shown by the relics of Amphibian and Terrestrial fossils of today.

MIGRATION.

Oil and gas migrate upward in the stratum. They also migrate laterally along the stratum if it is inclined.

In a horizontal stratum the oil and gas migrates upward to an impervious rock. Some rocks are more porous in one place than





VERTICAL SECTION SHOWING WHERE WELLS ARE SUNK

SYNCLINE

another. This is caused by pressure, silicification or by lime solutions descending or ascending and fixing in the pores of the rock.

Continuity of the impervious strata is essential towards the retention of an accumulation of petroleum. Lack of it is the cause of the blank or "duster" areas, as in the great Appalachian syncline.

In every field, of which the composition and structure is known, it is usually considered that the oil originated within or in proximity to the stratum in which it is found. Although there are cases of migration where the oil is found in another rock or sand than that in which it originated, this is the exception and not the rule.

Oils found in limestone are usually regarded as indigenous to it.

Orton says: "So common is the occurrence of petroleum in stratified rocks that wherever a close grained shale occurs there is almost always at least a small accumulation of oil directly underneath it. The same thing occurs when an impervious stratum of any other composition than shale occurs in the series." I think that Dr. Orton generalizes too much. Owing to the comparatively short time that this subject has been studied scientifically, this is, however, the case, to a great extent with most writers.

The rocks from which the oil and gas of oil fields are derived are of sedimentary origin; porous rocks, mostly sands or sandstones of various textures, embedded in and overlain by shales. Sometimes the porous rocks, which are the reservoirs of the petroleum and gas, are also underlain by shales and in cases, as in the Appalachian Fields, limestones underlay the lower shales. The latter case applies to the Carboniferous and the former to the Cretaceous and Tertiary series.

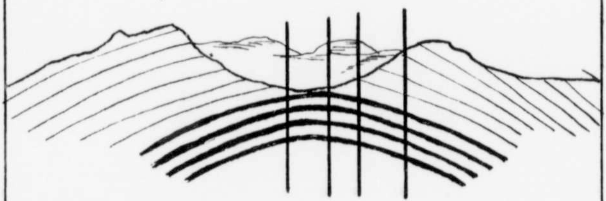
Oil bearing sandstones and sands vary in composition and have under the glass shown every conceivable color and texture. Oil fields have, in some localities, two or more sands that produce oil. This is usually the case in beds of Tertiary origin.

The Cretaceous rocks have shown petroleum in commercial quantities in only two series of its strata.

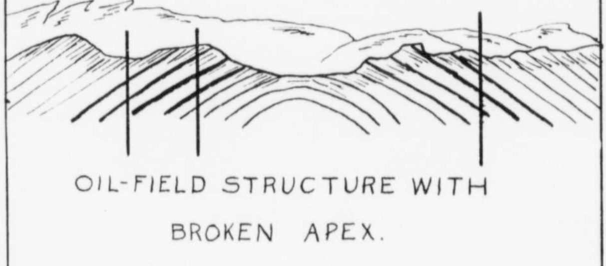
Sedimentary formations in which all petroleum is exclusively confined were originally deposited in a horizontal position.

The folding or wrinkling into anticlinal and synclinal forms is due to the terrestrial disturbances caused by the cooling off of the crust of the Earth.

Sandstones usually are more compact towards the bottom of the stratum. The constituents of sand are more heterogeneous nearer their origin than at a greater distance. Sandstones formed from the deposits



ANTICLINE WITH
GENTLE SLOPING LIMBS



OIL-FIELD STRUCTURE WITH
BROKEN APEX.

of littoral, estuarine and deltaic conditions make up oil bearing formations.

The composition of these sandstones is varied. It consists of fragments of every conceivable rock that could be on the course of the stream which emptied into the bay, estuary, lagoon or gulf. Under the microscope the polished grains tell whether they are much waterworn or were worn by the winds of a desert and then transported The amount of silt, coarseness of grains, quantity of grains in the mass, all tell a tale and must be considered.

The areas of producing territory usually parallel the main mountain ranges and vary much in shape.

LOCATIONS OF ACCUMULATION.

Dry rocks have shown accumulations of petroleum at or near the trough of synclines, especially where the dip of the rocks is not enough to overcome friction. Parts of the Appalachian Field exemplify this phase. This is usually exemplified in very low lying structures in the carboniferous series.

In wet, porous rocks the accumulation is at the upper limit of the anticlines or of a folded structure of the porous rocks.

A series of rocks varies in porosity laterally and vertically.

All conditions considered, the most probable place for accumulations of gas is at the crests or apices of anticlines.

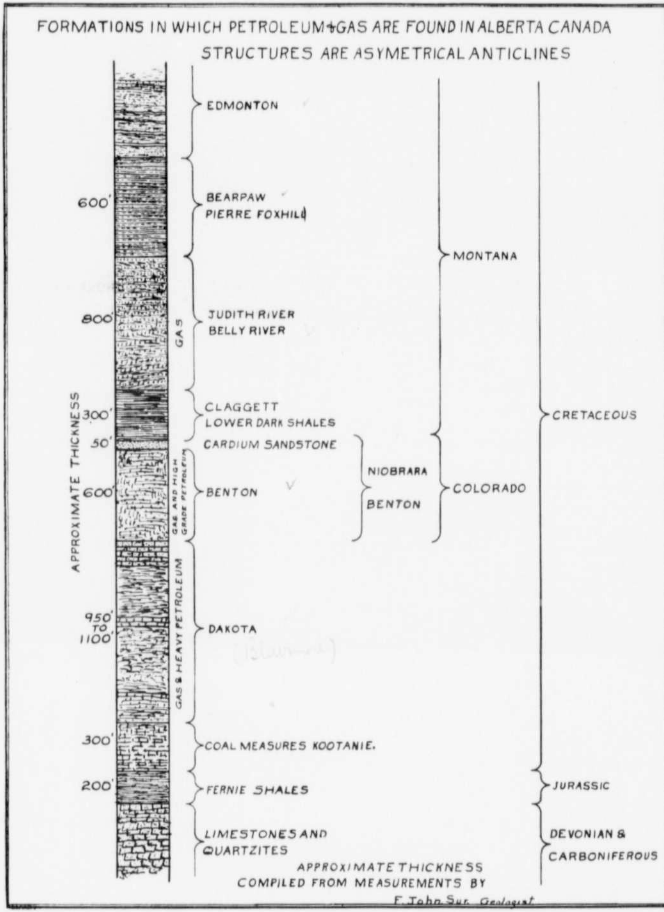
If the rocks are not porous, gas occurs in and with the oil body.

The impervious cover mentioned as one of the necessary adjuncts of the accumulation of deposits of petroleum is now found usually in the form of shales which were once clay, deposited after that of the petroleum-making material.

The next necessary adjunct towards the making of petroleum is the saline water, usually much more saline than sea water, which is found with or in the same stratum as the petroleum. This acted on or retarded the decomposition.

The main requisites of a productive oil field are a porous reservoir and an impervious cover and underlying bed. While the mineral may be formed in a stratum other than that in which it is found, in most cases it is indigenous to it.

In California marine sand acts as the retainer or reservoir, while in other fields a coarse-grained sandstone, or a conglomerate or a porous limestone acts as the reservoir. At times water and oil occur in the


FORMATIONS IN WHICH PETROLEUM+GAS ARE FOUND IN ALBERTA CANADA
STRUCTURES ARE ASYMETRICAL ANTICLINES
APPROXIMATE THICKNESS
600'
800'
300'
50'
600'
950' TO 1100'
300'
200'
GAS
GAS AND HIGH GRADE PETROLEUM
GAS & HEAVY PETROLEUM
EDMONTON
BEARPAW
PIERRE FOXHILL
JUDITH RIVER
BELLY RIVER
CLAGGETT
LOWER DARK SHALES
CARDIUM SANDSTONE
BENTON
DAKOTA
COAL MEASURES KOOTANIE.
FERNIE SHALES
LIMESTONES AND
QUARTZITES
NIOBRARA
BENTON
MONTANA
COLORADO
CRETACEOUS
JURASSIC
DEVONIAN &
CARBONIFEROUS
APPROXIMATE THICKNESS
COMPILED FROM MEASUREMENTS BY
F. John Sur. Geologist

same porous stratum, the water being saline or sulphurous. The water replaces the oil as the latter is drawn off.

Three conditions tend to make gushers or spouting wells:

1st. The weight of the overlying strata.

2nd. The water pressure, hydrostatic.

3rd. Gas pressure. This may be expected to produce a gusher if an accumulation of oil is a large one and the reservoir is loose sand.

Oil has been found in the many Geologic periods from the Silurian to the Tertiary. But the commercial deposits predominate in the Cretaceous and Tertiary formations. I here show the wide distribution of oil in the various geologic periods:

Burma—Tertiary
California—Tertiary
Assam—Tertiary
Punjab—Tertiary
Trinidad—Tertiary
Baku—Tertiary
Borneo—Tertiary
Sumatra—Tertiary
Java—Tertiary
Victoria, Australia—Permo-Carboniferous

Galicia—Tertiary
Roumania—Tertiary
Mexico—Tertiary and Cretaceous
Peru—Tertiary
Japan—Tertiary
Texas—Permo-Carboniferous, Cretaceous, Tertiary
New Mexico—Cretaceous
Alberta—Cretaceous
Wyoming—Cretaceous
Ontario—Paleozoic

VARIETIES OF OIL, HOW IT IS FORMED AND FORMATIONS IN WHICH IT OCCURS.

Mineral oil occurs as two distinct varieties—that of a paraffine base and that of an asphaltum base. It ranges from a water white transparency to intense black, the most common of which is dark green which, seen by reflected light, is shown to have a brownish yellow tinge. It is highly inflammable and the chief constituents are carbon and hydrogen, with varying quantities of oxygen and nitrogen. Some varieties are impregnated with or combined with sulphur.

The oils were formed in one of the two following manners:

1. That formed in the rocks by the decomposition of animal and vegetable matters.

2. That due to the natural distillation, by internal heat, of shales and hydrocarbons found in the Earth's crust.

Structural conditions play an all-important part in determining where an accumulation of oil may be found.

Oil is only obtained from unbroken and undisturbed strata. A fold anticlinal or synclinal of the oil-bearing strata asserts an all powerful influence on the creation of reservoirs of oil.

As I will use the word anticline quite often, I will here explain the meaning.

The folding of the strata has taken place along an axis. Where strata dip away from an axis so as to form an arch or saddle, the structure is termed an anticline or anticlinal axis. Where they dip towards an axis, forming a trough or basin, it is called a syncline or synclinal axis. In a simple or symmetrical fold the axial plane is vertical, or approximately so, and the limbs have on the whole the same general angle of inclination in opposite directions.

In many cases the axis is inclined and the dip on one side is much steeper than on the other, though on both sides still towards opposite directions. This inclination may increase until the fold is bent over, so that strata on one side are inverted and the dip is in the same direction, though it may be at different angles in the limbs.

An anticlinal or synclinal axis must always die out unless abruptly terminated by dislocation. In the anticline, the crest of the fold, after continuing horizontal, or but slightly inclined, at last begins to turn downward, the angle of inclination lessens and the arch then ends or noses out. In the syncline the trough eventually bends upwards and the beds with gradually lessening angles swing around it.

These folds often extend for a long distance with great regularity. For instance, as in the great California oil fields, one of which is nearly fifty miles long.

Subsidiary anticlines frequently cross the main anticlines and are at times as productive as the main anticline.

The difference of density separates the oil and water in the stratum, oil occurring in anticlines and water in the synclines. The gas arises to the highest point—the apex of the anticlines.

Needless to say that great care should be used in choosing the location of a well so that the oil-bearing stratum can be tapped at the most desirable place.

Better to spend one thousand dollars on responsible advice before the well is drilled than to spend $20,000.00 to $50,000.00 in drilling and find out that the oil is not where it was expected.

