2, 1953

In the Privy Council

No. 14 of 1952

ON APPEAL

FROM THE SUPREME COURT OF ALBERTA
(APPELLATE DIVISION)

BETWEEN

MICHEAL BORYS - - *(Plaintiff) Appellant*

AND

CANADIAN PACIFIC RAILWAY COMPANY and
IMPERIAL OIL LIMITED *Defendants (Respondents)*

RECORD OF PROCEEDINGS
VOLUME 3

Pages 407 - 577.

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37 Norfolk, The Strand, London,
for the Appellant.

BLAKE & REDDEN,
17, Victoria Street, S.W.1.,
for the Respondent
CANADIAN PACIFIC RAILWAY COMPANY.

LAWRENCE JONES & CO.,
Winchester House, Old Broad St. London, E.C.2.,
for the Respondent
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IN THE PRIVY COUNCIL

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Defendants
(Respondents)

RECORD OF PROCEEDINGS

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PART II

Exhibits

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	PART II - PLAINTIFF'S EXHIBITS Cont'd.			
17	Order No. 939-Certified Copy of a Report of a Committee of the Honourable the Privy Council, approved by His Excellency the Governor General in Council,	May 14,1887	113	786
18	Order No.1070-Certified Copy of a Report of a Committee of the Honourable the Privy Council, approved by His Excellency the Governor General in Council,	Oct.31,1887	113	786
19	Order No.2240-Certified Copy of Regulations governing the disposal of the Dominion Lands containing Minerals other than Coal in Manitoba and the North-West Territories; and of such Mineral Lands in British Columbia as are the property of the Government of Canada, except lands containing Gold or Silver,...	Nov. 9,1889	113	786
20	Order No.2774-Certified Copy of Amending Order in Council of the 9th day of November, 1889, Chapter 99 of the Consolidated Orders in Council in Canada,	Dec.18,1890	113	787
21	Order No.2020-Certified Copy of Amending Order amending Orders in Council,.....	Aug.25,1891	114	787
22	Order No.2090-Certified Copy of a Report of a Committee of the Honourable the Privy Council, approved by His Excellency the Governor General in Council,	Sep. 7,1891	115	787
23	Order No.2434-Certified Copy of a Report of a Committee of the Honourable the Privy Council, approved by His Excellency the Governor General in Council,	Oct.16,1891	116	787

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44A	Letter from Canadian Pacific Railway Company to The Registrar, Land Titles Office, Calgary, requesting Certificate of Title covering petroleum rights,	May 10,1929	223	790
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45A	Letter from Canadian Pacific Railway Company to The Registrar, Land Titles Office, Calgary, requesting issuance of separate Title for natural gas rights,	May 29,1929	224	791
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46A	Certified Copy of Certificate of Title No. 30-B-234 of Canadian Pacific Railway Company,	May 17,1923	225	791
46B	Certified Copy of Certificate of Title No. 43-V-35, of Royalite Oil Company Limited,	Oct.22,1930	225	791
47	Transfer No. 1194-U from Canadian Pacific Railway Company to Cecil Edmund Byron,	Jul. 8,1908	225	791
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No.	Description of Document	Date	Filed at	Printed at
124B	Document prepared by Dr. Fancher showing titles referring to The Canadian Petroleum Industry (see Exhibit 123),		615	834
125	Photostatic Copy of "The Oil-Well Driller, A History of The World's Greatest Enterprise, The Oil Industry", by Charles A. Whiteshot,		588	834
126	List, "Composition of Some Petroleum Gases of Alberta", submitted by Dr. Fancher,		600	835
127	List, "Physical Properties of Some Crude Oils of Alberta", submitted by Dr. Fancher,		600	835
128	Photostatic Excerpts from "Second Geological Survey of Pennsylvania, 1875 to 1879", by John F. Carll,		611	835
129	Photostatic Excerpts from "Technical Paper 51, Department of the Interior, Bureau of Mines, 'Possible Causes of the Decline of Oil Wells and Suggested Methods of Prolonging Yield', by L.G. Huntley",		611	835
130	Figure No.1 prepared by Dr. Fancher,		621	836
131	Figure No. 2 prepared by Dr. Fancher,		625	837
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133	Figure No. 4 prepared by Dr. Fancher,		630	839
134	First Annual Report on the Mineral Resources of Alberta, by Dr. John A. Allan,	1920	663	840

MR. RILEY: I wonder, sir, if I might just say one thing which will apply to all the experts my friends call. Our position, sir, is this, and I do not want to be getting up continuously to say it, that the scientific definition of petroleum or what it means in the scientific or chemical or mineral world has nothing to do with this lawsuit, and I do not want to say it again, but that is our position and we are not retreating from it.

MR. NOLAN: I understand that perfectly, my lord.

JAMES O. LEWIS, having been first duly sworn, examined by Mr. Nolan, testified as follows:

Q Mr. Lewis, you were asked by Imperial Oil to make a report on the issue that is being tried in this case?

A I was.

Q Is this document that has just been marked Exhibit 104 the report which you made to Imperial Oil?

A Yes, I think it is. It is the same as this one I have.

Q Now, Mr. Lewis, where do you reside? A. In Houston, Texas.

Q And what is your occupation? A. I am a consulting petroleum geologist and engineer.

Q Yes. What is the name of your firm? A. Petroleum Consultants.

Q When did you graduate, in what year and from where?

A I actually graduated in 1917 from Stanford University. I finished my academic work in 1909.

Q And after 1909 what work did you go into? A. For several years I was working in petroleum geology, in the first three or four years, in California. In 1914 I did some geological work in the Province of Alberta and in Montana, and some work in Wyoming in 1913. Just before that I did some work in geology in Texas. In the fall of 1940 -

Q 1940? A. 1914.

Q Yes. Before you get to 1914, what was this work you did in field geology, could you describe it a little more particularly? A. It was largely searching for oil and gas fields, but it also included some estimations of reserves and some engineering problems in the recovery of oil and gas.

Q And now in 1914, you were going to tell me? A. In 1914 I entered the service of the Bureau of Mines,

United States Bureau of Mines. The first year under a joint operation of the U.S. Bureau of Mines and the United States Indian Service I was stationed at Muskogee, Oklahoma, as oil and gas inspector, my chief duty being to advise the agency as to the waste of gas which was then going on, and from this for possible methods for mitigating that waste.

Q Yes? A. 1915 I entered the full service of the Bureau of Mines as a petroleum technologist, that was my title. In 1915 and '16 my principal work was research, and during that time I wrote several bulletins and papers on the recovery of oil and gas, and methods of estimating oil reserves.

Q When did you leave the United States Bureau of Mines?

A I left the United States Bureau of Mines in the fall of 1920.

Q What did you do then? A. After I left the Bureau of Mines I entered the firm of Smith and Dunn at Marietta, Ohio, who were specializing in increasing recovery from old oil fields by injecting gas or water into the depleted oil sands. I was in Marietta, Ohio, for two years.

Q When was that firm dissolved? A. I do not remember the exact date, but in 1922 I went to Tulsa, Oklahoma, still a member of the firm, and then about a year later the firm was dissolved and it became the firm of Dunn and Lewis, and continued to be a partnership. I had a partnership in that firm until 1940.

Q Yes. And you are the Mr. Lewis of that firm?

A That is correct, yes.

Q And when did you open a consulting office in Houston?

A I opened the consulting office under my own name in 1940. In 1945 or '46, I have forgotten the exact date, I formed the partnership of Petroleum Consultants with my partners, they being David G. Hawthorn and E.O. Bennett.

Q What is involved in your consulting work, Mr. Lewis?

A My consulting work generally has been the estimating of oil and gas reserves, problems in the production and recovery of oil and gas, and appraisal problems. I have also done work in the transportation of gas, in the estimation of markets, and work of that character.

Q Have you appeared before any regulatory bodies or commissions? A. Yes, I have appeared before the Federal Power Commission a number of times, before several State commissions, before the

Conservation Commission in this Province, and also before other governmental and state organizations, the Securities and Exchange Commission and Internal Revenue. I made special investigations for the United States Senate. And I have appeared before a number of the Conservation Boards of the various States that correspond to the one in Alberta.

Q And the Federal Power Commission? A. And the Federal Power Commission.

Q Mr. Lewis, would you be good enough to read to his lordship Exhibit 104, which was prepared and written by you, and, of course, Mr. Lewis, you will be permitted, I am sure, to make any comments that you care to make as you proceed with the reading. A. This is a report to the Imperial Oil Limited on the meaning of the word "petroleum", and is dated September 15th, 1950. I will not attempt to read the table of contents beginning on page 1. The title is "My Understanding of the Word 'Petroleum' ", and as a sub-heading I have "My Early Understanding of the Word 'Petroleum'."

I have been asked to give my opinion on the meaning of the word "petroleum" and in particular whether or not natural gas is petroleum and whether or not it was so considered on September 13th, 1906.

In the year 1906, I was an undergraduate in Stanford University, California, studying geology and preparing myself to make a career in the petroleum industry. Although I matriculated in the fall of 1905, my knowledge of the petroleum industry had not, up to 1906, progressed far enough that I had acquired any special knowledge of petroleum, but by the time I left the university in 1909, I had read the more important technical literature published on the subject in the English language, including works by Sir Boverton Redwood, by A. Beeby Thompson, both Englishmen, and by Frank Wigglesworth Clarke, an American.

It is my firm recollection that I had, before leaving the university, reached the understanding that petroleum was a generic term that embraced all the naturally occurring hydrocarbons (including some impurities but excluding

hydrocarbons in coal and oil shale) and that hydrocarbons embraced by the word "petroleum" ranged from gaseous, through liquid to solid forms, that chemically they were composed essentially of hydrogen and carbon in various proportions and in various molecular structures, petroleum being a mechanical mixture of many hydrocarbon compounds and that petroleum from various sources differed greatly in the proportions and natures of the hydrocarbons that composed the substances produced by the wells.

In 1916 I wrote Bulletin 148 for the U.S. Bureau of Mines which was published in 1917 and which was entitled "Methods for Increasing the Recovery from Oil Sands". On page 11, I stated that "crude oils or petroleum are mixtures of bituminous hydrocarbons, some of which are solids, some are liquids and some are gases, the solids and gases being soluble in the liquid". On page 12, I stated: ".....methane, which is the principal constituent of most petroleum gases....." and "The solubilities of the other petroleum gases, ethane, propane and butane....." On the other hand, I entitled this discussion "SOME PHYSICAL PROPERTIES OF PETROLEUM AND GASES" and "THE SOLUBILITY OF GASES IN PETROLEUM". Thus, I used "petroleum" ambiguously in the titles but in the text I specifically included the gases in "petroleum".

B. My Later Understanding.

The foregoing has been my understanding of the word "petroleum" ever since. In preparing to enter the petroleum industry, I expected to deal with gas, oil and natural tars, and asphaltic deposits. When I entered the services of the United States Indian Bureau in 1914, I was appointed an "Oil & Gas Inspector". When I entered the services of the United States Bureau of Mines in 1915, I was appointed as a "Petroleum Technologist" in the "Petroleum Division", and in 1918 I was appointed "Chief Petroleum Technologist" of the "Petroleum Division". My dutes and that of the Petroleum Division, were concerned more with natural gas than with oil because natural gas at that time was being wasted flagrantly and conservation of the gas was the most urgent problem. My experiences since then have been with natural gas and oil in

about equal proportions and in dealing with oil recovery problems, I invariably have found I have had to deal also with gas problems. In dealing with natural gas problems I often, but not invariably, have also had to deal with oil problems.

C. Dual Usage of "Petroleum".

I am fully aware that both before and since 1906 the word "Petroleum" has been variously and often carelessly used and is often used in a restricted sense as a synonym for "crude oil" to include only the liquid hydrocarbons as they are separated at the surface and are prepared for transporting to market. This prepared crude oil contains in solution paraffin, asphaltic solids and some gases and some of the constituents such as asphaltum and the gasoline fractions are not oily at usual temperatures and pressures. It has, however, been my experience, both from contacts with others engaged in the industry and from the literature that both before and since 1906, the words "petroleum Industry" connotes the broad usage and that it includes natural gas as well as crude oil and is synonomous with "oil and gas industry". There are many other evidences that among all those familiar with the industry, the word "petroleum" connotes a more inclusive meaning than "oil" or "crude oil".

I might add here that the oil and gas industry is generally considered to be one of the mining industries, so that we have in the mining industry assumed a still broader term, and that is shown by the fact that in the American Institute of Mining and Metallurgical Engineers they established at an early date the petroleum division which they still maintain, and I may say that many articles in the Petroleum Division of the American Institute of Mining and Metallurgical Engineers are solely on gas.

The dual usages of the word "petroleum" are typified by the definitions given by Sir Boverton Redwood, a world authority in his 3rd Edition of Petroleum published in 1913, and by Websters Empire Dictionary of 1904.

MR. NOLAN: My lord, there will be a number of references to literature. We have the books here, my lord, if my learned friends would like to see them, or your lordship would like to see them, they are available, to support the quotations that are being made, or for any other purposes which my friends might want to see them. We have not got all the literature because it will be explained to your lordship that some books, particularly the older ones, are quite unavailable and are in libraries from which they can not be taken.

Q Will you go ahead, Dr. Lewis?

A On page 1, volume 1, Redwood says in part: "Of the two general terms used to denote these substances, bitumen is older than petroleum, the latter not being found in classical Latin. At the present time, petroleum in its widest sense, may be considered to embrace all the hydrocarbons, gaseous, liquid or solid, occurring in nature, a list of the modern names of which will be found at the beginning of Section II". Webster, on page 1223 says in part: "Petroleum - (Petra, rock and oleum, oil). A variety of naphtha, also called rock or mineral oil, a liquid inflammable substance exuding from the earth, in some places collected on the surface of water in wells, in other places obtained in great quantities by boring into the coal-measures. It is essentially composed of a great number of hydrocarbons".

However, Webster's New International Dictionary 1914, page 1614, says in part, "PETROLEUM.....Rock oil, mineral oil or natural oil, a dark brown or greenish inflammable liquid which at certain points exist in the upper strata of the earth, whence it is pumped, or forced by pressure of the gas attending it....."

I have left out part of the quotation following that. The table below gives a list of the best known volatile products of American petroleum in order of volatility. "Cymogene is gaseous except at low temperatures; the other are liquids." The underscoring of "Cymogene is gaseous" is mine.

MR. RILEY: I wonder if we might have the underscoring explained to us, why "Cymogene is gaseous" is underscored, sir, if there is some significance.

A I just wanted to emphasize it to Imperial Oil Limited to whom this report was rendered.

Q MR. STEER: What is cymogene? A. I am coming to that. There follows a table in which the properties of Cymogene are given as:

"Specific Gravity 0.58 (110°B). (Note, 110° Baume is an arbitrary measure of the density of petroleum liquids used in the trade.)"

And then I have quoted again:

"Boiling Point 0°C (32°F)"

"Cymogene" has become an obsolete term. It corresponds to a hydrocarbon mixture consisting mostly of Butane which would now be known in trade as L.P.G. (Liquid Petroleum Gas).

I might explain that Cymogene is one of several terms which were used early in the industry which have become obsolete now. Gigolene and several others have been used, but we no longer use them.

The same duality of usage is found prior to 1906 and continues up to the present time. Frequently the usage is ambiguous and the reader cannot tell what the writer means by petroleum except from the context and quite often it cannot be told even by inference what usage was intended. There are also some special and even narrower restrictions of which Brannt is an example. On page 38 of "Petroleum", published 1894, William Theodore Brannt says in part, "The term petroleum which means rock oil, is in many languages used as a synonym for earth oil, it is, however, also generally employed to designate a certain distillate (illuminating oil or kerosene) obtained from crude oil, and, therefore, it would seem advisable to use the term only in the latter sense." Attention is called to the other contradictory statements made by Brannt shown in the statements excerpted from his book and submitted in evidence.

Other references and

discussions of them will be given later.

II. DEVELOPMENT OF KNOWLEDGE OF PETROLEUM.

D. Ancient Knowledge of Petroleum.

Exudations of petroleum gases, petroleum liquids and tarry or solid residues from petroleum occur extensively in the world and few areas of sedimentary rocks lack evidences of these hydrodarbons. They have been known from prehistoric times and they had been given various names and had been put to many uses long before the modern industry was established. Liquid petroleum most often occurred as maltha or tar oozing from porous rocks, rising up through the soil or entering water wells or springs and usually it was accompanied by some natural gas. Less frequently the seepages were of light oils either at the surface or in mines. The seepages in English coal mines gave rise to one of the many names "coal oil" which later was applied only to refined lamp oil or kerosene. Solid petroleum, asphaltum, ozokerite, gilsonite and various other varieties were known, these solids being derived from liquid petroleum by natural weathering and oxidation. Emanations of natural gas also occurred frequently; sometimes with little or no show of liquid or solid petroleum.

The liquid and solid petroleums were put to many uses in ancient times. In the biblical lands, tar was used as mortar and the word "slime" used in the Bible is believed to have referred to asphaltic tar. Natural tars were used to caulk boats and as a cement. In Egypt tar was used in embalming. Petroleum was also used medicinally under local names such as Seneca Oil, Icthyol, etc.

Gaseous emanations were not so noticeable as the solid and liquid hydrocarbons and were not so useful. They were the source of the eternal fires of the ancient Parsees and they are believed to have been the cause of the deliriums of some of the ancient oracles. Early in this century a cult of Spiritualists founded a colony on the asphalt impregnated soil where now is located the Summerland Oil Field near Santa Barbara in California, it being believed that the flames that burned without

visible source were a spiritual manifestation.

The word "petroleum" was in use long before the modern petroleum industry. I have found no record of when and how it was first used but Brannt speaks of its use in 1755. From the word itself it must be inferred that it was first applied to the oily substances oozing from the rocks and as the tars and asphaltum are not usually oily, it may be inferred that they may not have been originally included as petroleum and that neither were the gaseous hydrocarbons that usually accompanied the seepages of oil.

E. Modern Knowledge Disclosed a Need for Generic Definition of Petroleum.

As the science of chemistry was developed, it became apparent that chemically all the naturally occurring hydrocarbons, whether gaseous liquid or solid, were generically related and were members of several families of compounds. These chemical compounds were found to differ one from another most importantly as a result of differing proportions of hydrogen and carbon. Those which had the largest proportion of hydrogen were gases at ordinary surface conditions of temperature and pressures, those which had the largest proportion of carbon were solids at these conditions and those of intermediate proportions of hydrogen and carbon, were liquids. It was also found that the physical form which a hydrocarbon assumed was the result of the physical environment. Just as water (a liquid) can be converted to a gas (steam) by rise in temperature and to a solid (ice) by drop in temperature, so could each of the hydrocarbons be converted from one physical state to another and back again by moderate changes in temperature or pressure or by combinations of the two.

The essential knowledge of the chemical kinship of the hydrocarbons and of the convertibility of each of them from one physical state to another, was known before there was an important commercial industry.

When wells became the source of commercial supplies of oil, it was observed

that gas was almost invariably produced in large quantities with the oil and that the gas accompanying the oil did not differ chemically and physically by any important degree from those wells that produced gas only. This close association of gas and oil and the similarity of gases produced from oil and gas wells, made the oil producers conscious of the need for a term that covered generally the inflammable fluids that issued from the wells, whether in gaseous or liquid form.

When the origin of the oil and gas was investigated by the geologists and chemists, they came generally to the opinion that the gas and oil (with some unimportant exceptions) were of the same origin although there were for many years two opposed opinions as to the source of these hydrocarbons.

From these three approaches, the need for a generic term that would embrace all the natural mineral hydrocarbons whether in gaseous, liquid or solid form, became apparent and the word petroleum was adopted to this purpose. Bitumen had too broad and inclusive meaning as it included some of the coals, bituminous coal being the chief coal of commerce. The literature shows that petroleum was used in this generic sense long before 1906 and has been so used since then. There is no other word in the English language which has had this meaning. However, the original narrower meaning continued in parallel use.

As is well known, the English language is replete with words that have changed in meaning, words which have had several meanings or which have special meanings in various localities or in trade or in science. Naphtha is now understood in trade to refer to a distilled product from oil intermediate between motor fuel and lamp oil whereas its original meaning was natural crude oil. A change within our times is the use of the word gas for motor fuel.

F. Origin and Accumulation of Petroleum.

Hydrocarbons can be made in the laboratory from many materials both inorganic and organic. Many of these synthetically formed hydrocarbons also occur in petroleum. The early

discovery that hydrocarbons could be synthesized from inorganic materials and the finding of small quantities of hydrocarbons in volcanic emanations and in non-sedimentary rocks, led to a theory of inorganic origin for the commercial accumulations of oil and gas. This inorganic theory was mostly supported by chemists whereas the geologists mostly supported organic theories. The controversy was near its height in 1906. Eugene Coste, the Canadian chemist and geologist who first developed commercial gas in Alberta, was a leading advocate of the inorganic theory for the origin of gas and oil.

Though the theories postulated different source materials proponents of each of them believed that the gaseous liquid and solid hydrocarbons found in the commercial deposits were formed from the same source material, whether inorganic or organic.

The natural hydrocarbons which compose commercial oil and gas accumulations, are now considered by chemists and geologists to have originated from organic material deposited in fine fragments in marine muds which in course of geologic time have become shales and limestones. There are, however, different opinions with respect to the detail as to the sources and natures of the organic material and as to the processes of conversion into the hydrocarbons now found in the gas and oil fields. Among the differences in opinion was whether the first step in the conversion was the formation of gas from which the liquid and solid hydrocarbons were formed by further steps or whether the first step was the formation of solid or liquid forms of petroleum.

It is now generally agreed that sometime after deposition the organic materials were converted into numerous hydrocarbons, some of which were gaseous, some liquid and some solid. The liquids, including solids and gases, dissolved in them, and any free gases that occurred were expressed from the fine pored rocks in which the source materials were deposited, into porous, permeable rocks through which the mixtures of fluid hydrocarbons could migrate. As the hydrocarbon fluid mixtures were lighter than the water originally contained in the porous rocks, the hydrocarbons would migrate up

dip and finally accumulate into commercial deposits when further migration was stopped by some geological barrier.

These entrapped accumulations of hydrocarbons are the commercial oil and gas fields of today. The proportions of gaseous, liquid and solid hydrocarbons in the fields vary greatly and there are also variations in the chemical nature of the hydrocarbons. Some accumulations consist almost entirely of gaseous hydrocarbons, whereas others consist mostly of liquid hydrocarbons with solid hydrocarbons dissolved in them. These differences in nature and proportions of hydrocarbons found in the petroleum accumulations are believed to have resulted from differences in the original organic materials deposited in the marine muds; in differences in the physical conditions under which the source materials were converted into hydrocarbons; in differences in conditions of migration and accumulations and finally to differences in conditions to which the accumulations were later exposed.

It has been noted that generally the deeper accumulations have oils of lighter gravity and that the proportion of gaseous to liquid and solid hydrocarbons is greater than at shallower depth. It has also been observed that accumulations which have been exposed to atmospheric agencies in recent geologic time, lose most of the gaseous and volatile constituents and that tarry or solid residues are left. The Fort McMurray tar sands of Alberta are thought to be the largest accumulation of weathered petroleum in the world.

G. The Gaseous Hydrocarbons.

The gaseous hydrocarbons can occur either in the free state or dissolved in the liquid hydrocarbons. The free gas, being lighter and less viscous than the liquids, has tended to migrate ahead of the liquids and to accumulate in the structurally highest portions of the geologic traps in which the fluids finally came to rest. The volume of free gas may be such that it will occupy all the space in the trap and thus exclude all or virtually all of the liquids, which therefore had to migrate still further up dip.

Thus there can be a separation of gaseous from liquid petroleum during migration and only gas may be found in a trap whereas originally gas and liquid were formed together. So far as I can ascertain, there are evidences of oil in all the commercial free gas fields in Alberta, either rims of oil filled rocks around the margin of the gas accumulation, or signs of oil impregnating the gas filled rock, and always vapors of hydrocarbon liquids are found in the gas. The same statement holds true generally for all the important gas accumulations known to me in the United States.

Methane, which is the lightest and most volatile of the hydrocarbons found in petroleum, is often found unassociated with the heavier and less volatile hydrocarbons, however, I know of no important commercial deposits of this nature. Rotting vegetation gives off methane and usually methane gas arises from stagnate pools in marshes. The original word for methane was Marsh Gas. Methane also is usually found in coal mines and sometimes in gases emitted by volcanoes. Sewer gas also is partly composed of methane.

H. Bitumens.

Hydrocarbonaceous materials are found in oil shales and in all coals except anthracite and this material can be converted into gaseous, solid and liquid hydrocarbons by destructive distillation or other chemical processes. Some of the hydrocarbons so formed can also occur in petroleum, but many do not and the products are not now considered by chemists to be petroleum. In their original state, these hydrocarbonaceous materials in the coals and oil shales are called bitumens. The word Bitumen also includes Petroleum.

I. Impurities in Petroleum.

Besides the hydrogen and carbon, petroleum usually contains in small proportions sulphur, nitrogen and oxygen, either chemically combined with hydrocarbons or as part of the mixture of substances. Sometimes these substances occur in substantial proportions particularly in free gas.

THE COURT: I wonder if this would not be a good time to stop. It is 12:30, and without injury to our health, do you think we can get back by half past one?
MR. NOLAN: Yes, my lord.
MR. STEER: Yes, my lord.
THE COURT: All right, court will stand adjourned until 1:30.

: : : : : : :

AFTERNOON SESSION,
November 22nd, 1950.

JAMES O. LEWIS, (recalled) already sworn, examined by Mr. Nolan, testified as follows:

Q Mr. Lewis, at the adjournment you were reading at the top of page 12 of your report. You had got down to the heading "Common Origin of Gas and Oil was known before 1906". Would you please go on from there.

A J. Common Origin of Gas and Oil was known before 1906.

The preceding statements explain why in my opinion the important deposits of gas and oil had a common origin and why the proportions of gas and oil in an accumulation may vary widely between different fields. My studies of the literature convinces me that the opinion of a common origin of gas and oil was held by most investigators in 1906.

III. HOW OIL AND GAS OCCURS IN COMMERCIAL FIELDS AND HOW THEY ARE RECOVERED.

K. Descriptions of Types of Commercial Oil and Gas Fields.

Commercial gas and oil deposits are found in rocks which are porous and through which gas and oil can flow readily. Most commercial deposits are found either in sandstones or in limestones or dolomites. Dolomite is physically like limestone and for brevity the two will be referred to collectively as limestone. These rocks are of sedimentary origin and for the most part they were deposited under sea water.

Gas occurs in the fields in two forms "free" and "dissolved" in oil. Oil, as it is originally found in the fields, almost invariably contains much gas in solution and unless specifically stated otherwise, it is to be understood in this report, that when "oil" is mentioned, that it includes the solution gas.

The barriers which prevented the further migration of gas and oil through the porous rock and caused the commercial accumulations

could be one or a combination of several kinds. The strata are arched upward in many places like an inverted bowl and gas and oil that once entered such an upward arching, usually called a dome or anticline, would be entrapped, being prevented from escaping to the surface by shales or other impervious sediments overlying the porous rock and held in place by the water occupying the lower levels of the porous stratum, just as air can be entrapped under a bowl that is inverted under water. This type of accumulation is illustrated in cases B, C, D and E of Figure 1 and in Figure 2.

MR. NOLAN: My lord, this would be a convenient place, I think, to have those figures marked as exhibits, and they will be found in the back of the report, my lord, and I think they should be marked. If Figure I could be given a number.

THE COURT: Exhibit 105.

CROSS-SECTION OF MULTIPLE SAND FIELD PUT IN AND MARKED EXHIBIT No. 105.

MR. NOLAN: And Figure 2, my lord.

THE COURT: Exhibit No. 106.

CROSS-SECTION AND PLAN OF RESERVOIR PUT IN AND MARKED EXHIBIT No. 106.

MR. NOLAN: And perhaps while we are marking them you will give a number to Figure 3, which will obviate the necessity of turning to that again.

THE COURT: 107.

CROSS-SECTION OF FAULT TYPE OF FIELD PUT IN AND MARKED EXHIBIT No. 107.

Q MR. NOLAN: Now, Mr. Lewis, you have mentioned in your report Exhibits 105 and 106. You have something to say about those, have you?

A Exhibit No. 105, Figure No. 1, is to exhibit the occurrence of free gas and oil and water in a series of reservoirs in a structural entrapment, the Figure representing a cross-section of a dome or anticline.

Q This does not represent any particular field, Dr. Lewis? A. It does not represent any particular field but, on the other hand, is representative of conditions which frequently occur in nature. At the top of the exhibit, Exhibit 105, designated by the "A" on the left of the drawing, is shown a lens of sand occupied by drive free gas. That would correspond generally to such an accumulation as frequently occurs in the Viking and other sands in the Cretaceous formation. The underlying formation "B" represents a porous sandstone in which oil is accumulated in the upper part of the structure with water below, with the oil having solution gas, and the two reservoirs, "A" and "B" are separated by impermeable shale. "C" represents another sand which is thicker. That is a free gas cap at the top of the structure, with an oil column with solution gas directly below, and water below that, separated from the reservoirs above and below by impermeable shales. "D" represents a thinner reservoir rock or bed which also has a free gas cap and a thin oil column with solution gas below it, and water at a still lower level. At the bottom, as represented by "E" is another thick formation, which is porous, and which contains only gas rich in condensate in the structure with water directly below.

While I assumed that each one of these reservoirs rocks was sand or sandstone, it would be just the same if the reservoir rock was a porous limestone or porous dolomite.

In Exhibit 106 I have shown a hypothetical section of a rather thin reservoir rock with a gas cap and an oil column below that, and water below the oil.

Q Yes? A. And I have shown the top part of the figure, Exhibit 106, as representing a cross-section while the bottom part represents a plan. That is, the top part as you are looking at it in the vertical section through the field from the side, and the bottom part as if you were looking from the top down on it, and if you were on a map, and it shows too how the areas in the bottom part of Exhibit No. 106, the uppermost portion, if you drill into the reservoir rock, it would contain only gas; if you drill a little further downdip you would get

gas in the top of the sand and oil below it.

Q That is what is called a dome structure? A. This could be a dome structure, yes.

Q Then Exhibit 107? A. 107 is a cross-section of a different structural type which would correspond to the Turner Valley field.

Q Would you call it a fault type of field? A. Yes, I would call it a fault type of field where oil and gas were prevented from further upward migration by coming up against a fault, through dense rock, against the various rocks prevented further migration, with the segregation of the three fluids being in the same order, the free gas at the top, below that oil with solution gas, and below that oil with solution gas there is water.

Q What is a fault, Dr. Lewis? A. A fault is a dislocation of the formations in the earth, where they have been broken on one side of the earth's crust and is moved along the break with relation to the other, so that the rocks are disturbed from their original position.

Q And this is a type of entrapment, is it? A. This is one of the well-known types of entrapments for entrapping gas and oil.

Q Well, perhaps you might go back to the top of page 13 and say anything more you want to say about these figures or proceed with your script.

A Where free gas and oil are both present, the free gas, because it is of least specific gravity, will occupy the top of the dome or anticline, there will be oil containing gas in solution below it and water below the oil, as shown in examples C and D of Figure 1, and in Figure 2.

The upward arching of the rocks can have been caused by earth movements which folded the rocks or by the sediments being draped over buried hills or over buried fossilized coral reefs, or the accumulation can be in porous beds at the top of buried hills or in the more elevated portions of the coral reefs. Whatever may be the cause, the most important factors are that an inverted bowl is formed in porous rock overlain by impermeable rock.

In the Leduc field the accumulations are either in the elevated portions of a fossilized coral reef or in sands and limestones draped over the reef.