HOW THE GEOLOGIST WORKS.

In tracing the extent of underground formations, the exposures of broken strata are looked for first. From these are determined the direction in which the formation dips and strikes.

Exposures of strata are usually looked for in creeks, gullies, river valleys or hilltops—places where the erosion or weathering have washed or worn away the surface detritus.

From the indications thus shown, the geologist usually works toward the mountains, where he generally finds one stratum overlaying another, until he comes to where the igneous rocks of the primary series underlay all the others. The rocks of the main mountain ranges all underlay the sedimentary series. It is in the rocks of the sedimentary series that oil is found.

For instance, in tracing the underlaying formations from Black Diamond, Alberta, to the mountains, advancing westward, the strata is tilted in such a manner that each formation, which under or overlays the other, is shown. The thickness of each one can be measured until near Old Camp on Sheep Creek in the upper foothills. The Dakota sandstones are shown in which Ozokerite is found in the sandstone itself. Ozokerite is a solid residue from the inspissation of petroleum. By the action of weather, exposure, etc., the gases and the oils themselves have disappeared, but indications remain to show how much oil was, and is, in the undisturbed Dakota sandstones.

The significance taught to the geologist by the discovery of Ozokerite in the Dakota sandstones, which extend to and beyond the Black Diamond fields, enables them to determine whether the series is petroliferous or not.

Every rock or mineral must be carefully considered, dips of each separate formation figured, strike of dikes, lodes and all rock in place measured; all should be mapped and sketched, distances from outcrops paced or measured.

Other indications looked for are gas flows and springs in which oil shows. In all work, allowance is made for faulting, inverted anticlines and other natural disturbances. Accumulations of oil sufficient for commercial production occur where the strata are folded. Where the strata are flat there may be oil, but not usually in commercial quantities. When the stratum is tilted and the porous rocks of it contain oil the difference of density separates the oil and water. The specific gravity determines the position.

In the Alberta fields the anticlines are usually symmetrical. A symmetrical anticline is one in which the hade is vertical. Faults and dislocations play an important part in the distribution and accumulation of oil.

The location of a well on the anticline determines the productive possibilities. For instance, if a well penetrates the extreme top—crest or apex of a sharp anticline—in all probability the production will be only gas.

If a well penetrates the limbs or flanks of an anticline, the well will produce oil.

If a well penetrates the trough of a syncline, which is an inverted anticline, water will be the only production.

These conditions all prevail, providing the strata in the anticline contain oil. I do not mean to give the impression that all anticlines have oil in them. There are many sedimentary formations in which oil could not occur. Lakes of oil are unknown.

Breakfast in the mountains. One of the camps of the author while gathering data in the Alberta fields.

DRILLING METHODS.

A comparison of the different methods of drilling oil wells in the various great oil fields of the world and the relative measure of success attained is interesting to the man drilling in a new field.

There are two methods of drilling that have met with success and are now used universally. First, is the percussion method, in which are used free falling tools suspended from a hemp or steel cable, the weight of the tools being sufficient to break, grind or pierce the rock. Second, is the rotary method in which the bit is rotated on the bottom of a stem of pipe extending from the top of the hole to the bottom. The ground formation is pumped out of the hole by compression.

Under the head of percussion drills are included the Canadian type of rig, Standard, Imperial, California, Krupp, and others, all designed for some certain class of formation. Some are made with combinations of parts from the different types, the idea with each being to surmount some difficulty which the other designs would not meet.

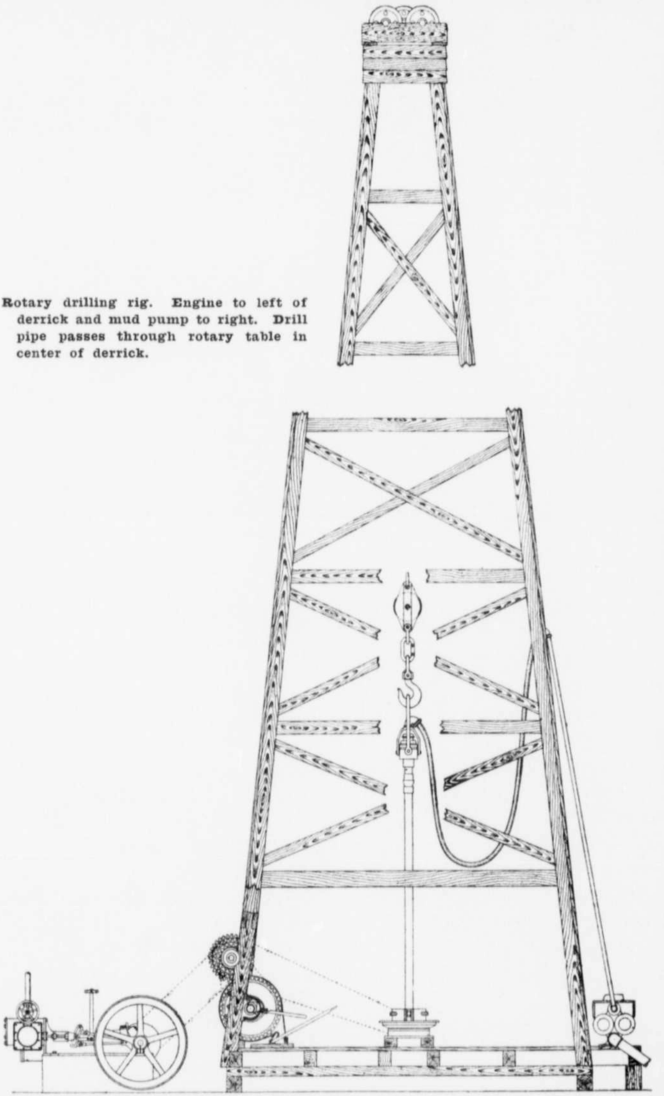
I will here give the principles of the different styles of drill rigs.

The percussion drilling rig of the various designs is used in any formation, hard or soft. It is particularly adapted to hard formations. The rotary rig is superior for sinking deep wells through loose or soft formations and is not a prospecting outfit. It should never be used except when all the underground formations have been proven and well defined as to depth and thickness.

In many fields a combination rotary and standard rig is used and, although it costs much more than any other class of rig, it is capable of surmounting any difficulties that may be encountered.

The principle of the rotary drilling rig consists of a rapidly turning column of pipe, the lower end of which has a sharp tool or bit for cutting the formation through which it passes. The principle is the same as with a carpenter's augur. Water, under heavy pressure, is forced through the pipe. Returning to the surface on the outside of the pipe, the water brings with it all cuttings and leaves a clean surface on the bottom for the bit to drill into. The rotary can be used in hard formations, an abrasive being used, but it is not so suitable as the percussion method in such cases.

The Canadian combination system is well adapted for hard formations, as it has an auxiliary attachment of poles by which the drill bit can be turned after each drop, thus cutting all parts of the surface equally. Especially in a highly tilted formation is this useful when



Rotary drilling rig. Engine to left of derrick and mud pump to right. Drill pipe passes through rotary table in center of derrick.

passing from one stratum to another. It also has the advantage of drilling with the cable or rope when required.

There are many classes of portable drilling plants, but they are not successfully adapted to deep well drilling.

Casing or steel tubing is used to prevent caving from the sides of the hole and to keep out water, shifting sands, gas and sometimes oil. Smaller sizes are used as depth is attained. A well may start with 20-inch casing and diminish in size to any dimensions, sometimes finishing with as small as 4-inch. One string passes inside of the other, and each string extends from the top of the hole, unless cut off after the well is completed. The object of the driller is to keep the casing as large as possible at all times and carry each string to the greatest possible depth.

Some wells at Baku, Russia, started with 36-inch casing, as many difficulties were encountered and had to be overcome. The formation was soft and broken up, quantities of quicksand gave much trouble, water flooded the wells and other things interfered with drilling.

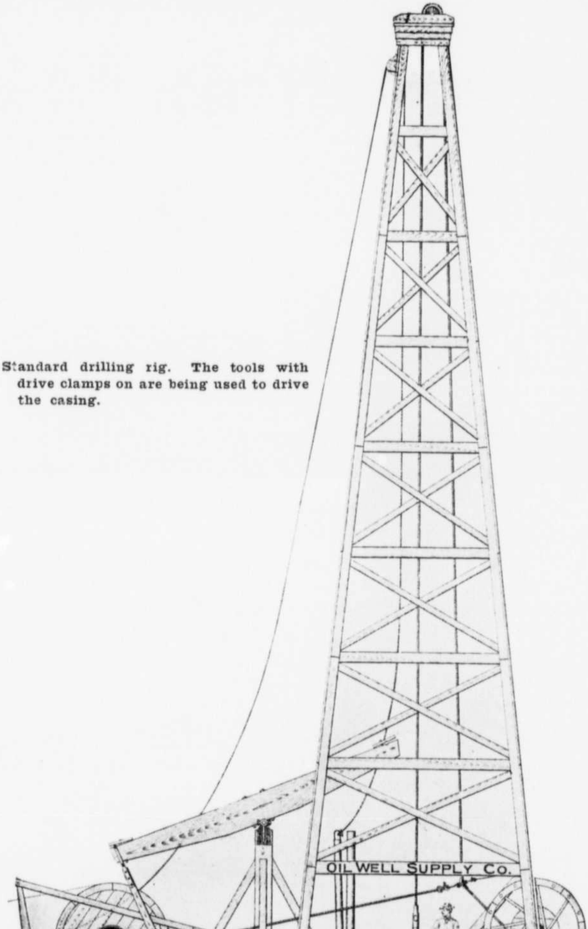
In Australia, where water wells are drilled to great depths, an average well being four thousand feet, the usual size of the hole at the top is eight inches in diameter. There the formation is very hard and compact. Some wells have no more than three hundred feet of casing at the surface. Below this the walls hold up. Granite, quartzite and sandstones are the predominating formations.

At Bradford, Pennsylvania, a well is being drilled which is now over 5000 feet deep, and it has no more than three hundred feet of casing in it. They have had some soft formation to go through, but have proven new things to the modern drill man who usually wants to case every foot.

Casing costs a great deal of money, being one of the heaviest items of expense. Much time is required to place the casing in the hole and, in many cases, difficulties of all kinds are experienced. Where under-reamers are necessary they sometimes cause great annoyance. The under-reamer is a tool or bit used to enlarge the hole below the bottom of the casing so that the hole will be large enough to permit the casing to pass.

In most fields casing is necessary, but where the formation will hold up there is no reason for it, other than to shut off water.

Derricks are built of wood or steel. Wood is cheaper in most regions. Where transportation problems have to be considered the steel derrick is used, it being lighter and more durable than wood and



Standard drilling rig. The tools with drive clamps on are being used to drive the casing.

more easily shipped. In Australia, where white ants eat all articles of wood, steel is necessary. In Chili and Peru, on account of the excessive dryness in the rainless tracts, steel derricks are used. However, it is usually a question of taste upon the part of the manager of the properties as to whether wood or steel derricks are used.

CABLES.—Formerly the hemp cables were almost universally used. Within the last few years steel cables have been more favored. Especially in wet wells or wells having hard walls are they found to be far better. They cost less than do hemp cables and the "breaking strain" is more. Another advantage the steel cable has over the hemp is that it will allow the tools to turn more in the hole.

Gas bubbles in Athabaska River, Alberta. For centuries huge bubbles have been constantly coming to the surface on this river. This gas comes from the Dakota Series. It is to some extent a "wet" gas.

DRILLING DON'TS.

Don't drill with dull tools.

Don't use corroded casing.

Don't use under-reamers any more than is absolutely necessary—better to drill a larger hole, if possible.

Don't use a hemp or manila cable for deep drilling, as it stretches too much. Wire is much more satisfactory after the first few hundred feet.

Don't let your tools get too far ahead of your casing. The top of the tools should not be permitted to get below the bottom of the casing. Keep your casing as close to the bottom of the hole as possible without its being so close that the shoe will be broken with the tools. Wells drilled where the formation has series of soft sand between harder strata of rock are subject to caves. If the casing is not kept as close to the drilling tools as possible, trouble is sure to occur. Soft formations cave in on the bailer or other tools when not cased off.

In anticlinal and synclinal structures the location of the well is the all-important point to be considered.

Don't drill in a syncline unless you want salt or sulphurous water.

Don't drill for oil on the apex or crest of a sharp anticline.

Don't drill for gas on the limbs or flanks of an anticline if you want maximum gas production.

Don't drill for anything in horizontal strata.

Don't drill where the oil occurs too deep for commercial production.

Don't drill too close to the outcrop of the oil sand, or you will find out that the oil is inspissated and only residue remains.

Don't drill any more when you get hot water from the drill hole at depth. This is a very bad indication for oil.

SOME REASONS FOR DECLINE IN PRODUCTION.

The poor management of the numerous mechanical equipments pertaining to oil wells is responsible in many cases for the decreasing production.

As in every other industry, great advancement has been made in oil well machinery within the last few years. Devices that save time and labor and increase production at less cost mean success.

First, is the subject of casing. In some districts casing corrodes more than in others and, if not looked after, will allow water to ruin a well that would produce for many years if taken care of properly. Especially is this so where the underground waters are sulphurous.

Second, wells having a paraffine base oil, if not steamed out at intervals, will "choke" the production, lessening gradually until the small amount produced awakens the manager to the fact that he could have had more oil for months if the well had been properly cared for. This "choking" is caused by the paraffine wax stopping up the channels that lead to the well.

Dynamite has been used with success in such cases. Steaming out is safer and more universally satisfactory.

Third, "bleeding" a well. A well that is pumped too fast or too long or too deep can be made to produce fifty per cent less than it would if pumped in such a manner as to use the expansive force of the gas accumulating in the hole.

Automatic devices for covering this feature of production are on the market and have been proven successful by the largest producers in all the fields.

Fourth, the use of compressed air in flowing a well rather tends to shorten its life than to lengthen it. Decreased vaporization and the formation of waxy sediments which tend to clog the sand in the immediate vicinity are the results of the continued action of compressed air in flowing a well.

Fifth, the wearing away of cement behind casing, as time goes by, by the constant pressure of the water and gas may result in a slow drip of water, which, if not stopped, will tend to ruin an otherwise long-time producer.

REASONS FOR NON-PRODUCTION

Most of the mistakes made in drilling oil and gas wells in Alberta and Saskatchewan would not have happened if the men in charge had used the data available on the subject, and thus profited by the mistakes of others. Entirely unnecessary mistakes represent the loss of thousands of dollars.

I refer, first, to the location of the drill holes; second, to actual drilling of the well.

According to the report of Mr. Wyatt Malcolm, issued by the Department of Mines Geological Survey, three wells were drilled by the Dominion Government in the nineties.

One was drilled at Athabasca Landing on an anticline, but could not attain sufficient depth to expose the Dakota series.

Another was drilled where the strata was horizontal and not in position to hold oil in commercial quantities.

Experienced oil men would not have drilled in these locations.

A well was drilled by a company for the municipality at Maple Creek, Sask., for gas, in a syncline where gas could not occur. An anticline with quantities of gas occurs less than a mile distant from where the well was drilled.

Because gas or oil or tar seepages occur on a property is no reason why there is gas or oil in commercial quantities on that piece of property.

In actual drilling the data above mentioned will save money and avoid many an expensive delay.

Another point to be considered in drilling for oil is the "drainage area." A lengthy flank of an anticline will produce more oil daily and for a longer period than a short one. The shallowest well produces less than the deeper well for the same reason.

LOGS OF WELLS.

THEIR VALUE AND INFORMATION THEY SHOULD CONTAIN.

To the investigator of oil-bearing formations the logs of all nearby wells are of great value in determining the thickness of strata.

The importance of structure is such that it must be determined with a great degree of accuracy. In most oil and gas fields the structures are not sufficiently pronounced to be traced by determining dips with a clinometer. It is, therefore, necessary to connect the outcrops of some easily identifiable bed by level lines which are also tied to all wells whose logs can be obtained.

The method of obtaining from surface observations and well logs a contoured representation of the oil and gas sands is fully explained by W. T. Griswold in U. S. Geological Survey Bulletin 318, and should be familiar to every oil prospector.

Sometimes it is necessary for the investigator to examine over a great radius of land to find the formations that are necessary to correct determinations of thickness and depth.

In acquiring the logs of wells from oil or gas well operators, tact is recommended. In new fields great secrecy is usually maintained.

Usually when a man exacts information he gives the same value of information in return.

In questioning for information the following is suggested of the greatest value:

A—Elevation at casing head.

B—Depth and thickness of each set of formations penetrated and distinguished by the driller.

C—Fossils. Coal. Get samples.

D—Depths yielding water, oil, gas, tar or distinct rocks.

E—Local and geologic names of productive horizons.

F—Method of drilling, difficulties, casing used, tools.

G—Quantities of gas, oil, water yielded.

H—Temperature of both salt and fresh water.

ALBERTA FORMATIONS.

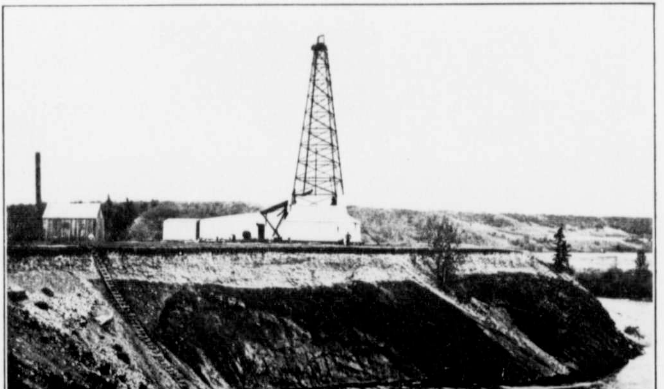
Extending through Montana into Alberta as far north as the Athabasca River is a formation called the "Cretaceous" that is oil bearing in one stratum. The oil-bearing series is called the "Dakota."

Wherever a known oil-bearing series folds into a certain form or structure known as anticlinal and where that structural form is not broken oil is usually found.

Wherever wells have been drilled in the abovementioned formation in Alberta under the abovementioned structural conditions and have struck the "Dakota" sandstones oil has been encountered, except where wells were drilled too close to the exposure or outcropping, where asphalt and tar is all that remains of the oil.

The Alberta series of anticlines constitute the most extensive of possible, unproven oil lands in the explored world. To verify this statement, I need only to refer to any of the standard works on economic geology, to the Government Geological Reports and to every geologist who has visited Alberta. All report favorable conditions.

Gas in commercial quantities has been found throughout Alberta wherever it has been drilled for, near the crest of anticlines, in cretaceous formations lying above the Dakota series. The majority of this gas can be used for compressing to gasoline.



Dingman No. 2, Alberta fields, showing flank of anticlinal flexure.

OIL FROM ALBERTA FIELDS IS PHENOMENAL IN VALUE.

TESTS MADE ON PRODUCT FROM DINGMAN WELL SHOW NINETY PER CENT GASOLINE CONTENT.

"One of the most remarkable and peculiar oils we have ever come across—in fact, phenomenal. The test that has just been made shows a 90 per cent gasoline content—that means that the crude petroleum, in its refined state, is 90 per cent gasoline. Having ascertained this, it is no surprise that they were able to drive in from the well on the crude product and find that it developed 25 per cent increased efficiency." These remarks were made by J. A. Kelso, Managing Director of the Kelso Testing Laboratories, after an analysis of samples of oil from the Alberta fields.

Speaking further upon the subject of his results with the Black Diamond field oils, Mr. Kelso said: "The distilling was effected under a heat of from 50° to 150° Centigrade. The fact that we were able to obtain some of the gasoline at a temperature of from 50° to 75° Centi-

Dingman Well where high grade oil was found in Benton shales at a depth of 2800 feet. This was the Discovery Well in the Alberta fields.

grade means that it is possible to obtain a very high grade of gasoline from this oil.

"We found the specific gravity of the crude oil to be 62.5 Beaume, or .734 specific gravity compared with water. The S. G. of the distilled gasoline was 67.5 Beaume, or .710 as compared with water. The residue which was left in the retort was of a clear darkish brown color, of a paraffin order."

COMPARATIVE DATA OF ALBERTA OILS WITH THAT OF OTHER FIELDS.

	Specific Gravity compared with water.		
California fields (1)	.777		
California fields (2)	.920	to	.983
Pennsylvania fields	.801	to	.817
Texas fields	.835		
West Virginia fields	.841	to	.873
Beaumont, Texas	.904	to	.925
Wyoming fields	.912	to	.945
Alberta field (Black Diamond)	.734		

"The oil from the Dingman well bears a close resemblance in specific gravity to that which comes from the Smith Brothers and Sweeney well at St. Mary's, in West Virginia, the oil there having a specific gravity of .788. The same may be said of another well in the same locality, which is drilled in Big Injuns sand."

Bailer being drawn from Dingman No. 1 well and bringing with it high grade oil.

FIELD EQUIPMENT FOR PROSPECTING.

The equipment necessary in geological determinations is usually light and is not expensive.

It consists of the following articles:

A compass sufficiently large to be reasonably exact, with Clinometer and level attached. The Brunton Compass serves the purpose.

A hammer weighing about one and three-quarter pounds with one side flat and the other drawn out as a pick, so that it may be used to either break or dig out of the croppings the rock fragments or fossils by which the country rock formations are judged.

A bag of strong canvas or leather for carrying the specimens of rock or fossils.

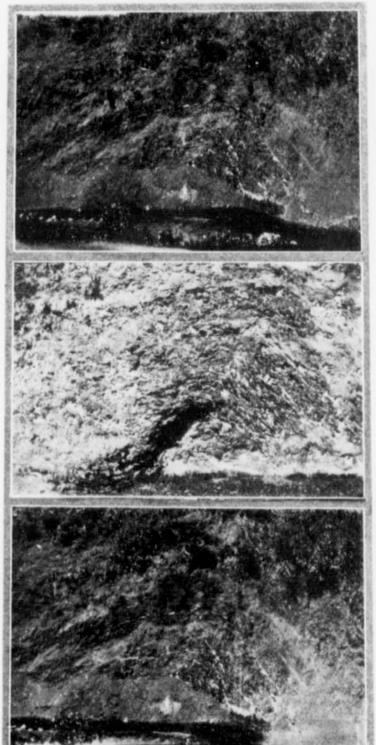
An aneroid, carefully selected, in a case made for it, by which the altitude is ascertained.

A camera that is compact and not too cumbersome.

Note books for sketches and field notes. Sometimes a field glass.

Light boots with hob nails. A pedometer is sometimes used in registering distances paced.

Seepages in Dakota Sandstones in Alberta on East slope of Rocky Mountains with conglomerate underlying.



Crest of anticline exposed by erosion. These views show the texture of the formation in such a way as to give an exact idea of the way the oil bearing strata occur at depth. On account of exposure all oil has drained from this formation.

THE COMPRESSION OF NATURAL GAS TO GASOLINE.

The compression of the gases from oil wells, both of asphaltum and of paraffine base, is now commercially successful. Up to three years ago this was only done by chemists in experiments and was then thought of, by oil operators, as not practicable.

Vast quantities of gas, running up into the hundreds of millions of cubic feet per day, were wasted and in many fields are yet being wasted for lack of knowledge (I refrain from using the word ignorance) on the part of the oil well operators.

Most of the gases contain a high percentage of volatile oils which, by compression at a certain temperature, will compress to gasoline or benzine and the remaining gas, which is dry, can still be used for fuel or illuminating purposes.