These were done by Mr. Gustafson in several of his sections which he presented yesterday and this morning.

The fossil coral reef is of the same origin as the coral reefs being formed in tropical seas today. The Leduc reef was formed in Devonian times many millions of years ago when this part of Canada contained a marine sea, with waters of tropical warmth. The conditions in the Leduc field will be described in more detail by other witnesses. I referred here to Mr. Gustafson.

Another barrier to migration can be lack of permeability of the rock in an up-dip direction. Most sandstones were deposited originally as sand bars under water and they extend over limited areas and are enclosed in shales as shown by Case A, Figure 1, thus gas or oil can migrate to the up-dip margins of the lens and can go no further and the oil or gas can accumulate in commercial quantities in the more elevated portions of such lenses. Many of the Cretaceous gas and oil fields of Alberta are in such entrapments. Sometimes a lens may be completely filled with either free gas, or oil, only, or free gas can occur in the uppermost portion of the lenses and oil below, but most often water occurs in the lowest portion of the lens.

In limestone porosity and permeability is irregularly distributed and gas and oil can be entrapped in the highest parts of a porous portion of the otherwise dense limestone. This form of entrapment is essentially similar to a sand lens entrapment. Similarly oil and gas can accumulate in the up-dip portions of porous beds truncated by erosion.

Where the sediments are dislocated by faults, the permeable rock layer may be cut off by a fault and the severed end may be sealed by an impermeable rock which will prevent further upward migration of gas and oil. The Turner Valley and other fields in the foothills of Alberta are accumulations in limestones against such fault barriers. This type of entrapment is illustrated in Figure No. 3.

An accumulation of gas and

oil which is separated by impermeable beds above and below or by water from other accumulations is known as a reservoir. A reservoir may contain only free gas, or oil only or free gas in the upper portion with oil in the lower portions. A field can consist of only one reservoir or a number of reservoirs, one superimposed over the other at different depths. Leduc is a multiple reservoir field. Figure No. 1 illustrates a multiple reservoir field.

L. Solubilities of Petroleum Gases and Solids in Petroleum Liquids.

Gases are soluble in most liquids, a familiar example being Carbon Dioxide (CO_2) in carbonated water. Petroleum gases are highly soluble in petroleum liquids. While in solution, both gases and solids take on the physical properties of a liquid just as does salt or sugar when they are dissolved in water. The quantities of a gas or of a solid that will go into solution are affected by temperature and pressure. The solubility of gas is affected most importantly by pressure and the quantity that can be held in solution is nearly proportional to pressure. The familiar example is the bottle of carbonated water. When it is opened and the pressure is reduced, the gas can be seen evolving from solution and escaping to the atmosphere.

Original reservoir pressures are usually approximately proportional to the depth at which they occur, thus usually the pressure in a reservoir at 4,000 ft. depth is twice as great as in a reservoir only 2,000 ft. deep. Usually pressures increase with depth at the rate of 450 pounds per square inch for each 1,000 ft. of depth.

M. Free Gas.

Where the quantities of gas that accumulate in a reservoir are greater than can be held in solution by the oil that entered the reservoir, the excess gas accumulates as free gas in the higher portions of the reservoir and this free gas accumulation is known as a gas cap. Below the gas cap will be the oil which will be saturated with dissolved gas thus the reservoir will contain gas in two states, i.e., free and solution gas. Referring

again to the bottle of carbonated water, the space at the top of the bottle that is filled only with carbon dioxide gas corresponds to the free gas of the gas cap and the carbon dioxide dissolved in the water below corresponds to the oil column with its solution gas. Gas caps are shown in Cases C and D of Figure 1 and in Figures 2 and 3.

The physical principles which I have described were known before 1906 and it was also known in the petroleum industry that natural gas occurred both in the free state and dissolved in the oil as it originally was found underground. The principle of the Anticlinal Theory, which had been advanced before 1906 was that the fluids would stratify in accordance with their respective specific gravities, the free gas occupying the highest parts of the entrapment, the oil with its solution gas occurring next below the free gas and the water occupying the lowest part of the porous rock. There have, of course, been great advances in detailed knowledge of reservoir conditions and still greater advances in the techniques of operating reservoirs so as to extract the greatest quantities of gas and oil from them. These advances have shown that it is essential that the gas and oil be controlled conjointly if greatest gas and oil recoveries are to be attained.

A gas is defined as an aeriform fluid. However, a substance can change from a solid to a liquid to a gas or reversible upon changes in temperature and pressure or by solution, hence it is necessary to specify the physical environment. In English and American usage the standard is at a temperature of 60°F. and a pressure of 14.65 pounds per square inch absolute. A standard cubic foot of gas is the quantity of gas that will occupy a cubic foot of space at these standard conditions. However, in trade, gases are measured at various base pressures and in Alberta a base pressure of 14.4 pounds per square inch absolute is used. The quantity of gas in a cubic foot of gas at 14.1 is slightly less than at 14.65 pounds per square inch.

In distinction from solids and liquids which are virtually incompressible, a physical property of a gas is that it is compressible and expandable approximately in inverse

proportion to the pressure. At great depths the pressure may be so high that a standard cubic foot of free gas will occupy less than 1% of a cubic foot of space and each cubic foot of space may contain more than 100 Standard Cubic Feet of gas. As the gas is produced, pressures will be decreased and the gas remaining in the reservoir rock will expand. As depletion goes on, each cubic foot of reservoir space will contain lesser and lesser quantities of gas.

When gas goes into solution, it is compressed to an even greater degree and over 300 cubic feet of gas can be compressed into one cubic foot of liquid space. While in solution, gas may be considered to be liquid.

The solution gas affects favorably the physical properties of the oil in the reservoirs. The more gas that is in solution, the less viscosity and less surface tension has the oil so that it flows more readily through the porous rock and less is retained by capillarity. When pressures are reduced and gas evolves from solution, these favorable physical properties are reduced, hence it has become recognized as good practice to retain as much of the gas in solution as is practical until oil recovery has been completed. This was known in 1906 in science but was not then commonly known in the petroleum industry.

Petroleum natural gas invariably contains some hydrocarbons which are liquids under standard conditions when isolated from the more volatile gases because petroleum liquids will vaporize in a gaseous atmosphere at temperatures well below their boiling points just as water will evaporate in the air. This was generally known in the industry in 1906. These vaporized liquids are often more valuable than the gases themselves.

Whereas the petroleum gases which occur originally dissolved in the petroleum liquids underground, volatilize at normal surface temperatures and pressures and can be readily separated from the liquid, the petroleum solids which also occur originally in solution, do not readily separate themselves from the liquids. Except for minor quantities that separate out in the wells or in the bottoms of tanks, these solids must be

separated by volatilizing the liquids by heat and vacuum. The more volatile hydrocarbons are thus boiled off leaving an asphaltum residue from some oils and a wax distillate from other oils. From the wax distillate, paraffin wax is separated by the final steps of refrigeration and filtering. This was known in 1906.

N. The Principles of Recovering Oil.

The operation of producing oil consists of:

(1) Causing the oil to flow from the reservoir rock into the well;
(2) Flowing or lifting the oil up the well to the surface;
(3) Separating at the surface the oil from the gas and sometimes from water that may also enter the well.

The most important is the first step, for upon that step depends the percentage of the oil originally contained in the reservoir rock that may be brought to the surface and reduced to possession. Three natural forces are recognized as agents for moving the oil from the reservoir rock into the well, i.e.,

(1) the expansion of the gas dissolved in the oil or of free gas super-adjacent to the oil;

By "free gas super-adjacent to the oil" I refer to the gas in the gas cap.

(2) the displacement of oil from the pores by upward rising of sub-adjacent water; and
(3) the downward drainage of the oil by gravity.

The first mechanism is recognized as the least effective and the other two as the most effective. Efforts are always directed toward using either water drive or gravity drainage where conditions permit and choice is made between the last two in accordance with natural conditions and practical considerations.

When a well taps an oil reservoir rock, it provides an avenue of escape for

the pent-up gas forces and as the gas and oil leaves the reservoir, pressures are reduced around the well and gas from more distant parts of the reservoir expands and flows through the pores of the reservoir rock toward the well moving oil with it. As pressures are reduced, water from below or around the margins of the oil accumulation may start to flow into the reservoir, displacing the oil from the pores and driving it to the wells. Where conditions are favorable, this water invasion may be so active that the field may from then on be operated as a water drive field and ultimately from 40% to as much as 80% of the oil may be recovered before daily production declines to unprofitable rates. But in order to make this operation successful, it is necessary to regulate the rate of withdrawal of the gas and oil to the rate at which water can enter and displace the oil effectively.

Where a gas cap exists, it is essential that none of the free gas be produced until oil recoveries have been completed. If the gas is drawn off and pressures reduced in the gas cap, that portion of the oil that otherwise would be recoverable from the reservoir rock will be driven upward into the gas cap rock which previously had contained no more than traces of oil and, of the migrated oil, all or a large portion will be rendered irrecoverable. The reduction in pressure will also cause loss of solution gas from the oil which will be detrimental to oil recovery.

A recently introduced practice is to supplement the natural water drive by injection of water into the producing formation below the level of the oil-water contact.

Where conditions are not suitable for a water drive an endeavour will be made to operate on the principle of gravity drainage. This is applicable only where the reservoir rock is very porous and permeable and the bedded rock is inclined. In this operation, pressures are maintained as nearly as possible at their original values and thus little of the gas is permitted to come out of solution. The plan is to suppress gas evolution and gas movements to a minimum and to allow the oil to drain itself down dip. If the reservoir contained a gas cap originally, none of the free gas is produced but as the oil is drained down dip, the gas follows

and the gas cap spreads. Where no gas cap existed originally, a secondary gas cap will be formed as the oil drains down dip, the gas either coming out of solution from the oil if pressures are reduced any, or the gas produced with the oil is gathered and injected back into the highest parts of the reservoir to refill the space vacated by the oil which has drained down to lower elevations.

As with water drive, the production of oil must be restrained to the rate at which gravity will operate effectively and this is usually at a slow rate of withdrawal often only 2% to 4% of the reserves being withdrawn each year so that it usually takes from 30 to 50 years to deplete a reservoir in this manner and meanwhile little if any gas will be available for marketing. This method of operation, including the reinjection of all gas and even injecting gas from other sources, is in the interests of conservation and recoveries are comparable to those gained by water drive.

Where conditions make it impractical or impossible to operate a reservoir under either the water drive or gravity drainage principles, it becomes necessary to operate under the principle of solution gas drive which is the least effective of the three and results in recoveries of less than 10% under unfavorable conditions and seldom if ever more than 30%. Whereas it is necessary that production rates be slowed down under the other two principles, there is often no appreciable gain in oil recovery under solution gas drive by slowing up production. The gas evolves from solution as pressures drop and the expanding gas drives the oil out of the pores of the reservoir rock. The gas oil ratios increase as the oil is depleted and production stops when the gas is gone.

A practice started as early as 1911 is to inject gas or air into the porous rock to supplement the depleted gas and this has often been effective. In more recent years the reinjection of the produced gas has started early in the life of the field and often has been more effective than waiting for the depletion of the original gas, but in places conditions make this ineffective. Where there is an original gas cap in a reservoir that is adapted only to solution gas drive, the gas cap gas should not be depleted through wells in the gas cap

but the gas should be produced through oil wells both to prevent oil migrating up into the gas cap and to cause the gas to pass through the oil bearing rock thus increasing oil recovery.

The relationship of gas caps to oil recoveries under the three principles can be better understood by reference to the three Figures which I have submitted.

In 1906 the knowledge of oil recovery was rudimentary and conservation was not practiced. It was generally believed that oil was driven out of the rock by the force of the expanding gas and it was also believed that in places water helped to flush out the oil. A noteworthy case of water flushing was at Petrolia in Ontario.

It has become recognized in recent years that oil recoveries can be greatly increased by carefully applying engineering principles, that where conditions are favorable, the oil should be withdrawn slowly so that either water drive or gravity will become effective and solution drive be prevented. It has also become recognized that with virtually no exceptions, the gas in an original gas cap should be produced through oil wells in gravity drainage and in solution gas drive fields, and that in many reservoirs all gas produced should be reinjected back into the reservoir. It is now known that for highest oil recovery the recovery of gas should be made incidental to and subservient to oil recovery, and that in most reservoirs the gas cap gas should not be made available for sale until twenty and sometimes fifty years after the field starts to produce. The conservation authorities have been giving more and more weight to these principles and have been putting public interest ahead of private interest to the extent of infringing seriously on equities.

O. Gas Produced from Oil Wells.

The proportion of gas to oil is expressed as the gas oil ratio which is the cubic feet of gas produced with each barrel of oil. Gas oil ratios very widely. They depend
(1) upon the gas originally dissolved in the oil;
(2) upon whether there is a gas cap;
(3) upon the manner of operating the wells and the

reservoir; and
(4) upon the degree of depletion of the reservoir.

Commonly gas oil ratios range from 500 cubic feet to several thousand cubic feet of gas to a barrel of oil, but occasionally so little gas is dissolved in the oil that the gas oil ratio may be less than 100 cubic feet to the barrel and the gas is almost imperceptible at the surface.

Under some natural conditions the gas oil ratio can be partly controlled by the manners in which wells are completed and operated and by the manner in which the reservoir is operated, but the irreducible minimum is the quantity of gas that is dissolved in the oil within the reservoir under the pressure that exists at the time. At the existing pressure the quantity of gas that is dissolved in the oil is an integral part of the reservoir liquid and it must move through the rock and enter the well with the oil. This solution gas can evolve and become free gas only when pressures in the well itself and at the surface are reduced below reservoir pressure. Neither the solution gas nor the oil in which it is dissolved, can be withdrawn separately from the reservoir in any practical way; they must necessarily be produced together.

Under most operating conditions, pressures are reduced partly or sometimes entirely during the depletion of the field and this causes evolution of gas from solution and reduces the quantity of gas that remains dissolved in the oil that is still in the reservoir. However, the result is to increase the gas oil ratio of the produced oil because most of this freed gas must necessarily flow through the reservoir rock in a co-mingled stream into and up the well to the surface. The gas oil ratios many at times be partly controllable but there are physical and practical minimums that are beyond control and neither the gas nor the oil can be withdrawn from the reservoir separately at lesser gas oil ratios.

Whether or not the statements made in the three preceding paragraphs were understood or agreed to in 1906 is immaterial because they were physical and practical facts then just as

they are today.

IV. THE CONFLICTS IN INTEREST THAT CAN ARISE UNDER SEPARATE OWNERSHIPS OF OIL AND GAS.

P. Conflict of Interests that can Arise in Oil Fields under Separate Ownerships of Gas and Oil.

Under separate ownership it would be necessary to decide whether the oil or the gas owner had precedence with respect to the rate of production of the well because the markets available and the facilities for handling the two fluids could be quite different and the two owners might want to produce the two fluids at quite different rates, thus there could be a market for all the oil produced but not for all the gas that was unavoidably produced with the oil. These differences would be seasonal for there is a much greater market for gas in winter than in summer. There would also be questions of divisions of costs of wells and operations between the owners and responsibilities for wastes or damages. The Conservation Board could be expected to require that the gas not be wasted but, as the oil owner would have no control over the disposition of the gas, he would be estopped from producing the oil if the gas owner was unwilling or unable properly to dispose of the gas.

MR. STEER: My lord, I think I had better say here that a great deal of what has been stated is not strictly evidence. It is more a matter or argument. And I would like to emphasize as to what was said in the beginning that such evidence as this should be taken subject to our objection.

THE COURT: All right. Go ahead, Mr. Lewis.

MR. NOLAN: Yes, Dr. Lewis.

A Q. Handling of Oil and Gas at the Surface.

Under modern field practices the stream of co-mingled gas and oil which issues from a flowing well is passed through a cylindrical pressure vessel in which the gas is separated from the liquids. The relative completeness of the separation depends upon pressure and temperature held in the vessel. This vessel is known in field parlance as a "separator" or "trap".

Complete separation of the hydrocarbons which are gases when in the pure state from hydrocarbons which are liquid when in the pure state at standard conditions of pressure and temperature, are never achieved in the separator or in the storage tanks. When the crude oil reaches the refinery, it still contains small quantities of methane and ethane and larger quantities of propane and butane remain in the motor fuel and other light products. On the other hand the raw gas from the separator contains important quantities of hydrocarbons which are liquids at standard conditions when isolated from the gaseous hydrocarbons.

After separation, the raw gas usually goes to a plant where the vapors of the hydrocarbons that are liquids at atmospheric pressures and some of those that are liquids at moderately higher pressures, may also be extracted. The first category of condensed vapors are known as "casing-head gasoline" or "natural gasoline". The second category consists of butane and propane which sometimes are separated and sold separately or at other times are sold as a mixture which is known in the trade as L.P.G., which is the abbreviation for Liquefied Petroleum Gas. This term, which has been adopted in recent years, should be noted as a recognition in the trade that petroleum includes the gases. The product is also known as bottled gas and by various house brand trade names. It is a product of the Natural Gas Industry.

After the extraction of these components, and after gas for field uses has been taken, the residue gas is disposed of in various ways. In the past much of such gas was wasted into the air. At some places it is now injected back into oil reservoirs to increase oil recovery and in others, the gas goes into pipe lines to be transported to distant markets.

The oil from the separator goes to field tanks where most of the remaining solution gas is weathered out and a final separation is made of any water or sediment that may be produced. This oil which is now acceptable to the oil pipe lines is known in the fields as "stock tank oil" or "pipe line oil" and it is the crude oil of commerce. It then is piped in oil lines to the refineries where

the "Crude" is first boiled and the hydrocarbons distillated off in order of their volatility, the principal commercial products being motor fuels, kerosene, diesel engine oil, lubricating oils, heavy fuel oils, road oils, paraffin waxes or asphalts. This is known as straight distillation and was practiced in 1906. Since 1906, most of the heavier products from straight distillation are afterwards chemically altered by cracking or by other processes into motor fuels.

In wells that have ceased to flow naturally because the pressure and volume of gas has been reduced by depletion, the oil is lifted from the well by a pump which operates within a tubing hung in the well. The well itself acts as a separator, the oil being taken out through the tubing and most of the gas passing up to the surface through the annular space between the tubing and the casing. At the surface the oil is taken through oil gathering pipe lines to treating and storage tanks and thence through oil pipe lines to market. The gas is taken through gas gathering pipe lines usually to gasoline plants and the gas residue is disposed of in the same way as for flowing wells.

R. Variable and Changeable Composition of Oil Well Gas and Practical and Legal Problems that could be Caused by Divided Ownership.

The quantities of liquids that can be extracted from an oil well gas (known as casinghead gas) depends upon:

(1) The natural qualities of the reservoir fluids;
(2) the manner in which they are separated at the surface or in the well; and
(3) upon the reduction in pressure within the reservoir itself.

The composition of the gas that issues from a well changes importantly during depletion of the field, particularly in those fields where pressures are not maintained by water drive, whether natural or artificial, or where gas is not reinjected into the reservoir to maintain pressure.

As the pressures decline the more volatile liquid hydrocarbons in the oil vaporize thus enriching the gas and impoverishing the oil. In the early life of a reservoir, the natural gasoline vapors in the gas, as usually separated from the oil stream at the surface of a flowing well, are likely to be less than half a gallon of natural gasoline liquid for each thousand cubic feet of gas produced, and the gas then is likely to consist of more than 90% methane. When pressures get low, the gas will contain several liquid gallons of natural gasoline vapors per thousand cubic feet of casinghead gas and, in some very old fields, the contents are known to exceed ten gallons per thousand cubic feet of gas, and the gas to contain only a minor percentage of methane. At this stage, the gas consists almost wholely of hydrocarbons which would have been produced and sold as part of the crude oil in the earlier life of the wells. In this manner there is a transference from liquid phase to vapor phase of some of the hydrocarbons during the process of depleting an oil reservoir.

The liquids recoverable from the casinghead gas of an oil well, particularly after depletion is far advanced, are usually more valuable than the residue which are piped away to gas markets.

The foregoing statements on the handling of the production from oil wells are based upon the operating practices and knowledge of today. In 1906 the few separating devices were crude and ineffective, and flowing wells usually discharged directly into tanks from which the gases vented through stacks into the air. Little of the gas from flowing oil wells was saved. The gas from pumping wells was almost invariably saved, at least to the extent needed for lease operations and much of the excess gas was saved for sale to pipe lines. The extraction of gasoline from the gas was in its early stages of development and was applied principally to oil fields which were being vacuum pumped. The oil, after the gas had been weathered out and the water and sediment settled out, was delivered to pipelines as it is today. Butane and propane were not being recovered commercially. Artificial stimulation of production by either gas or water injection had not

started but natural water floods were recognized. The pumps used for lifting the oil were essentially the same as those used today. It was well recognized that the gas accompanying the oil got richer and richer and that the oil got heavier and heavier as the oil and gas were depleted, particularly after vacuum was applied to the wells.

Regardless of the state of knowledge in 1906, the conditions that prevail today indicate clearly the practical and legal difficulties that would arise in operating oil wells under separate ownerships of the gas and liquids. As the values involved are very large, it could be expected that every phase of the problem would be brought into court for adjudication.

First of all the definition of petroleum would have to be made specific. Assuming that the separation between gas and petroleum would be between the gaseous and liquid phases of the hydrocarbons, it would be necessary to specify the temperature and pressure and the other conditions under which separation of the fluids would be made as each of the fluids has both a gaseous and a liquid phase. If the condition specified was that in the reservoir as it occurred naturally before disturbed by man, all the solution gas would be petroleum for at that time the gas was physically a part of the liquid as much as were the solid hydrocarbons that were in solution. Petroleum engineers refer to this fluid as reservoir oil or reservoir liquid. All the originally free gas would accrue to the gas owner.

Under the above definition, the separation of rights would not be difficult in reservoirs that contained in commercial quantities either free gas alone or oil alone, but in reservoirs containing a free gas cap with oil below, difficulties of separating ownership between the gas that was originally free and that which was originally in solution, would be physically and practically insurmountable. Once fluids began to be withdrawn from either the gas cap or from the oil column, a tendency for co-mingling of the fluids would start within the reservoir and within the well. If the pressures were reduced more rapidly in the gas cap, solution gas would evolve and rise up into the gas cap and oil

would too, thus the owner of the gas would capture some of the originally dissolved gas and there would be no feasible way to tell how much of the gas issuing from the wells came from one source or the other.

However, it may be expected that the Conservation Board would intervene under such conditions because such an operation of a gas cap oil reservoir would be wasteful as it would seriously reduce the quantities of oils that could be otherwise recovered.

Another definition could be based upon whether the hydrocarbons were in gaseous or liquid state at the surface. This would raise another set of problems. Assuming that the standard temperature of 60°F. and the standard pressure of 14.65 pounds per square inch absolute were specified, it would also be necessary to specify whether the separation should be between each hydrocarbon in its isolated state at, say, standard temperatures and pressures. If so, only methane, ethane, propane and the butanes would belong to the gas owner and the oil owner would be permitted to extract all other hydrocarbons from the gas.

Another definition could be what the producer could market as crude oil, the gas separated from the stock tank oil going to the gas owner. As stated before, the quantities of the more volatile hydrocarbon liquids that will be retained in the stock tank oil or in the gas will depend upon the separating equipment, how it was operated and the temperature and pressure at the time of separations, and some exact standards would have to be set up which would be difficult to apply and which could be expected to engender much controversy. Controversy would also extend to the manners of operating the wells and the reservoir for they too could seriously affect the richness and value of the gas.

In whatever way separation of gas from oil was made, the questions would arise of delaying the production of gas or reinjecting it in the interests of conservation and the migration of gas occasioned thereby from the property in which the gas owner had rights into one in which he did

not, for the operating of pools in the ways that are conducive to highest oil recoveries, almost always cause serious migrations of both oil and gas from one property to another.

S. Separate Marketing of Oil and Gas has led to Different Definitions of Petroleum.

Once the gases and liquids are separated in the field, they go into different transportation systems, are handled by different men, go to different markets and for the most part are put to different uses. It is quite apparent that those who deal with the hydrocarbons after they leave the field will not have the need for the same generic word that will include both gas and liquids as will the producer or the geologist or the petroleum engineer or the chemist who is interested in all the hydrocarbons.

For those who handle the petroleum gases, natural gas is a sufficient word but for those who handle the petroleum liquids there is a need for a generic term which will embrace all the various liquid and solid hydrocarbons which are derived from the crude oil which include such dissimilar products as petroleum ether, motor fuel, cleaner's naphtha, kerosene, diesel engine oil, light and heavy lubricants, vasoline, paraffin wax, heavy fuel oils, road oils and asphaltum. For a general term covering the crude oil and the products derived from it, the word petroleum has been retained in its narrower sense as it would not be necessary for understanding among those handling the crude oil after it leaves the field to say petroleum liquids. As there are many more who deal with and consume petroleum after it leaves the field, the restricted definition appears to be in more common usage which is reflected in the dictionary definitions.

However, the trade has found it necessary for clarity to use the term Liquefied Petroleum Gas (L.P.G.) as liquefied gas could be one of many other gases that had nothing to do with natural hydrocarbon gases.

Other than for the more recent adoption of the term Liquefied Petroleum Gas,

the statements set forth in the two preceding paragraphs were true long before 1906.

The two usages of the word petroleum that have arisen have resulted in much confusion. Frequently the meaning of the speaker or writer can be inferred only from the context and often the word is used carelessly. As would be expected, the technically informed men who are better informed on the natures, origins and occurrences of the natural hudrocarbons and who endeavour to use terms more precisely are most apt to use petroleum in its inclusive sense whereas the men who handle the oil after it leaves the field are most apt to limit petroleum to the liquid hydrocarbons. The non-technical man in the field is most apt to use gas and oil and is not apt to use petroleum in the usual line of his work. From the references I have read, I believe the foregoing statement also applied to 1906 and it is my recollection that it applied to those with whom I came in contact in my upper-graduate work in college and when I first entered active work in the industry.

T. Problems of Separate Ownerships of Oil and Gas in Free Gas Accumulations.

A well is called a gas well when its production consists predominantly of gas. The definition is necessarily arbitrary but standards have been set up by various regulatory bodies. In Texas a well with a gas oil ratio in excess of 100,000 cubic feet of gas to each barrel of oil is defined as a gas well. However, there has come into recognition in recent years a third class of wells known as distillate or, more properly, condensate wells. These are deep wells and the fluids in the reservoir are in what is known as the retrograde condition. The fluids under original conditions in the reservoir are all in the gaseous phase but much of the vapors condense into liquids as pressures are lowered in the reservoir and as both pressures and temperatures are lowered when the fluids are brought to the surface and passed through the separator. Turner Valley is an outstanding field of this nature.

Gases in the deep reservoirs are usually rich in the vapors of hydrocarbons which are liquid at standard conditions of temperature and pressure and usually the fluids from a separator will be at a gas oil ratio much less than the Texas statutory 100,000 to 1. Sometimes the full mixed stream is piped directly to an extraction plant and at other times the production is handled as it would be from an oil well, the stream is passed through a separator and the gas taken thence through one pipe line system and the liquids through another. The liquids usually contain not only natural gasoline but also kerosene and heavier hydrocarbons. There is no way in which the fluids can be entirely separated within the reservoir. Of necessity both must flow into and out of the well in a co-mingled stream.

Because the vapors will condense in the reservoir when pressures are reduced and the condensates will become so dispersed in the reservoir rock that little can be recovered, and, because also there may not be an adequate market available for the gas, the practice of cycling has been often used in condensate fields. In this practice the stripped gas is forced back into one part of the reservoir which maintains pressure and drives the rich gas to the producing wells. This causes migrations of the fluids from one property to another and it is recognized that this should be done as a unitized operation, i.e., the property owners should pool their interests equitably in a reservoir so that conflicting interests will not interfere with operations. Under some conditions cycling is recognized as necessary for conservation, and it might be required by the Conservation Board.

The retrograde phenomenon was not known in the industry in 1906 nor was the existence of a condensate reservoir recognized; however, should it be held that petroleum does not include the hydrocarbon gases, it will be necessary to decide whether the hydrocarbons that were in vapor state in the reservoir under original conditions but which condense or which can be extracted and maintained as liquids at the surface are petroleum. If they are held to be petroleum, the exact conditions for separation and condensation must be

specified; also it must be decided whether the owner of the liquid has the right to produce the gas and to inject it back into the formation. If this is done, the gas will eventually become available to the gas owner ten, twenty, or more years hence, but the present value of the gas will be reduced.

In gas cap fields a well can be completed in a part of the gas cap that contains gas only and initially the well will produce gas only. Depending upon the natural conditions and upon the manner in which the reservoir is operated, the well may continue to produce gas only or it may start to produce some oil and finally become a low gas oil ratio oil well. If the gas cap is depleted more rapidly then the oil column, the pressures will be reduced more rapidly and oil will tend to rise into the gas cap and be dissipated in the manner previously described. This was known in 1906 and a recognized practice was for an owner of a well producing only gas to blow his gas well into oil. This practice has been stopped in the interest of conservation.

In the reverse manner a well completed in the oil column so that initially it produces oil at a low gas oil ratio may in time turn into a gas well. This occurs when the reservoir is so operated that a gas cap is expanded down dip and the oil caused to drain out by gravity, thus in time the oil recedes below the level of the well and the well will thereafter produce gas with little or no oil. When this stage is reached, the well should be shut in and the oil should be produced from structurally lower wells. This practice was not known in 1906, but is recognized as in the interests of conservation as it is one of the two most efficient ways of oil recovery.

In this practice all or nearly all of the gas is withheld from market until oil recovery has been completed and, in the interests of conservation, all or nearly all the gas should finally be produced through wells that were drilled for oil. Usually such gas as is produced during the depletion of the field, is passed through a gasoline extraction plant and then is compressed and injected back into the apex of the reservoir through what

would be otherwise classified as gas wells. The gas will finally become available for sale years later, usually twenty or thirty or more years later.

Many conflicts in interest between the owners of the gas and of the oil can be expected to arise and also between the owner of the gas and the conservation authorities. There will be questions as to the sharing of costs and expenses particularly when wells change status from oil to gas. A particularly difficult one would arise if the hydrocarbons originally in vapor state in the reservoir were awarded to the gas owner. Passing the gas through the part of the reservoir that contained oil would under some conditions cause the vapors to be stripped from the gas by the oil and to be produced as a liquid co-mingled with the oil and, under other conditions, gas could strip volatile hydrocarbons from the oil which would be produced as vapors with the gas. The problems would be most acute when the wells were borderline between gas and oil wells and the problems would be virtually insoluble.

In the shallow reservoirs that contain only gas in commercial quantities, the problems would not be so many or so difficult. Such gases usually contain little vapor of liquid hydrocarbons that will condense at the surface naturally though they often contain enough natural gasoline, butane and propane to warrant processing if the volume of gas is large. In 1906 all such gas was passed directly from the well into pipelines and transported to market but it was the usual and necessary practice to install drips along the pipe lines to collect water and gasoline that condensed in the lines, especially in winter. Where the wells produced much water or natural gasoline drips would be placed close to the well. It was well known before 1906 that inflammable, gasoline-like liquids condensed in virtually all gas lines.

The questions that would arise in such dry gas fields, should petroleum be held not to include gas, are whether the liquids that could be extracted from the gases and sold as liquids including butane and propane which must be confined at above atmospheric pressure, be considered

as petroleum.

Another problem that would arise would be the relationship of gas to oil until a field had been fully explored. Quite often the gas cap is discovered first and the presence of a commercial oil column is not known until years later, as was the case in Turner Valley. Until a reservoir has been fully explored by wells, it cannot be known whether a commercial oil column is associated with the gas and whether producing the gas might not be injurious to an oil column that has not yet been discovered.