The wet, or "casing head gas," as it is called, usually comes from the main body of the oil and is one of the favorable indications looked for by the oil man as to whether oil exists in the formation in which he is drilling.

Sometimes in a compact sandstone or coarse textured sandy shale this gas is found as a saturated gas in the form of a high grade gasoline, hundreds of feet from its source, being compressed by natural conditions which are now copied artificially, i. e., a certain pressure at a certain temperature. For example: A test plant was erected by Irving C. Allen and G. A. Burrell at the compressing plant of the Penn. Gasoline Company at Follansbee, West Virginia, U. S. A., which consisted of a gas engine, a small compressor, cooling coils of ordinary one-inch pipe immersed in a tank for holding the cooling mixture and a storage tank made of six-inch steel tubing. A pressure of 415 pounds at a temperature of 2° Centigrade liquifies practically all the gas.

430 lbs. at 4 degrees Cent.
506 lbs. at 9.1 degrees Cent.
600 lbs. at 77.5 degrees Cent.

By reverse procedure, a gramme of liquid will yield 500 to 600 c.c. of gas at 0 Centigrade, or one gallon of liquid yields 50 cubic feet of gas. Higher pressures required higher temperatures. It is to be remembered that a wet gas was used—that is, a gas from off the oil body. About 2000 cubic feet of gas compressed to one gallon of liquid.

Sometimes the natural gases contain lighter products that do not liquify with the first compression. It is then passed on to another compressor and even to a fifth compressor. The last three and at times the last four products are not liquid, but can be put into cylinders and sold for consumption for illuminating purposes, as a compressed gas, to homes, factories and establishments that are not accessible to pipe lines from the sources of supply. If all these products, both oils and gases, were more universally recognized and used the producer and the consumer would both be benefited.

As the above mentioned experiments were carried on by the United States Bureau of Mines to increase the efficiency in the production of mineral fuels, they are worthy of note and study by the oil well operators of Alberta and all other parts of the Globe where quantities of gas are daily being wasted. The day will come, and I believe it will be soon, when the governments will legislate against the waste of natural gases. In fact, legislation of a very strict nature on this point has already been inaugurated in California. There is no new gas being made to replenish the rapidly exhausting deposits. It takes ages to form naturally—geological ages far beyond the scope of man's judging, as far as time figures.

The first gas-gasoline plant in California was established in 1911. The results obtained were so satisfactory that others quickly followed the lead of that company. In two years' time two hundred and fifty-one gas-gasoline compressor plants were in operation in the United States, with a total production difficult to ascertain. California alone produced 7,200,000 gallons in 1912 from ten compressor plants.

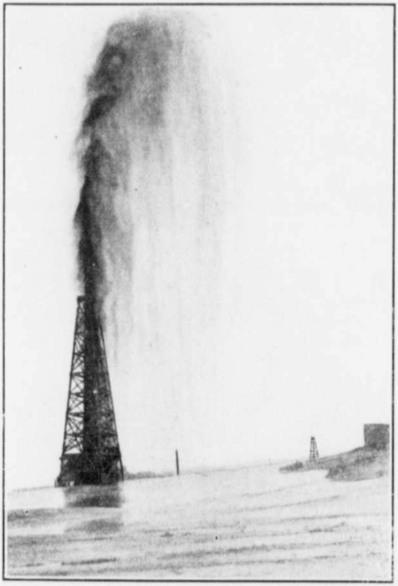
One of the camps of the author on the Athabaska River while gathering data on the geology of the Alberta fields.

DEEPEST WELLS.

The deepest drilled hole is at Czuchow, Silesia, and was drilled to a depth of 7349 feet. Surface diameter, 17 inches; diameter at bottom, 2 inches; temperature at bottom, 182 degrees Fahrenheit; cost, $18,-241.00; duration of work, eighteen months.

The deepest well in the United States is near West Elizabeth, Pennsylvania. Depth, 5575 feet; diameter at surface, 10 inches; diameter at bottom, 6¼ inches; cost, $40,000.00.

(I quote Henry P. Westcott's Handbook of Natural Gas for the above statements.)



View of famous Lakeview Gusher in the Midway Oil Field, California, shooting nearly three hundred feet into the air. This well produced over 10,000,000 barrels of oil in the eighteen months that it was gushing. At the end of that time it stopped producing as suddenly as it came in. Later it was redrilled and gave a daily production on the pump of about fifty barrels.

SUMMARY OF OIL OCCURRENCE IN THE PRINCIPAL FIELDS OF NORTH AMERICA.

FIELD—	STRUCTURE—	GEOLOGIC AGE—	FORMATION—	CHARACTER OF OIL—
Appalachian	Geosyncline with subordinate anticlines	Ordovician to carboniferous	Mostly sandstone	Paraffine base
Lima and Indiana	Anticlines	Ordovician	Mostly limestone	Paraffine base Sulphur
Illinois	Low anticlines	Carboniferous	Sandstones	Paraffine and mixed oils
Michigan	Probably anticlines	Silurian	Sandstones	Paraffine base
Wyoming	Usually folded	Carboniferous to Tertiary	Sandstones	Paraffine and Asphaltic
Colorado	Folded	Cretaceous	Sandstone and Shale	Paraffinic
Gulf Coast	Domes	Tertiary and Cretaceous	Dolomite and Sandstone	Mainly asphaltic
California	Anticlines	Tertiary	Sandstones, Shales and conglomerates	Asphaltic
Alaska	Anticlines	Jurassic to Tertiary	Sandstones and Shales	Paraffine base
Southern Alberta	Anticlines	Jurassic to Cretaceous	Sandstones	Paraffine base

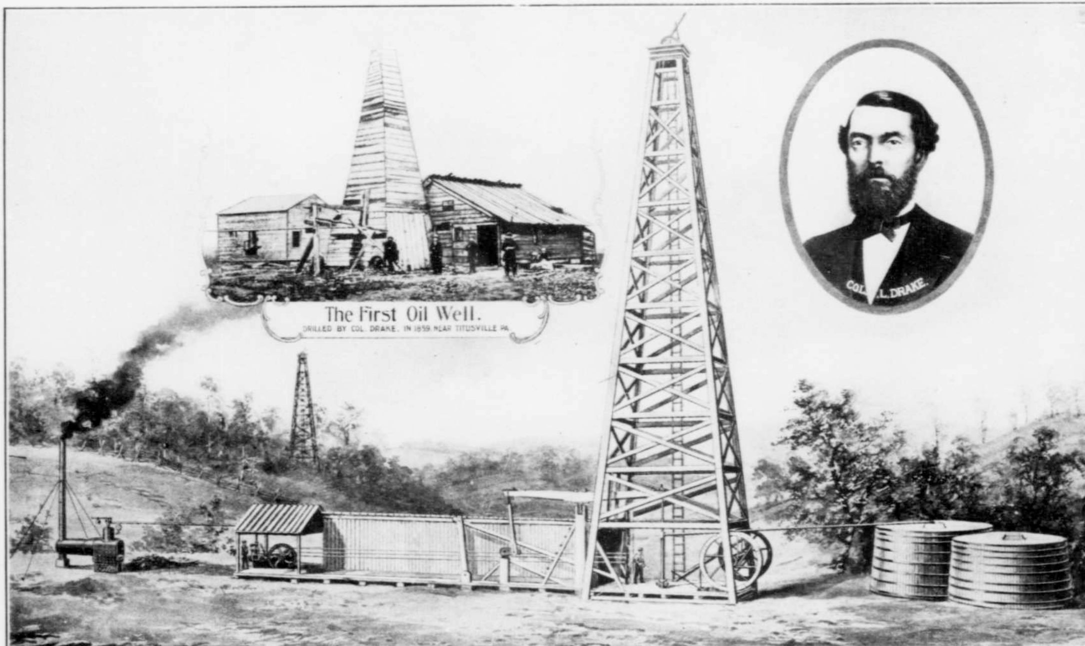
As will be seen, the oils of paraffine base are usually found in the older rocks.

The strata must be in certain folded positions to produce oil in commercial quantities.

Tertiary formations produce 75% of the World's supply.

The Cretaceous Age produces the highest grades of oil.

OIL FIELDS
OF
NORTH AMERICA



The old and the new. Upper: the first oil well drilled in America and Col. Drake who drilled it. Below is a well with modern equipment pumping oil into tanks.

ALLEGHENY.

The Appalachian Oil Field is the largest in area of any in the United States.

It is formed of a Geo-Syncline that includes portions of the States of New York, Pennsylvania, Ohio, West Virginia, Kentucky and Tennessee.

The rocks are chiefly sandstones with some limestones which are underlain by thick beds of shale, under which are great limestone beds. The sandstones alone are from 1,500 to 2,500 feet thick.

This great trough extends over parts of the abovementioned States and covers an area of about 45,000 square miles, of which about 3800 miles are producing. The producing areas consist of sands underlying subordinate anticlinal folds in different portions of the great trough. The general direction of the producing anticlines is northeast by southwest.

The wells are from 100 to 4000 feet deep. In some portions there are three producing sands, the deepest usually being the most productive.

The oil occurs in rocks ranging from the Carboniferous system to the Devonian system, geologically.

These fields reached their height of production in the early nineties and it was in these fields that modern systems of drilling were first developed. Previous to their discovery the use of drills and drilling machinery were unknown.

The first man to foresee the proper use of petroleum was Dr. Hildreth, who in 1826 wrote an article which was published in one of the periodicals of the day in which he said: "This product offers great resources as an illuminating agent and will certainly become of great utility in lighting the future villages of Ohio."

The first oil used for illuminating purposes was offered for sale about 1850 by a Pittsburg druggist, Samuel Kier, who introduced it as Kier's Petroleum or Rock Oil. It came from a well about 400 feet deep in Alleghany County, Pennsylvania. He first sold it as a curative for human ills. It was a failure as such and he afterwards sold it for illuminating purposes, which later proved successful.

Edwin S. Drake in 1858 drilled the first drilled well using anything like the modern system of tools. He encountered difficulties, each one of which had to be solved without precedent. He used the first iron casing ever used to keep out the water and to hold up the soft

Below is a well with modern equipment pumping oil into tanks.

formation, drilling, as they do nowadays, inside the casing. Three feet per day was the average drilled. One morning, in August, 1859, they came to work and found the well filled with oil.

The names of Drake and Billy Smith, his driller, are and will be handed down in history as the discoverers of the modern drilling methods. Others have improved them to their present stage of perfection.

From that day in August the oil-drilling industry advanced with giant strides to one of the great industries of modern times.

One of the camps of the author while making his geological examinations in British Columbia.

TEXAS.

The Texas Oil Fields were first brought to the attention of the general public early in the year 1901, although discovered sometime before this. Great excitement prevailed at the time of this discovery, as a result of which vast fortunes were made and lost within a very short period.

Some of the wells in the Spindle Top District near the town of Beaumont were enormous gushers, producing from 75,000 to 100,000 barrels a day.

The excitement was increased by the fact that some of the wells caught fire, resulting in enormous and spectacular losses.

This district probably holds the record for rapid production in the United States, for, as gusher after gusher was brought in, the public went stock crazy and poured out millions of dollars for development and production purposes, demanding nothing else but feverish efforts at well drilling, in consequence of which wells were drilled in all localities regardless of geological conditions.

In some parts of the field the network of derricks was so close that some were braced against others for lack of space to brace otherwise. On one small plot of less than two hundred acres two hundred and eighty derricks were in operation at one time.

So great was the drain upon the producing section that the production rapidly dwindled. This field, which produced the extraordinary volume of 34,000,000 barrels in four years, shortly after became a field of medium size wells, all of which had to be pumped.

A great many of the wells indiscriminately located produced nothing. In fact, so soon as the field was subjected to careful geological examination it was discovered that the possible producing area was limited to about three hundred acres and no oil has been found outside the designated territory.

The Texas oil is of an asphaltum base, fairly high grade, and commands a good price.

The formation is principally a porous dolamitic limestone of the Cretaceous period.

As a result of these discoveries, attention was directed to a part of Texas which was formerly relatively unimportant. A number of towns sprung up, the chief of which is Beaumont. The seaport of Port Arthur came into existence principally as a result of the oil discovery. Four railroads were built into the territory in addition to pipe lines.

A new system of pumping was installed and wells—as many as thirty or forty—are pumped by one engine, which greatly minimizes the cost. New drilling systems were invented and new methods for fire prevention and suppression were devised; also a new invention for capping wells.

The average depth of the Texas wells is 900 to 1000 feet.

Lakeview Gusher, Midway Oil Field, California, after it had demolished derrick and covered everything near it with sand from the well. At the time this picture was taken the oil was still shooting from fifty to one hundred feet into the air through a large pool of oil that had formed around the top of the well.

CALIFORNIA.

The principal California oil belt is about fifty miles long and from ten to seventeen miles wide. It is the old Sunset, Maricopa, Midway and comparatively new North Midway fields connected by continuous development from one to the other. All are now considered as one big field which is commonly known as Midway.

In some places there are three parallel anticlines from which oil and gas are extracted.

Salt water in large quantities comes from the wells in the synclines, which are parallel to the anticlines.

The reservoir of the oil is a fine-grained marine sand, which is sometimes thrown up with the oil and plugs the well.

The deepest well is 5200 feet and had such a gas pressure that it blew the tools out of the well many times before a method for keeping them in the hole was discovered.

Gushers of all sizes, as well as flowing and pumping wells, have been brought in in this field. The greatest gusher was the Lakeview, which came in with an initial production of 40,000 barrels per day. This increased until it reached the high figure of 90,000 per day. From this amount the production decreased until it was 5000 per day. While producing at about this last rate just eighteen months to the day after it came in it suddenly stopped on account of caving in at the bottom. It has been redrilled and has since been pumping at the rate of about fifty barrels per day. The Standard, Associated, K. T. & O., Honolulu Consolidated and others have all brought in gushers that have produced all the way from 20,000 to 50,000 barrels per day.

The Coalinga Field in Fresno County has been a producer of more than 2,000,000 barrels per month. The Midway and Coalinga fields are the largest. In addition to these are the Kern River, Santa Maria, Los Angeles, Whittier-Fullerton and a number of other smaller fields, all giving a present production of something over 8,000,000 barrels per month.

The California oil is dark and heavy, with an asphaltum base, and commands a price of from 40c to $1.20 per barrel in the field.

The California product, being of an asphaltum base, is not all refined. Much of it is piped to the seaports, where it is pumped into tank steamers in the crude state and shipped to all parts of the World. In its crude state it is also extensively used in locomotives, most of the railroads west of the Rocky Mountains using this form of fuel exclusively. Great progress, however, has taken place in the refining of California oil in the last few years. After the lighter parts, such as benzine, gasoline, naphtha, kerosene and sometimes lubricating oils have been taken off, the residue is used for fuel, making a much better product for this purpose than the crude. When it is refined to the extent that it is too low grade even for fuel the residue is used for road-making purposes, it being one of the most valuable products available for this purpose. A very large industry has grown up in this branch of California oil.

There are three pipe lines from the California fields, varying from 200 to 400 miles in length. Pumping stations occur at frequent intervals, which relay the oil from station to station.

In parts of the Midway field in California more than a thousand oil derricks can be counted from one position.

The average derrick is 84 feet high and a 25-horsepower engine is usually used. For drilling, steam power is generally used, the steam being generated by the use of oil or gas, or both, under the boilers. In a few instances the gas engine and the electric motor have been used. For pumping, the electric motor and the gas engine have come into quite general use.

Some of the wells furnish gas for other wells for fuel, from which a large profit is derived, the usual charge being about $200.00 per month for each well.

The discovery of oil in these fields has, within a few years, brought in the railroad, telegraph, telephone, water pipe lines, eight towns, numbers of schools and public institutions, and gives employment to thousands of men in a district that was formerly an empty desert.

Seepages from top of Dakota and bottom of Benton formations, Alberta, Canada. These seepages have been exposed for thousands of years, hence the oil is inspissated and only the residue remains.

MEXICO.

The Tampico Oil Fields enjoy the distinction of being the only seaboard oil fields in the World.

These fields are situated on the coastal plains of Mexico, which affords an easy means of outlet for the oil. This enables the convenient accumulation of the production of the Tampico fields at one central point, this point being the port of Tampico, where a fine harbor exists and the seagoing vessels of the World find safe harborage. The accommodations for all classes of ocean-going vessels at Tampico are on a par with such harbors as New York and San Francisco.

The full significance of this convenient situation is appreciated when it is considered that there is a great oil field practically at seaboard. Geographically, a better location for the building of an oil port city could not have been selected than where Tampico is built, affording as it does a ready entry into the markets of the World. It furnishes the products of the oil fields a direct line to Europe, a direct line to New York and all Atlantic Coast ports of North America, a direct line to all the Atlantic Coast ports of South America and, on the completion of the Panama Canal, a direct line into the Pacific and the Oriental markets.

The demand for this oil is already indicated by the prices received even at this early stage of the field's development. For instance, the Doheny interests some time ago closed a contract for two and one-half million barrels from their Dos Bocas-Casino wells, receiving therefore 92½c per barrel. This is an unusually good price, when it is considered that the gravity of the oil runs from 20° to 22°.

IMMENSE OIL RESERVES.

There has been no attempt as yet to estimate the enormous oil reserves contained in the measures of the Tampico region. The phenomenal wells that have been brought in at widely separated points show the general saturation of an extensive area. The prevalence of live oil seepages over a strip of country 60 miles wide and extending 100 miles north of Tampico and 130 miles south is an indication as to the magnitude of the field. Furthermore, these seepages do not confine themselves to any straight lines, but rather are dispersed throughout the region at frequent intervals, demonstrating a general occurrence of the oil. In other words, these seepages are interspersed throughout a region having an extent of 60 miles in width by over 200 miles in length. The exudations from these seepages, in many instances, have caused the accumulation of extensive residuum asphaltic deposits. The active state of many of these seepages shows the oil is still accumulating from the original source and, where wells have been sunk in the vicinity of some of these seepages, enormous producers have been brought in. In fact, the capacity of some of the wells is so great as to be difficult of belief. The more prominent of these may be described somewhat in detail.

FAMOUS MEXICAN GUSHERS.

Two wells owned by the Doheny interests drilled at Juan Casiano are producing respectively 15,000 and 20,000 barrels daily. The oil from these wells is of 20° to 22° in gravity and they lie on the well-known Dos Bocas-Casiano anticline, which begins at tidewater and extends for 50 miles inland. This belt is the most promising of any in Mexico, the famous Dos Bocas Gusher having been brought in on the north dip of this anticline. The gravity of the oil here is higher and the gas pressure greater than in any of the other fields. The pressure is enormous, far exceeding that in the famous Midway belt of California.

The Dos Bocas Gusher has stood out strong in the romance of oil history since and before its destruction by its own pent-up energy. Descriptive writers have enlarged upon this wonderful well, which, at its zenith, spurted oil 1500 feet into the air, and is estimated to have thrown over 9,000,000 barrels of oil before it destroyed itself. This stupendous production would have been equivalent to 1000 barrels per day for 25 years. It began to gush on July the 4th, 1908, and all efforts to control it were futile. It finally tore a hole in the Earth which is now a lake of water 23 acres in extent. This well was brought in by the Pearsons.

The Pearsons have also brought in another huge gusher to the southwest of this well known as the El Potrero gusher. This well was brought in on the 27th day of December, 1910, and before it was controlled, over a million barrels of oil escaped into the Tuxpam River.

This well, for a time, gushed an 8-inch column of oil to a height of 197 meters, or 640 feet. The daily flow kept increasing until the middle of March, 1911, when it was estimated to be flowing from 75,000 to 80,000 barrels per day. This oil is also of a good grade, 22° gravity, having an asphalt-paraffine base.

THE VARIOUS FIELDS.

The Tampico field, as a whole, is divided into several separate fields or local subdivisions. These, with the conditions which prevail in each, are described in brief as follows:

SOTO MARINA FIELD.

The Soto Marina field is the northernmost field of all the Tampico fields. It borders the coast and extends along the ocean for about 60 miles. Its width is as yet undetermined. There are numerous oil seepages occurring throughout this field and a few wells are being drilled which probably foreshadows the development of this region on an extensive scale. The oil is heavy, having an asphaltic base.

EBANO FIELD.

The Ebano field is the next field lying south of the Soto Marina field and back of the port of Tampico. It is reached by the Mexican Central Railroad, a distance of 60 miles, to where the wells of the Mexican Petroleum Company are located.

It was here in the Ebano field that the first developments in Mexico were conducted. Messrs. Doheny and Canfield of California organized the Mexican Petroleum Company and successfully developed this field. The oil is of low gravity with asphaltic base.

DOS BOCAS-CASIANO FIELD.

The Dos Bocas-Casiano field lies south of the port of Tampico. Beginning from tidewater, it extends fifty, or more, miles inland. Numerous seepages occur throughout this field and the oil is of light gravity and very suitable for refining.

This field enjoys the distinction of being the home of the famous Dos Bocas Gusher, hereinbefore described. The Dos Bocas-Casiano field is an intermediate field lying between the two northern fields just described and two other fields to the south to be described.

CERRO VIEJO FIELD.

This field lies south of the Dos Bocas-Casiano field and is of great promise because of the phenomenal gushers which have been brought in. The El Potrero Gusher broke loose with an initial capacity of from 30,000 to 40,000 barrels, and within a few days reached a daily capacity variously estimated at 75,000 to 100,000 barrels. A large part of this oil escaped and flowed down the Tuxpam River to the sea, covering the surface of the ocean for miles in extent, but the well was finally controlled. The oil is of the light variety. Pipe-lines have been built to convey the production of this field to steel storage tanks placed at tidewater, harbor improvements having been put in at the mouth of the Tuxpam River, which will afford proper shipping facilities to the various foreign markets. This field has been chiefly developed by the Pearson interests.

FURBERO FIELD.

The Furbero field lies about 60 miles south of Tuxpam. A number of wells have been drilled in this field and considerable production obtained, but some difficulty was encountered in transporting the oil to the coast until Pearson & Sons laid a pipe-line from the wells to Tuxpam, where they loaded tank steamers from a deep-sea pipe and used the oil at their refinery. This, to date, marks the southern boundary of the Tampico fields.

It will be seen by the foregoing that the most important oil-bearing region in the Tampico fields includes the Dos Bocas-Casiano field and the Cerro Viejo field.

This region has been pronounced by the World's most competent oil experts to be the best and most extensive of all the oil regions of Mexico.

This has been shown to be the "true gusher belt" of Mexico, and the majority of the wells drilled recently have been large producers and the majority of those to be drilled in the future, likewise, are expected to be of the gusher class and of large capacity.

Numerous seepages show the general occurrence of oil underlying this region. Many of these seepages are giving out high grade oil which has been marketed for many years for lubricating purposes just as it comes from the ground.

FORMATIONS AND DRILLING CONDITIONS.

Another advantage of this section is the favorable character of the formation and the cheapness with which wells can be drilled. The fact is more or less true that most all wells in Mexico are cheaply drilled. The maximum depth to the oil strata in this section approximates 2000 feet, and wells have been contracted for $10,000 apiece where the depth reaches this point, while those of a lesser depth are put down proportionately cheaper.