V. MEANING OF THE WORD "PETROLEUM" IN LITERATURE

U. Search for Meaning of the Word "Petroleum".

In the several statements which I have made on the state of knowledge in 1906, I have relied not only on old literature, but to an even greater extent upon my recollections of personal communications to me from oil and gas producers whose experiences went much further back than 1906. These producers were mostly men who had grown up in the business in the old fields of California, Pennsylvania, Ohio and West Virginia. From such men I learned much after I began work in the industry in 1909.

In my earlier work for the United States Bureau of Mines on oil and gas recovery problems, which began eight years after 1906, a major consideration was to find out what had been learned in previous years, what were the beliefs and opinions of the experienced men in the industry, what had been the histories of the old fields, and how had practices and opinions developed. The purposes were several. I wanted to benefit from these long years of practical experience. I wanted to find out what practices and opinions were sound, what needed investigation, where and how could scientific principles be applied profitably and finally, how could my findings be presented in publications so that they would be most favorably received in the industry.

In addition to my personal recollections of how the word petroleum has been

used by those I have known in the industry, I have made searches through publications in the Library of Congress, the libraries of the United States Geological Survey and the United States Bureau of Mines, all in Washington, D.C., also in the public libraries of Tulsa, Oklahoma, and Houston, Texas, and in my own library. The publications examined were dictionaries, encyclopaedias, books and articles published on the industry, particularly those published before and shortly after 1906. My search was not exhaustive as that would have been impractical, but I examined the more important references published around 1906. I found the dual meanings and ambiguous references to which I have previously referred, and I satisfied myself that I had obtained a fair cross-section of the references and that the others not examined could reasonably be expected to fall into the same pattern. I was particularly influenced by Clarke's Data of Geochemistry which I will discuss further.

I have had prepared photostats of relevant excerpts from the references I examined, and I submit these excerpts as exhibits. Wherever possible I am also submitting as an exhibit the publication itself.

V. Dictionary and Encyclopaedia Definitions.

The dictionaries which I examined with the exception previously noted used narrow definitions which fitted the original meaning of rock oil and which did not cover all the non-aeriform natural hydrocarbons. Webster's Empire Dictionary of 1904 (previously quoted) states: ".....a liquid inflammable substance....." but even excluding the gases, natural hydrocarbons are not all liquids and enormous and valuable deposits of asphaltum and other solid hydrocarbons are found in many places in the world, among them being the asphaltum deposit of the Island of Trinidad, B.W.I., which, for many years, was the chief source of paving asphaltum for the world.

In other dictionary definitions, petroleum is defined as an "oily inflammable liquid" but some of the naturally occurring hydrocarbons as produced by wells consist of light hydro-

carbons which are not only at usual atmospheric temperatures and some of the very heavy crudes produced by wells are sticky rather than oily, nor are the naturally occurring solid hydrocrabons, such as Trinidad asphaltum, oily. Moreover, when the crude production is distilled in the refineries, it is separated into groups of hydrocarbons, some of which like motor fuel are liquid but not oily and some like asphaltum are neither oily nor liquid. Of the many hydrocarbon compounds which are found in the liquids produced by oil and gas wells, many are not oily or are not liquid when isolated in the pure state.

The dictionary definitions are not precise and scientific, and in my opinion do not correctly define what is considered to be petroleum in either the producing or the other branches of the industry. There are many other instances where dictionary definitions lag far behind either or both scientific and popular usages.

The encyclopaedias sometimes give both definitions and sometimes only one of the two. Most editions of Encyclopaedia Britannica define petroleum as does Redwood in the quotation I have previously given. But of the three recent American editions of encyclopaedias for which I submit excerpts, it will be noted the The Encyclopaedia Americana, 1945 edition, specifially includes the gases as petroleum; that a recent edition of National Encyclopaedia associates gas with petroleum liquid but is not specific; that An Outline for Home Study Encyclopaedia Britannica, 1939, says, "propane and butane, petroleum gases, are now common words"; but Encyclopaedia Britannica, 1948, described only liquids under petroleum, whereas in earlier editions the broad definition was used.

W. Clarke's "The Data of Geochemistry".

In my opinion Bulletin 330 of the United States Geological Survey entitled "The Data of Geochemistry" and authored by Frank Wigglesworth Clarke, represents the best reference on the technical and scientific knowledge existing in 1906 on the origin and composition of petroleum. The book was published in 1908 but of the many

references given in the footnotes, none are later than 1907 and only a very few were even of that date.

The Data of Geochemistry was published while I was an upper classman in college and I was instructed by my teachers to familiarize myself with the contents. It was the first book on geology, other than college text books, that I ever owned.

The purposes of this publication are set forth in the last paragraph of the introduction. It was considered at the time as the reference to which a government or other geologist should turn when need for an understanding of the chemical processes of geology, and the footnotes were considered to be a bibliography of the more worthwhile of other references. In my opinion, it may be considered to be the best summation of the scientific and technical literature up to 1908, and it carries the weight of the United States Geological Survey.

Speaking of the paraffin (also called methane) series of hydrocarbons, Clarke says, in part, on page 619: "Each member of the series differs from the preceding member by the addition of the group CH_2, and by the physical characteristics of greater condensation. Methane, CH_4, for example, is gaseous; the middle members of the series are liquids, with regularly increasing boiling points; the higher members are solid, like ordinary paraffin. These hydrocarbons are especially characteristic of the Pennsylvania petroleum, from which the following members of the series have been separated." There follows a table on page 620 entitled "Paraffins from Pennsylvania Petroleum" in which the hydrocarbons are classified as gaseous, liquid and solid, this table being quoted from "Das Erdol" 2nd edition by H. Hofer, published in 1906. Hans Hofer, a German, was considered to be the outstanding world authority of his day on the chemistry of the hydrocarbons.

Other statements and other tables given by Clarke show that the three physical phases in which the chemical compounds might occur

were embraced by him in the word "petroleum".

Clarke, in the paragraphs under the sub-heading, Synthesis of Petroleum, beginning page 627, discusses the synthesis of gaseous, liquid and solid forms and under the sub-heading of Origin of Petroleum beginning page 631, discusses the theories of origin and shows that a common origin for all the hydrocarbons whether in gaseous, liquid or solid phase at the surface, was considered probable in all the various theories that had been proposed.

Although the Data of Geochemistry had not been published when the contract to sell the land which is in dispute, to Simon Borys, was executed, all of the many other publications which are listed in the footnotes, and from which Clarke derived his opinion were, with a few unimportant exceptions, available to anyone who desired to learn what was petroleum.

X. Usage of "Petroleum" in Titles.

Besides the specific definitions of petroleum, there are many uses of the word that connote the inclusive meaning and these usages began before 1906 and extend to the present day. There are many technical and trade associations that use only petroleum in the title yet both gas and oil come within the scope of their activities. Among such organizations are:

American Petroleum Institute. A trade organization which also covers technical work and endows research, organized about 1919.

American Association of Petroleum Geologists. An organization that deals mainly with economic geology but also scientific problems; founded about 1916.

The Petroleum Division of the American Institute of Mining and Metallurgical Engineers. An organization of engineers engaged in these industries but interested also in technical and scientific work. The Institute is an old organization but the Petroleum Division was established after 1906.

Petroleum Institute of Technology. This is the leading British technical organization in petroleum which was founded after 1906.
The Petroleum Administration for War. This functioned during the last war and supervised both the oil and natural gas industries.
Among text books that deal with both oil and gas are:

"Petroleum" by Sir Boverton Redwood	British	1906
"Petroleum" by A. Beeby Thompson	British	1910
"The American Petroleum Industry"	American	1916
"Handbook on Petroleum Industry"	American	1922
"Petroleum Production Engineering", L. C. Uren,	American &	1924 1934
"Science of Petroleum" various authors	British	1938
"Petroleum Production", Wilbur F. Cloud	American	1939
"Elements of the Petroleum Industry" various authors,	American	1940
"Petroleum Bibliography", De Golyer & Vance	American	1944

Many universities give courses in Petroleum Engineering which also cover natural gas.

There are numerous companies that use only "petroleum" in the company names yet deal in oil and gas.

It is to be noted that there are some organizations, text books or companies, that have petroleum in their names that deal only with liquid petroleum; there are many companies that use oil and gas, a few that use oil only, yet deal in gas too, and many that deal only in gas and use either gas or natural gas only in their names. There are also some that use both "petroleum and natural gas" in their names.

Y. Ambiguous and Tautological Usages of "Petroleum".

I can say generally that where oil or crude oil is used with reference to the liquids produced from oil wells, that there will be no question about what is meant in any branch of the

industry and I believe this is also true among people not in the industry but who have at least a superficial knowledge of it. On the other hand, I believe that the word Petroleum would immediately arouse a question as to meaning unless it was perfectly clear from the context what was meant by the user of the word. This is also true of the numerous other words in the English language which likewise have more than one meaning.

Because of the two usages, quite often the term petroleum and natural gas are used in order to make certain that no misunderstanding can arise. I have sometimes used petroleum and natural gas when I have thought the one I addressed might possibly not otherwise be sure whether natural gas was included. In such cases I have considered that certainty of understanding was more important than tautology.

Q MR. NOLAN: Dr. Lewis, before you go on to your Summary Statement or conclusion, is there any other literature that you would like to refer to that is not contained in the report? A. Well, I have examined quite a good many references, some of which I have here, and if you would like them introduced I could introduce them at this time.

Q This would be the proper time. What is the first one, Dr. Lewis? Have you a list there? A. I have a list made out. The first one, I think, on my list is Bulletin 148 of the United States Bureau of Mines.

Q The first one I have here on your list is Beeby Thompson, isn't that right? A. It is the first one I mentioned in my report.

Q Well then, have you quote from Beeby Thompson?

A Yes, I have quoted from Beeby Thompson.

Q Have you quoted from Sir Boverton Redwood? A. The 3rd edition, 1913.

Q You have quoted from Redwood in the 3rd edition, 1913? A. That is correct.

Q What about Sir Boverton Redwood and Arthur W. Eastlake, 1915? A. I have not quoted from Redwood and Eastlake in my report, but it is one of the books I examined.

Q Would you like to quote from it? A. Yes. This book is entitled "Petroleum Technologists' Pocket Book" by Sir Boverton Redwood and Arthur W.

Eastlake, and on page 3 it contains the following:
"Definition of Petroleum: Petroleum, or bitumen, is the generic name given to hydrocarbon compounds occurring in nature. These substances may be either solid, liquid or gaseous. The solid kinds are known as asphalt or ozokerite, the liquid as mineral oil or petroleum, and the gaseous as natural gas."

Q What is the next book you would refer to?

Q MR. RILEY: Did I understand aright that liquid is petroleum? A. "The liquid as mineral oil or petroleum and the gaseous as natural gas." In other words, it gives the two meanings, the generic and the restricted meaning.

Q MR. NOLAN: What is the next, Dr. Lewis, in the list? A. Uren, 1924.

Q Yes?

MR. STEER: These are not in the memorandum.

MR. NOLAN: They are not, I am sorry, Mr. Steer, but they are other books. The books are here and we will keep them here if you would like to look at them.

Q This last one is what, Lester Charles Uren? A. Lester Charles Uren, and the book is called "Petroleum Production Engineering" by Lester Charles Uren, Associate Professor of Petroleum Engineering, University of California, 1st edition, 1924.

Q And you desire to read from page 3? A. I desire to read from page 1.

MR. STEER: I wonder before you go on, could we have the date of the Redwood and Eastlake book?

MR. NOLAN: 1915, Mr. Steer.

A On page 1, under "Physical Properties and Chemical Constitution of Petroleum" -

Q You are reading from Uren's book? A. I am reading from Uren.

Q Yes?

A "Varieties and Forms of Petroleum.
Petroleum is a mixture of naturally occurring hydrocarbons which may assume either the solid, liquid or gaseous state. These three phases of petroleum are transmutable, one into the other, by the application of moderate changes in temperature and pressure. Some of the constituents of petroleum are solids at ordinary

"earth temperatures, but the application of heat to produce a slight rise in temperature will cause them to assume liquid form; and further heating to the boiling point will convert them into gases and vapors. Other constituents are vapors at ordinary temperatures, but earth pressures naturally developed within the containing rocks will cause them to condense, forming liquids. Relief of this pressure will permit the liquid to vaporize again, providing the temperature does not change. Liquid petroleum may also be converted into the solid or gaseous state by evaporation of the lighter and more volatile fractions, the latter forming gases or vapors, and the heavier fractions forming solids. The solid and gaseous forms are soluble in the liquid forms. Chemical changes such as oxidation of the liquid petroleum may also be instrumental in causing solidification."

And it states which members of the hydrocarbons are gaseous and which are liquid and which are solid.

Q Now, what is your next book, Dr. Lewis? A. There is more I would like to read from that.

Q Yes? A. With regard to the table, reading from the bottom of page 2, he says:

"An examination of Table 1 will give the reader some idea of the great variety of combinations of hydrogen and carbon that have actually been identified in petroleum. Doubtless there are many more which have not as yet been isolated."

And in the footnote he states that this table was compiled from the work of Clarke, Mabberly and others, by J.H.G. Wolf. And on page 4 there is a series of properties of liquid petroleum. On page 6 there is a series of properties of the solid forms of petroleum. On page 7 there is a series of properties of the gaseous form of petroleum. Beginning at page 8 there is the origin of petroleum, which includes the discovery of the gas. I would like to state that Uren has been more specific than nearly any of the other authors in keeping the definition clear as between liquid, solid and gaseous petroleum. However, in certain places in the same text he has used it in the narrow sense as, for example, in the distillation of petroleum where, obviously, it is not

necessary to repeat the word "liquid" by reason of the contents showing quite clearly what was implied.

Q What is your next piece of literature? A. I would like to say also that I have examined the 1934 edition and it is essentially the same.

Q Yes? A. The next is Chambers' Encyclopaedia, 1926, volume 8. I am not sure, but I believe this is referred to by Dr. Fisher.

MR. STEER: She referred to the later edition, I think.

A A later edition, was it?

Q The 1935 edition was the oldest one we could obtain.

A On page 65, under "Petroleum", and it has in parenthesis:

"(rock-oil: Latin petra, rock, oleum, oil),"

and the definition for petroleum is given as:

"an inflammable substance, essentially liquid in form, composed of carbon and hydrogen, and found impregnating the rocks of the earth's crust, or as a superficial exudation. In its narrow sense the term is restricted to the liquid phase of the material; but there are gradations both to the solid and gaseous condition, and the term is often used broadly to cover both these variations."

Q Now, what is the next? A. Next is Hollis P. Porter, Petroleum Dictionary for office, field and factory, the Petroleum Dictionary, 1930. This book is entitled: "Petroleum Dictionary for office, field and factory" by Hollis P. Porter, Member of American Society of Mechanical Engineers and American Petroleum Institute. This is the first edition, published in 1930.

Q Page 155, Dr. Lewis? A. I might state that this book is very commonly used in offices of gas and oil companies for secretarial use. On page 151 it defines petroleum as:

"Petroleum: In its widest sense the term petroleum embraces the whole of the hydrocarbons, gaseous, liquid and solid, occurring in nature. The word petroleum in general use signifies an oily, inflammable liquid mixture of numerous hydrocarbons, chiefly of the paraffin series, occurring naturally, oozing from crevices in rocks, floating on the surface of water, or in subterranean deposits in rocks, from which it may be obtained by drilling. The petroleums found in different areas

"vary widely in composition and appearance. In general, there are three kinds of petroleum, namely, paraffin-base, which carries solid paraffin hydrocarbons and little or no asphalt; asphalt-base, which contains asphalt and practically no paraffin; and paraffin-asphalt, a combination of the two. Also known as Rock Oil, mineral oil, natural oil, coal oil, earth oil, seneca oil."

Q What is the next, Dr. Lewis?

Q MR. RILEY: Was that page 171?

A 151.

Q MR. NOLAN: The next, Dr. Lewis?

A. G. H. Richter, Textbook of Organic Chemistry.

Q This is an instance in which we have not got a book?

A Yes.

Q What have you before you? A. I have a photostat which was taken from the textbook.

Q Did you examine the original book? A. I did.

Q Is that a true copy of what is contained in it so far as the pages are concerned? A. Yes, it corresponds with the notes I took when I read the book.

Q Why didn't you bring the book? A. It was not obtainable.

MR. NOLAN: I think, my lord, under those circumstances perhaps I would be permitted to ask him with regard to that.

MR. STEER: I have no objection.

THE COURT: All right.

Q MR. NOLAN: Will you please read what you intend to read from the Richter book, giving us the date of the publication and the page from which you are reading. A. I am reading from page 19 under the subject matter "petroleum". I may say before I read that the part that I am going to in places refers to petroleum as a liquid state, but it also contains this table, which is called Table VII, and contains a partial list of the hydrocarbons reported to be found in petroleum, and it says paraffin, hydrocarbons in petroleum, and it says, under gas and gives methane, ethane, propane, normal butane and under gasoline it gives pentanes, hexanes, octanes, and what-not, and I won't read the rest because they are either liquids of solids.

Q All right. What is the next on your list? A. The Encyclopedia Americana, 1945 and 1949.

Q And the fact that you are reading from a photostat is for the reasons that you have already explained to us? A. Yes. I saw the original of these in the Library of Congress at Washington, and I made copies in my own handwriting, and compared that with the photostat.

Q What is the date of this Encyclopedia Americana?

A The date I am reading from is 1945, but the one I saw in Washington, I believe, was 1949, but I have compared them and they are the same as to the definition.

Q What volume? A. Volume 21, and the reference is, I think, page 680.

Q And 681? A. I am reading nothing from 681.

Q Page 680, is it? A. Yes. It has material on petroleum at page 681, but I am reading only that which seems to be pertinent to the point at issue.

"Petroleum, from the Latin petra (rock) plus oleum (oil) is a complex misture of chemical substances, predominantly hydrocarbons of various types, but also often containing smaller proportions of other chemical substances. Elements such as oxygen, nitrogen, and sulphur may enter these substances, and occasionally play the part of useful constituents, although most often they merely are impurities.

In form, petroleum ranges from gases to solids, but its most important state is as it comes from the ground in the form of oil, the only liquid mineral, commonly and commercially known as 'crude oil'. Petroleum also occurs as a colorless vapor, natural gas, which is comprised of the lighter and more volatile portions of the hydrocarbon mixture, and as a solid or semi-solid, asphalt."

This, as well as most other references, goes into usages in the narrow sense as well, after stating its broad.

Q And what you have just read to us is also contained in the Encyclopedia Americana 1949 edition? A. That is correct.

Q You have read the 1949 edition? A. Just a minute. Yes, I have compared the two.

Q And they are the same? A. Yes.

Q What is your next, Dr. Lewis? A. The Encyclopedia Britannica edition.

Q What year? A. 1948.

Q At page? A. 164.
Q And what does it say at page 164? A. It is the 1948 edition of the Encyclopedia Britannica.
Q What volume number is it, do you know? A. The volume, I do not have it. I may have it in my other notes. Well, we have got the page, page 164 anyway.
Q MR. RILEY: What is the heading, Dr. Lewis, "petroleum"? A. The heading is "natural gas". It is not contained on page 164. It must be on a preceding page. This is only a partial reproduction. At the top of the page occurs this sentence:

"On practically all the large transporting systems gasoline and liquefied petroleum gas recovery plants are installed."

And then under "Major Uses of Natural Gas", under item (4):

"As source of liquefiedlpetroleum gas recovery - 141,505,000 gal."

Q MR. NOLAN: And what is the final reference to which you would like to draw the attention of the court? A. The National Encyclopedia, volume 8. I do not think I have the date of this encyclopedia either in the photostatic copy, or in the notes. I neglected to take it. The only thing I can say is I remember taking it and it was of recent date, and it was in the last few years.
Q And what pages are you reading from? A. I am reading from page 24:

"The majority of the hydrocarbons in petroleum are liquids, but solids and gases occur dissolved in them."

MR. STEER: Would you read that again, Dr. Lewis:
Q MR. NOLAN: A little louder, Dr. Lewis.
A "The majority of the hydrocarbons in petroleum are liquids, but solids and gases occur dissolved in them."
Q Now, Dr. Lewis, will you turn your attention to page 43 of Exhibit 104, and proceed with the reading.
A I would like to -
Q Is there any other? A. I have others that I can give you, if you wish. I would like also to make a general statement on what I have read and what others I have examined.
Q Yes? A. I have found -
Q A little louder, please. A. I found that the

references that I examined that they divided themselves almost equally into those which made or gave a broad statement or generic statement of meaning and those which did not. However, in those that did give the generic statement, they would very frequently also use the word in two ways, sometimes one, sometimes the other.

Q All right. If you will go on then with your statement. A. I would like to refer to Paul Paine.

Q Yes? A. I only have my notes with regard to Paul Paine, and I do not know if it is admissible or not.

Q You can give us the best recollection of what he said.

A I have a copy of my notes here.

Q You may refer to them.

MR. RILEY: I think it would be advisable to have the book, Mr. Nolan. I have several extracts from Paul Paine to put to him if he can answer them.

MR. NOLAN: Have you the book?

MR. RILEY: No.

MR. NOLAN: Where is the book?

MR. RILEY: It is in my office, but I neglected to bring it.

MR. NOLAN: I am sorry you haven't got it. You do not want him to refer to his notes?

MR. RILEY: Well, if he refers to his notes, he may do so, as long as you let me point out numerous other things contained in Paul Paine's book.

MR. NOLAN: I can see no reason why I should object. If I bring anything out that is contained in the book, Dr. Lewis can be cross-examined on it.

MR. RILEY: Yes.

MR. NOLAN: Yes, Dr. Lewis?

A The book is entitled "Oil Property Valuation" by Paul Paine, August 1942, chapter 2, Properties, page 40; "Definitions".

"Natural gas is the gaseous form of petroleum. Any gas found ready formed in nature is natural gas, but a custom has grown in connection with differentiation between (1) the gas which occurs along with the oil from oil wells and (2) the so-called dry gas which occurs alone and not along with oil, of calling the latter natural gas, and this expression has found a wide usage

"in contracts and legal papers. This dry gas is also called rock gas. On the other hand, dry gas and residue gas are both terms which have been applied to that gas which has been treated and had removed from it the gasoline vapors contained."

And then in chapter 5:

"Petroleum has been defined in several ways. The word is generally used to describe mineral liquid oil. As found in nature, mineral liquid oil has a great variation of physical and chemical characteristics,"

which is a somewhat contradictory statement in the same reference.

Q MR. NOLAN: Yes? A. This is from a book entitled "Principles of Oil and Gas Production by Roswell H. Jackson and L.G. Huntley, 1916, the 1st edition, and I do not have the book here. This is a copy that I made in my own handwriting. It has been reproduced. And from chapter 1:

"Varieties of Oil and Gas",

page 1:

"Oil petroleum consists of a mixture of liquid hydrocarbons which are members of a series varying from substances which are solid at ordinary temperatures to the lightest gases. Chemically, these hydrocarbons exist in one of several rock series."

And he describes the varieties of hydrocarbons. And he goes on and describes the various ones which form natural gas, gasoline, and other things. I think those are all that I have reference to except that I have here a petroleum bibliography by De Golyer and Vance, Bulletin 53 Texas Experimental Station, published in 1944, and it is illustrative of the many books which use petroleum in the title and yet have numerous references to natural gas.

Q Then, Dr. Lewis, does that bring us to your Summary Statement? A. Yes, I think so.

VI. SUMMARY STATEMENT

In my testimony, I have endeavoured to show why two usages of the word "Petroleum" arose before 1906 and why the two usages have continued. I have endeavoured to show why there has been a need for those concerned with the production, origin and chemistry of oil and gas, particularly those of some technical understanding, for a generic word that would include all the naturally

occurring hydrocarbons of common origin, whether they were observed in their gaseous, liquid or solid states, and that the state in which the hydrocrabon was observed was a matter of physical environment only. Petroleum was the word adopted for this purpose before 1906. Since 1906 this inclusive meaning has come into increasingly firm usage by those concerned with oil and gas scientifically and technically and in titles of organizations and books.

I have also endeavoured to show why, in my opinion, those who have dealt either with gas alone or oil alone after they leave the field have had less need for such an inclusive meaning. "Natural Gas" was adopted before 1906 as a sufficient term for the hydrocarbons handled in gaseous phase as no other gases that occurred naturally were of commercial importance, yet in recent years the natural gas industry has adopted L.P.G. which is the abbreviation of Liquid Petroleum Gases, as a trade name for hydrocarbons that are extracted from natural gas and that occur naturally as gases at normal surface temperatures and pressures. Those who dealt with the hydrocarbon liquids after they left the field had need for a word that generically covered the many dissimilar products that were derived from the liquids that would distinguish them from crude and refined vegetable and animal oils which were also important in commerce. Petroleum has been used in a narrower sense for this purpose to designate "crude oil" and the liquid products derived from "crude oil".

I have also pointed out that it is exceedingly difficult to separate the gaseous from the liquid hydrocarbons and that they are never completely separated in the oil and gas fields and rarely in trade. Natural Gas of commerce invariably contains vaporized liquid hydrocarbons and the "crude oil" that reaches the refinery invariably contains gaseous hydrocarbons in solution and important quantities of gaseous hydrocarbons reach the consumer dissolved in motor fuel or in other light refinery products. This overlapping of hydrocarbons in the gaseous and liquid products taken from the wells can be varied widely by field operations and is a constant source of confusion.

I have also endeavoured to show how the two meanings have resulted in confusion, ambiguity and conflicting and careless usages, so that it is often necessary to refer to the context to learn what the user meant by "petroleum" and the same user sometimes employed the word in one sense and then the other depending upon whether he was then considering the aggregate of hydrocarbons or only the liquids, and depending also upon whom he was addressing. Because of this confusion in usage, caution at times has required that "petroleum" and "natural gas" be coupled together to make certain that there could be no misunderstanding between parties even when used by those who recognized it to be tautology.

The foregoing summary statements are based upon a search of the literature particularly that preceding or closely following 1906. Of the references found, the most important in my opinion is "The Data of Geochemistry", by Clarke, published in 1908 by the United States Geological Survey. Clarke made a digest of the important technical literature on oil and gas prior to 1908. He may be fairly considered to have been both competent and disinterested. Clarke included the gaseous hydrocarbons as petroleum.

It is my recollection from my early contacts, beginning in 1909, with practical oil men in the field and with those dealing with leases, and from examination of lease forms, and forms used in reporting oil and gas operations, that the word "petroleum" was not then in common usage among such men, and that "oil and gas" were the commonly used terms. At the same time, usage of the word "petroleum" in its broader sense was recognized among such men in such titles as the "petroleum industry". I know of no reason to believe that any change in usage had occurred between 1906 and 1909 and many of the records that I examined in 1909 and in the years following soon thereafter, were dated earlier than 1906.

In my opinion, the correct meaning of petroleum in 1906 and today is the inclusive one and that the hydrocarbon gases are petroleum as well as the liquid and solids of like

origin. In my opinion the restriction of petroleum to the liquid phases, or to an "oily, inflammable liquid" are secondary and incomplete usages.

In my opinion, the separation of title to gas and oil, particularly in an oil reservoir, would result in creating great practical and legal difficulties and that it would result in wasting gas, lessening oil recovery and increasing the costs of recovery.

Q Is there anything that you would like to add to what you have told us, Dr. Lewis? A. I might as an analogy of the uses of words in the generic sense and the restricted uses refer to coal. In the generic sense coal covers lignite or ground coal, the various grades of bituminous coals, and anthracite or hard coal, but it has been my observation and experience that almost always you can go into an area and if you say "coal" they will take it to mean bituminous coal, because that is the coal that is most commonly used, and if you want lignite you are probably asked to state "lignite" or "ground coal", and if you want anthracite you have to specify that, so that instead of using or saying "bituminous coal" you have to say the different kinds you want, although it has been understood in my experience that when you say "coal" that you mean "bituminous coal".

Now, there are local usages depending on the coal which might be more permanent. Just as an extreme example, when I was in Trinidad some years ago I was puzzled to the constant reference to coal there, and I afterwards found in time that what they were referring to there was charcoal, because that was a commonly used substance. But if you wanted to be sure that you are understood when you say "coal" that you mean all the coal, all the varieties, you have got to say it in a way that it is understood in its generic sense. In other words, you have got to say "all coals", or use some other such similar term. In other words, in regard to coal there is a generic term for coal which includes all varieties, and there is a local usage which applies to one variety, and I think that is a somewhat similar condition of usage which has arisen with respect to petroleum, that there is a generic

use, that it is used in the generic sense, and it is also used in a restricted sense where the meaning is clear, where it is clear that you are only referring to the liquids, just as Uren and others who have used the generic sense will drop down and use the restricted sense, because it would be unnecessary to repeat constantly that you are referring to the petroleum liquids because it is self-evident from the context that that is what you mean.

Q Thank you, Dr. Lewis.

THE COURT: All right, we will adjourn for 15 minutes, and at 25 minutes to 4 o'clock we will resume.

(Hearing resumed after short adjournment.)

THE COURT: Any cross-examination?

MR. STEER: My lord, the cross-examination of Dr. Lewis divides itself naturally into two parts, and those parts have been prepared, one by Mr. Riley and one by myself. I mentioned the matter to my friend, Mr. Nolan, who has said, subject to your lordship's approval, that he has no objection with regard to our dividing the cross-examination in that way, and we think it will save time.

THE COURT: All right.

CROSS-EXAMINATION BY MR. RILEY:

Q Mr. Lewis, sir, I understood you to read from the work of Hollis P. Porter, a petroleum dictionary published in 1930. I wonder if I might have that book for a minute. First of all, who is Mr. Hollis P. Porter? A. He is deceased, and was a petroleum engineer. I think he was a graduate in mechanical engineering and was formerly employed by the Gulf Oil Company, but at the time that he wrote this dictionary he was not employed by anyone.

Q I note from the book itself that it is published by the Gulf Publication Company? A. That has nothing to do with the Gulf Oil Company.

Q The Gulf Oil Company was one of the major oil companies in the United States? A. That is right.

Q Will you tell me if he gives a definition of natural gas? A. I believe he did.

Q Just read me Mr. Porter's definition of natural gas.

Q "Natural Gas: A hydrocarbon gas found in nature of variable composition, which is usually high in methane and olefine gases. It may or may not be associated directly with petroleum. It is used as a fuel, is generally much higher in heat content than manufactured gas. It contains 900 to 1200 B.T.U. per cu.ft."

Q Now, will you tell me if he gave a definition of oil?

A Yes. Do you wish me to read it?

Q Yes, please, sir.

A "Oil: An unctuous combustible substance, liquid or at least easily liquefiable on warming and soluble in ether but not in water. This term includes fatty oils and acids; mineral oils, such as petroleum products, including lubricating oils."

Q Now, we do have, do we not, sir, at least three classes of oils, and when I used that expression, three classes, I mean, we have animal oils? A. Yes, sir.

Q We have vegetable oils? A. Yes, sir, we do.

Q And we have mineral oils? A. Yes, sir.

Q And whatever the disagreement between us may be as to the proper interpretation of "petroleum", at one time "petroleum" did mean mineral oil? A. Yes, originally.

Q All right. In contradistinction to that animal or vegetable oil? A. Yes. There are so many oils that you have got to use either a prefix or a qualified term, or it has got to be in association with either an industry or people or something else that will define it. That is, in the petroleum industry, in the oil and gas industry, you would know right away that it was a mineral oil.

Q Now, you also read from Mr. Paul Paine's book but only from your notes, I believe, sir? A. Yes.

Q And his book was "Oil Property Valuation", published in 1942, and you read from page 40? A. I read from two pages, page 40 and page 99.

Q Yes. Now, I am just going to ask you to say whether or not you started off on page 4, - I am sorry, page 40: "Natural gas is a gaseous form of petroleum", do you recall that? A. Yes, I do.

Q Now, will you tell me if immediately preceding that paragraph the following paragraph appears, and here is the paragraph:

"As often happens during the youthful period in an industry, the precise meanings of many words and expressions which have had a wide use in the petroleum industry have not become clearly established, or have meanings that are not always uniform in different localities. H.F. Porter has endeavoured to clarify the definitions in his informative Petroleum Dictionary, but this will not reform the vernacular of the oil fields, and it seems desirable to explain in somewhat greater detail the scope of meanings of some terms which are used in various ways and to point out the need for great care to guard against misunderstandings which might result."

A I do not know. I do not remember whether I read it or not. I probably did, because I went through it, but it was some time ago and I am not sure whether I read that or not. I probably did.

Q Well, how do we go about finding out, if that is the paragraph immediately preceding what you have read from? A. About the only way is to have the book.

Q All right, sir. Now, you talk about natural gas being the gaseous form of petroleum, if I appreciate your evidence, in at least the broader sense. Is that correct? A. Yes.

Q Would it be just as true to say that natural gas is the gaseous form of oil? A. No, I do not think so.

Q Why not, sir? A. I have seen some references, occasional uses in that way, but they are very few, and to my mind they are not proper uses because oil has always been used as a liquid. It is oil, the qualities - you will define, I mean, oil defines a quality rather than a substance. And you mentioned before, there are all kinds of oil, vegetable, mineral and animal oils. It is a quality rather than a substance.

Q Well now, look. If I reserve oil, do I not reserve a substance? A. You have to specify. You would have to use some qualifying term there.

Q I see. A. What kind of oil.

Q Now look, you are familiar with the different forms of oil and gas leases used throughout the United States, except in two States, are you, sir? A. Most of the States.

Q And the terms "Oil and Gas" are used in all but two

of the States? A. Yes, I suppose they are, I could not say whether they are used in all but two of the States, but have been used wherever I have worked.

Q And the leases which you have practically universally in the United States are oil and gas leases? A. Yes, that is the common form.

Q And you would expect on coming to the Province of Alberta to find something similar, some similar document in use here? A. Something that would correspond to that, yes.

Q Yes, something that would correspond to that. And you have heard a lot about those documents during the course of the trial here, have you not? A. I have heard a number of them, yes.

Q Heard a lot of them? A. Yes.

Q And our petroleum and natural gas leases correspond, would you say, in your opinion, with your oil and gas leases? A. I am not a lawyer.

Q No, I know, but as a layman that would be putting it fairly, would it not? A. Well, I presume that is true, but I do not know that it is a fact.

Q Well, just let us look at a few of the exhibits here. Exhibit 81, Mr. Lewis, being the regulations for the disposal of the petroleum rights, the property of the Canadian Pacific Railway Company in the Provinces of Manitoba, Saskatchewan, Alberta and British Columbia; and you recognize those as large Canadian Provinces, do you not, sir? A. Yes, sir, I believe they are.

Q They are. And we were told when that document was given to us that this document has been in force by the Canadian Pacific Railway since 1914, I believe. I want you to assume that in my questioning.

A Very well, I will assume it.

Q All right. Will you read paragraph 13 of that document?

A "If the Lessee shall develop natural gas in connection with his drilling operations to obtain petroleum, he shall forthwith make application for the acquirement of such natural gas under the terms of the Company's regulations relative thereto and shall pay to the Company the royalty on such natural gas as therein provided."

Q Yes. And does it not appear to you that the word "petroleum" is in the sense in which you use oil

across the line? A. No, I do not think so.
" If the Lessee shall develop natural gas in connection with his drilling operations to obtain petroleum, - "
and that means to me that natural gas is one variety of petroleum. You might have in there whatever they wanted to. They could make any lease they wanted. They might have specified a certain amount of oil, paraffin oil, or ashpaltum oil, or might have specified tar.

Q Your answer to me is that you would take the words:
" "If the Lessee shall develop - "
you realize that the Lessee has already the petroleum, you say that the words:
" If the Lessee shall develop natural gas in connection with his drilling operations to obtain petroleum, he shall forthwith make application for the acquirement of such natural gas under the terms of the Company's regulations relative thereto and shall pay to the Company the royalty on such natural gas as therein provided,"
you say that the substance, "natural gas" is included in the word "petroleum" even in this document?

A Now, that is the way that I read the one paragraph. In the first place, you are asking me for a legal construction. I am not a trained lawyer. Another thing, you are asking me to construe it from one paragraph and not from the whole document.

Q Would you construe it from the whole document by reading the whole document? A. Well, if you wish me to. It is a lawyer's construction of a legal matter. All right, I'll go ahead and do it. Well, I find this rather confusing, but what it is worth, on a first casual reading of the thing, I would say the intent was to dispose of the petroleum rights. Now, it speaks up here of barrels, which, of course, obviously refers to the liquid, and it gives a measure of the amount of barrels on discovery which should be a measure. I will read this:
"If Petroleum to the volume of five barrels a day is not found in any one or more wells, the Lessee shall have the privilege of surrendering his lease of any quarter section or legal subdivision on which such well is located, but shall not be entitled to a refund of any rent for such land paid in advance as required by these regulations,"

I would consider that as a measure of the rights in this case of the Lessee of surrendering the land. I believe that is what it applies to. And then it goes down here, and you can not measure gas, naturally, in barrels, so that you have got to provide some other form of rights:

> " If the Lessee shall develop natural gas in connection with his drilling operations to obtain petroleum, he shall forthwith make application for the acquirement of such natural gas under the terms of the Company's regulations relative thereto and shall pay to the Company the royalty on such natural gas as therein provided."

Well, I would look at that as simply being two forms of substances of petroleum, and the second one provides a little different manner of payment of rental.

Q That is the best answer you want to give me?
A That is about all I can say about it.
Q Isn't it obvious, Mr. Lewis, that if this was drafted in 1914 the drafter of that pamphlet or those regulations could not have been aware that natural gas is a gaseous phase of petroleum? A. Pardon me?
Q If the reporter will repeat my question.
BY THE REPORTER (reading):

> "Q. Isn't it obvious, Mr. Lewis, that if this was drafted in 1914 the drafter of that pamphlet or those regulations could not have been aware that natural gas is a gaseous phase of petroleum?"

Q MR. RILEY: Isn't it obvious, Mr. Lewis?
A I don't think so.
Q If he was aware of that definition of petroleum, that petroleum included solids, liquids and gases, you still say that he would draft that form of a document? A. I don't know of any reason why he shouldn't. I think I could draw a little clearer one.
Q I see. A. But maybe I am flattering myself.
Q Have you seen the drilling and production regulations we have in force in this Province under our Oil and Gas Well Act? A. No, I have not. I have seen a larger pamphlet which includes the law, and might include the same thing. I am not sure it is the same thing. I have read that. I do not know whether it is the same thing or not.

Q Well now, this is Exhibit 7 we are looking at, and refers to a definition of "petroleum", page 8, subsection 1(e):

" 'Petroleum', in addition to its ordinary meaning, includes any mineral oil or relative hydrocarbon and natural gas existing in its natural condition in strata,"

".....in addition to its ordinary meaning....."

What do you say the ordinary meaning of "petroleum" is? A. Ordinary meaning, well, I don't know just what "ordinary" would mean up here.

MR. STEER: "I don't know what ordinary means."

MR. RILEY: "Would mean up here".

Q Now, going along a little farther, let us turn to Section 17:

" In all proven or well-defined petroleum or natural gas fields, or where it is to be expected that petroleum or natural gas will be encountered, adequate preparation shall be made for the conservation of petroleum or natural gas before 'Drilling-in' a well, and the petroleum or natural gas horizons shall not be penetrated until proper equipment, as approved by the Board, is installed on the well."

Is it your feeling that the draftsman of this legislation knew of the wide generic meaning of petroleum? A. He may have.

Q He may have. In your country you would have used the words: "oil or natural gas fields"? A. I have seen both used. I have seen "petroleum and natural gas", and "oil and natural gas", but "oil and natural gas" is, I believe, the most common.

Q Next,

" If the operator encounters significant quantities of petroleum or natural gas or water in a well, he shall immediately notify the Board, by the most reasonably expeditious method, of the character, extent and quantity thereof."

That is Section 18. Isn't it obvious that they are using the word "petroleum" in the sense of oil?

A Yes, I think it is, in that case.

Q And Section 20:

" No well shall be drilled beyond any significant petroleum, natural gas or water

"stratum, regardless of the volume, without sealing off such stratum....."

Isn't it pretty obvious that they are using the word "petroleum" in the sense of oil? A. I think they are using it in the narrow sense there. They are doing one of two things. I do not know which was in their mind. They are either deliberately using it in the narrow sense, because it was their opinion that using it in the combined sense it might be mistaken, and they are using it that way so that there would be no mistaking the meaning as a matter of caution.

Q Section 21:

" Whenever a stratum known to contain petroleum or natural gas in the general area is encountered in any well, such stratum shall be adequately protected from infiltrating waters in such manner as may be prescribed by the Board."

Isn't it obvious that "petroleum" is being used as meaning oil? A. I would give the same answer as to the preceding question.

Q " No operator shall drill for petroleum or natural gas on any land under which there are workable beds or seams of coal which are being worked, or in respect of which operations have been undertaken for the working of the coal therein contained, unless in the opinion both of the Board and of the Director of Mines it is practicable to drill for petroleum or natural gas through such beds or seams of coal without danger,"

and so on. That is Section 24.

A I think the same answer is applicable.

Q Section 28, sir:

" If the escape of petroleum or natural gas is not prevented or if a flow of water is not controlled, the Board may, with the approval of the Minister, take such effective means as may appear to it to be necessary or expedient in the public interest to control and prevent the escape of the petroleum or natural gas,"

and so on. The same answer? A. The same answer.

Q Section 30, sub-section (1):

" When it appears to the Board that water is penetrating any petroleum or natural gas-

"bearing stratum,"
the same answer? A. The same answer.

Q Section 31 (1):

" Operators shall use every possible precaution, in accordance with the most approved methods, to stop and prevent waste of petroleum or natural gas in drilling and production operations, and in storing, piping or distributing petroleum and natural gas, and shall not wastefully utilize petroleum or natural gas, or allow same to leak or escape from natural reservoirs, well, tanks, containers or pipes."

The same answer? A. The same answer.

Q Yes. 31(2):

" No well shall be allowed to produce petroleum or natural gas from different pools or zones at the same time, from the same string or column of casing, unless upon permission in writing from the Board."

A In regulations of that kind it is quite obvious if they are going to, for clarity, if they are going to use, for clarity, they are going to use the one set of terms, and they are going to use them throughout.

Q I need not go on. It is quite plain to you, is it not, sir, in all fairness, that the word "petroleum" is being used throughout in the sense of crude oil?

A I will put it this way. In the way it is put there, that is probably what they meant. Only they may have used it as a matter of caution rather than as a matter of understanding.

Q I see. A. And I do not know which.

Q All right, sir. Now, sir, the literature that you have referred to in some cases was English and in the majority of cases American? A. Yes, I think the majority was American.

Q I may put it this way, there is no Canadian? A. No, I would not say that. There are Canadian publications, the publications by, I believe, the Province of Alberta and the Dominion.

Q That you read or referred to, sir? A. I did not refer to any of them.

Q That is what I am saying. I am talking about the ones that you referred to. A. I did happen to examine a number of Canadian publications, but I did not find anything that was pertinent. By

that, I mean anything that the use was clear enough that you could tell what it meant.

Q Now, if I, in the year 1906, had reserved natural gas alone from the sale of my land, do you say that I reserved nothing? A. No, I do not say that. I say that you reserved natural gas.

Q I reserved the natural gas? A. Yes.

Q Do you recognize natural gas as a separate and distinct substance capable of being reserved?

A I recognize natural gas as being one form of petroleum, one form of hydrocarbons.

Q When I say, do you recognize natural gas as a separate and distinct substance and capable of being reserved? A. Well, I will put it this way, it is capable of being reserved, but with difficulties.

Q And why do you put it that way? A. Because it would be very difficult to define exactly what natural gas is, and very difficult to operate and separate your property rights in such a way that you could make it practically feasible to divide it.

Q Now look, we can not get into the sphere of difficulties of construction, that is something for the court. You have had in the United States divided titles and thousands of them? A. Yes, we have.

Q And a lot of litigation over them? A. Yes, a lot of litigation.

Q And it has been found that natural gas is a separate and distinct substance in the eyes of the law?

A I could not say that, I do not know.

Q And you never heard the expression of one of your Chief Justices about natural gas being a separate and distinct substance? A. Never.

Q I suppose you occasionally read Summers on Oil and Gas? A. No, I never do read it.

Q You never do read that? A. No.

Q You have never seen it? A. Yes, I have seen it.

Q Have you got it in your library? A. No.

Q What about Thornton on Oil, have you got it in your library? A. No, I do not have any legal books.

Q I see. A. I go to a lawyer when I need legal advice.

Q I see. Now, I am showing you a few more exhibits, if I may. The first is Exhibit 70. You will notice the heading "Petroleum and Natural Gas Lease", being an Imperial Oil Limited form. You observe that?

A I observe that, yes, sir.

Q "The Lessor, being registered as owner.....of the petroleum and natural gas and all related hydrocarbons within, upon or under....." certain lands, do you say that the draftsman of that document knew of the generic meaning that you have given in this courtroom? A. Well, I would say this, whether he knew about it or not, he was probably uncertain as to the legal implications of that and he evidently drew it in an omnibus terminology there which he felt would cover everything in that thing.

Q In your country it would be called and Oil and Gas Lease? A. Yes, generally. I have seen leases in the States where it is not called "Oil and Gas", where they said "Petroleum and Other Substances", where they thought it might be available. Some of them cover sulphur where they thought it would be available.

Q I am showing you Exhibit 69, being another Imperial Oil lease. A. Yes.

Q You will notice it has "Petroleum and Natural Gas Lease" and the wording is the same? A. Yes.

Q And your answer is that would be the same? A. Yes, my answer to that would be the same.

Q And I show you another form, being Exhibit 68, another Imperial Oil form, with regard to petroleum and natural gas and all related hydrocarbons, and your answer would be the same to that? A. Yes.

Q And without going through them, I may say to you that the wording is the same in Exhibits 67, 66, 65, 64, 63, 62, 61, 71 and 59, and you think the answer to the uses of the words "petroleum and natural gas lease" and leasing the petroleum, natural gas and related hydrocarbons would be the same to each of those documents, if I put them to you separately?

A Yes, if the wording is the same I would give the same answer.

Q I suppose, sir, that it is quite possible to have petroleum mean crude oil? A. Well, as I have said before, it is a secondary meaning.

Q You mean, confined to crude oil? A. Yes, certainly. I think it is one.

Q Yes. Was secondary for the purposes of the derivative meaning? A. By custom.

Q By custom? A. Yes. There are many words which have been enlarged and many words have been contracted from the original meaning.

Q We are both agreed on this, that originally it was

rock oil? A. Yes.
Q Sometimes called mineral oil? A. Yes. Of course, when you say originally rock oil, we know that the paraffin oil or the rock oil, I do not know where it was used originally or what it applied to, but all we can do is assume it.
Q Now, sir, we come to some use that has been made by our own Statutes that I just want to put to you for a minute. Sir, I take you back to a Statute passed in 1908 by our Dominion Parliament called "The Dominion Lands Act", and before I question you about it, I will tell you this, that the Dominion Lands Act is an Act, among other things, whereby people were permitted to homestead and the Dominion reserved certain things out of the homestead. Section 37 reads this way:

" Lands containing salt, petroleum, natural gas, coal, gold, silver, copper, iron or other minerals may be sold or leased under regulations made by the Governor-in-Council."

Now, you see the section goes on, but those are the only words I am concerned with:

"lands containing salt, petroleum, natural gas".

Would you say that the Legislature in viewing those as one substance or two? A. Well, I would say that they were either uncertain that one word covered both of them or that in their own minds they thought they should be distinguished.
Q I see. Rather curiously, we have a new Income Tax Act in this country passed in 1948, Section 33(c), reads:

"A corporation whose principal business is refining, marketing of petroleum, petroleum products or natural gas....."

and it goes on. It has to do with refining and marketing of petroleum, petroleum products or natural gas. Do you say that in 1948 they were uncertain as to the meaning? A. Well, I would judge, due to the fact that we are in this courtroom, it must show an uncertainty of meaning.
Q In 1948? A. I presume we were heading for this case by that time?
Q I will try some Provincial Acts for a moment. A. Yes.
Q First, there is the Mineral Taxation Act in 1923.

" 'Minerals' shall, but not so as to restrict in any way the ordinary meaning of the word, include natural gas, petroleum, gasoline and all oils of a mineral nature."

You will notice the words include "natural gas", "petroleum". It is natural gas, petroleum. Do you say that the Legislature there was dealing with one substance or two? A. They must have thought they were dealing with several substances.

Q Yes. They were dealing with natural gas as a substance, petroleum as a substance, gasoline as a substance, and all oils of a mineral nature as a substance. A. Evidently they were not sure that gasoline and other hydrocarbon liquids were petroleum. They use a very narrow definition, if you go by that.

Q Now, we come down to a Statute passed in 1938, being The Oil and Gas Resources Conservation Act, and they define petroleum there as follows:

" 'Petroleum' - - "

note this language,

"in addition to its ordinary meaning - "

MR. HELMAN: You are not reading the Act, the '38 Act. I have it in front of me.

MR. RILEY: I am not reading the '38 Act?

MR. HELMAN: No.

MR. RILEY: Now, there were two passed in '38, weren't there?

MR. STEER: That is Chapter 1. I am looking at the Statute of 1938.

MR. RILEY: The 2nd Session, 1938.

MR. HELMAN: I am looking at Chapter 15 of '38.

MR. RILEY: This is the 2nd Session.

Q " Petroleum in addition to its ordinary meaning includes any mineral oil or relative hydrocarbonsand natural gas existing in its natural condition in strata."

I ask you again, what do you say the ordinary meaning of petroleum was in 1938? A. Well, I would infer from that, whoever drafted that document, that the ordinary meaning did not include natural gas and these other substances which they mention in addition to the ordinary meaning shall include, shall include, was that it?

Q Yes? A. I would say that he was uncertain as to the definition.

Q Another interesting definition of that Act, sir:

" 'Oil' means crude petroleum, oil and all other hydrocarbons regardless of gravity which are or can be recovered from a pool in

"liquid form by ordinary production methods."

A I might say that I have seen laws when I have had occasion to look up anything of the kind, and also documents, where they have defined terms for the purposes of that document or that law, which will apply so far as the document or that law is concerned, whether or not they apply generally. That is as I understand it. And I know I have done it in contracts in which I have been a party, where we have defined terms and conditions which may apply only to that document and not apply generally. I would think in my own mind that some of these things are of that nature.

Q It may very well be, sir, but on the other hand there is the principle that the Legislature is supposed to use the words in their ordinary language. A. It might be the intention, but I have seen cases where they do not.

Q Next, we will go to the Pipe Line Regulation Act, 1939.

" Petroleum, in addition to its ordinary meaning, includes petroleum products and natural gas."

Isn't it obvious there that they are dealing with three substances, petroleum, petroleum products and natural gas? A. Yes.

Q Now, sir, getting back to your brief for a few moments, much of that brief would come within what we might call reservoir engineering, is that true, sir? A. That is true.

Q And reservoir engineering is a new science? A. No, I would not say so.

Q Well, what would you say, sir? A. I would say it is a developing science. We know more about it every day than we did the day before, but the basic principles, not all of them, were mostly known years ago. There was a geologist and an engineer in the geological survey by the name of Carllback in the '80's, I think, that set forth quite clearly a good many of the principles of reservoir engineering.

Q Are you a member of the American Petroleum Institute?

A I believe I am. I think I am.

Q You have been one for some years, I suppose? A. Yes. I believe I pay a cheque every year and never attend the meetings.

Q I am suggesting to you that on September 12th, 1927, your Gas Conservation Committee of the American

Petroleum Institute passed a resolution regarding the importance of natural gas in the conservation and production of petroleum and the best means for its efficient utilization, is that correct? A. I do not know.

Q Well now, in your library have you got the book "Function of Natural Gas in the Production of Oil"?

A Yes, I have it.

Q You have read it? A. I have read parts of it. I do not remember much about it.

Q That is what that book is about, isn't it, sir, the studies coming out of that resolution? A. I do not know what led to that book.

Q Well, perhaps we will start and read it for a page or two. Now, first of all, we have got the right book, "Function of Natural Gas in the Production of Oil" by H.C. Miller? A. I may say I looked over Miller in connection with this case and I did not find anything in it which I thought was informative on it.

Q Let me get at it this way, that this book is concerned with utilizing natural gas in a fashion to give the greatest oil recovery, that is the purpose of this whole study in this book, isn't it?

A Yes, that is the main purpose.

Q And the introduction by Mr. Miller clearly says that this paper represents work done under a co-operative agreement between the United States Bureau of Mines and the American Petroleum Institute, printed by the permission of the Director of the United States Bureau of Mines, that is right, isn't it, sir?

A Yes, that is what it says here at the bottom of the page.

Q And the Gas Conservation Committee met at Colorado Springs on September 12th, 1927, and unanimously passed the resolution? A. I would like to add another thing with regard to that. As you see, Mr. Miller is a petroleum engineer, the senior petroleum engineer of the U.S. Bureau of Mines, but Mr. Miller is a petroleum engineer writing about gas.

Q This book is not about gas, is it? A. It is.

Q You keep that book in front of you. It is called "Function of Natural Gas in the Production of Oil"?

A Yes.

Q And the whole purpose of that book was to show the petroleum industry how they could best use natural gas in the increasing production of oil, in increasing

the production of oil? A. Yes.
Q So that what is the sense of saying it was written by a gas man? A. I did not say it was written by a gas man, it was written by a petroleum engineer. It is a petroleum engineer writing about gas. It is another case where you get the broad view of the word implied by the title.
Q Turn to page 214, will you, sir. See if you can follow me. You see the words "natural gas consists mainly of methane and ethane with smaller percentages of other hydrocarbons of higher molecular weight, nitrogen and other gases"? A. Yes.
Q "The percentage composition varies with locality and condition of production."
A Yes.
Q "A gas containing larger proportions of the more easily condensable higher hydrocarbons is classed as a 'wet gas'."
A Right.
Q ".....while one consisting very largely of methane and ethane is called "dry'."
A Yes.
Q "When available, a wet natural gas is probably the most desirable gas for repressuring operations."
A That is right.
Q And when he speaks "for repressuring operations", that is, to keep the reservoir pressure up so that there will be oil recovered? A. No, repressuring means after the reservoir pressure has gone down.
Q What is the reason for keeping the pressure up?
A I did not say that.
Q What is the desire to keep pressure up? A. There are a number of reasons. One is to keep the gas in solution and to keep up the best physical qualities of the oil. There are a number of other reasons, but that is sufficient.
Q All right, let us keep going here.
"It is more soluble than dry gas and reduces viscosity to a greater extent."
A Yes.
Q "Its use introduces no new gases to the formation and it can be reused as produced with the oil at the well."
A Yes.
Q "The chief disadvantage of the use of a wet

"natural gas in its commercial value for other purposes."

Now, note this next language:

"In many cases the higher hydrocarbons may be removed for use in the production of gasoline, thereby leaving the gas dry. The dry gas often has sale value for use as fuel. Yet if the use of the gas for repressuring purposes will considerably increase the ultimate oil production from a pool,,it seems very doubtful economy to utilize it in other ways. In old fields this has often occurred, so that there is no choice left but to use other gases for repressuring."

A Yes, I recall that.

Q And you agree with those conclusions as a petroleum engineer? A. Yes, in general I would say this is a good conclusion. It is not always feasible, but it is a desirable thing to do.

Q And the plain thesis therein is that natural gas has got a greater value to the producer of oil in producing oil than it has commercially for sale as a product? A. Wait a minute. That is a pretty broad conclusion from a statement of that kind. It is not always so; in some cases it would be.

Q Well, let us go back over it again.

"In many cases the higher hydrocarbons may be removed for use in the production of gasoline, thereby leaving the gas dry. The dry gas often has sale value for use as fuel. Yet if the use of the gas for repressuring purposes will considerably increase the ultimate oil production from a pool....."

A There is your qualification.

Q "....it seems very doubtful economy to utilize it in other ways."

A You see the qualification in there.

Q It is very doubtful economy if it will increase the oil production from a pool? A. Yes, that is your qualification.

Q You say natural gas won't always increase the oil production from a pool? A. It does not always necessarily do so. For example, you can very often do a much better job by using water, and there are other cases where the injection of the gas back into the reservoir would decrease rather

than help the oil recovery. It is hard to generalize about these things. You have got to get down to specific cases.

Q All right, sir. Now, turning to page 13 of the book, you will note the statement - he is dealing with the origin and mode of formation of petroleum and its migration and accumulation - you will note the statement:

"Whether the oil as it exists and is produced today is simply a modification of that formed during the life processes of the plants and animals has not yet been proved."

A Where is that?

Q Page 13, sir, I would think towards the bottom of the page. Well, I will find it for you, and I will read it back to you, and you can tell me whether or not you agree with it.

"Whether the oil as it exists and is produced today is simply a modification of that formed during the life processes of the plants and animals has not yet been proved."

A Would you mind reading that again. I am not sure I got it all.

Q "Whether the oil as it exists and is produced today is simply a modification of that formed during the life processes of the plants and animals has not yet been proved."

A I take that to mean, the statement that it has not been proved, just what the oil was, and whether it did come, taking the modification, from plants and animals deposited in the region.

Q Well, he is dealing with the transformation, I take, of oil from the theory that it originates in animal and vegetable matter in sedimentary rocks, how it got into the present condition, the transformation of it? A. I think that is what his meaning is, that it is not proved just how the oil was formed, from these statements, and if he says that I think he is right. We know in a general way, but the specific processes have never been agreed upon as between investigators. It is still an open question.

Q Yes? A. As to that.

Q I am sorry, I did not mean to cut you off. A. It is still an open question as to that.

Q He goes on to say:

"By what means source material is transformed

"into petroleum in nature is one of the great unsolved problems of petroleum geology."

A I would agree with that as far as that is concerned. We know what it generally is.

Q "One of the theories is that the oil is formed from its mother substances relatively soon after these have been buried in the sediments, through the action of bacteria and various chemical reactions associated with that action. This is the so-called biochemical theories."

A That is a correct statement.

Q That is one of the theories? A. Yes, that is one of the theories and a correct statement.

Q "Others have suggested that the action of high pressures, possibly accompanied by local and temporary high temperatures, in connection with earth movement, such as faulting, may have been the principal cause of the change of part of the organic material into the form of petroleum."

A It may have been suggested, but I know that is not commonly thought.

Q Well, is it a view that is held even by a minority, let us put it that way? A. Well, I will have to say this, that I do not remember hearing anybody proposing that.

Q I see.

"A suggestion of a large-scale method by which the source materials may be 'cracked' into petroleum is derived from the fact that in the regions in which the rocks have been subjected to high pressures and high temperatures during the formation of mountains, so that they have been partly metamorphosed, the organic source rocks are found to have lost their volatile constituents, including both the gases and the oils. It is suggested that such partial metamorphism of the source rocks by dynamic forces is capable of generating large quantities of oil."

A That is an opinion that is not generally held. I might say that I know Mr. Miller quite well and he is not a geologist.

Q You see, I am not asking anything about that except this, is it an opinion that is held by some?

A Oh, I do not know any opinion that is not held by some.

Q There are many different opinions, aren't there, sir?
A Yes, there are many different opinions.
Q "Still another group of scientists hold that much of the petroleum originally was deposited with the sediments in the form of free oil, disseminated in minute globules which were later squeezed out of the source rocks and concentrated into commercial pools. Certain evidence from California seems to support this view."
A That is the view held by an Englishman and not generally held.
Q Then, after giving all these theories, he says: "It is entirely possible, and even probable, that, while no one of the theories sketched above completely explains the generation of oil from its source rocks, each of them is a true explanation which is applicable in certain instances."
A No, I do not think that that is generally agreed to. I think that most investigators who are not committed to any one theory to the point where they can not keep an open mind will agree that there are several possible ways of forming oil, and it may have been formed in different ways in different places, but I do not know of any man who would agree to all those things.
Q No, I am not putting it forward for that reason, I am merely putting it forward as showing the different views of different groups. I do not care whether it is in the majority or not, I just put them forward as views held. A. Well, if you want a general statement that there are lots of views as to the origin of oil, I agree with you.
Q Don't you personally believe that in various localities and under various conditions oil may have been formed in all of the ways I have mentioned, or might have been formed in several different ways? A. I am not sure of that.
Q You are not sure of that? A. There may be one basic process. We are trying to explain them all.
Q Now, oil has been found in igneous and crystalline rocks? A. Yes, I know of whole oil fields produced out of igneous rock.
Q And just for the purposes of the record, igneous is a rock which was in a molten condition as much as rotting? A. Yes. But you can take

igneous rocks, you can have igneous rocks, but it does not necessarily form in the igneous rocks. The place that I know where you have a whole oil field producing from igneous rocks, the general opinion is that the oil was formed in adjacent sedimentary rock.

Q How did the oil get to the igneous and crystalline rocks if it was formed in the sedimentary rocks?

A Very easily, by migration.

Q Do you know that or is that a theory that is held?

A It is no more or no less than oil migration in sedimentary rocks. The circumstances are just as easily explained in both cases.

Q It is something, as I said earlier, it is something that has not been proved but people hold views on it?

A It is proved to this extent, that the evidence with regard to that is so overwhelming that nobody really doubts it. Of course, when it comes to proving it, nobody was there at the time, and you have got to infer these things rather than have actual proof.

Q Now, at page 26, he says:

"In their original state, in an undrilled or virgin oil field, the several hydrocarbons that comprise natural gas under surface conditions of temperature and pressure may be considered as existing in four separate phases:
(1) Dissolved gas in the oil;
(2) Free gas mingled in the pore spaces with the oil, or collected above it in structurally high parts of the reservoir formation;
(3) Gas in the liquid phase; and
(4) Adsorbed gas. "

Is that an accurate statement? A. That is true.

Q What is "adsorbed gas"? A. Well, I am not quite sure of that, but I think that is true that the adsorption is the surface effect, the surface energy effect, and liquid can be adsorbed, and my understanding is that to a very slight extent even gases can be adsorbed. You can get a better answer to that from Dr. Katz.

MR. NOLAN: Did Mr. Miller write the whole of that book?

MR. RILEY: No, he did not. It was written by a collection of people.

MR. HELMAN: Page 26 is written by Professor Lacy.