The chief formations in this field are shales and sand layers. These sand layers range up to several hundred feet in thickness and form the reservoirs for the oil. These layers are very porous, thus affording great storage capacity for oil. The shale is not too hard to drill and, yet, not so soft as to cave. It stands up well, and holes are often put down in this formation without casing until the capping to the oil sand is reached. The casing is then let in and the cap-rock penetrated, whereupon the pent-up gas pressure causes the oil to gush. Throughout this region a gusher may be expected in all properly located wells, as the character of the formations of this region, together with the position in which they lie, furnished the proper condition for the accumulation of the oil and gas under-pressure.

GEOLOGY OF THE DIFFERENT FIELDS.

THE EBANO FIELD.

The principal geological features which prevail in the Ebano field are a succession of shale and calcareous strata overlaying limestone beds, all being penetrated by Tertiary igneous rocks.

Due to the low topographical character of this region, a large part of the sedimentary rocks are buried beneath surface clays and silt deposits. The underlying Cretaceous is considerably folded, the folds often being sharp, while the overlaying strata shows but slight folding. The general dip of the formations in the Ebano field is to the south-east. The dip in these top measures is usually of low angle.

Petroleum is indicated by surface exudations. Oil rises to the surface in some of the water courses and is carried down stream considerable distance, while the exudations which occur on the land surfaces evaporate, losing their lighter qualities, forming residual or asphaltic deposits. The occurrence of oil throughout this region is somewhat irregular and the results obtained from any one well can not be relied upon as indicative of conditions to be met in adjacent territory. The productive zone is confined to fault lines so that wells, to be successful, should be drilled upon or very close to these faults, or, as in some instances, in or near vents connected with features of an igneous character.

This field has produced to date a heavy yield of low gravity oil which has been largely used in supplying the Mexican Railway system. Some of it has been refined with more or less success, but, since the bringing in of the large gushers in the Dos Bocas-Casiano field, Mr. Doheny, who is responsible for the development of the Ebano field, has practically diverted his efforts to the more southerly Dos Bocas-Casiano field, where the yield is not only infinitely greater but the oil is of high gravity and more suitable for refining purposes.

DOS BOCAS-CASIANO FIELD.

This field has a distinct geological definition, the oil-bearing strata being exposed along a chain of low hills having an easterly-westerly trend, which can be traced for over fifty miles.

There is no difficulty in investigation along these hills, as the formation has been uplifted during recent disturbances, showing the stratified rocks dipping with more or less regularity away from them. These stratified rocks are largely made up of limestone, sandstone and shale measures. The layers of sandstone are loose, ranging from 30 to 100 feet in thickness and are very porous, thus affording great storage capacity for oil. Intrusive rocks outcrop at various places along these hills and there are numerous oil seepages in the vicinity of these intrusive rocks and at the axis of anticlines.

The oil from these seepages ranges in gravity from 14° to 18° (B). This field, without doubt, is destined to become highly productive, as is indicated by the developments at Juan Casiano, where the Huasteca Oil Company, better known as the Doheny interests, has brought in some very successful wells.

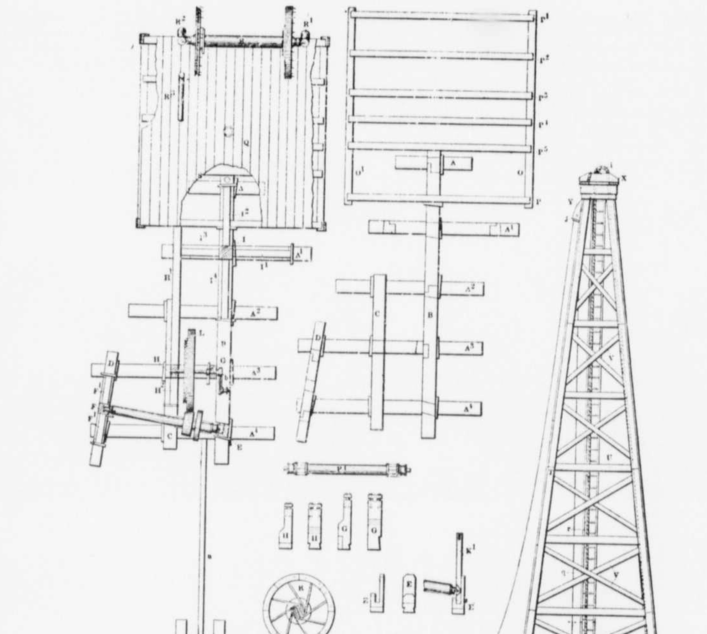
CERRO VIEJO FIELD.

The Cerro Viejo field lies to the south of the Dos Bocas-Casiano field just described, and in a measure parallels it, lying as it does on the opposite side of a mountainous elevation which divides the two fields. The character of the formations and the oil which they yield are largely similar in each. Shale and sandstone strata penetrated by intrusive rocks are the chief geological features of the district. The existence of oil is proven in a great part of the region by numerous oil seepages. Very successful wells have been drilled in this region and one in particular, the El Potrero, stands today as the record well of Mexico since the unfortunate destruction of the Dos Bocas Gusher by fire. It is believed, from a study of the general character of the formations throughout this region, that a number of wells of this high type can be brought in. There are a number of good producing wells besides the large gusher mentioned, and they all indicate the high character of the oil-bearing formations in this part of the Tampico region.

MATERIAL FOR STANDARD 82-Ft. DERRICK 20-Ft. BASE.

Pcs.	
1 —	14 x 14 x 14 x 30 x 26 ft. O. P. Beam
1 —	22 x 24 x 9 ft. O. P. Engine Block
1 —	16 x 16 x 30 ft. O. P. Main Sill
1 —	16 x 16 x 20 ft. O. P. Sub Sill
1 —	16 x 16 x 16 ft. O. P. Sampson Post
1 —	16 x 16 x 14 ft. O. P. Jack Post
6 —	14 x 14 x 16 ft. O. P. Mud Sills
1 —	14 x 14 x 16 ft. O. P. Tail Sills
1 —	14 x 14 x 20 ft. O. P. Blocking
2 —	14 x 14 x 14 ft. O. P. Casing Sills
3 —	14 x 14 x 12 ft. O. P. Pony Sills
2 —	12 x 12 x 24 ft. O. P. Bull Wheel and Calf Wheel Post
1 —	12 x 12 x 20 ft. O. P. Back Brake
1 —	12 x 12 x 14 ft. O. P. Bumpers
1 —	8 x 8 x 26 ft. O. P. Bunting Pole
2 —	8 x 8 x 22 ft. O. P. Side Sills
11 —	8 x 8 x 22 ft. O. P. Derrick Sills
2 —	6 x 6 x 20 ft. O. P. Dead Men
2 —	6 x 6 x 18 ft. O. P. Jack Post Braces
1 —	6 x 6 x 16 ft. O. P. Calf Wheel Braces
5 —	6 x 6 x 14 ft. O. P. Sampson Post Braces
5 —	4 x 6 x 16 ft. O. P. Short Braces
2 —	16 x 16 x 16 ft. O. P. Crown Block
1 —	5 x 16 x 12 ft. O. P. Knuckle Post
1 —	6 x 6 x 6 x 16 x 12 ft. O. P. Pitman
1 —	5 x 5 x 5 x 14 x 12 ft. O. P. Swing Lever
4 —	3 x 12 x 18 ft. O. P. S. 4 S. Bullwheel Arms
2 —	3 x 12 x 16 ft. O. S. S. 4 S. Calf wheel Arms
16 —	2 x 12 x 20 ft. O. P. S. 1 S. Band Wheel
54 —	2 x 12 x 20 ft. O. P. Derrick Foundation
8 —	2 x 12 x 18 ft. O. P. Girts
8 —	2 x 12 x 16 ft. O. P. Girts
4 —	2 x 12 x 14 ft. O. P. Girts
32 —	2 x 12 x 24 ft. O. P. Doublers
6 —	2 x 10 x 26 ft. O. P. Starting Legs
5 —	2 x 10 x 18 ft. O. P. Short Starting Legs
48 —	2 x 10 x 16 ft. O. P. Derrick Legs
1 —	2 x 8 x 26 ft. O. P. Bunting Pole to Jack Post
12 —	2 x 8 x 18 ft. O. P. Derrick Roof
5 —	2 x 6 x 26 ft. O. P. Belt House
17 —	2 x 6 x 20 ft. O. P. Braces
8 —	2 x 6 x 18 ft. O. P. Braces
12 —	2 x 6 x 16 ft. O. P. Braces
2 —	2 x 6 x 14 ft. O. P. Engine House
3 —	2 x 6 x 12 ft. O. P. Engine House
20 —	2 x 4 x 16 ft. O. P. Ladders
3 —	2 x 4 x 14 ft. O. P. Engine House

3 — 2 x 4 x 12 ft. O. P. Engine House ....
30 — 1 x 12 x 20 ft. O. P. Boarding Up ....
146 — 1 x 12 x 16 ft. O. P. Girts ....
50 — 1 x 12 x 14 ft. O. P. Engine House ....
60 — 1 x 12 x 12 ft. O. P. Boarding Up ....
60 — 1 x 6 x 16 ft. O. P. Braces ....
2 — 5 x 6 x 16 ft. O. P. Oak Top of Crown Block..........
1 — 2 x 12 x 16 ft. Oak Top of Beam..........



A derrick for standard drilling rig without calf wheel. The plan for floor timbers is also shown. The floor construction is shown with location of bull wheel, belt wheel and sand reel. The construction of bull wheels and belt wheel is also shown.

STANDARD CABLE TOOL EQUIPMENT.

To Drill to 3000 Feet.

CASING:

300 ft. 15½-in. 70-lb., 10th Coalinga special Steel Casing.
1000 ft. 12½-in., 40-lb., Coalinga special Steel Casing.
2000 ft. 10-in., 40-lb., Coalinga special Steel Casing.
2500 ft. 8¼-in., 32-lb. or 28-lb., Coalinga special Steel Casing.
3000 ft. 6¼-in., 24-lb. or 20-lb., Coalinga special Steel Casing.

RIG IRONS:

1 Set 6-in. x 7 ft. 6 in. Ex. heavy California Rig Irons with Patent Calf wheel attachment and D D Sand Reel.
1 Set Double Tug Cants, complete.
1 Set Rig Iron Bolts and Washers, Guy Wire and Nails.

ENGINE AND BOILER:

1 12 x 12 30 h.p. Steam Drilling Engine complete.
1 12 x 6-ply 90 ft. Stitched Rubber Belt.
3 Pr. 12-in. Belt Clamps.
1 2 Gt. C. I. Lubricator.
1 150-ft. Telegraph Cord.
1 Telegraph Wheel.
1 40 h.p. Canadian Type Boiler complete with stock and fixtures.
1 6 x 4 x 6 Boiler Feed Pump.
1 "C" Penberthy Injector.

CORDAGE AND WIRE LINES:

1 2¼-in. x 1500-ft. Manila Cable, Est. Wt. 2800 lbs.
2 2½-in. x 90-ft. Bull Ropes, Est. Wt. 400 lbs.
1 1-in. x 3500-ft. Steel Drilling Cables.
1 9/16-in. x 3500-ft. Steel Sand Line.
1 ⅞-in. x 100-ft. Steel Casing Line.
6 1-in. Wire Rope Clips.
6 9/16-in. Wire Rope Clips.
6 ⅞-in. Wire Rope Clips.
300 ft. ¾-in. Manila Rope, Est. Wt. 75 lbs.
300 ft. 1-in. Manila Rope, Est. Wt. 120 lbs.

LARGE STRING DRILLING TOOLS:

(All joints 3¼ x 4¼—7 1 & H 5 in. Sq.)
1 15½-in. x 6-ft. All-Steel Drilling Bit, Est. Wt. 1250 lbs.
2 12½-in. x 6-ft. All-Steel Drilling Bit, Est. Wt. 2000 lbs.
2 10-in. x 6-ft. All-Steel Drilling Bit, Est. Wt. 1500 lbs.
2 8¼-in. x 6-ft. All-Steel Drilling Bit, Est. Wt. 1200 lbs.
1 Set Tool Gauges for above.