Q MR. RILEY: Who is Professor Lacy?
A He is a physicist in the California Institute of Technology.
Q Do you know him? A. Very well.
Q His writings are authoritative? A. Yes, he is considered an authority on his subject.
Q Now, I take it, sir, that we agree on this principle, that the amount of gas dissolved, for example, in the oil in the reservoir at Leduc is directly proportional to two things, one is the reservoir temperature and the other is the reservoir pressure? A. Not directly proportional, but almost close enough that I won't argue with you about it.
Q Can you tell me the temperature of the reservoir at Leduc? A. I do not remember any testimony on that.
Q No, there has not been yet, sir, and I just wanted to know if you knew? A. I do not know.
Q And can you tell me the pressure? A. I do not remember any evidence. If there was any evidence on that I do not remember it.
Q No, there has not been. I thought just perhaps you would know, Mr. Lewis? A. Now, there is a statement I made there - I would like you to confine your statement to one of the reservoirs, if you will.
Q Let me take the D-3 reservoir then, as an example.
A Yes, all right.
Q Exhibit 103 does not give us the temperature, but it does give us the pressure, 1,984, Mr. Lewis, in a particular well, Leduc 6. Tell me, is the pressure at the bottom of the bore hole necessarily the same as farther back in the reservoir? A. Well, initially in a new field where it has not been disturbed it would be, but as soon as they begin to take fluid out of the reservoir, it will not be unless they shut the well in long enough to reach full equilibrium with the pressures throughout. There is a time lag there.
Q Let me discuss for a moment with you what happens to the oil from the D-3 zone. We start with oil, with gas in solution in the reservoir? A. Yes.
Q Don't we, sir? A. Yes.
Q Then it moves towards the bore hole, does it not?
A Yes.
Q And the gas renders a service in getting the oil to the bore hole? A. Not necessarily. There are two functions of gas. One is the effect of the

physical quality of the oil, the effect on the physical quality of the oil, and in that sense it has no motivating force at all. The other sense would be as an expansible force. It can have an active force, but a reservoir such as Leduc, and I am not in a position to state whether it is a fact, I can only state it on this condition, that it has no water drive, and you might not be using the motivating force of the gas at all, you might be depending on the water as a motivating force and keep the force of the gas entirely inactive. That depends on the natural condition and the way it is operated, and I could not say which is which.

Q I won't press you on that. On this move from the reservoir to the bore hole, is the gas in solution escaping from the oil? A. It depends on whether you are lowering your pressure.

Q If you are lowering the pressure the gas will be escaping? A. Yes. In that case the oil was fully saturated with gas, so that under the conditions you have there if you lowered the pressure at all a certain amount of the gas is escaping from solution.

Q Now, isn't the pressure at the bottom of the bore hower than in the remaining parts of the reservoir?

A Yes, during the time of the production.

Q Now, we have got the oil and gas in solution to the bore hole, some gas has escaped. Now, as we come up the bore hole, isn't the natural gas escaping all of the way up the hole from the bottom?

A Yes, under conditions of natural flow.

Q I am assuming natural flow. A. You have a lowering of pressure from the bottom of the well to the top and, therefore, the escape of gas from the solution.

Q And we can not get down into the reservoir away from the bore hole and pick up a barrel of oil, can we, sir? Oil and gas in solution? A. No, you can not do quite that, but you can go in there with one of these bottom hole samplers, get a sample, close your well in until the pressure is equalized and, in effect, you are getting the same sort of fluid you would away from the bore hole.

Q And the effect of the gas being in solution in the reservoir with the oil is to give you a larger volume of a liquid than you have when it comes to the surface? A. Well, when you have gas

in solution in the liquid the total fluid is in what you might call an expanded state, and when you get the gas out of solution it is like taking any one of the components out, such as gasoline, and you reduce the volume. If you take a barrel of residue oil in its original condition and bring it to the surface and allow the more volatile hydrocarbons to escape in reducing pressure, to enter the gassy state and so forth, you are going to have a shrinkage of your reservoir oil, and your barrel will be something less than a barrel when it reaches the surface.

Q Because it has been depleted by the gas that has escaped? A. Depleted is not a good word.

Q What is a good word? A. I would say being reduced in volume by taking away some of the fluid. That is not very well stated but it gives the idea.

Q What I am getting at is this, as we are reducing pressure and getting towards atmospheric pressure the gas is escaping? A. Yes.

Q That is all I want. And at atmospheric pressure it will be a gas, won't it? One will be a gas and the other will be a liquid? A. Well, that depends on how you define gas. There will be certain of the hydrocarbons which will be in vapour form, certain of the hydrocarbons which would be vapour if they were isolated and taken out of solution, but they are still in solution. Now, if you wanted to define gas as a substance of certain hydrocarbons, that is one thing; if you want to define it as a condition, it is something else.

Q I would like to define it as a substance, if I may.

A As a substance?

Q Yes? A. When you separate your gas from the oil and define it as a substance, now, first of all you have got to draw an equation between gas, which is gas in the term of the substance.

Q Well, is there such a thing as a substance called natural gas? A. Well, I do not think scientifically there is.

Q Well, what about in common, ordinary, every-day talk?

A Well, in common, ordinary, every-day talk, why, the fluids you get out of a well which enter your pipe line or where you are handling it in the aeriform state is called natural gas.

Q What do I burn in my home? What do all the people around here burn in their homes? A. I will take your word for it, natural gas.

Q All right. Now, sir, going back to the book that we were dealing with, will you turn to page 45, at the bottom of page 45. We had better find out what chapter it is and who wrote it. A. Does it make any difference?

Q My friends were asking as to who the author of it was. I notice at page 1 the term, "Reservoir Gas Oil Ratio, the number of cubic feet of gas per barrel of oil originally in the reservoir". Is that an accurate statement of gas-oil ratio, reservoir gas-oil ratio? A. Yes, it is often referred to as the solution gas-oil ratio,

Q At the bottom of page 45, Mr. Lewis, follow this language:

> "The blowing of gas wells in the hope that oil will eventually appear is usually inadvisable. In any event it is wasteful of gas energy which is so important in expelling oil from reservoir sands. More often than not, when oil does appear or the well is placed on the pump, the gas pressure has been dissipated to such a degree that oil production is very small. An outstanding example of waste of gas energy occurred at the Cook pool, Shackleford County, Texas, when the gas from two wells was allowed to blow into the air in an effort to convert a dry gas area on top of the structure into an oil-producing area."

Now, do you know the Cook pool, Shackelford County, Texas? A. I know where it is and a little about it.

Q Can you place the occurrence that the author is speaking about? A. I do not remember hearing about this particular incident. I know what happened after, that they re-injected the gas, and it was considered one of the outstanding cases of beneficial results from pressure maintenance.

Q Now, tell me, sir, about these experiments with regard to injecting gas. Turn to page 161, Mr. Lewis, of the book, and there some of the experiences are recounted. The author says:

> "In the Bradford field, Pa., forty-one wells were drilled between 1885 and 1896. Air, because gas was not available, was first injected into the sand through nine key wells in October, 1925."

So that as recently as October, 1925, the experiment

there was tried with air? A. I might save a little time by saying that this was done by my partner and myself.

Q This particular part of the book? A. No, we did not write the book, but we supervised the injection of air in those wells.

Q That was in October 1925? A. As far as I remember, it sounds about right.

Q We will just go through it in quick fashion. In November, 1926, air was injected into an area in Crawford County, Illinois? A. Yes. My firm did the engineering on that. We were the advisory engineers.

Q Yes. And in 1926 an experiment was made in Salt Creek, that is Wyoming, isn't it, sir? A. I did not have anything to do with that.

Q And in June, 1927, the Elk Basin field, Wyoming?

A I did not have anything to do with that.

Q And in 1927 the Seal Beach field, California?

A Nor that.

Q And that is about the time that that dates from?

A No.

Q Were there any earlier experiences? A. Re-pressuring started in 1911.

Q Where and when? A. Marietta, Ohio, started by my partner, Mr. Dunne.

Q What about the experiment? A. 1911 on the Cumberland farm near Marietta, Ohio.

Q What was the result of the experiment? A. Very favorable.

Q Did you use air or gas? A. Used air.

Q From 1911 until these experiments started in 1925, '26 and '27, were there any others? A. Many of them.

Q Where were they? A. Most of them around that area, around Marietta, Ohio, and West Virginia, and also some in Kansas, and in Northeastern Oklahoma.

Q Who is Mr. E.L. De Golyer? A. He is a petroleum geologist, very well known.

Q His writings are authoritative? A. Well, as much as you can say about anybody being authoritative.

Q Well, he is as good as any one of them, let us put it that way? A. On some subjects he is better than most of them.

Q And on what subjects do you recognize him as an authority? A. On general subjects in petroleum and natural gas, oil and natural gas, and on other subjects.

Q He is the author of several publications, isn't he, sir? A. Yes.
Q One of the latest being "The Elements of the Petroleum Industry"? A. I think that was the publication.
Q He was the editor of that? A. Yes, he was the editor of that.
Q It was published by the American Institute of Mining and Metallurgical Engineers in 1940? A. Yes.
Q And it is recognized as an authoritative work?
A What do you mean by authoritative?
Q Well, you accept it, don't you? A. Not always, not by a long shot.
Q Well, do you recognize the Encyclopedia Americana of 1924 as authoritative? A. No, I do not believe everything in that edition.
Q Well, the article on petroleum? A. I just said, I just quoted it as an example, as a statement of one publication.
Q You do not necessarily regard it as authoritative?
A Well, here you had dozens of different citations by Dr. Fisher and myself and others and they differ quite widely. Now, they can not all be authoritative in the sense that they are all accurate. If you mean accuracy and dependability, I do not say they are authoritative, any one more than the other. Some I believe in and some I do not.
Q All right. Have you read the publication, "Natural Gas Investigation, Federal Power Commission, Report of Commissioner Nelson Lee Smith and Commissioner Harrington Wimberly"? A. I haven't read it but I know of it.
Q On page 71 we have the following:
"The production of oil requires the expenditure of energy. It must be moved through the pores of the reservoir sand to the well bore and then raised to the surface. Oil, in itself, possesses virtually no mechanical energy which can be utilized in its production and - - "
A That is a statement I do not agree with.
Q You do not agree with that? A. No.
Q "- - and hence, the required energy must be supplied from other sources."
A I do not agree with that.
Q "One of the primary sources is natural gas."
Do you agree with that statement? A. One of the primary?

Q Yes? A. I would say one of the sources.
Q One? A. What do you mean by "primary", or what does he mean?
Q Do you know fields where one of the primary sources is natural gas for producing oil? A. I do not know any field where the source of energy was entirely or particularly natural gas.
Q Is Turner Valley a good example? A. I think that is probably right. I do not know enough about it. I have never heard of any water flooding up there. I presume it is right.
Q And you do not know how much in Leduc the energy is caused by water drive and how much gas in solution and gas cap, do you? A. No, I am not in a position to apportion the recovery forces among those three elements.
Q "One of the primary sources is natural gas. This fact was little realized 15 or 20 years ago."
A That is wrong.
Q That is wrong? A. Yes.
Q "E.L. De Golyer has stated, 'it was not until 1917 that even the most advanced technologist of the time understood the function of gas in the production of oil'."
A He is referring to my Bulletin 148, and he is wrong there, there was quite a bit known before my time.
Q So that Mr. De Golyer is wrong.
"It was not until 1924 that Beecher and Parkhurst gave us the first quantitative basis for our understanding of the importance of the solubility of gas in oil and viscocity effects of such gas."
A That is the first time that was known in, generally, in the oil industry. Now, the principles of that, I believe, were known long before that.
Q Might not have known them in that part of the world?
A That is true.
Q We do not know much up here, do we, now along the lines of petroleum sciences? A. There is a lot to be learned.
Q Yes.
"In the earlier history of the industry, natural gas produced with oil was considered a nuisance and was largely blown to air."
A Well now, that needs qualification. After it got to the surface it was sometimes considered a nuisance

and was blown to the air, but it was generally recognized almost in the initial stages of the industry that gas was largely the motivating force for lifting the oil out of the well to the surface. In fact, there are air-lifting patents. You go back to ten years after the Drake well, and the air lift was a means of artificially putting gas into the well, and they had these air lifting patents, and they tried those to lift it to the surface when other things failed.

Q I suppose patents are not any test? A. It is a test of the knowledge.

Q Just a couple of more questions and I will ask that we adjourn. Perhaps I could ask this, and we could then adjourn.

"In the earlier history of the industry, natural gas produced with oil was considered a nuisance and was largely blown to air. In many instances, the gas was produced as rapidly as possible in order to get rid of it in the hope of obtaining greater production. The fallacy of this concept of reservoir conditions is now fully realized."

A I might add that I wrote a technical paper for the Bureau of Mines on that very subject together with some of the other questions that you have asked me known as technical paper number 130, and that was written by W.F. Murray and myself.

Q And the article goes on:

"It is an accepted fact today that gas plays one of the principal roles in oil production."

A That is right.

MR. RILEY: Would this be a good time to adjourn, my lord?

THE COURT: Would everybody be agreeable to we adjourn until 9:00 o'clock tomorrow morning? We get along faster when we are fresh, that is one thing, and we have not finished one witness today.

MR. NOLAN: All right, my lord.

THE COURT: Everybody agreeable for 9:00 o'clock?

MR. STEER: I am, my lord, I wonder if we might or could know how many witnesses are yet to be called, only the number, because we would be able to form some idea whether we could finish this week.

MR. NOLAN: I have one more, so far as I am concerned.

THE COURT: We will adjourn until 9:00 A.M. tomorrow morning.

(Hearing was then adjourned until 9:00 A.M., November 23rd, 1950.)

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Morning Session,
November 23, 1950.

THE COURT: All right, Mr. Riley, you have not finished?

MR. RILEY: Not quite, sir.

JAMES O. LEWIS, recalled, already sworn, cross-examined by Mr. Riley, testified as follows:

Q Mr. Lewis, sir, will you look at your brief for a moment? I observe that you refer to Sir Boverton Redwood at page 1, again at page 3 you refer to his Third Edition of Petroleum published in 1913, and at page 41 one of the reference books you give is Petroleum by Sir Boverton Redwood, British, 1906. Have you that work with you? A. No, I do not believe I have.

Q You did in your research refer to Sir Boverton Redwood's book on petroleum, 1906? A. I did, on page 41.

Q Yes, but I mean in your research, you read the literature? A. In 1906?

Q Yes? A. I do not believe I did. This looks to me like it was a mistaken date. I do not know how that got in there that way.

Q Well, 1906 is, in fact, the date of the second edition, is it not, sir? A. I could not answer that. I may have that in my notes, but my recollection is dim on that.

Q Have you any recollection of the first paragraph in Volume 1 of 1906, the edition which reads as follows, in defining petroleum:

> "The natural product referred to under the names petroleum, rock oil, earth balsam, earth oil, mineral oil, bitumen, maltha, asphaltum, pissasphaltum, pisselaeum, mumia, carabe, brea, oleum Medeae, St. Quirinus's Oil, Seneca oil, Rangood oil, Persian naphtha, Trinidad pitch, Barbados tar, etc., and equivalent terms in other languages, has been known from very remote times."

A I do not know where I saw that, but I have seen that

and similar statements in Redwood. At one place he gives his broad definition and then he gives or lists these various terms that have been used for petroleum and various varieties of petroleum.

Q Well, let me get at it this way. You have no recollection of doing any research for the purposes of this case on the 1906 edition of Sir Boverton Redwood, and it is not one of the books that you particularly refer to? A. I am not sure about that. I would have to look back at my notes.

Q All right, sir. Now, I observe, sir, that in much of the literature, publications by the United States Bureau of Mines, publications by the American Petroleum Institute, and as recorded particularly in the Encyclopedias, we find the phrases: "reserves of petroleum", sometimes "crude petroleum" and sometimes "crude oil". Are there tables showing reserves of crude oil or crude petroleum? A. They use them both ways in the United States, in the narrow way and the broad way.

Q What I am interested in is this, how does one calculate reserves of petroleum? A. You are referring now to liquid petroleum?

Q I am referring, sir, to the use by the American Petroleum Institute and the United States Bureau of Mines. A. I think what you are referring to is the tables which show the petroleum in barrels.

Q Yes, that is correct. A. The method of calculating is in two different ways, one is to calculate the reservoir space, and Mr. Nauss, Dr. Nauss outlined that, and the other way is to plot curves of the pressures. They are both recognized.

Q What I am getting at is, when you look at these tables expressed in barrels of reserves of petroleum, or crude oil, or crude petroleum, whatever you want to call it, I take it what is intended to be shown is the reserves calculated in barrels at the surface?

A Well, I think you will find all those tables for that, and it is calculated in barrels.

Q Yes, where? A. In all of the tables I think it will be stated at the head of the columns, at least, all I have seen, but not clearly implied, and those tables show the reserves usually in barrels, usually in terms of recoverable oil.

Q What I am getting at is this, we all know that a barrel of oil at the well head may be different and less than a barrel of reservoir fluid, don't we?

A That is right. Now, wait a minute. The fluid can either be gas or liquid. You mean as a reservoir liquid?

Q Well, we know there is a difference between those two? A. Yes.

Q And the tables all speak of, in calculating reserves in barrels, the oil at the well head? A. The tables when they talk about commercial reserves are in barrels, what we call stock oil.

Q Which is a different thing from the reservoir liquid?

A Oh, yes, quite different.

Q Quite different? A. Yes.

Q Now, sir, I believe you have been engaged on the application for permission to remove or cause to be removed natural gas from the Province of Alberta of Western Pipe Lines Limited? A. That is right.

Q And there is presently an application by Western Pipe Lines Limited before the Petroleum and Natural Gas Conservation Board for a permit to export natural gas? A. That is right.

Q The application being to take natural gas from the Province of Alberta to the east? A. That is right.

Q As far as Winnipeg? A. Yes.

Q And Winnipeg is what, 600 miles distant from Calgary?

A I think that is about right. I have never tried to measure the distance.

Q And the thought is that the natural gas will be transported by means of a natural gas pipe line? A. That is right, yes.

Q And I observe, sir, that you were here giving evidence on the 19th day of June, 1950? A. Well, I do not remember the date but that sounds right.

Q I am looking at Volume 1 of the reports for that day, page 15,

"JAMES O. LEWIS, having been first duly sworn examined by Mr. Martland, testified as follows:

Q Mr. Lewis, would you mind telling the Board your name and residence and outline your qualifications, please? A. My name is James O. Lewis, and I am a resident of Houston, Texas. I am a member of the firm of Petroleum Consultants, and I have been engaged in the consulting business in Houston for the past ten years. I am engaged in petroleum and gas geology and in the engineering phases of both petroleum and gas."

A Yes, I said that, and I said the same thing the other day. Apparently you did not pick it up.

Q What I am suggesting, what I am getting at, is this: I am not suggesting there is any difference in your position, I am merely asking you about the use of the words by you:

> "I am engaged in petroleum and gas geology and in the engineering phases of both petroleum and gas."

Is that the way you normally use the word "petroleum"?

A When I am dealing with certain people, or when I want to emphasize, as I did there, since this was a gas hearing, that gas is important, I am very likely to make a statement of that kind. Also, I am like everybody else, I carelessly slip into things, just like I mispronounce words, and like everybody else in writing books I am likely say it in a book, and slip into these implied things.

Q All right, sir. I find amongst one of your reports, too, dealing with the natural gas reserves - by the way, one of the things you did was to calculate the amount of natural gas in place in various fields? A. Yes.

Q And by "in place" we mean underground? A. That is right.

Q And we include in that gas in solution in the liquid?

A Yes.

Q Now, I observe in one of your reports in estimating the amount of gas to be available from Leduc, and you say that you have assumed an increase in gas/oil ratio of two to one over the next 10 years, therefore you have considered the available gas to remain constant. And you say that it is believed to be conservative since it is entirely possible for the gas/oil ratio to increase to three or four to one. Now, I want to ask you . . . A. May I ask a question?

Q Yes? A. Is that my testimony or Mr. Hawthorn's testimony?

Q I understood that this report was read into the record by you. Were you here in September? A. Yes.

Q Perhaps Mr. Nolan can tell us. A. I read part of it into the record, and a portion of it was read by Mr. Hawthorn.

Q In either event, it is the considered opinion of your firm? A. Yes.

MR. NOLAN: I think those were the

deliverability characteristics and they were dealt with by Mr. Hawthorn. A. That is my recollection.

Q MR. RILEY: Well, I do not care to read it in, but it was the considered opinion of your firm?

A Yes, it was something to which I agreed, so far as my information went.

Q Now, I just want to ask you, you are talking about the gas/oil ratio, and talking about it increasing as much as three or four to one, do I take that to mean that if we now have 800 cubic feet of gas in a barrel of oil that there is a possibility of that increasing to say 2400 or 2500 cubic feet per barrel. A. Yes, I think so.

Q All right, and I will go over it shortly. And then you said that it is generally considered that it will not be available for 20 to 25 years or more, and that actually the gas cap will be produced to some extent as will be evidenced by increasing gas/oil ratios. And then you go on to say to the effect that the gas cap may never be opened to straight gas production, and that all of the gas in the gas cap may be produced through the oil wells and that this might take place to a considerable degree over the next 30 years. Now, sir, that was the opinion of your firm? A. That is right.

Q And held by you? A. Yes.

Q Thank you, sir. Oh, one other thing. In your reading of Canadian literature, to assist the Court in this case, and to determine in which of the two senses petroleum is used in this country, if there be two senses, did you examine land titles and the reservations of petroleum and natural gas in this Province?

A No, I did not do so. I did not look at any such documents.

Q Did you examine our common forms of leases for petroleum and natural gas as used through the years? A. I did not.

Q Did you analyze the statutes and regulations dealing with petroleum and natural gas, both in the Dominion and in the Province, through the years. A. No, I read the last, I think it was set out, the recent law, and also the rules and regulations of the Conservation Board, I read that.

Q The recent one? A. Yes.

Q But you did not go back through the years? A. No, I did not.

Q And you did read the Dinning report, I believe? A. I

did read that.

Q And you have no objection to that report being added as a reference work? A. You mean as my reference work?

Q Well, I do not care whether it is yours or somebody else's. A. I do not care either, just so long as it is not mine.

Q All right, sir.

MR. STEER: I have no questions, my lord.

MR. NOLAN: I have no questions, my lord.

THE COURT: All right, thank you, Mr. Lewis.

MR. NOLAN: I will call Dr. Katz.

DONALD L. KATZ, having been first duly sworn, examined by Mr. Nolan, testified as follows:-

Q What is your full name, Dr. Katz ? A. Donald La Verne Katz.

Q Where do you reside? A. Ann Arbour, Michigan.

Q When were you born? A. August 1st, 1907.

Q And what are your educational qualifications? A. I received my Bachelor's degree in Chemical Engineering in 1931, and my . . .

Q From where? A. From the University of Michigan.

Q Yes? A. And my Doctor of Philosophy degree from the University of Michigan in 1933.

Q You also received a Master of Science degree from the University of Michigan? A. Yes, sir, in 1932.

Q Now, would you outline briefly for us the highlights of your professional career? A. Upon leaving university in 1933 I worked for three years for the Phillips Petroleum Company in Bartlesville, Oklahoma. During this time I launched a research program into the producing phases of the industry. I studied the behaviour of oil and gas wells and took samples of oil and gas from the wells. I analyzed them in the laboratories and applied my scientific training in the use of the information for the industry. In 1936 I returned to the University of Michigan as an Assistant professor of Chemical Engineering, and I have been at the university since that time. During summer periods and at intervals during the year, I have had occasion to work in the industry. I have tested wells. I have made reports on reservoirs,

reservoir reserves. I have appeared before Commissions. And in the laboratory at the University I have conducted research on the nature of oil and gas and other mixtures, and I have published a large number of papers in such journals as "The Petroleum Technology", "The Journal of the American Institute and Metallurgical Engineers" and "Industrial and Engineering Chemistry." Also some articles in the American Petroleum Institute publications. And I have done a considerable amount of work in the field of Chemical Engineering, heat transfer and things of that kind.

Q You say a large number of publications? A. Well, I have published some 93 or 94 up to date.

Q Now, in addition to your academic duties you accept outside retainers, do you not? A. Yes, on occasion I have done engineering studies for companies and associations.

Q Would you mention just a few of the companies by whom you have been employed? A. Well, a recent study I made was for the Western Gulf Oil Company in Los Angeles and the California Oil and Gas Field. I have recently worked for the Michigan Consolidated Gas Company in their hearings before the Federal Power Commission. Two years ago I spent a considerable amount of time for the Natural Gasoline Association of America with regard to the methods of testing condensate wells.

Q Have you accepted any retainers in Canada by any Boards or bodies? A. I have been employed by the Natural Gas Utilities Board and by the Conservation Board in the Province of Alberta.

Q The Natural Gas Utilities, you mean the Board of Public Utilities? A. No, the Gas Utilities Board.

Q Yes? A. Mr. Blackstock and the late Dr. Boomer.

Q And in any other provinces of Canada? A. I had a project for the Natural Resources Department in the Province of Saskatchewan.

Q Now, in addition to writing reports, have you had any oil field experience, I mean, of a practical nature? A. Yes, I have operated oil wells and gas wells, and tested the wells, taken pressures and temperatures and flow rates, and things of that type on many an occasion.

Q When you were employed by the Natural Gas Utility Board of Alberta, how long ago was that? A. About six years ago, I believe, about 1944.

Q Yes, and I understand you made a study of what is called the Paloma field in California? A. Yes.
Q When was that? A. That was in 1948 or 1949.
Q You say you have 92 or '3 or '4 publications to your credit? A. Yes.
Q Do they deal with petroleum, or do they deal with oil or gas or both? A. Yes, over half of them deal with oil and gas and my particular field of interest has been in what you might say the gaseous phases of the mixtures, in other words, the behaviour when you have gases as well as liquids present.
Q Well, now, at the present moment you are Professor of Chemical Engineering in the University of Michigan?
A That is right.
Q And what is the nature of the courses which you give at that university, what do they deal with? A. Well, I give a course, one of the courses, or basic course, in Chemical Engineering is in what we call the unit operations of chemical engineering, and one is what we call a graduate course, which is called "Petroleum Production Engineering No. 355".
Q Yes. Do you deal with such matters as plant design and design of cycling plants? A. Yes. I have a course which is divided into two parts. The first part of the course deals with the basic qualities of gas and oil mixtures, and such items as the density of gases, surface tension of liquids, viscosity of gases and liquids, the methods of computing gas reserves, the methods of computing oil reserves by what we call the material balance methods. The second half of the course the students selected a design problem. A plant design. Each year we have always had a design of what is called a cycling plant for recovering the liquids from high pressure gases, high pressure gas fields. In addition the students selected problems of particular interest at the moment. This past year, because of some work which we had been doing, the students designed a low temperature recovery plant for recovering not only natural gasoline, butanes and propanes, but also ethane in the liquid state.
Q Yes? A. And I have on occasion, I do not recall whether I did it this year or not, but on several occasions my students have designed natural gas liquefication plants.
Q What are they? What are they used for? A. Well, it has been done actually in the City of Cleveland,

and it has been done to liquefy the gas from a pipe line in order that you might have it when there is a drop in the gas on a cold winter's day, when the demand for natural gas is high and your pipe line is not able to carry or has not got the capacity to deliver gas to the people and you re-vaporize the natural gas and have extra fuel.

Q Now, Dr. Katz, you were asked by the defendant, Imperial Oil Limited, to prepare a report dealing with the issues in this case? A. Yes, sir.

Q Did you do so? A. I did.

Q Is this the report that you prepared (indicating)?

A Yes, it is.

MR. NOLAN: I will ask, my lord, to have this marked. I take it that we will follow the same procedure and Dr. Katz will read his report?

THE COURT: It seems to me to be the better manner.

MR. STEER: Subject to all objections, my lord, with regard to any matter that may come up.

MR. NOLAN: Yes, subject to all objections.

MR. STEER: I must say that there was a very great deal of argument in Mr. Lewis's report, in my respectful submission.

THE COURT: Well, I have no doubt at all about that, but if Mr. Nolan sees fit to take his copy of the report and ask this witness questions and the witness answers, Mr. Nolan is likely to get it all in anyway by means of question and answer.

MR. STEER: Oh, I expect so anyway.

THE COURT: I know that some of the material that I allowed in for the plaintiff, without any doubt at all technical lawyers would object to, and I have no doubt they would object to this. However, I let that material in. Now, the situation is reversed and I have not any intention of changing the original ruling. I am going to give both sides all the opportunity they want, and as long as they want to prepare their arguments. They are going to be written and they will have the opportunity of disputing all these things or, at least, arguing against them and showing why I was wrong. So that I can see in this case no harm being done in reading the whole thing in, the objectionable as well as the acceptable, and so I am going to permit it.

MR. NOLAN: Thank you, my lord. May

Dr. Katz' report be given a nu ber, my lord, so that he may refer to it?
THE COURT: It will be Exhibit 108.

REPORT OF DR. D. L. KATZ
MARKED EXHIBIT 108.

Q MR. NOLAN: Now, I will ask you, Dr. Katz, if you will please proceed and read your report, the Exhibit number 108, making any explanatory remarks you see fit, as you are reading it? A. "Report and Testimony Prepared by Donald L. Katz for Imperial Oil Limited, October 31st, 1950." I will pass over the Table of Contents.

Q Yes?

A

PART I

PETROLEUM RESERVOIRS

Since the early days of the petroleum industry it has been known that wells produced both gaseous and liquid constituents as observed at the exit from the well. Both gases and liquids were known to be composed of a large number of hydrocarbons compounds which may be classed into families. Under the pressure at which petroleum exists in the earth normally gaseous constituents are dissolved in liquids. Over the years, knowledge has been accumulated relative to the behaviour and compositions of the fluids issuing from oil and gas wells. During the past 20 years, studies have been concentrated on quantitative evaluations of phenomenon known qualitatively for many years. For example, the quantity of the gaseous constituents present in liquid phases, known as solubility, have been measured in the laboratory while in earlier years only the fact that gas would dissolve in oil was known.

1. Petroleum Traps

Oil and gas accumulate in certain porous rock in the earth; sandstones, limestones, dolomites, etc. The porosity may be relatively uniform, such as for sandstones, and represent the space between the sand grains. For limestone or dolomites, the pore space may be solution cavities in addition to

spaces between crystals. In addition to porosity, the petrolific rock must have the ability to transmit fluids through it to permit movement of oil and gas to wells. This property of rock is called permeability with units of measurement called millidarcies.

The well that penetrates a petroleum bearing rock or formation allows the fluids in the pores of the rock to flow to the well bore and out to the surface of the ground through pipes. The product from a well may be a gas (natural gas), a liquid (crude oil), or a mixture of liquid and gas.

2. Kinds of Petroleum Reservoirs

The accumulation of petroleum in porous rock varies from field to field in the relative amount of normally gaseous constituents as compared to the normally liquid constituents contained therein. Some fields contain almost wholly gaseous constituents and the field is called a gas field for it produces only natural gas. Others have a mixture of crude oil and gas, with gas dissolved in the oil layer in the reservoir. If sufficient gas is present it will form a gas phase above the oil, often called a gas cap. Sometimes all the gas dissolves in the oil at pressures below those in the reservoir so that the oil phase is under-saturated with gas. Shallow oil reservoirs are at low pressure and the amount of gas dissolved in the oil at these low pressures may be relatively small.

The effluent from a well tells one the nature of the occurrence in the ground, within limits. Separators are usually installed on new wells to separate the products into a liquid oil phase and a gas phase.

Q Now, I observe you are going to mention a figure, Dr. Katz. Do you want to explain that figure at this stage? A. Yes.

Q You do? A. Yes.

MR. NOLAN: Perhaps we should have that marked separately, my lord, if we may, please. It is Figure 1 in the back of the book.

THE COURT: Exhibit 109.

FIGURE SHOWING OPERATION OF SEPARATOR ON WELLS MARKED EXHIBIT 109.

Q MR. NOLAN: All right, Dr. Katz?

A Exhibit 109 is a diagram of the operation of a separator on wells. The well head is shown from which the material comes from the earth and goes through a pipe to the vessel called a separator. In this particular case, the pressure on the separator is at 200 pounds per square inch. The temperature is 40° Fahrenheit. The mixture from the well separates into two phases, a gas phase and a liquid phase. The gas phase goes through a meter and in this case it goes through the meter at approximately 200 pounds per square inch and goes to a gas gathering line. The liquid leaves the bottom of the separator, and in this case goes directly to a storage or stock tank, and the liquid leaving the separator is reduc d in pressure from the 200 pounds per square inch to atmospheric pressure. As it goes into the stock tank more gas is evolved from the liquid. In this case we have 245 cubic feet of gas vented to the atmosphere.

In the stock tank we have in this case 1007 barrels of liquid that have a gravity of 43.4° A.P.I., or American Petroleum Institute scale. We have a block on the upper left of the diagram which shows the composition of streams and the percentages given are in molecular percentage, which are the usual method of representing analyses. We have shown various components, methane, ethane, propane and so on. The first column is well effluent. That is the total product leaving the well. It shows 30.3% methane, 13.1% ethane, and so forth.
Yes?

A Now, when the effluent is divided into separator gas and into separator liquid, we have given the analysis of the separator gas which goes to a gas gathering line and it is 75.69% methane and so on. The separator liquid analysis is not given because the separator liquid, as it enters the stock tank, divides again into a gas called the vented gas and into a stock tank oil. You will note that the vented gas composition only has 15% of methane and some 35% of ethane and so on. The stock tank oil has a very small percentage of methane, nevertheless it is there, a small

percentage of ethane and then the propane is up to 5%. The oil in the stock tank, of course, is accumulated until the tank becomes full, at which time the well is turned into another tank and this tank is metered or measured, and the oil is sold to the pipe line. This particular operation is for a well which does not produce, in fact, water, so that it is necessary to treat the oil between the separator and the stock tank.

Q Well, I think you might proceed now with the script, please? A. Figure 1 shows the results of such an operation for a well producing reservoir crude oil with dissolved gas. From the measurements of reservoir pressures and temperatures and the examination of samples of oil and gas recombined in the laboratory, it is possible to tell whether the well is producing from a reservoir containing both gas and liquid phases or whether only a liquid phase exists in the reservoir. The well in Figure 1 is producing 1.44 barrels of liquid measured at the conditions of the reservoir.

At high pressure, greater than about 2000 pounds per square inch, a gas phase in contact with a liquid oil phase will contain considerable amounts of the normally liquid constituents. When these gases are reduced in pressure and temperature during flow from the wells, much of the liquid constituents condense. Turner Valley naphtha was such a condensate from gas contained in the gas cap in the Madison limestone.

The quantity of gas accompanying the oil is one way to describe the products from a well. Those reservoirs which produce up to 2,000 cu. ft. of gas per barrel of liquid are known to have a liquid phase in the reservoir. On the other hand those wells which produce no liquid are producing from a gas phase in the reservoir. Wells producing 8,000 cu. ft. or more of gas per barrel of liquid are either producing from a gas phase or from both gas phase and a liquid layer in the reservoir. The colour and specific gravity of the liquid and the reservoir pressure give a fair indication of whether the well is producing from a gas phase alone or from both oil and gas phases. Condensates from reservoir gas phases are lighter

in colourthan crude oil and have higher gravities on the American Petroleum Institute scale.

Q Now, Doctor, you are going to refer to Table 1, and this might be a good place to mark it.

MR. NOLAN: My lord, if we may mark Table 1 at this time. It is the first of the documents attached to the report, page 27, my lord.

THE COURT: All right, Exhibit 110.

TABLE OF KINDS OF PETROLEUM FIELDS MARKED EXHIBIT 110.

A And on page 27 of the report . . .

MR. NOLAN: Well, now, will you proceed to explain Exhibit 100, being Table 1, Doctor?

A It is entitled "Kinds of Petroleum Fields". We have several column headings. The first one is "Kind of Reservoir", and the first kind of reservoir which I have given is "Dry Gas". "Field Name", Viking-Kinsella or the Hugoton are the two fields given as examples. The "Initial Reservoir Pressure", which, of course, is related to the depth which is given. And the next column gives the approximate depth. At Hugoton the initial pressure was 485 pounds, approximate depth about 2900 feet. The next column is "Cubic feet of gas per barrel of liquid." That is separated at the well head under normal operating conditions, and in these two fields there is no liquid recovered at the well head. And the last column gives the gravity of the liquid and its A.P.I. scale.

The next type of reservoir, kind of reservoir, which I have indicated, is "Wet Gas or Condensate." Turner Valley is an example. At initial reservoir pressure of about 2200 pounds per square inch, approximate depth of about 5000 feet, and the gas/oil ratio was 60,000 cubic feet of gas per barrel of liquid, which was normally called naphtha, and the gravity was about 60, the A.P.I.

I have the next wet gas or condensate and that is from the Leduc D3, this is the gas cap which has been described, and the initial pressure was about 1894 pounds, and the depth some 5300 feet. The cubic feet of gas per barrel of liquid are not known. However, it is known from a drill stem test of the Imperial Leduc No. 8 that naphtha was recovered in the drill pipe and it had a

gravity of about 54. The other wet gas or condensate type of reservoir I have referred to is the Paloma field in California.

Now, the third category or kind of reservoir that I have given is "Crude Oil (undersaturated with gas)", that means that when you start producing in a reservoir of this type and the pressure goes down, you will not get a gas phase form immediately. You may at some later date when the crude oil becomes saturated with gas at that pressure, or when you reach the pressure at which the crude oil is saturated with gas. The Lloydminster field in Alberta and Saskatchewan is one of the examples of that type, with a pressure of some 900 pounds and a very small amount of gas is present. I have estimated it at about 5 cubic feet per barrel. Then the East Texas field, which is the largest field in Texas, is an example of an undersaturated crude oil, which had an initial reservoir pressure of about 1600 pounds, a depth of 3500 feet, and only 300 cubic feet of gas per barrel was obtained. As I recall, the reservoir pressure has to be reduced to something like 750 pounds in this reservoir before the gas will start coming out of solution.

Now, the last category which I have in "Kind of Reservoir" is Crude Oil (saturated with gas). Every field which has a gas cap has a crude oil layer which is said to be saturated with gas as evidenced by the excess gas in the gas cap. Sometimes they are saturated with gas at approximately the initial reservoir pressure when there is no gas cap. The Leduc D2 and D3 are given under that heading, and, of course, the Turner Valley crude oil zone was saturated with gas which was in the gas cap above it. Oklahoma City was a field with which I have had to deal with considerably, and the Paloma field in California, which is the same field and the same formation from which the condensate comes in the earlier category.

Q All right, thank you. A. Table I lists the quantity of gas accompanying the liquid in separators for some typical fields. The compositions of the gases and liquids will now be described.

3. Chemical Analyses

Petroleum consists of several hydrocarbon

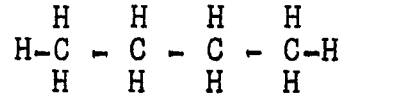
families, the principal one is the paraffin family. Paraffin hydrocarbons have the formula C_nH_{2n+2}. Methane (CH_4), in years past called marsh gas, is the simplest and most volatile. It boils at -259°F. at atmospheric pressures. Ethane (C_2H_6) is the next member boiling at -128°F. while propane (C_3H_8), the third member, boils at -44°F.

Other families of hydrocarbons such as naphthenes, olefins, and aromatics are present in petroleum but do not have constituents which are gaseous at atmospheric pressure and temperature. I should add at that point that the olefins do have substances which are gaseous at atmospheric pressure but they are not present in the naturally occurring hydrocarbons.

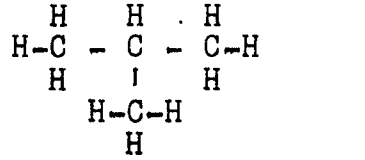
Q What are olefins, Dr. Katz? A. Well, if you take some hydrogen away from ethane, it becomes ethalene and that is an olefin and we do not find ethalene in natural gas, only ethane.

Q Thank you.

A Beginning with butane (C_4H_{10}), the fourth member of the paraffin series there are different compounds for the same number of carbon and hydrogen atoms because they may be arranged in a different manner. The compounds having the carbon atoms in a chain are called normal while those with side chains are called isomers. And I have shown here the structural pattern for normal butane and iso-butane, showing that normal butane has 4 carbon atoms in a row, while iso-butane has 3 in a row and an extra carbon atom attached to the centre of the three in a row.



Normal butanes



Iso-butanes

As the number of carbon atoms increase, the

possible number of isomers increases rapidly, octane (C_8H_{18}), which is a component of gasoline, has 17 isomeric arrangements. The number of compounds in petroleum is measured in terms of hundreds of thousands. Only the simpler ones which have differences between themselves are identified as compounds. Thus the relatively few constituents of natural gas are given by name while gasoline which contains hundreds of compounds is described in terms of the boiling range obtained by distillation. The hydrocarbons which boil over a given temperature range are often described as a petroleum fraction.

4. Constituents of Petroleum

Q That brings us to Table 2? A. Yes, Table 2.
MR. NOLAN: That brings us to Table 2, my lord, which is to be found at page 28 of the report, and if it might be given a number, please?
THE COURT: Exhibit 111.

TABLE SHOWING CONSTITUENTS OF PETROLEUM MARKED EXHIBIT 111.

Q MR. NOLAN: Dr. Katz, will you proceed to explain 111, being your Table 2, please? A. This table entitled "Constituents of Petroleum" lists the hydrocarbon constituents normally found in natural gas, crude oil and mixtures thereof. I have given the name of the compound, the decreasing boiling point, increasing boiling point, you might call it decreasing volatility. Methane, the first one, has one carbon atom; ethane has two, propane has three, the iso-butane and the normal butane would come separately, although they have each four carbon atoms and because of the different arrangement of the atoms they have different boiling points. Well, going on, I do not give the isomers.

Q MR. STEER: Will you explain what an "isomer" is? A. I will be glad to explain it, Mr. Steer.

Q Please do. A. It is when the arrangement of the carbon atoms is different.

Q Oh, yes, yes. A. The 4 in a row is normal, and the side one is an isomer, so the pentane has and isomer present and a normal, and the hexane has

four or five isomers, so that we call them hexanes, heptanes and octanes, which means there is a large portion of them, and heptanes and octanes are as high as you ever go when you are dealing with these compounds when describing petroleum materials. Now, I have the fourth column in that table, "Product of Commerce Containing Constituent". Methane, the product of commerce containing methane in appreciable concentrations is natural gas. The product of commerce containing ethane is natural gas, and since the work which I did this Spring I could now say that ethane as a liquid, is a member of commerce.

Propane is natural gas, and the propane is such that it is sold as a relatively pure constituent, the L.P.G., which is liquefied petroleum gas.

Now, the iso-butane is the first constituent that is normally recovered in the product known as natural gasoline. Sometimes it is sold just as a mixture, as a butane, and would be sold as a butane, sometimes it is liquefied petroleum gas.

Normal butane is in natural gasoline, and it is the first of these constituents that you would have in your motor fuel. In the winter time the constituent of the gasoline which makes your car start on a cold morning is the normal butane in it. On the other hand, if you had butane in your car in the summer it would vaporize in your fuel pump and you would have a vapor lock. So that butane is one of the motor fuels used in the winter time and not summer. It might be sold as liquefied petroleum gas as well.

Now, pentanes are in natural gasoline and they are in motor fuel, and they are, as I said, normally liquid at room temperature, if it is not too high. And so on with the other constituents. You will see that octanes are still in natural gasoline and motor fuel and the decanes are still in motor fuel and then you come to tetradecane, which is in kerosene and light furnace oil. Then you will find the hexadecane in mineral seal oil and furnace oil. The triacontanes in light lubricating oil and heavy fuel oil, just as the tetracontanes are in lubricating oil and heavy fuel oil.

And finally you get down to asphaltene, which is used for asphalt, road oil, bunker fuel oil and things of that type.

Now, I have shown in this table only the variety of them. This could be called the variety of the constituents of petroleum, if we wished, but as I have indicated, you would not find any of the constituents in appreciable quantities in natural gasoline, L.P.G., natural gasoline and so on, from these others.

The last column I have is "General Range of Constituents in Field Stream", and the purpose of this is to give some idea of the magnitude and the range of the constituents present in various streams. It is not an exact thing. For example, in dry gas I have shown methane, ethane and propane, and then, of course, there might be some isobutane and normal butane and there might be small concentrations of pentanes and hexanes, but the primary constituents are methane, ethane and propane.

Now, the field separator gas, you will see, starts with methane and goes well through the octanes, as I have indicated. Of course, it is not a definite point where you can state it is. It is within a general range that is indicated.

The gas condensate well effluent, that is the well produced from a high pressure reservoir, containing a reservoir gas phase from a high pressure gas cap, would start with methane and would contain constituents up as high as what we would call mineral seal oil.

Now, crude oil well effluent has the full range in it.

Stock tank crude oil, and the next three, I think, - and I have stopped them at the propane, - I have already shown there is a tiny concentration of methane, a little ethane, and propane is the chief constituent of significance, but the others are there. In the stock tank condensate, I have shown it as a little more volatile, and probably would have a little more propane in it, and I have gone a little higher. The L.P.G. is relatively

narrow and would have propane, iso-butane and normal butane also as primary constituents. Natural gasoline has iso-butane and would go through the octanes as primary constituents.

Q Yes. You might tell me, Dr. Katz, whether this Exhibit 111, was that prepared by you for the first time in connection with this litigation? A. No, it is a table from this and from a report which I prepared in 1948 in respect of the Paloma field, and I have changed, for the purposes of this exhibit, one or two of these arrows showing the general range of constituents in field stream, because at Paloma we were dealing with products that were specialized and had specialized names, which would be of no significance here, so that I have changed one or two of those arrows, but the remainder of the diagram and the table are exactly as I have used before.

Q Now, are these constituents that show on your first column of Exhibit 111, beginning with methane, are they always found together in reservoirs? What I mean to say is, do you always have some butane and some propane when you have ethane and pentane, or is one constituent sometimes missing? A. Well, I have never seen a mixture in which you had a constituent missing. In other words, when you talk about the family of hydrocarbons, there is an inference that all members of the family are there. They may be there in varying concentrations. You might have methane in a high concentration and ethane in a very low, and propane in a low concentration. But I have never seen a mixture that did not have all of these constituents in it, unless they were in such light concentrations where they could not be enumerated. In natural gas, you cannot tell whether there is any heptane any more because if it gets down to 1/100% you cannot tell, because we do not measure that low, and in crude oil there might be the question whether there is any methane, also when you have very little ethane and propane, but generally I am sure you will find the gradual change from one constituent to another.

Q Thank you. Now, you were on page 5, Dr. Katz.

A 4. Constituents of Petroleum.

Table II, which we have just discussed, lists the paraffinic constituents of petroleum which

include all the normally gaseous constituents. Nitrogen, carbon dioxide, helium, and hydrogen sulphide may be present in natural gas, usually as minor constituents. The produce of commerce which contains the constituents are indicated on the table.

The products of commerce are dry natural gas, liquefied petroleum gas, natural gasoline, stock tank condensate or naphtha and stock tank crude oil. Natural gas may have accompanied crude oil from the earth or it may have been produced from a gas field. Liquefied petroleum gas is extracted from separator gases, condensed, and marketed as a liquid under pressure. Natural gasoline likewise is extracted from separator gases and is marketed as a normal liquid for blending with ordinary motor fuel. Condensate and crude oil are transported to refineries for processing.

The range of constituents in the several field streams shows that there is considerable overlap between the streams. Any attempt to separate part of a well stream and say this is "natural gas" would bring out that such a separation was arbitrary and that it could have been separated in a different manner (temperature, pressure) to bring about a different division of the well stream. Sometimes a series of separators is used and the amount of gas leaving the first separator is less than for a single separator.

Q Now you have come to Figures 2 and 3 which are to be found on pages 31 and 32? A. Yes.

MR. NOLAN: My lord, if they could be marked now, it might be convenient.

THE COURT: Pages 31 and 32?

MR. NOLAN: Yes, my lord, Figure 2.

THE COURT: Exhibit 112 will be page 31, is that right?

MR. NOLAN: Yes, my lord.

FIGURE OF OPERATION OF SEPARATOR ON WELLS MARKED EXHIBIT 112.

MR. NOLAN: And could we have page 32

marked, my lord?
THE COURT: Exhibit 113.

FIGURE SHOWING OPERATION OF DOUBLE-STAGE SEPARATORS ON WELLS MARKED EXHIBIT 113.

Q MR. NOLAN: Would you proceed to explain Exhibits 112 and 113, being your Figures 2 and 3?

A I will discuss first Exhibit 112, which is on page 31, and is Figure 2, entitled "Operation of Separator on Wells." This figure is similar to Exhibit 109, excepting the temperature and the pressure on the separator was different, and the products from the well, that is, the separator gas, the vented gas and the stock tank oil thereby become different in their compositions and quantities.

Again the fluid from the well head, a mixture of oil and gas, enters the separator. This time the separator is operating at 10 pounds per square inch. The temperature is at 80° Fahrenheit. The mixture enters the vessel called the separator. The gas that is formed under those particular conditions separates from the liquid that is formed under those conditions. The gas is metered, in this case it is 877 cubic feet. That is measured at the standard conditions of 60° Fahrenheit and 14.4 pounds. I should say, computed to the standard conditions. It is actually measured in the meter at 10 pounds per square inch, approximately 10 pounds in this case. This gas would go to the gas gathering line. The liquid from the separator goes through a pipe into the stock tank. This liquid having a pressure of only 10 pounds on it would not contain as much dissolved gas in it as before. So that in the stock tank the gas that is formed is 5.8 cubic feet of gas, which is vented to the atmosphere. In this particular case we have 0.909 barrels of a liquid having a gravity of 40.2° A.P.I.

Now, I have again given the composition of streams in molecular percentages in the block in the upper left of the exhibit. The components are methane, ethane and the properties as before. The well effluent is the same. It is the same composition; it is the same well effluent. The

separator gas has 50% of methane, as compared to 75% in the previous example, in Exhibit 109. The vented gas has 20.62% of methane as compared to 15.31% in the previous example, Exhibit 109. And the stock tank oil is a little different. It is not much different. It is similar to the stock tank oil, excepting there is a difference particularly in the hexanes plus fractions. That is the basic part of the oil itself. 86.96% of the hexanes plus in this case, whereas there was 76.63% in Exhibit 109.

Now, I will turn to Exhibit 113, page 32, Figure 3, which is entitled "Operation of Dougle-Stage Separators on Wells." This is the type of operation which Imperial used on most of their wells as described by Mr. Gustafson. They do not use this operation on all of the wells, I understand, because of various problems in the field, but it might be said to be more typical of the present operation with the gas conservation plant in operation.

In this case, the material comes from the well head, and it is the same reservoir material. It comes from the well head into the separator, the first or primary separator, which serves the same function as our separator in the previous exhibits, and is operating at 100 pounds per square inch and at 60° Fahrenheit. The gas that is formed at this particular, at these particular conditions of temperature and pressure, go through the meter at about 100 pounds per square inch, and we compute from the reading on the meter that there were 656 cubic feet standard. "Std" means standard cubic feet. That means measured at 14.4 pounds per square inch and 60° Fahrenheit. The gas goes to what they call a high pressure gathering system. The liquid that is formed under these conditions goes to a secondary separator. In Mr. Gustafson's figure he called it a treater because he was particularly interested in that case in removing water. If no water is present it simply goes to a second separator, and in this case I have had the second separator operating at a pressure of 10 pounds and at a temperature of 60° Fahrenheit.

From the liquid which enters this separator there is divided and taken an amount of gas which is metered and computed at 93.2 standard

cubic feet of gas.

The liquid from this separator at 10 pounds goes into the stock tank, and in this case 33.5 standard cubic feet of gas are vented to the atmosphere and we obtain one barrel of stock tank crude oil for these amounts of gas.

Now, again I have given the compositions of the streams. I have given the well effluent, which is the same as exhibits 109 and 112. I have given the first stage separator gas, which, again, is different. It is neither the 75% methane on Exhibit 109, nor is it the 50.16% methane on Exhibit 112, but it is 65.11% methane, and, likewise, the other donstituents are not the same, at least, identically the same.

The second separator gives off gas which goes to a low pressure gathering system, and I have given the analysis here. You will see that it is different in terms of composition from the other gases. Again, the vented gas is given and it also is different. And I have here stock tank oil, the first stage of stock tank oil, and it really should be called the separator liquid and not the stock tank oil, because I have only one stock tank. The second stage is the stock tank oil as given in the vessel called the stock tank.

Now, I would like just to explain one more thing about all three figures, Exhibits 109, 112 and 113.

Q I was going to ask you one question about them first, Dr. Katz. I think you have used the expression that these were computed compositions. What does that mean? A. Well, yes, these are computed compositions. Starting from the experimental analysis of the fluid coming out of the well, that is the well effluent, the composition is an experimental composition, and it is the same in all three cases. We can from this well effluent composition and the temperature and the pressure, and in the separation, compute the concentration and quantity of the gas phase form and the liquid phase form and these are the computed results.

Q That is the sort of information I would want if I were contemplating the building of a plant? A. Yes, that is the sort of information you would want if you were contemplating the building of a plant, and the same sort of information which the Imperial Oil Limited obtained when they were projecting their gas conservation plant, and they have shown me checks between the computed compositions and the experimental compositions, with which checks I am very familiar, due to the early work I did at the Phillips Petroleum Company.

Q Was there something you wanted to say about Exhibits 109, 112 and 113? A. Yes, I wanted to say that in each case we have taken 1.441 barrels of liquid from the reservoir, that is, measured in the reservoir, and have taken it through three types of separation, and the fluid composition which we have taken is the Leduc D3 liquid phase in the reservoir. We have taken it through three types of separations which are within the range of operating conditions which have existed in Leduc field, and we have obtained different compositions of gas, different quantities of gas, and we got different quantities of stock tank liquid or crude oil. You will note that we have one barrel of stock tank crude oil in Exhibit 113. That is the starting point for our calculations. If we had one barrel there, it took 1.441 in the reservoir, to give us that one barrel. Therefore, we use the same quantity of fluid liquid from the reservoir in the other two computations, and you will that in Exhibit 112, for that type of separator operation, we only obtained 0.909 barrels of stock tank crude oil, which is substantially 10% less oil. And in the operation on Exhibit 109, we received approximately one barrel.

Q I follow you. Now, you were at the top of page 6, Dr. Katz? A. Figures 2 and 3 show the operation of separators on wells producing from the same reservoir crude oil as Figure 1. It may be seen that the natural gases from these three separators are different in composition and quantity because the temperatures and pressures for the separation are different.

5. Compositions of Reservoir Fluids

The analyses are given as molecular percentages, a common practice in the industry. The analyses of a reservoir fluid may be computed by adding the constituents

in the separator gas and liquid together and obtaining a composite composition. In some cases a sample is taken from the bottom of the well and analysed. This has been done for several typical reservoirs in Table III.

MR. NOLAN: Table III, my lord, is to be found at page 29 of the report.

THE COURT: Exhibit 114.

TABLE SHOWING COMPOSITION OF RESERVOIR FLUIDS MARKED EXHIBIT 114.

Q MR. NOLAN: Would you please explain Exhibit 114, Dr. Katz? A. Exhibit 114 is entitled "Composition of Reservoir Fluids". You will note that I am using the word "fluid" to denote either reservoir liquid or reservoir gas, or it may simply be a single phase without any need for distinction as a gas or a liquid. The first two I have given are the same as Mr. Gustafson gave, the Leduc Oil D2 and the Leduc Oil D3. These compositions are the molecular percentages of the constituents indicated, such as methane, ethane, propane and so on. They are what we could call the liquid layer in the D3 and the D2 reservoir at Leduc, and so I have called it Leduc Oil D2 and Leduc Oil D3. The third composition I have given is the Oklahoma City Oil or liquid phase in the reservoir, and you can see that it is different but still related in having similar concentrations of these same components or constituents. At Paloma, California, which is the reservoir which I mentioned that I had worked in in 1948 I have given the oil composition, and you will note that we have now 55.80% methane and only 28.02% of the constituents hexanes and heavier, the basic constituents of crude oil in a stock tank, and the reason for that is that the pressure in that reservoir is much higher than these other pressures we have used and found, 4663 pounds for this particular field, and, of course, the temperature is much higher, it is up to 250° Fahrenheit. I have also given the gas phase at Paloma. This has a gas cap and a normal oil phase. This is the gas cap which is being produced in a cycling operation and it has 71.01% of methane in the gas phase in the reservoir, and it has 9.24% of hexanes and heavier. You will note that the pressure that this sample was obtained at was 4700

pounds and a temperature of 235° Fahrenheit.

I would like to point out that one of the interesting things in the field in which I worked was to look for a reservoir where the differences between the oil and the gas are disappearing, becoming so small that you can not tell whether it is an oil or a gas, and Paloma is a long ways in that direction.

I have here the Leduc gas in the D3, which is an analysis of the gas produced, I believe, in a drill stem test, and we have also given here the Viking gas from the Leduc area, and the compositions are given. I believe that the carbon dioxide and nitrogen concentrations with regard to the Leduc and the Viking gas are interchanged.

Q They are correct. A. I am sorry.

Q Just let us be clear about that. What do you use for nitrogen in the Leduc gas? A. It should be 7.41% nitrogen, and .72 carbon dioxide. Is that what your copy shows, Mr. Nolan?

Q Yes, that is right. A. My copy was transposed.

Q It is all right on my copy. Well, now, you were in the middle of page 6, Dr. Katz, and had just mentioned Table III? A. These all contain some normally liquid and normally gaseous constituents. Examples could be shown which emphasize that at high pressures, the reservoir fluids are only slightly different, whether a liquid or a gas phase. At Paloma, California, for example, the condensate well producing the composition shown on Table III, yields 8,000 cubic feet of separator gas per barrel of condensate in the stock tank. A well producing only from the liquid phase in the reservoir yields 1,200 cubic feet of separator gas per barrel of crude oil in the stock tank.

6. <u>Physical Behaviour of Petroleum</u>

Since about 1930, laboratories have been studying crude oil and natural gas under pressure intensively. Subsurface samples or recombined separator gas and liquid give the reservoir fluids for examination. In the laboratory, glass windowed cells permit the observation of gas evolving from oil

under pressure. Techniques have been devised for examining oil and gas in all-steel equipment as well.

The accumulation of petroleum in an earthen trap includes all constituents, methane through lubricating oil fractions or asphalt. In some reservoirs, large quantities of the high boiling crude oil constituents are present in proportion to the gaseous constituents. When this mixture arrives at the pressure and temperature of the reservoir, the gaseous constituents all dissolve in the liquid phase so that only a homogeneous solution of hydrocarbons exists. A lowering of the pressure on a sample of the reservoir liquid at the reservoir temperature shows that gas will begin to evolve at some pressure called the bubble point or saturation pressure. Gas evolves as the pressure is lowered to atmospheric. This gas is said to be dissolved in the crude oil, and the quantity of gas is sometimes spoken of as the solubility of the gas in the oil. A well producing such a reservoir fluid to a separator would yield both oil and gas, and there would be no indication at the well head that the effluent from the well was a liquid phase in the reservoir. Figures 1, 2 and 3, which I have recently described. . .

Q Exhibits 109, 112 and 113? A. That is right. Figures 1, 2 and 3 show diffreent separator operations on wells producing from the same liquid phase in the reservoir.

7. Solubility of Gas in Reservoir Crude Oil

The evolution of gas from a reservoir liquid (crude oil) is illustrated in Figure 4.

Q Would this be a convenient point to discuss Figures 4, 5 and 6, Dr. Katz? A. Yes.

Q Would you like to discuss them all at the same time?

A Yes.

MR. NOLAN: Perhaps, my lord, I could have marked Figures 4, 5 and 6 at pages 33, 34 and 35.

THE COURT: Figure 4 will be marked Exhibit 115.

FIGURE SHOWING GAS EVOLUTION CAUSING SHRINKAGE MARKED EXHIBIT 115.

THE COURT: Figure 5 will be Exhibit 116.

FIGURE SHOWING EFFECT OF PRESSURE ON GAS SOLUBILITY MARKED EXHIBIT 116.

THE COURT: And Figure 6 will be Exhibit 117.

FIGURE SHOWING EFFECT OF PRESSURE ON SHRINKAGE MARKED EXHIBIT 117.

Q MR. NOLAN: Will you mark those in your own book, Dr. Katz?
A. Yes.
Q You have marked them?
A. Yes.
Q And refer to them, if you please, by their exhibit numbers.
A. I will discuss first Exhibit 115, entitled "Gas Evolution Causing Shrinkage of Reservoir Crude Oil - Leduc D-3". These results are based on laboratory measurements made by the Madison Natural Gas Company on a sub-surface sample obtained from the Imperial Leduc No. 6 on August 11, 1947. I have shown a diagram of a glass-windowed cell, which is a steel container some 24 inches long, and it has a glass window in it, approximately an inch thick. We may say it has two windows in it, one in the front and one in the back, so that with the light behind it you can see the fluids in the cell, either gas or liquid, under pressure, much as you would see the material in a bottle or flask. The sub-surface sample is transferred into such a glass window cell by means of a mercury method, and one may place the sub-surface oil in the first cell, where the pressure gauge reads 1894 pounds per square inch, and this 1894 pounds is the pressure at which we find that gas is just beginning to come out of solution. Upon placing the fluid in the cell at, say, 2000 pounds, it would all look the same. As you drop the pressure on it, it would remain looking the same until you reached 1894 pounds, at which pressure bubbles of gas would start to form. At that point, gas is removed from the valve at the upper part of the cell, below the pressure gauge, and the arrow indicates that the gas is removed from the cell at that point.

The next diagram showing the

cell is the way it would look after you had removed gas, until the pressure reached 1600 pounds per square inch. The quantity of gas is shown in the table below. It shows the gas evolved, the next to the bottom line, the gas evolved, cubic feet from previous pressure, and this is all based on a given volume of phase, and we started with 1.4 barrels, which is shown in the third line down. You will see it was 1.4 barrels in that first phase, and it is now down to, or has dropped to, 1.36 barrels.

MR. STEER: Could I interrupt a moment, Mr. Nolan?

MR. NOLAN: Yes.

Q MR. STEER: I did not quite get how you reduced the pressure. A. You reduced the pressure from the first sketch of the cell to the second sketch of the cell by removing gas from the fluid in the upper part of the chamber from the pressure gauge where the arrow indicates.

Q Yes? A. The gas is removed there. The pressure in the first diagram in the cell is 1894 pounds per square inch, and in the second diagram it is dropped to 1600 pounds per square inch, and we have indicated t the quantity of gas in the table below it.

Q Oh, yes, I see. A. And you will see that each one shows the pressure at each stage in the cell. The temperature is constant for all of these. It is the reservoir pressure, the reservoir temperature, I mean. It is the temperature, so that we have the materials at the same condition they are in the reservoir. In the liquid volume phase, we start with an arbitrary amount of 1.40 barrels. We did not actually have that much. We had about 200 cc's but it is computed on the basis of 1.4 barrels liquid phase. As you will see, however, we have removed some gas and the liquid phase has now shrunk and it is now 1.36 barrels, and the gas phase volume reported has a volume of space within the cell of 0.04 barrels. The little pink portion at the top is the gas phase which is appearing. We proceed to the third diagram, and in going from the second to the third diagram, the pressure is reduced from 1600 pounds per square inch to 800 pounds. We removed 238 cubic feet of gas, as shown on the next to the bottom line, 238 cubic feet of gas from the previous pressure, and the accumulative total gas removed is 326 cubic feet. You will see that of our 1.40 barrels of the original fluid in the reservoir, the liquid, I should

say, has become 1.26 barrels of liquid phase and 0.14 barrels of vapor phase. In other words, the pink, which is the vapor phase, is increasing in size.

In going from the third to the fourth diagram, the pressure is reduced from 800 pounds per squsre inch to 200 pounds per square inch. In this particular phase, you take out 212 cubic feet of gas, or 212 cubic feet of gas were evolved from the previous pressure, and the accumulative total gas we have taken out is 538 cubic feet, as indicated in the bottom line below the fourth sketch of the glass windowed cell.