1 5-in. x 30-ft. Stem.
1 5-in. x 10-ft. Sinker.
1 Set 6¼-in. x 8-in. Stroke Jars.
1 Set 6¼-in. x 8-in. Stroke Jars, 24-in. head.
1 2¼-in. New Era Rope Socker.
1 1-in. Solid Wire Rope Socker.
1 6-in. D. S. Casing Hook.
1 12½-in. Under-reamer.
1 10-in. Under-reamer.
1 8¼-in. Under-reamer.
1 Extra set each size cutters for above.
1 Set 3¼ x 4¼—7 5-in. sq. Box and Pin Joints.
1 Sub 3¼ x 4¼—7 Box to 2¾ x 3¾—7 Pin.
1 Sub 2¾ x 3¾—7 Box to 3¼ x 4¼—7 Pin.
1 11-in. x 19-ft. B. & D. Boiler.
1 9-in. x 20-ft. B. & D. Boiler.
1 7-in. x 20-ft. B. & D. Boiler.
1 Set Mogul Casing Tongs and Jaws for 15½, 12½, 10, 8¼ and 6¼-in. Casing.
1 Set Kellerman Back-up Tongs.
1 Set 5-in. 350-lb. Tool Wrenches.
1 Spider, liner and slips for 15½-in., 12½-in., 10-in., 8¼-in. and 6¼-in. Casing.
1 15½-in. x 16-in. Drop Drive Head.
1 12½-in. x 16-in. Drop Drive Head.
1 10-in. x 16-in. Drop Drive Head.
1 8¼-in. x 16-in. Drop Drive Head.
1 15½-in. x 16 x 1¼-in. Baker Casing Shoe.
1 12½-in. x 16 x 1¼-in. Baker Casing Shoe.
1 10-in. x 16 x 1-in. Baker Casing Shoe.
1 8¼-in. x 16 x 1-in. Baker Casing Shoe.
1 15½-in. x 16 x 1¼-in. Common Casing Shoe.
1 12½-in. x 16 x 1¼-in. Common Casing Shoe.
1 10-in. x 16 x 1-in. Common Casing Shoe.
1 8¼-in. x 16 x 1-in. Common Casing Shoe.
1 Set 5-in. (6 x 6 x 22-in. material) Drive Clamps.
1 D. C. Wrench for above.
1 Set Extra D. C. Bolts.
1 No. 2 Barrett Jack and Circle, complete with extra handle.
1 1 x 6 x 12 Derrick Crane.
1 2-Ton Moore Anti-Friction Hoist.

1 2-in. x 6-ft. B B Temper Screw with 2¼-in. Manila Rope Clamps.
1 1-in. Wire Rope Temper Screw Clamps.
1 5-in. Barrett Swivel Wrench with 4-in. Bushings.
1 Set 15½-in. Fairs Mannington Imp. Elevators with 2¼-in. links.
1 Set 12½-in. Fairs Mannington Imp. Elevators with 2¼-in. links.
1 Set 10- in. Fairs Mannington Imp. Elevators with 2¼-in. links.
1 Set 8¼-in. Fairs Mannington Imp. Elevators with 2¼-in. links.
1 Set 15½-in. x 1 x 8 Anchor Casing Clamps.
1 Set 12½-in. x 1 x 8 Anchor Casing Clamps.
1 Set 10-in. x 1 x 8 Anchor Casing Clamps.
1 Set 8¼-in. x 1 x 8 Anchor Casing Clamps.
1 32-in. Triple Bronze Bushed Steel Casing Block.
1 26-in. Steel Snatch Block.
1 O. K. Spudding Shoe.
1 8¼-in. or 10-in. special 1500-lb. Gate Valve to drill through.

STRING SMALL TOOLS:

(Joints 2¾ x 3¾—7 I & H 4 in. sq.)
2 6¼-in. x 6-ft. All-Steel Bits.
1 6¼-in. Tool Gauge.
1 4-in. x 28-ft. Stem.
1 4-in. x 10-ft. Sinker.
1 5-in. D S Casing Hook.
1 Set 5¼-in. x 8-in. Stroke Jars.
1 6¼-in. Under-reamer.
1 Extra Set Cutters.
1 5-in. x 20-ft. B. & D. Bailer.
1 Set 4-in. 250-lb. Tool Wrenches.
1 6¼-in. x 16-in. Drop Drive Head.
1 6¼ x 12 x ⅞-in. Baker Shoe.
or
1 6¼ x 12 x ⅞-in. Common Casing Shoe.
1 Set 4-in. (6 x 6 x 22-in. material) Drive Clamps.
1 D C Wrench for above.
1 Extra Set D C Bolts.
1 Set 6¼-in. Fairs Mannington Imp. Elevators.
1 Set 6¼-in. x 1 x 8 Anchor Casing Clamps.
1 Set 2¾ x 3¾—7 4-in. sq. Box and Pin Joints.

DERRICK TOOLS:

1 No. 4 Star Blower.
1 No. 3 Comb Pipe Vise.
1 250-lb. Anvil.

1 Comb Dressing Block for Under-reamer Cutters.
1 No. 7 Little Giant Screw Plate.
1 No. 1 A Toledo Ratchet Pipe Stock and Dies, 1 in. to 2 in.
1 No. 2 Mall Pipe Stock and Dies, 1/4 in. to 1 in.
1 No. 2 Barnes Pipe Cutter and 6 Extra Wheels.
1 No. 4 Barnes Pipe Cutter and 6 Extra Wheels.
1 No. 13 Vulcan Chain Tong.
1 No. 15 Vulcan Chain Tong.
1 No. 16 Vulcan Chain Tong.
1 Set Extra Jaws, Bolts and Chains for above.
1 Portable B S Forge.
1 Set B S Swages, Flatters and Hardies.
1 20-in. S. L. Tongs.
1 20-in. C. L. Tongs.
1 22-in. Pick-up Tongs.
1 12-lb. Sledge and Handle.
1 14-lb. Sledge and Handle.
3 O. K. Derrick Hatchets.
1 Set 2-in. Crumbie Tongs and Extra Dies.
1 Set 2 1/2-in. Crumbie Tongs and Extra Dies.
1 12-in. Eng. Combination Wrench.
1 15-in. Eng. Combination Wrench.
1 8-in. Stillson Wrench.
1 14-in. Stillson Wrench.
1 18-in. Stillson Wrench.
1 24-in. Stillson Wrench.
1 L. H. R. P. Shovel.
1 No. 3 Steel Square.
1 Plumb and Level.
1 5-ft. One-man Crosscut Saw.
1 26-in. Disston Hand Saw.
1 Saw Set for Crosscut Saw.
1 Saw Set for Hand Saw.
1 R. R. Pick and Handle.
1 Mattock and Handle.
1 12-in. Ratchet Brace.
1 Set 1/4-in. to 1-in. Auger Bits.
1 10-in. Single Wood Tackle Block.
1 10-in. Double Wood Tackle Block.
1 10-in. Triple Wood Tackle Block.
1 7/8-in. x 36-in. Ship Auger.

1 1-in. x 36-in. Ship Auger.
1 1¼-in. x 36-in. Ship Auger.
1 1½-in. x 36-in. Ship Auger.
1 No. 2 Pratt Auger Handle.
1 Adj. Hack Saw Frame.
1 Doz. 12-in. Hack Saw Blades.
1 No. 5 Iron Jack Plane.
100 lbs. No. 4 Babbitt.
1 6-in. Babbitt Ladle.
1 Yd. 1/16-in. Red Sheet Packing.
1 Yd. ⅛-in. C I Sheet Packing.
1 Yd. ⅛-in. Asbestos Sheet Packing.
5 Lbs. Flake Graphite.
10 Lbs. Italian Hemp Packing.
6 12-in. M B Files.
6 14-in. F B Files.
6 14-in. H R B Files.
12 6-in. S T Files.
1 D B Axe and Handle.
1 S B Axe and Handle.
12 5-in. Hay Fork Pulleys.
2 Cold Splitting Chisels.
2 Hot Splitting Chisels.
2 Punches.
2 Hand Cold Chisels.
2 Diamond Point Chisels.
1 A. E. Nail Hammer.
1 No. 4 Broad Axe.
1 Clark's Large Expansive Bit.
1 No. 14 Belt Punch.
1 Grindstone and Frame.
1 B. S. Post Drill and Set Drill Bits, ¼-in. to 1-in.
2 W. P. Crowbars.
2 No. 2 O. B. P. Machine Hammers.
6 Extra 56-in. Sledge Handles.
6 Extra 34-in. Pick Handles.
6 Extra 36-in. Axe Handles.
6 Extra 18-in. Hatchet Handles.
6 Extra 18-in. Hammer Handles.
6 Extra 18-in. Derrick Hatchet Handles.
1 Set Front and Rear Casing Wagons.
2 3-in. x 18-in. Jackscrews.

1 Draw Knife.
12 12-in. Strap Hinges.
12 12-in. Hinge Hasps and Staples.
2 Yale Padlocks.
2 Bars ½-in. Rd. Iron.
2 Bars ⅝-in. Rd. Iron.
2 Bars ¾-in. Rd. Iron.
2 Bars 1-in. Rd. Iron.
2 Bars ⅞-in. Oct. Tool Steel, Asst. Nuts and Washers.
1 50-ft. Steel Tape.
2 3-in. Flue Cleaners.
1 3-in. Flue Expander.
2 No. 4 Zinc Oilers.
1 No. 13 Coppersized Steel Oiler.
4 No. 2 Cold Blast Lanterns.
12 Extra Globes and Wicks.
2 Calking Tools.
50 Lbs. White Waste.
1 5-lb. Can Cup Grease.
10 Gals. Engine Oil.
10 Gals. Cylinder Oil.

FISHING TOOLS:

(All joints 2¾ x 3¾—7 I. & H. 4-in. sq.)

1 Set 5¼-in. x 36-in. Stroke Jars.
1 Combination Socket for 6¼-in. hole with Bowl for 8¼-in. hole, slips to catch rope socket neck.
1 Combination Socket for 10-in. hole with Bowl for 12½-in., slips to catch rope socket neck.
1 Slip Socket for 6¼-in., with 2 sets slips.
1 Slip Socket for 8¼-in., with 2 sets slips.
1 Slip Socket for 10-in., with 2 sets slips.
1 Slip Socket with long Reins for 8¼-in. hole, with Bowl for 10-in. and 2 sets slips.
1 Horn Socket for 8¼-in. hole, with 10-in. Bowl.
1 Boot Jack for 8¼-in. hole, with 10-in. Bowl.
1 Rope Spear.
1 2-Prong Rope Grab.
1 Horse Show Trip Knife, complete.
1 Wire Rope Knife, with Hards and B. B. Swivel
1 12½-in. C. S. Fluted Swedge.
1 10- in. C. S. Fluted Swedge.
1 8¼-in. C. S. Fluted Swedge.

1 6¼-in. C. S. Fluted Swedge.
1 Bit Hook.
1 8¼-in. x 8-ft. Single Spud.
1 12½-in. Henderson Trip Casing Spear.
1 10 -in. Henderson Trip Casing Spear.
1 8¼-in. Henderson Trip Casing Spear.
1 6¼-in. Henderson Trip Casing Spear.
1 12½-in. Casing Cutter with Extra Set Cutters.
1 10 -in. Casing Cutter with Extra Set Cutters.
1 8¼-in. Casing Cutter with Extra Set Cutters.
1 6¼-in. Casing Cutter with Extra Set Cutters.
1 2-in. x 12-ft. B B Jar Bumper.
1 12½-in. Forged Steel M. & F. Nipple.
1 10 -in. Forged Steel M. & F. Nipple.
1 8¼-in. Forged Steel M. & F. Nipple.
1 6¼-in. Forged Steel M. & F. Nipple.
1 12½-in. Case Hardened Nipples.
1 10 -in. Case Hardened Nipples.
1 8¼-in. Case Hardened Nipples.
1 6¼-in. Case Hardened Nipples.
1 12½-in. x 10-in. Swedge Nipple.
1 10 -in. x 8¼-in. Swedge Nipple.
1 8¼-in. x 6¼-in. Swedge Nipple.