The fifth is the one marked zero pressure and it is at atmospheric pressure, zero pounds per square inch gauge, and we have taken off another 208 cubic feet of gas for a total of 746 cubic feet of gas that have been evolved in this particular process at the reservoir temperature. The liquid that we started with, of 1.40 barrels, of that we now have 1.04 barrels. The volume in the gas phase is 0.36 barrels. Now, in order that we may relate the volume of the crude oil in the reservoir to the volume which you have in the stock tank at 60 degrees, as it goes to market, the cell is cooled from 152 degrees Fahrenheit to 60 degrees Fahrenheit, and the volume of liquid is again measured. No gas is taken off in this particular process. It is closed to the atmosphere, so that no gas could go off. Actually, the pressure goes down a little. In this case we now have 1 barrel, which was our standard for calculation, as you would see. We have one barrel of liquid and we have a volume of gas phase of 0.40 barrels. And this represents what takes place for the oil which remains in the reservoir during the producing process. This is not necessarily what takes place for the oil which comes out and goes through the separator. This is the process which takes place for the oil which remains in the reservoir, at least, through a portion of the various pressure reductions.

Now, Exhibit 116, page 34, being Figure 5, in order that such information might be useful, it is plotted on a graph, and we do not want to know how much gas is evolved at the various pressures per unit of oil in the reservoir, we want

to know how much gas is evolved per barrel in the stock tank at 60 degrees Fahrenheit, so that we plot on the curve the Leduc D3 at 152 degrees Fahrenheit. The circles, the hollow circles on Exhibit 116, are the same data from which I obtained Exhibit 115, and you will see that at about 1900 pounds there were about 746 cubic feet of gas in solution.

Q MR. NOLAN: You might just explain that the pressures are on the lower part of the table or chart? A. Yes.

Q And that the cubic feet of gas are on the left-hand vertical column? A. Yes, sir. We plot the pressure along the bottom and the first point we would plot would be at 1894 pounds, and would be the first circle on the left side of the chart, and we plot the cubic feet of gas that are in solution. I might add measured at 60 degrees and one atmosphere per barrel of stock tank oil, measured at 60 degrees, and from the previous exhibit, Exhibit 115, we noted there were a total of 746 cubic feet of gas which were evolved, so that we plotted that point 746 cubic feet opposite the 1894 pounds per square inch. And similar points, as you take the gas out of solution, are plotted, so that this curve in fact tells you how much gas there is in the oil, per barrel of stock tank oil, that will come out of the reservoir liquid as the pressure is reduced from any particular pressure down to atmospheric, all at reservoir temperature.

Now, I have plotted, in addition to the Leduc D3, I have plotted the data for the Ledud D2 oil, which was obtained from a report of the Madison Natural Gas Company, the Imperial Leduc No. 5, and was obtained on August 10th, 1947. The analysis for the oil is given in Table III, which is Exhibit 114. The temperature used for the reservoir is 3 degrees lower because it is not quite so deep, so that it is 149 degrees Fahrenheit for the Leduc D2, and the crosses represent the points for measuring the solubility of the gas at Leduc D2 formation.

Now, just as a comparison to show that this is the sort of solubility curve that you would get for various oils, I put on the diagram the result which we have measured and ob-

tained for Oklahoma City in the gas reservoir at 132 degrees Fahrenheit and the original pressure was some 2700 pounds.

I would turn now to Exhibit 117, which is a quantitative plot of the volume of liquid which you have as the gas is coming out of solution. It is called the "Effect of Pressure on Shrinkage of Crude Oil Saturated with Gas." Again we plot the pressure along the bottom of the scale and we plot what is called a "Formation Volume Factor" along the left. These numbers are the same numbers that I have been using when I described figure Exhibit 115, the volume of the liquid phase when you have one barrel of stock tank crude oil.

Let us take the first point again on the Leduc D3. You will note that the pressure is at a point corresponding to some 1894 pounds. You will note that the formation volume factor is given as 1.4. That means that it takes 1.4 barrels of reservoir liquid in the Leduc D3 formation at 152 degrees Fahrenheit to make one barrel in the stock tank at 60 degrees. The other points tell you the number of barrels of liquid you must take at the corresponding pressure in order to get a barrel of oil in the stock tank.

Now, again, I have shown these results for the Leduc D2 at the reservoir temperature of 149 degrees Fahrenheit. And, just as a matter of comparison, the results for the Oklahoma City oil at 132 degrees Fahrenheit.

Q Dr. Katz, will you just look at Exhibit 115 for a moment, if you will, please? At page 33 of your report. A. Yes.

Q Now, I want to ask you if the reservoir crude oil in this glass windowed cell shown on Exhibit 115, is that a liquid? A. Yes. In the first cell it is all liquid up to where you lower the pressure and up until you reach the point of 1894 pounds, at which point gas will evolve. Before you reach the 1894 pounds it is all liquid.

Q It is this same material which at the well head yields from 700 to 900 cubic feet of gas per barrel of liquid, as you showed on your exhibits 109, 112 and 113. A. Yes. We took 1.441 barrels

of that liquid for these exhibits and showed the amounts of gas that you obtained from that amount of liquid under the three types of separations shown on Exhibits 109, 112 and 113.

Q Well, could you or could you not say that the gas observed at the well head was gas or natural gas in the reservoir? A. Well at the condition in the reservoir that is shown on Exhibit 115 it is a liquid, it is a part of the liquid, the same liquid of which the crude oil is a part, but it is a uniform liquid solution.

Q Could any part of it be said to be natural gas? A. Well, it is a liquid, and I do not see how anyone could say it was a natural gas. It is a liquid solution. I have called it reservoir crude oil.

Q Now, I just want to ask you one more thing. Can the fluid in your cell, which you have shown to us, which represents the condition in the reservoir, can that be divided into two distinct things, namely, oil and gas? A. Well, I do not think it could be divided into two things that are distinct. I mean, I have divided it by three methods into a gas and into a liquid, but I do not see how they could be called distinct when by these separations they are made into gas and into oil. In that sense, let us say you had a sugar solution instead of a solution of hydrocarbons such as we have here. The sugar in the water could be extracted as sugar and it would be distinct, it would be separate and you would get a definite yield.

Q Yes? A. In that sense the gas that you get from this could not be said to be distinct.

Q I suppose it would be fair to say that it is of a gradually changing composition, is it? A. Yes. The gas composition that you get from that material depends upon the condition and the type of separation you have, and I have given three examples in these exhibits, 109, 112 and 113, but there are many other ways that you could separate it, and get different divisions of this material into gas and into liquid.

Q Now, will you please proceed with the reading of your report, and I think you were at the bottom of page 7?

A A reservoir oil is placed in a glass windowed cell under pressure and the gas released.

Q You are referring to there? A. Figure 4, which is Exhibit 115.

Q Thank you. A. As the gas boils out of the solution, the volume of the liquid decreases or shrinks.

This is observed by a lowering of the liquid level in the glass windowed cell. The quantities of gas withdrawn at the several pressures are shown quantitatively for several reservoir liquids on Figure 5.

Q Which is Exhibit 116? A. That is right.

8. Shrinkage of Reservoir Crude Oil upon Gas Evolution

When the gas comes out of the liquid phase, it carries both normally gaseous constituents such as methane and ethane and normally liquid constituents such as pentanes. The boiling out of the gas reduces the quantity of the liquid just as boiling a tea kettle causes it to go dry. The quantity of shrinkage is observed in the glass windowed cell illustrated by Figure 4, which is Exhibit 115. On Figure 6 are plotted the data to show the quantitative effect of pressure reduction on shrinkage.

Q And Figure 6 is Exhibit 117? A. That is right. The presence of constituents in crude oil which will vaporize upon the lowering of pressure is a very important fact relative to the recovery of oil. The expansion of gas out of oil away from the well causes oil and gas to flow to the well.

9. Effect of Gas in Solution on Viscosity and Surface Tension

The evolution of gas from crude oil raises its viscosity and surface tension. The recovery of crude oil from porous rock depends to a considerable degree upon the oil viscosity. More viscous oils are more difficult to recover and a larger percentage is usually left in the reservoir.

Surface tension is that quality of a liquid which causes it to be retained in porous rock. Coffee enters a lump of sugar by surface tension effects when the lump just touches the top of the coffee. The higher the surface tension, the more the liquid clings in the pores of the rock. Gas evolution raises surface tension and thereby increases the tendency of the oil to remain in the reservoir and be unrecovered.

Q Just in a word, what is "viscosity"? A. Well, viscosity is the propery of a liquid which tells us the type of flow you will have. Molasses is viscous,

and gasoline has a low viscosity.

10. Condensate Production.

Natural gases under pressure may contain high boiling constituents, such as the constituents in motor fuel or kerosene, in the gas phase. These constituents will condense to the liquid phase when the pressure on the gas is reduced. This process is known as retrograde condensation. Wells producing gas of this nature yield liquid condensate in the separator due to the temperature and pressure decrease as the stream flows from the reservoir up the well bore. The condensate may be "water white" like undyed motor fuel or it may have color similar to higher boiling fractions. This condensate was called naphtha at Turner Valley and has been called "distillate" extensively.

An example of separator operation on a condensate well is given by Figure 7.

MR. NOLAN: I am going to ask, my lord, to have Figures 7 and 8 marked. They are pages 36 and 37. I am going to have them marked now because they are discussed together.

THE COURT: Figure 7 on page 36 will be Exhibit 118.

FIGURE SHOWING SEPARATION OF CONDENSATE FROM WELL STREAM FROM GAS PHASE MARKED EXHIBIT 118.

THE COURT: And Figure 8 on page 37 will be Exhibit 119.

FIGURE SHOWING RETROGRADE CONDENSATION FROM GAS PHASE MARKED EXHIBIT 119.

MR. NOLAN: Thank you, my lord.

Q Will you explain Exhibits 118 and 119, please?

A Exhibit 118 is entitled "Separation of Condensate from Well Stream Producing from Gas Phase in Reservoir." It does not say so but the figure is from the Paloma Reservoir, and these results are results from tests which I made there some two years

ago. The flow, as it comes from the reservoir, liquids and gases mixed, and they come from the well head as indicated, out of the tubing and go to the separator, which is like the separator operating on the oil wells at Leduc. In this case, however, a higher pressure is used. This is a test that is being conducted so the pressure was used at 469 pounds per square inch, and the temperature happened to be 69 degrees Fahrenheit. The fluid came from the well into the separator and at the temperature and pressure of the separator, you see the change at the top into a gas stream, which is metered, and at the meter it is at the pressure of about 469 pounds, and when it is computed to cubic feet at 60 degrees and one atmosphere we obtain 8530 cubic feet of this separator gas. The liquid left in this high pressure separator goes to the stock tank and as it is reduced in pressure from 469 pounds per square inch to atmospheric pressure, 73 cubic feet of vent gas are given off from the tank and go to the air. The liquid that is in the stock tank, the condensate so called, the condensate has an A.P.I. gravity of 52.8 degrees, which means that it has a lower condensate material than a normal crude oil, and it is accumulated in a stock tank and sent to market just as if it were crude oil.

This diagram, Exhibit 118, gives the composition of the stream in molecular percentages and as it was during the separator operation. Again we have the constituents methane, ethane, propane, iso-butane and so forth, and we give the molecular percentages. The well stream, since it comes from a well produced from the gas phase in the reservoir, has 74.4% methane, and it is, of course, a mixture at the well head. This is the composite composition of the liquid and the gas at the well head. And it has 8.3% of ethane, and so on down the list. You will note that the hexanes and heavier fractions are only 7.7 in this case.

The separator gas is the gas leaving the top of this vessel and going to a separation plant, and that had 84.8% methane, 7.9% of ethane, and 3/10ths of 1% of hexanes and heavier.

I have given you the separator liquid, which is a liquid at 469 pounds and 69 degrees, but this separator liquid divides into the stock tank

liquid and the vent gas. I do not have the analysis of the stock tank liquid, but I do have the analysis of the vent gas showing it has 33.4% methane, 18.2% ethane, and so on. With the exception of the ratio of the gas to the liquid and the small difference in the quality of the liquid, this well producing from the gas phase in the reservoir is very similar to an operation of a well producing from a liquid phase in the reservoir.

Exhibit 119, on page 37. . .

THE COURT: I think before we start that we will adjourn for 15 minutes to exactly 11 o'clock. We have been going two hours and if it is not hard on the rest of us, it is hard on the Court Reporter, Mr. Howard, so that we will adjourn until exactly 11 o'clock.

(Hearing resumed after short adjournment.)

THE COURT: All right, Mr. Nolan.

Q MR. NOLAN: You were about to discuss and explain Exhibit 119, being your Figure 8, Dr. Katz?

A Exhibit 119 shows the glass windowed cells and is called "Retrograde Condensation from Gas Phase by Pressure Reduction" as observed with the glass windowed cell. This is for the material produced from the well shown on Exhibit 118. A sample of the gas and a sample of the liquid obtained from the separator in Exhibit 118 are recombined in the proportions in which they were produced from the well and placed in the glass windowed cell at the pressure and the temperature indicated. We put them in the cell at a higher pressure than the 469 pounds, and it is at 256 degrees Fahrenheit in this case, and then we lower the pressure in the cell until the pressure reaches 4650 pounds, at which condition you will see liquid beginning to form. This condition could be called the dew point, because this liquid looks like dew, or the beginning of rain, and it is even spoken of as the "dew point". At that point gas is removed from the fluid at the top of the cell and below the pressure gauge and enough gas is taken out so that the pressure goes down to 4000 pounds per square inch.

On the table below the cells is shown first the pressure and the temperature, which remains constant at the reservoir temperature, and for

the volume of the liquid phase at 4650 pounds there is zero liquid, and, going along, at the 4000 pounds, there is 5.1. Now, these units of volume are in c.c.'s, cubic centimeters, if you wish, and they are an arbitrary volume of liquid and gas.

The volume of gas phase which was 100 at the beginning is now 94.9, has now become 94.9. In other words, the pink space in the second cell is 94.9% of total space, and the volume of liquid which is the green in the bottom of the cell is 5.1%. I have shown again the volume of gas which has been withdrawn, which is only of minor interest at this point.

The third cell indicates the condition after the pressure has been lowered to 3310 pounds by the withdrawal of gas from the top of the cell. You will note the volume of liquid has gone up to 9.4 c.c.'s or 9.4 parts out of a total of 100 parts of volume in this cell. This liquid is a relatively white-coloured liquid. I would like to explain what you see as the pressure is lowered. It is a very enticing and very interesting phenomenon as the pressure is lowered between the 4000 pounds and the 3310 pounds. The gas phase gives up a liquid just like a rain, you can just see the rain coming out of there, the hydrocarbon liquid dropping out of the gas phase, and, of course, it is the accumulation of these liquid droplets in the bottom that causes the increase in the volume of liquid at the bottom of the cell. At the same time that the liquid is raining out of the gas phase, gas is bubbling out of the liquid phase, so that we have a real interchange. In other words, the 9.4 c.c.'s of liquid in the 3310 pound gas are not the same as the 5.1 c.c.'s which comes out at the 4000 pounds. There is a difference. And, of course, there is an interchange of constituents, the liquid drops out of the gas and the gas comes out of the liquid. We have a net increase under this particular pressure figure.

Now, the fourth cell where the pressure is 2495 pounds shows the volume of liquid which has now gone up to 10.7 c.c.'s or 10.7 parts out of the total volume of liquid, the remaining being the gas phase. And, finally, I have shown when we

come to that 980 pounds when liquid now starts to decrease in total volume. In other words, when we went from 2495 to 980 pounds there would be some of the liquid coming out of the gas phase through the bottom, rain through the bottom, and there would be a bubbling up from the liquid phase to the gas phase, and the net exchange in this case would be in favour of the reduction of liquid rather than an increase in liquid. This could be continued to atmospheric pressure and you would have some liquid left. I do not think we conducted the experiment that far along, but there would be some liquid left, which I would estimate would be about two c.c.'s, maybe three or maybe four c.c.'s, something like that, depending on the amount of fluid with which you are dealing.

Now, this represents what takes place for the material in the reservoir when the well is producing condensate. This is representative of what takes place for the fluid which remains in the reservoir during these pressure changes, and the liquid which we have formed is called liquid formed by retrograde condensation; that is, the pressure is decreasing rather than increasing.

Q And what was initially a gas phase has become a gas and a liquid? A. That is right.

Q Now, you were reading, Dr. Katz, from page 9, and you just had mentioned the figure 7, which is nine lines from the bottom. A. Yes. Figure 7 is Exhibit 118.

Q Yes. Where you stopped was "The ratio of gas to liquid," and would you pick it up there, please?

A The ratio of gas to liquid is 8530 cubic feet of gas per barrel of condensate in the stock tank. The condensate is a little lighter in density than an average crude oil and has a greenish yellow cast.

To illustrate retrograde condensation by pressure reduction, Figure 8, that is Exhibit 119, has been prepared. The glas windowed cell (containing reservoir fluid) is shown at successive stages of gas withdrawal and subsequent condensation accompanying the pressure reduction. It is seen that a gas phase is converted to a mixture of gas and liquid by the usual pressure changes which occur for a reservoir. The liquid contains kerosene and other constituents which were in the gas phase in

the reservoir. Natural gas produced from a condensate reservoir which is declining in pressure will gradually produce less condensate. Per unit of gas, I should add. For this reason, the pressure of condensate reservoirs is often maintained by the cycling of dry gas back to the reservoir.

11. Mechanism of Reservoir Operation.

The prime concern in the petroleum industry is high recoveries of crude oil or condensate. Gases expand upon pressure reduction so that reservoirs containing gases may be depleted effectively by pressure reduction. Liquids not saturated with gases will expand little and so a very small recovery may be expected from reservoirs containing them unless something displaces the oil.

There are three primary ways by which crude oil is removed from the porous rock into the wells: expansion of gas (dissolved or gas cap drive), water displacement, and gravity drainage. Expansion of dissolved gas has already been mentioned. A gas cap above oil saturated with gas provides extra gas to push oil to the wells. To obtain the highest oil redovery, wells must be completed in such a way that the gas pushes as much oil ahead of it as possible. The well bore cannot be open near the gas zone for then the gas would go directly to the well without moving oil ahead of it. Also, the well must be operated in such a way that gas cap gas does not "break through" the oil zone, as would occur if the well were produced at exceedingly high rates.

Water under crude oil in the reservoir may be connected to a source such that when the pressure on the oil is reduced, water flows to displace the oil and maintain the pressure. This is called a water drive. Sometimes water moves slowly and the pressure on the oil zone is lowered considerably; such a condition is described as a partial or slow water drive.

In gas drive fields, after the gas is essentially dissipated, considerable oil is still in the porous rock. There is no oil level, but the rock originally filled with oil is still wet with it. Gravity forces cause this oil to move gradually down

slope. Wells at the bottom of the structure will receive oil by gravity drainage.

Combinations of these mechanisms occur for most fields. Water drive is usually the most efficient and should be allowed to take place when it occurs. It is necessary to operate wells with the whole reservoir in mind for the greatest overall recovery.

12. Gas-Liquid Interchange in Reservoir.

There is an interchange of constituents between liquid and gas phases in the reservoir in all mechanisms of recovery, except in the case of water drive so active as to maintain initial reservoir pressure throughout the life of the reservoir.

Pressure reduction on a reservoir of crude oil saturated with gas causes gas evolution in the reservoir. Further pressure reduction not only causes more gas evolution but a redistribution of constituents between the oil and gas phases. The gas phase composition changes with pressure changes.

I might add at this point that this description of the liquid running out of the gas and the gas boring out of the liquid is observed when you are taking these measurements on a sample of crude oil originally, containing dissolved gas originally. In other words, the appearance has little difference whether you are talking about a condensate or a crude oil sample in the proportion of liquids and gases.

Likewise, a condensate reservoir initially containing natural gas with dissolved liquid constituents will have liquids precipitate from the gas with pressure reductions. These reservoirs have a continual redistribution of constituents between the gas phase and the liquid phase in the reservoir.

The products from a well after the reservoir has had a reduction in pressure no longer can be said to represent an initial gas phase or an initial

reservoir crude oil phase since a redistribution is likely to have taken place since discovery.

13. Extraction of Liquids from Natural Gas

Natural gases from separators or wells usually contain constituents which when isolated are liquids. Thus plants are constructed to extract these constituents as natural gasoline, often called casinghead gasoline. It is a liquid similar to motor fuel and may be used as such in winter. Extraction plants also recover propane and butane which require moderate pressures to maintain them in the liquid state at atmospheric temperature. Propane and butane are sold under the name of liquefied petroleum gas (LPG) or as "bottled gas".

There are several ways of extracting liquid constituents from natural gas. Absorption with mineral seal oil is a common method, compression and cooling are alternate processes.

In the extraction process, a considerable portion of the methane and ethane are reduced to the liquid state at some stage. Later they are used as plant fuel or leave the plant as dry natural gas.

Q Now, that brings us to Figure 9, does it not, Dr. Katz?
A Yes, it does.
MR. NOLAN: I think I might as well have it marked here, my lord. It is on page 38, the last page in the report.
THE COURT: Page 38, Figure 9, will be marked as Exhibit 120.

FIGURE OF FLOW SHEET OF EXTRACTION PLANT FOR NATURAL GAS MARKED EXHIBIT 120.

Q MR. NOLAN: Will you explain Exhibit 120, Dr. Katz, please? A. Figure 9, Exhibit 120, is a flow sheet of an extraction plant for recovering the liquid from natural gas. This is a general flow sheet. This, or these are computed results which may have been obtained for a plant producing gas from a separator shown on Figure 2, which is Exhibit 112. In other words, I have taken a plant and assumed that it was going to extract the liquid products from 10 million

cubic feet of gas measured at standard conditions, 10 million cubic feet of gas, of the composition which came from the separator on Exhibit 112.

Those 10 million cubic feet of gas enter an extraction plant, and the material is divided, as I have shown here, into four products. The first product is dry natural gas. In this particular type of extraction, which I have given, which is a normal extraction, from which one might expect 6,950,000 cubic feet of dry gas. I show 34,600 gallons of propane. Now, these gallons are United States gallons. The conversion factors I used were the factors for U.S. gallons rather than Imperial gallons. I have shown a pressure gauge here of 95 pounds per square inch. This is about the pressure which would be required to get the propane into the liquid stage. I show the extraction of 18,100 gallons of butanes and 31,900 gallons of natural gasoline. And I have indicated the pressures which normally would be used for storing such products.

I have given the composition of streams in molecular percentages. The separator gas is the same as that on Exhibit 112. The dry gas, of course, is what is left after the liquid products have been extracted. And I have taken typical compositions in order to obtain the quantities I have here, and given the analysis of the propane, which is the liquefied petroleum gas, and those percentages are 2% ethane, 96% propane and 2% iso-butane. And the natural gasoline I have shown has normal butane in it but no iso-butane. This is the normal type of extraction plant, and the extraction method, of course, is not important. It may be one of several procedures.

Q Dr. Katz, I observe that you have 10 million cubic feet going into the extraction plant, and that you use as plant fuel 450,000 cubic feet, and that you have left 6,950,000 cubic feet of dry gas. A. Yes.

Q That is a decrease of roughly 3 million cubic feet. Now, what does that show, Dr. Katz? A. Well, that simply means that the decrease of volume in the gas is the result of that amount of gas having been condensed into the liquid state to form the propanes, butanes and the natural gasoline.

Q In other words, you have produced approximately 84,000

gallons of a liquid product? A. That is right.

Q Has the industry made any effort to convert ethane into a liquid, or even methane? A. Well, yes. This Spring I was connected with a project in obtaining experimental data in the laboratory for the design of a plant where I was not only going to extract natural gasoline, butanes and propanes, but I was going to extract liquid ethane.

Q That is all you have to say, is it, on this chart, Dr. Katz? A. Yes.

Q At the bottom of page 12, you were reading at the third line from the bottom.

A Figure 9, Exhibit 120, shows the calculated yields of products for an extraction plant operation on 10,000,000 cubic feet of gas per day of the composition taken from separator of Figure 2, which is Exhibit 110. The flow sheet illustrates that natural gas may include a considerable proportion of condensible liquid constituents.

In some crude oil fields, the entire well effluent is piped to a central plant and processed. The products may be a dry gas, crude oil, natural gasoline and LPG, or all the liquids may be combined into one stream and sent to a refinery. At different periods of the year when the market changes for LPG, such a plant would recover different amounts of propane and butane. Thus, the processor changes the form in which these intermediate hydrocarbons are sold -- as a liquid or as a gas.

14. Summary on the Nature of Petroleum Reservoirs

1. Natural gas is not a distinct substance; it is a mixture of hydrocarbon gases, the composition of which depends upon temperature, pressure and source.

2. The constituents present in a natural gas may have occurred in two forms in the reservoir; (1) as a gas pahse or (2) dissolved in a liquid phase (reservoir crude oil).

3. Natural gas constituents associated with normally liquid constituents in reservoirs serve in the recovery of the normally liquid products. Gas

expansion brings crude oil to the well bore and gas is a carrier of condensate in high pressure gas phase reservoirs.

4. Efficient production of crude oil and condensate require a minimum net withdrawal of gas from the reservoir until the major oil production is accomplished.

5. In the simultaneous production of crude oil and natural gas, there is an interchange of constituents between the liquid phase and the gas phase in the reservoir, in the well bore and in separators. The final products depend upon the conditions of the final separation.

6. The natural gas from an oil-gas separator or gas from gas fields normally contain constituents which may be extracted and sold as liquids (natural gasoline and LPG).

7. There is no point at which a distinct division of a well stream can be made into natural gas and liquid product short of an arbitrary specification of the separation process.

PART II

USAGE OF THE WORD PETROLEUM

The usage of any word is related to the background of the individual using the word. Even dictionary definitions are simply a reflection of the sphere of activity of the editor. The fact that dictionaries must be revised is testimony to the growth of word meaning among people. Dictionaries normally lag in giving the intended complete meaning of words spoken or written at a given time. In technical work, the writer has found that dictionaries are inadequate and of little value for definitions.

The word "petroleum" comes from petra (Greek), rock, and oleum (Latin), oil, and from its derivation means "rock oil". Some people cling to this definition in their usage. Others, who have contact with the phase of the oil and gas industry which is concerned with recovering hydrocarbons from

the earth, learned that in spite of its origin, the word "petroleum" must of necessity include all hydrocarbons produced from the earth whether gaseous or liquid.

The intended meaning for the word "petroleum" wherever used would depend upon the context and upon sources of information relating to the context. For example, in the refining of crude oil and distributing of liquid fuels, the word "petroleum" is frequently used to refer to the liquid products. Persons in such an industry might be very careful to distinguish between natural gas and oils by the terms "natural gas and petroleum". On the other hand, persons considering the retention of oil and gas in the earth as mineral rights would use the term "petroleum" to include both gaseous and liquid hydrocarbons.

In a sense "petroleum" has two meanings: (1) the literal abridged dictionary definition which is based on the origin of the word, and (2) the general meaning to include gaseous and liquid hydrocarbons adopted by usage, and given in more complete definitions. During the early years of the industry, those who saw natural gas accompany crude oil from wells gradually began to consider gas and oil as having one source and, in fact, as being inseparable in any consideration relative to their existence in the earth.

1. "Petroleum" a Broad Term including Natural Gas

The writer surveyed more than 100 books and journals dealing with petroleum in various libraries. From these books it was found that those writers concerned with natural gas as well as crude oil used the term "petroleum" as an inclusive word of both natural gas and crude oil. Some writers specifically state that the term "petroleum" includes natural gas. Others use the word "petroleum" as a title covering treatment of natural gas as well as crude oil.

Many persons engaged in refining or marketing liquids made from crude petroleum termed them petroleum products. These people accepted the broad use more slowly than those handling natural gas intimately associated with the crude oil. The

influence of the refiners and marketers in the literature is great by the force of numbers. However, time has shown that the broader meaning prevails. Today there are many definitions and usages of the term petroleum which include natural gas. The American Petroleum Institute has had a project at California Institute of Technology for twenty years primarily for investigations of the behaviour of natural gas constituents. The writer has published many articles dealing primarily with natural gas constituents in the A.I.M.E., that is the American Institute of Mining and Metallurgical Engineers, Petroleum Development and Technology. Petroleum Engineering schools normally integrate material on natural gas with material on crude oil. The American Petroleum Institute has a Committee on Measuring, Sampling and Testing Natural Gas and Natural Gasoline.

The Science of Petroleum, a treatise in five volumes, covers natural gas and natural gasoline and a definition of petroleum states specifically that it includes natural gas (Vol. I, p.12). The writer has used the term many times in his technical papers; Table II was prepared two years ago by the writer in a private report. with the slight modifications which I have mentioned to you. The knowledge and language used in the petroleum industry has grown over the years. Since 1906 was a significant date in this case, a survey was made of the writings up to that time.

Q Yes, go ahead, Dr. Katz.

A 2. Literature before 1906

To trace the evolution of the knowledge and language on the term "petroleum", references have been assembled to show the following may be substantiated from printed matter found in libraries on or before 1906.

a. The single word "petroleum" was considered an adequate title for books, chapter headings, tables, etc. when the printed material included references to natural gas. From my reading of references 2 through 6, I found that natural gas was included under the title of petroleum.

Q All the references are set out, Dr. Katz, on pages 25 and 26 of your report? A. I have given the references there so that you might find them in the library.
Q Now, do you want to refer to reference 2 through 6?
A If I may.
Q You are producing photostats and not the original volumes. Have you any explanation for your inability to produce the original volumes? A. They were in the university libraries and I did not have the privilege of bringing them with me. I brought one or two books with me but the remainder of them were large and bulky, and many of them were Government books which the university does not permit to be taken from their libraries.
Q Are you prepared to say that the photostats are true copies? A. Yes, I am.
Q Of what was in the original volume? A. Yes.
THE COURT: Now, I was wondering, Mr. Nolan, if the rest of this report lends itself to cross-examination. If it does, we might as well have the witness read it. If it does not, could we not take it as being read and include it as a part of this report?
MR. NOLAN: Yes.
THE COURT: It does not help very much, does it, for this witness to read it, when he has couched this part, in any event, in language that even you and I can understand.
MR. NOLAN: Yes, my lord. The difficulty is when he refers to his references they are not contained in the report. I mean, they are in a book and he would want to read that passage from the book.
THE COURT: All right.
MR. NOLAN: But as we go along, we may be able to shorten it, my lord, and I will endeavour to do it, because I appreciate that putting it on the record will serve our purpose, and will also that of my friends, I am sure.
THE COURT Well, if there are objections then the Court Reporter ought to have them.
MR. NOLAN: Yes. Will you go on, please, Dr. Katz? A. Reference 2 is to a book entitled "Petroleum, Its Production and Use, by Boverton Redwood, 1887. In the preface it states,

> "The following pages have been reprinted from the Journal of the Society of Science and Arts, London, with the omission of such portions as would seem to

"be of little or no interest to American readers."

On page 16, he states,

"Petroleum occurs, as we have seen, in all forms, from the gaseous to the solid. "

On page 17,

"Crude petroleum, in the liquid form, consists almost entirely of carbon and hydrogen,. . ." and he goes on with the sentence, perhaps I should read it,

". . .usually in the proportion of about 85% of the former to 15% of the latter, but there are also sometimes present in small quantity oxygen, nitrogen and sulphur."

I should add that a book of the same title "Pretroleum and its Products" by Boverton Redwood was printed in England, and both of them are based on lectures which Sir Boverton Redwood made after coming to the United States and observing the American practice.

Q MR. STEER: Was he a citizen of the United States? A. No, of England.

MR. HELMAN: He is Sir Boverton Redwood.

MR. STEER: Oh, yes.