ROTARY DRILLING EQUIPMENT.

1 Rotary complete, with Screw Wrench, 4 Extra Spacing Washers and two Quick-Opening Wrenches.

1 6-in. Mogul Extra Heavy Hoisting Drum, including Clutch, Sprockets, Bearing Boxes, Set Collar, Brake Levers, Bolts and Brake Band.

1 3 15/16 x 12-ft. Mogul Line Shaft, complete with Bearings, Set Collar, Sprockets, Cat Heads, Post Bolts and Keys.

3 Oak Posts for setting up.

2 6-in. Mogul Superior Loose Bail Hydraulic Swivels, with Spanner Wrench.

2 2½ x 6-ply 30-ft. Wire Wound Rotary Drilling Hose.

2 Set 2½-in. Hose Couplings and Clamps.

1 1¼ x 4-ply 25-ft. Rubber Derrick Hose.

1 12-in. Mogul 5-Pulley Steel Adjustable Crown Block.

1 44-in. 4-Sheave Extra Heavy Bronze Bushed Self Oiling Steel Block.

1 3-in. Rd. Iron "C" Hook.

1 6-in. D. S. Casing Hook.

1 12 x 12, 30-h.p. Steam Drilling Engine, complete.

1 2-qt. C. I. Lubricator.

2 10 x 5¾ x 12 Mogul Duplex Pumps.

1 40-h.p. Canadian type Boiler, complete with fixtures.

1 "C" Penberthy Injector.

1 6 x 4 x 6 Duplex Boiler Feed Pump.

1 6-in. Steel Slide Tong.

1 8¼-in. Steel Slide Tong.

1 10-in. Steel Slide Tong.

1 12½-in. Steel Slide Tong.

1 15½-in. Steel Slide Tong.

1 Set 6-in. Fairs Mannington Improved Elevator with 44-in. Bails.

1 Set 8¼-in. Fairs Man. Imp. Elevators with 2¼-in. Lines.

1 Set 10-in. Fairs Man. Imp. Elevators with 2¼-in. Lines.

1 Set 12½-in. Fairs Man. Imp. Elevators with 2¼-in. Lines.

1 Set 15½-in. Fairs Man. Imp. Elevators with 2¼-in. Lines.

2 No. 13 Vulcan Chain Tongs.

2 No. 15 Vulcan Chain Tongs.

2 No. 16 Vulcan Chain Tongs.

2 Set extra Chains, Jaws and Bolts for above.

40 6-in. Rotary Tool Joints, 5 x 6—7 Pin and Box.
2 6 x 5 Forged Steel Swivel Bushings.
2 6 x 4 Forged Steel Swivel Bushings.
2 6 x 8¼-in. C C Steel Water Head Bushings.
2 6 x 10-in. C C Steel Water Head Bushings.
2 6 x 12½-in. C C Steel Water Head Bushings.
2 6 x 15½-in. C C Steel Water Head Bushings.
1 6-in. Tool Steel Saw Tooth Rotary Shoe.
1 8¼-in. Tool Steel Saw Tooth Rotary Shoe.
1 10-in. Tool Steel Saw Tooth Rotary Shoe.
1 8¼-in. x 16-in. Special Mogul Drive Shoe.
1 10-in. x 16-in. Special Mogul Drive Shoe.
1 12½-in. x 16-in. Special Mogul Drive Shoe.
6 18-in. x 6-in. Fish Tail Bits, 5 x 6—7 Pin.
8 14-in. x 6-in. Fish Tail Bits, 5 x 6—7 Pin.
12 12⅜-in. x 6-in. Fish Tail Bits, 5 x 6—7 Pin.
12 11⅞-in. x 6-in. Fish Tail Bits, 5 x 6—7 Pin.
3 6 x 6 x 36-in. Offset Steel Drilling Collars to fit 6-in. Drill Stem and 5 x 6—7 Bit.
80 Ft. S S 40 Special Steel Chain.
20 Ft. S S 124 Special Steel Chain.
300 Ft. 1¼-in. Manila Rope for Cat Line.
1000 Ft. ⅞ x 19 Steel Rope for Hoisting.
3000 Ft. 9/16 x 7 Steel Rope for Bailing.
6 ⅞ Wire Rope Clips.
6 9/16 Wire Rope Clips.
1 6-in. Parker Releasing Spear, with Trip Device.
1 10-in. Kamerer Over Shot to catch 6-in.
1 Mogul Reversible Tong with Jaws for 6-in. Drill Stem, 6-in. Tool Joints and 8¼, 10, 12½, 15½ Casing.

FITTINGS TO CONNECT UP PUMP AND ENGINE.

1 Parker Valve Trap.
2 Plain Oil Country Lubricators.
2 2-in. I. B. B. W. Stop Cocks.
1 1-in. I. B. B. W. Stop Cocks.
2 3-in. B. B. B. M. Gate Valves.
4 2-in. Brass Joint Flange Unions.
2 2½-in. Brass Joint Flange Unions.
4 1 x 4 Nipples.
12 2 x 6 Nipples.

6 $2\frac{1}{2}$ x 6 Nipples.
10 3 x 6 Nipples.
3 3 x 10 Nipples.
3 6 x 5 Swedge Nipples.
3 4 x 3 Swedge Nipples.
2 6-in. x 10-ft. Pump Suction Pipe.
200 Ft. 2-in. Pipe for Steam Connections.
40 Ft. $2\frac{1}{2}$-in. Pipe for Stand Pipe.
12 2-in. C. I. Elbows.
4 $2\frac{1}{2}$-in. C. I. Elbows.
5 3-in. C. I. Elbows.
2 6-in. C. I. Elbows.
2 6-in. Foot Valves and Strainers.
3 2-in. Brass Globe Valves.
2 $2\frac{1}{2}$-in. Q. O. I B Gate Valves.
6 2-in. C. I. Tees.
6 2-in. C. I. Plugs.

EXTRA ROTARY PARTS.

1 Mogul Rotary Pinion.
1 Set (4) Tool Steel Grip Rings.
2 Rotary Screws and Nuts.
1 Rotary Clutch.
1 Rotary Clutch Sprocket.

EXTRA LINE SHAFT PARTS.

1 11 Tooth Sprocket.
1 12 Tooth Sprocket.
1 24 Tooth Sprocket.
1 30 Tooth Sprocket.
6 Extra Keys.
1 15 Tooth Engine Sprocket.
80 Ft. No. S S 40 Special Steel Chain.
20 Ft. No. S S 124 Special Steel Chain.

EXTRA SWIVEL PARTS.

1 Set (2) Alloy Steel Ground Swivel Cone Plates.
1 Set (12) Alloy Steel Ground Swivel Cones.
1 Bottom Hose Stem Glands.
1 Hose Stem with Centre Ball Race.
1 Set Outer Ball Races for Hose Stem.

1 Set Hose Stem Balls.
1 Gooseneck, complete.
1 Bottom Swivel for 6-in. Drill Stem.
1 Set Extra 6-in. Slips for Spears.
2 $2\frac{1}{2}$ x 6-ply 30 ft. Wire Wound Rotary Drill Hose.
2 Extra Sets Hose Clamps.
2 Extra Sets Hose Stems.

LIST OF STANDARD TOOLS, WHICH, ADDED TO ROTARY OUTFIT, COMPLETES A COMBINATION OUTFIT.

RIG IRONS:

1 Set 6-in. x 7-ft. 6-in. Ex. Heavy California Rig Irons with patent Calf Wheel Attachment and D D Sand Reel.
1 Set Double Tug Cants, complete.
1 Set Rig Iron Bolts and Washer Guy Wires.
65 Ft. S S 40 Chain.

ENGINE AND BOILER:

1 12 x 12 30-h.p. Steam Drilling Engine, complete.
1 12 x 6-ply 90-ft. Rubber Belt.
3 Pr. 12-in. Belt Clamps.
1 2-qt. C. I. Lubricator.
1 150-ft. Telegraph Cord.
2 Telegraph Wheels.

CORDAGE AND WIRE LINES:

1 $2\frac{1}{4}$-in. x 1000-ft. Manila Cable, Est. Wt. 2800 lbs.
2 $2\frac{1}{2}$-in. x 90 Bull Ropes, Est. Wt. 400 lbs.
300 Ft. $\frac{3}{4}$-in. Manila Rope, Est. Wt. 75 lbs.
300 Ft. 1-in. Manila Rope, Est. Wt. 120 lbs.
350 Ft. $1\frac{1}{4}$ Hard Lay Manila Rope for Band Wheel Lagging.
1 3500 x 0/16 Sand Line.
1 1 x 3500-ft. Artilling Cable.

LARGE STRING DRILLING TOOLS:

(All joints $3\frac{1}{4}$ x $4\frac{1}{4}$—7 I & H 5 in. Sq.)
1 $15\frac{1}{2}$-in. x 6 All-Steel Drilling Bit, Est. Wt. 1250 lbs.
2 $12\frac{1}{2}$-in. x 6 All-Steel Drilling Bit, Est. Wt. 2000 lbs.
2 10-in. x 6-ft. All-Steel Drilling Bit, Est. Wt. 1200 lbs.
2 $8\frac{1}{4}$-in. x 6-ft. All-Steel Drilling Bit, Est. Wt. 1200 lbs.
1 Set Tool Gauges for above.
1 5-in. x 30-ft. Stem.
1 5-in. x 10-ft. Sinker.

2 Sets 6¼-in. x 8-in. Stroke Jars.
1 Set 6¼-in. x 8-in. Stroke Jars, 24-in. Head.
2 2½ New Era Rope Socket.
2 1-in. Solid Wire Rope Socket.
1 12½-in. Under-reamer.
1 10-in. Under-reamer (2 Extra Springs).
1 8¼-in. Under-reamer (2 Extra Springs).
6 Extra Set each size Cutters for above and Keys.
1 Set 3¼ x 4¼—7 5-in. Sq. Box and Pin Joints.
1 Sub 3¼ x 4¼—7 Box to 2¾, 3¾—7 Pin.
1 Sub 2¾ x 3¾—7 Box to 3¼ x 4¼—7 Pin.
1 11-in. x 19-ft. B. & D. Bailer.
1 9-in. x 20-ft B. & D. Bailer.
1 7-in. x 20-ft. B. & D. Bailer.
1 Set 5-in. 400-lb. Tool Wrenches.
1 Spider, Liner and Slips for 15½-in., 12½-in., 10-in., 8¼-in.
1 15½-in. x 16-in. Drop Drive Head.
1 12½-in. x 16-in. Drop Drive Head.
1 10-in. x 16-in. Drop Drive Head.
1 8¼-in. x 16-in. Drop Drive Head.
1 Set 5-in. (6 x 6 x 22-in. Material) Drive Clamps.
1 D. C. Wrench for above.
1 Set Extra D. C. Bolts.
1 No. 2 Barrett Jack & Circle complete with extra Handle.
1 2-in. x 6-ft. B. B. Temper Screw with 2¼ Manila Rope Clamp.
1 ⅞-in. Wire Rope Temper Screw Clamp.
2 1-in. Wire Rope Temper Screw Clamps.
1 5-in. Barrett Swivel Wrench with 4-in. Bushings.
1 Set 12½ x 1 x 8 Anchor Casing Clamps.
1 Set 10-in. x 1 x 8 Anchor Casing Clamps.
1 Set 8¼-in. x 1 x 8 Anchor Casing Clamps.
2 12-in. Steel Snatch Blocks.
1 O. K. Spudding Shoe.
2 No. 14 Belt Punches.