A I do not have the original English book, but I have page 1, a photostatic copy of page 1, and it is entitled "Lecture 1, delivered March 8, 1886" and it starts as follows:

"In considering historically the subject of these lectures, it will be convenient to accept the name petroleum (which is obviously derived from the two Latin words petra, rock, and oleum, oil) in it broadest signification, as embracing not only the liquid oils which flow from the earth in various localities, but also the solid or semi-solid forms as well as the gaseous forms; and, in addition, the similar products obtained by the distillation of Boghead coal, bituminous shales, brown coal and peat."

And on the same page, after describing the gas which was produced from various rocks in Persia, he states:

"It is worthy of note that a similar temple exists near Kangra, in the Punjab, where petroleum gas escapes from the ground, and it is probable that in past ages the same priests officiated in these localities, journeying with pilgrims from one to the other."

Q MR. NOLAN: Yes? A. Now, Reference 3 is a book entitled, "A Practical Treatise on Petroleum", by Benjamin J. Crew, 1887, on page 203 where on the left it says "A Practical Treatise on Petroleum". At the head of the page on the right it states "Origin of Natural Gas", and there is a table which starts "Natural Gas, its origin, natural gas wells," and so forth, and with regard to the origin of natural gas there are about as many various matters respecting the origin of natural gas as have been formed respecting the liquid petroleum.

On page 215 of the same book there is a table entitled "Table Showing the Properties of the Chief Gaseous Elements of Natural Gas" and including some of the heavier hydrocarbons. The paraffins are listed as marsh gas, ethane, propane, butane, pentane, hexane, and so forth, and their properties are given.

I might add that Benjamin Crew died before this book was published, died in 1885, and it states in the preface that he had been an active worker in the field of petroleum refining for many years.

Reference 4 was taken from Cassier's magazine and has reference to "Engineering Illustrated, Volume 21, November, 1901 to April 1902." I am referring to page 123 of the article entitled, "Petroleum in California" by W. L. Watts, E.M., of the California State Mining Bureau. And the first paragraph reads as follows:

"California's mineral wealth consists not only in those minerals from which metals are obtained, but also in numerous other mineral substances, which become in greater demand as manufacturing interests expand and as civilization advances. The most important of the latter class of minerals, which, in a commercial sense, may be regarded as non-metallic, are the hydrocarbons; and of

"these, petroleum, in the form of asphaltum, oil, and natural gas, are of the greatest value."

Reference 5 is from the Proceedings of the American Chemical Society for the year 1903. I am reading from page 699, Reference 5. "Petroleum in California", by Edmond O'Neill, received February 9, 1903.

"Within the past few years petroleum has developed a new industry . . . "

Excuse me.

"Within the last few years California has developed a new industry, that of petroleum. The knowledge that it existed is not new. Seepages occur in various parts of the State, and natural gas is found over a very large area. Immense deposits of asphaltum occur in the southern counties and were used by the early Mission Fathers. Attempts were made to distil the crude oil and in 1855 Pico erected a small refinery."

Reference 6 is from "The Mineral Industry", its statistics, technology and trade during 1905, printed by the Engineering and Mining Journal in the year 1906, and under the table of compounds, page 12, excuse me, page 13, it is Roman numeral 13, there is this article:

"Oil and Gas Development in the Mid-Continental Field in 1905, by Erasmus Haworth, page 478."

I have pages 478 and 479. On page 478 the title is: "Oil and Gas Development in the Mid-Continental Field in 1905" and on page 479, that page has the heading "Petroleum", and I read:

"Outside of this area a number of outlying discoveries have been made; such as gas at Arkansas City and Newkirk; and oil and gas near Ardmore in the Chickasaw Territory. The Arkansas City-Newkirk field is evidently about the same geologically as the large field; but the exact geological conditions about Ardmore (and a few other places where traces of oil and gas have been found) have not yet been thoroughly worked out."

That is all of the references to which I have referred.

Q Well, then, if you will go to the top of page 18 of

the script, Dr. Katz, and perhaps you will read that first full paragraph? A. Discussions of the origin of crude oil recognize a similar origin for natural gas. Occasionally, the origin of dry gas in natural gas fields was considered as being different from that of crude oil, but most writers believed oil and gas to have a common origin. In my reading of References 2, 8, 9 and 12 I found that natural gas was known to have a common origin with crude oil.

Q Now, do you want to refer to References 2, 8, 9 and 12 in this connection? A. Briefly, yes. I am referring to Reference 2 in the book by Boverton Redwood on page 9.

"In relation to the geology of natural gas, Mr. Ashburner points out that the oil and gas regions of Pennsylvania are shown by the strata drilled by the gas wells in the neighborhood of Pittsburg to be one in a geological sense."

Reference 8 is The Universal Cyclopaedia, published in 1900. I read from page 244.

"Petroleum and Natural Gas, Geology of: Petroleum and natural gas appear to be inseparably connected. Wherever large supplies of the one exist the other is in almost all cases not far distant."

Q What volume was that, Dr. Katz? A. Volume 9.

Q Thank you. A. Reference 9 is The New International Encyclopaedia, Volume 8, 1903. Under the title "Petroleum", page 1019, I find:

"Origin and Geological Occurrence. The geological history of petroleum and natural gas are closely connected, so that what is said of one practically holds true of the other."

Reference 12 is from the Geological Survey of Ohio, a Preliminary Report upon Petroleum and Inflammable Gas, by Edward Orton, State Geologist, 1887.

"Origin of Petroleum and Gas. It is not necessary. ." I read on page 9,

"It is not necessary to consider the origin of natural gas and petroleum separately. They have a common history. They are produced from the same sources, accumulated by similar agencies, and stored in the same reservoirs. In order of formation, petroleum is probably first. It is

"the more complex in composition and thus nearer to the organic world from which it is derived. Gas is the same substance on the downward road to the simplicity of inorganic compounds. No process is known by which gas is built up into oil, but the breaking up of petroleum into gaseous products is seen to be constantly going forward in nature, and it is also effected in the large way artificially.

Petroleum never exists free from gas, but it is sometimes asserted that gas is found that has no connection with petroleum. This claim is probably a mistaken one, and if the driest gas could be followed throughout its underground reservoirs, it is altogether probable that accumulations of oil would be found along the line in every case. There is no horizon known that produces either substance to the entire exclusion of the other."

Q Now, if you will go to the middle of page 18, and read from there, please? A. Yes. Natural gas was known to accompany the production of crude oil and oil could not be produced without producing the gas.

In my reading of References 2, 3, 7, 10, 11 and 12 I found that natural gas was known in 1906 to accompany crude oil.

Reference 2 is, again, this book by Boverton Redwood, in 1887, page 19.

"From the crude oil, as it issues from the earth, methane, ethane, and propane are given off in gaseous form, so that from American petroleum the paraffins referred to have been separated. Methane is a colourless, inodorous gas, burning with a yellow flame of little luminosity. Ethane is also a colourless, odourless gas. Propane liquefies at - 20 degrees C. Normal butane condenses at 0 degrees C. to a liquid, boiling at 1 degree C., which constitutes the greater part of the petroleum product known as 'cymogene'. Normal pentane occurs with iso-pentane in the most volatile portion of petroleum spirit."

Then Reference 3 is the book,

"A Practical Treatise on Petroleum", by Benjamin Crew, and it says at page 468:

"Since 1859, when the drilling of oil wells in Western Pennsylvania was commenced, natural gas has been obtained either in conjunction with oil or in wells which produced only a trace of oil. In most of the flowing oil wells, the pressure which forces the oil up the well results from the gas contained in the oil sand in the immediate vicinity of the well, or at a considerable distance away. In the former case, gas is frequently mixed up with the oil as it intermittingly flows from the well mouth, the gas coming from the well continuously between the oil-flows; while in the latter case, no perceptible quantity of gas is obtained from the well. I believe that, by special examination, all the oil coming from the Pennsylvania and New York wells may be proved to contain some gas."

Reference 7 is The Encyclopaedia Britannica, 9th Edition, Volume 23, 1888, page 813.

"Gas seems to be a general concomitant of the oil all through the petroleum region, but for a long time the outflow of gas from the oil wells was looked upon as a nuisance. According to Mr. Ashburner, the amount of gas at present flowing from the explored sands of Pennsylvania is probably two or three times greater than is required to meet all present demands."

Q Reference 10? A. Reference 10 is from the Department of Commerce and Labour, Bureau of The Census, Special Reports, Mines and Quarries, 1902, from the Washington Government Printing Office 1905. I am reading from page 725, which has a page heading "Petroleum", with a sub-heading "Petroleum and Natural Gas."

"Petroleum and natural gas are intimately connected in composition and occurrence, one being a gaseous and the other a liquid hydrocarbon, and with but few exceptions they are associated in all of the fields, the gas occupying the upper portion of the same strata which contains the petroleum."

Q Reference 11. A. Reference 11 is from "Oil fields of the Texas-Louisiana Gulf Coastal Plain", by C. W. Hayes and William Kennedy, 1903, page 155.

The sub-heading is "Cause of Pressure".

"Two theories have been employed in explaining the pressure which causes oil and gas to gush, namely, the hydrostatic theory and the gas-expansion theory."

Later on the same page it says,

"It appears highly probable that the pressure in the oil reservoir is due largely to the expansive force of the associated gas."

And on page 156,

"A common method of raising oil in wells which do not flow is to carry air under high pressure to the bottom of the well by means of a small pipe within the casing. When the air is turned on and accumulates sufficient pressure to lift the column of oil in the casing, the oil is expelled in a pulsating stream exactly similar to a natural gusher. In one case, however, the expansive force of artificially compressed air is the expelling force, and in the other case it is the expansive force of the naturally compressed gas which is associated with the oil in the rock reservoir."

And later there is this statement:

"If the pressure to which the gushing in the Spindletop and other Coastal Plain pools is due is chiefly the expansive force of gas, it follows that this force will expel only a part of the oil, and the remainder will necessarily be won by pumping or by supplying the place of natural gas by compressed air. If the oil and gas were arranged in the order of their specific gravities and sharply separated by a plane surface, the gas, being at the top, would naturally be first tapped and would escape without lifting the oil. It would force the oil out only from such wells as did not tap the reservoir in its higher portions, but lower down where the oil reached entirely to the cover, by exerting a downward pressure on the oil. The conditions theoretically existing in an oil pool are shown in the accompanying sketch, Figure 9. The well 'A' taps the top of the reservoir and yields only gas; the well 'B', on the side of the reservoir, penetrates only oil-bearing rock and the oil is forced out by the downward pressure of the overlying gas; the well 'C' penetrates the reservoir

rock below the lower limit of the oil, and hence yields only water which may or may not flow at the surface."

I should point out at this point that the Figure 9 is similar to one of the diagrams which Mr. Lewis presented as an exhibit, and which shows an accumulation of gas above oil, and the oil above the water. He goes on to say,

"These simple theoretical conditions are, however, seldom, if ever, realized in nature. It is evident that the oil and gas in the Texas-Louisiana pools are not sharply separated by a plane surface. Some of the wells on Spindletop, it is true, have yielded only gas, and certain portions of the reservoir must therefore contain only that form of hydrocarbon as shown on the diagram; but these gas wells are not all shallower than some which have yielded oil, and hence the two substances are not separated by a horizontal plane. It is probable that under the pressure existing in the oil reservoir the liquid hydrocarbons absorb a very large volume of the gaseous compounds, and it may be that the expansion of this absorbed gas is the principal agent in causing the oil to gush."

MR. RILEY: What is the name of that work again?

MR. NOLAN: It is reference 11 on page 25.

MR. RILEY: Thank you.

MR. NOLAN: Reference 12. A. Reference 12 is the same material which I have previously read and I don't care to read it again.

Q Will you then please go to the middle of page 18 again?

A Yes. The constituents of natural gas were known to be members of the same hydrocarbon family as the normally liquid hydrocarbons in crude oil. These constituents were known to be present in stock tank crude oil, and were separated by distillation. In my reading of References 2 and 3 it is clear that knowledge existed that methane, ethane and propane were found both in natural gas and crude oil.

Apparently I have read the material from Reference 2 already.

Q So that it leaves Reference 3, which was Mr. Crew's

book. A. Maybe I have quoted that. Yes, I have already referred to the table there, which shows that the natural gas contains methane, ethane and propane and the other hydrocarbon constituents present in the liquids.

Q Will you go to the bottom of page 18, the last paragraph? A. Yes. Natural gas was marketed as a commodity of value and its value listed each year in census and reference works. In my reading of References 10 and 13 I found that natural gas had value prior to 1906.

Reference 10 is from the U. S. Department of Commerce and Labour, Bureau of the Census, 1905 printing, and it gives the value of petroleum and natural gas in 1902, and it gives the columns "Value of Petroleum", "Value of Natural Gas", and it lists the total at 71 million for the petroleum and 30 million for natural gas.

Reference 13 is the U. S. Geological Survey, Department of Interior, Mineral Resources of the United States for the calendar year 1905, Government Printing office 1906, and from page 812, "Mineral Resources" and referring to "Production of Natural Gas in Canada", it says:

> "The following statistics regarding the production of natural gas in Ontario, Canada, have been furnished by the Ontario Bureau of Mines, Toronto."

And then it gives a table which I won't read, and then there is a footnote,

> "It is reported by the geological survey of Canada that during the year 1906 there was produced at Medicine Hat, Province of Alberta, Canada, gas to the value of $33,000 from a total of 12 producing gas wells. This makes the total value of gas produced in Canada in 1905 amount to $349,476."

Q Will you please go to the top of page 19? A. Natural gas and crude oil were both produced in the Province of Alberta between 1900 and 1905. Earlier production in Ontario paralleled production of oil and gas in the States.

In my reading of Reference 13 I found that by 1906 it was common knowledge that natural gas was produced in Alberta.

Definitions which specifically state that the term petroleum includes natural gas were found.

No statements were found that the term petroleum did not include natural gas but many writers use the term in its narrow sense as being synonymous with oil.

In my reading of References 2 and 4 I found it specifically stated that petroleum includes natural gas or that it occurs in gaseous form.

I do not think I will read them. They are the same references to which I have already referred and read.

Q MR. RILEY: Let me be clear about this last paragraph. That does not relate back to the preceding paragraph, as it does not relate to the Province of Ontario, the Province of Alberta, or the Dominion of Canada? A. No.

Q All right.

Q MR. NOLAN: Will you go on, please, Dr. Katz?

A 3. Literature since 1906.

There has been a gradual increase in the recognition that petroleum includes both gaseous and liquid hydrocarbons. The literature indicates that writers who are concerned with geology and production are most likely to make clear cut statements which include natural gas when speaking of petroleum.

The article by F. W. Clarke, Reference 14, printed in 1908 (probably conceived and written a year or two earlier) is outstanding in explaining the knowledge of petroleum. On page 620, he gives a table showing the paraffins from Pennsylvania Petroleum to contain methane, ethane, propane, butane, pentane, etc.

The Propane-Butane Handbook has been published since 1932 by the Western Gas. The following excerpts from the 1935 edition describe the use of the term liquefied petroleum gas as applying to propane and butane condensed from natural gas (later from refinery gases). The term LPG or LP Gas was used in the industry from the early 1930's and today is an important branch of the petroleum industry.

The Preface of the 1935 edition reads as

follows:

"The two years which have elapsed since publication of the original Handbook have recorded many changes in production and marketing of the liquefied petroleum gases. In this short time extensive distribution has begun to open in Europe, South America and other sections. Petroleum refineries have supplemented natural gasoline plants as major sources of production. Use of liquefied gases as internal combustion engine fuel in motor trucks, buses, tractors and locomotives, as well as in stationary engines, has created a new and promising outlet for the industry's products"

And it goes on to say,

"Table No. 1 on page 247 of this edition is a 13-year summary of liquefied gas distribution in the United States. For the past two years it shows increasing demand for these gases in the bottled gas and industrial fields, and a slight drop in their use for gas manufacturing."

I might read what the table says on page 247, and at page 246 it starts, "The distribution of bottled gas", an article, and then at page 247 there is a table No. 1 entitled "Liquefied Petroleum Gas Growth", 1922-1934, and it gives the years, the gallons per year, the distribution in bottled gas, industrial and miscellaneous, and gas manufacturing. And then it says that in 1934 there were 50 million gallons per year, and it says that the sale of liquefied petroleum gas was confined primarily to bottled gas business prior to 1928.

One could turn to such authorities as Doctors Sage and Lacey who conduct Project 37 for the American Petroleum Institute. A publication by them has the following introduction, and this is read from Reference 16:

"Under the usual conditions of production practice petroleum arrives at the surface of the earth in a physical state considerably different from that in which it existed in the underground reservoir. The relative rates of production and the properties of oil and gas measured at surface conditions do not constitute, in general, even a qualitative description of the fluids

"existing in the reservoir."

This article was written about a well producing from the same reservoir as Figure 7. (Paloma, California).

Q Exhibit 118? A. Which is Exhibit 118, and concerns the Paloma reservoir in California.

MR. NOLAN: There are, my lord, three additional references which are not included in the lists on pages 25 and 26 of the report.

Q The first of them is, Dr. Katz? A. Craig's Oil Finding. It is a book published in 1920, "Oil Finding."

Q By whom? A. By E. H. Cunningham Craig. This is the Second Edition and the second impression, and it was published in London, England. I am reading from page 184, Chapter 7, and the chapter is entitled "Natural Gas or Gaseous Petroleum". It reads:

"The term 'Natural Gas' is used extensively in the United States and Canada to denote the supplies of inflammable gas that are obtained by drilling and are distributed by pipe lines and marketed for power purposes and domestic use.

The term is, of course, a misnomer, but it is a useful one, serving to distinguish the gas delivered from its rock-bound reservoir by nature from the gas made in gas-works, which presumably should be labelled 'artificial gas'.

The natural gas which is of importance commercially, and which is the subject of this chapter requires, therefore, more precise definition; it is admittedly intimately connected with phenomena relating to petroleum, it is even, we may say, generically connected with liquid hydrocarbons, and the term 'gaseous petroleum' proposed by the late Sir Boverton Redwood, though possibly open to criticism on the grounds of strict scientific definition, is certainly the best term that has been suggested, and serves to explain itself and to fill the want of a suitable name under which the origin, occurrence, and utilization of this valuable produce can be discussed.

It is true that in using the term 'gaseous petro-

"leum' it may be held that a great question has been begged, but the evidence, as will be seen, is so conclusive that there is a connection between liquid petroleum and the more important supplies of inflammable gas that an apology is hardly necessary.

Seeing that it is only in North America that gaseous petroleum is deliberately drilled for, distributed and marketed on a large scale, it may not be recognized by every one what a very valuable product this gas is, and what a very large part it plays in industrial life. The continent of North America furnishes more than two-thirds of the world's supply of liquid petroleum, yet the value of the gaseous petroleum won and utilized in a year is far in excess of that of the oil. The utilization of gaseous petroleum has increased by leaps and bounds in recent years, prevention of waste has been recognized as a national necessity, and the search for new gas fields had become as important and as keenly prosecuted as the search for new oil-bearing territory."

On page 198, under the chapter "Natural Gas or Gaseous Petroleum", we find:

"All oil contains gas in greater or less quantity, chiefly methane, but also ethane, the gaseous olefins, etc. This gas may be considered to be combined with, dissolved in or occluded in, the oil; it is really potential gas, and does not exist as gas till release of pressure allows it to expand and disengage itself from the liquid prison. As has been shown, it is probably the release of pressure that has caused such a re-adjustment among the mixed hydrocarbons as to allow of methane and other gaseous compounds being evolved. Everywhere round a body of oil where egress is not prevented, gas will be found filling all porous strata and often exerting great pressure."

The next book to which I wish to refer is a booklet entitled "Petroleum", and this books says that it is "The Story of an American Industry", and it was prepared and published by the American Petroleum

Institute, and the copyright is for 1949. I would like to read from page 1, chapter 1.

"What is Petroleum? Petroleum is one of the oldest natural products used by man, but so secreted is this invaluable gift of Mother Nature in the dark recesses of earth's great storehouse that no one is yet certain whence petroleum came, what its origin, or how extensive the supply. Although we know a great deal about it, petroleum lore is ever changing. Every generation, every decade, indeed every day, adds to our knowledge, disclosing errors or omissions in our conclusions of yesterday."

Then there is a sub-title "Petroleum, A Complex Substance." And this reads,

"Petroleum is found in solid, liquid and gaseous states. It is a complex mixture of hydrocarbons and their sulphur, nitrogen and oxygen compounds. The individual compounds vary widely in their characteristics, and petroleums from different fields vary widely in their properties bedause of the nature and proportions of the compounds present."

And then there is another sub-title, "Crude Oil", and it reads:

"Liquid petroleum is usually termed 'crude oil', but frequently is called just 'crude'. It is the raw material from which so many useful products are made at petroleum refineries. It is sometimes thick like tar, sometimes viscous and heavy like syrup, again light and volatile like gasoline. In colour it ranges from almost black, yellow or brown, through shades of red and green to water clear. Oil is commonly classified as paraffin-base or asphalt-base, from the nature of the residue left after distillation. If it contains both paraffin and asphalt, it is known as mixed-base crude."

Then there is another sub-title "Found in the Earth", and under that reads:

"Petroleum is found deep beneath the surface of the earth. It is usually, but not invariably, found in sedimentary rocks that were laid down in ancient seas, and is frequently associated with salt water. It is a non-metallic mineral, and is principally obtained from drilled wells, although some is mined. Its name is derived

"from the Latin words 'petro', rock, and 'oleum', oil; but the meaning has been expanded to include those natural waxes, oils, and gases of common origin and usual association."

I would like to refer also, briefly, to page 66, which is headed "Transportation" and the sub-heading "Natural Gas Pipe Lines".

"Although liquid petroleum may move to market by one or more of the methods described, natural gas moves only by pipe lines. A converging system of smaller lines collects natural gas from the wells in a field and delivers it first to an extraction plant where lighter hydrocarbons, such as propane, butane, pentane, etc., are removed from it in the form of casinghead gasoline. These valuable products are separately processed into liquefied petroleum gas (or LPG, as it is commonly called), or are sent to refineries for blending into high-quality gasoline."

And the last one is Information Circular 7519 of the U. S. Bureau of Mines, dated May, 1949, and entitled "Questions and Answers on Propane and Butane Fuels." In the foreword it says:

"The following questions and answers were prepared principally to supply information in answer to general inquiries received by the Bureau from those contemplating the use of propane and butane fuels."

On the next page,

"What are propane and butane fuels? Propane and butane fuels are petroleum products somewhat lighter in weight and much more readily gasified than gasoline. Such a fuel is often called 'Liquefied petroleum gas', or 'LP-gas'; at ordinary atmospheric temperatures and pressures the fuel exists as a gas, but when subjected to pressure it liquefies readily."

Now, the next paragraph starts as follows:

"Liquefied petroleum gases occur in the earth with natural gas and crude oil and are obtained from them by various methods."

Q Will you go now to page 21, to the first heading, please? A. Yes.

4. Usage by the Writer

The writer has reviewed his articles dealing with oil and gas to find the usage of the term "petroleum". The following examples indicate definitely that the broader meaning was commonly used. In the article on Retrograde Condensation in 1940 (Reference 17) a condensate well producing from a gas cap was described under the title "Significance of Retrograde Condensation in the Petroleum Industry."

And this was the paragraph in that paper,

> "The behavior of petroleum hydrocarbons in the retrograde regions has become of prime interest in the withdrawing of petroleum from the earth and does have an influence on several processing operations."

Retrograde condensation is a phenomenon of the gas phase and can only occur in petroleum reservoirs when methane and ethane are primary constituents of the mixture.

In 1941 an article on the Density of Natural Gases states in part (Reference 18):

> "The densities of natural gases are necessary in many engineering computations in petroleum production and utilization. Gas reserves, changes in reservoir pressure, gradients in gas wells, metering of gases, pipeline flow, and compression of gases are typical problems requiring the density of the gas."

In 1943 an article on Vapor-Liquid Equilibria of Natural Gas-Crude Oil Systems says in part (Reference 19):

> "A knowledge of the physical behaviour of naturally occurring hydrocarbon mixtures is fundamental to the treatment of many problems in the production, transportation and refining of petroleum. The recent discoveries of pools having formation pressures up to 7500 lb. per sq. in. and higher, and the development of full-scale equipment to operate at pressures of 5000 lb. per sq. in. or more have greatly increased the need for knowledge of the composition, temperature, pressure and density relationships of co-existing vapor and liquid hydrocarbon phases."

In a radio address in 1945, the writer

said in part (Reference 20):

"Natural gas is composed of the hydrocarbons methane, ethane and propane. These compounds belong to the same family as gasoline, kerosene and fuel oils refined from crude oil. Since natural gas and these liquid oils belong to one family, it is natural to find them together in petroleum reservoirs.

Porous sandstones or limestones in the earth's crust form the reservoirs in which oil and gas accumulate. In general the reservoirs near the earth's surface are found to contain oil or gas under low pressure while deep reservoirs contain either dry natural gas or crude oil with a small amount of dissolved natural gas. Dry natural gas is the term used to indicate that no liquid will separate from the gas as it is produced from the well. Crude oil found at 3000 feet below the earth's surface might contain 400 cu. ft. of dissolved gas per barrel of crude oil, which gas vaporizes as the oil is produced.

Deep petroleum reservoirs are usually found to contain either wet natural gas or crude oil with a large amount of natural gas dissolved in the oil in the reservoir. Wet natural gas yields a liquid condensate similar to gasoline as it is produced from the well."

In the Section I of book "Natural Gasoline and the Volatile Hydrocarbons (Reference 21), the first chapter dealing with methane, ethane, etc. is titled "Behaviour of Petroleum Hydrocarbons."

I found also a statement of interest on page 7 of this booklet, and it is a concluding sentence to a rather lengthy discussion on language used in describing vapors and liquids under the title "Retrograde Condensation", and at the conclusion of that language the following statement is made:

"These definitions agreed with common usage in the petroleum industry and are etymologically correct."

In the Hanlon Award Address, given before the Natural Gasoline Association of America on April 22

of this year, the writer said in part (Reference 22):

> "Let us turn now to our own industry - the recovery of volatile hydrocarbons from natural gas - an important portion of the Petroleum Industry. A fund of scientific knowledge was accumulated for us early but in many cases it was not readily available at the time it was needed. I would like to review for you the source of some of this knowledge and the role of the engineer in utilizing it."

The writer had not heard of this case at the time of the address.

These examples could be continued, but they would only verify that one writing concerning crude oil and natural gas, whether or not the gas was associated with crude oil, would use the term "petroleum" to embrace all the hydrocarbons contained in porous rock in the earth.

5. Conclusions

Persons dealing with the production of crude oil and natural gas adopted the term "petroleum" as a single word to include all hydrocarbons in the porous reservoir and issuing from wells. Some had made specific statements to that effect prior to 1906 and others limited their usage of "petroleum" to titles for material on natural gas as well as crude oil. It was common knowledge that crude oil and natural gas had a common origin, were intimately associated by solution of gas in the liquid, and that several hydrocarbon constituents were common to crude oil and natural gas. Today, most authorities accept the inclusive nature of the term, "petroleum", by definition and usage.

The term "all petroleum" today includes natural gas as well as crude oil and enjoyed that meaning prior to 1906.

MR. NOLAN: That concludes my examination-in-chief of Dr. Katz, my lord.

THE COURT: I suppose if we adjourn for one hour, that will be sufficient, and everybody will be satisfied?

MR. NOLAN: Yes, my lord.

MR. STEER: Yes, my lord.

THE COURT: Very well, Court will stand adjourned until 1.30.

Afternoon Session,
November 23, 1950.

THE COURT: All right, Mr. Steer.
MR. HELMAN: Before Mr. Steer starts to cross-examine this witness, I have one question that I want to ask him, and perhaps it will break up into two or three.
THE COURT: All right.

DONALD L. KATZ, recalled, already sworn, examined by Mr. Helman, testified as follows:-

Q Dr. Katz, I want to revert back again to the first part of your testimony where you were dealing with the physical aspects of oil and gas, and I wanted to read to you a sentence from the judgment of the Privy Council in the Barnard-Argue-Roth-Stearns Oil and Gas Company Limited v. Farquharson, in 1912 Appeal Cases, page 864, and I would like your comments on that sentence, having regard to the evidence that you have given us. Now, I am reading at page 869, at the bottom of the page, and it is there stated as follows:

> "It is clearly established by the evidence that this gas is not volatilized rock oil, nor is rock oil condensed natural gas. The gas is not an exhalation of the oil, nor is it held in solution by the oil to any considerable extent."

Now, will you please comment on that? The case was decided in 1912, and perhaps I will just put the case in front of you, so that you can visualize the passage I have read. It is right at the bottom of the page, Dr. Katz. A. With regard to the statement "this gas is not volatilized rock oil", they could not have been referring to the type of gas that I was referring to in Exhibits 109, 112 or 113, because that gas certainly would have been called volatilized rock oil; and the statement "nor is rock oil condensed natural gas", they could not have been referring to the type of liquid hydrocarbon which is produced today, which is called condensate or naphtha, and which I have described in Exhibit 118; "the gas is not an exhalation of the oil, nor is it held in solution by the oil to any considerable extent", that statement, of

course, is not true, unless you are referring to atmospheric pressure or thereabouts.

Q So that the scientific testimony which you have given us shows that those expressions and the evidence which was given in that case is not in accord with the scientific views as held today?

A That is right.

CROSS-EXAMINATION BY MR. STEER:

Q You, Dr. Katz, I understand, are among the most highly trained engineers in the United States?

A Well, I have my Doctor's degree in the field of chemical engineering.

Q What is that again? A. I have my Doctor's degree in the field of chemical engineering.

Q Yes? A. There are many others with that training.

Q Yes, and your experience, I believe, goes back to the year 1933? A. That is right.

Q And the passage to which you just referred in a judgment of our highest Court at that time was the, the speech was delivered in 1912? A. I understand that.

Q You, of course, are absolutely unaware of the situation as it existed in 1912 except to the extent that you have told us today that you gathered from your reading, that is correct?. A. That is right.

Q And are you prepared to tell us what goes on underneath the surface of the earth which brings about the existence of these substances which we know as oil and natural gas? A. No, I could not tell you about the origin. I just know certain facts about their occurrence.

Q I know. And you can bore through strata and you can determine in what kind of beds, now rock, and originally probably organic matter, these substances originated, is that right? A. Now, I do not know that it is known whence they came. I can find them. Where they came from I do not believe that people know in any specific degree. They have general ideas.

Q And you are not prepared to say that natural gas that exists underneath the surface of the earth is an exhalation of rock oil, are you? A. Well, some of it I know is and some of it I do not know. If it is found in the dry fields originally, which we call a dry gas field.

Q Yes? A. We do not know.
Q Now, we have got some 50 or 60 dry gas fields or wells in this Province of Alberta, have we not?
A Well, you have got a goodly number.
Q Yes. And just how that natural gas originated that became dissolved in the oil you do not know, and nobody knows? A. Well, the exact procedure, no, but we do have reason to believe that the natural gas that is dissolved in the oil had a similar origin to the natural gas that is found as free gas, as both of them are similar to the material that exists in the reservoir as a liquid.
Q Quite so. So that from that evidence you cannot say that rock oil, as we might call it, is condensed natural gas, can you? A. Not in the general expression.
Q What do you mean by "not in the general expression"? In any expression? A. Well, you can take what you call a mineral oil, it is a liquid product that has been condensed from the gas phase.
Q Quite so. You can take what comes out of a well drilled in a combined gas and oil field, and you can take the product that comes out of the bore hole, and you can subject it to varying degrees of temperature and pressure, and you can get varying substances as the result, that is right? A. That is right.
Q Yes. That is what I understood your technical evidence to be. And your technical evidence, I think I may take it, Dr. Katz, does not differ in any degree from that which was given by Mr. Gustafson?
A I do not think it differs.
Q No. You show us how you take the product that issues in its natural state from the bore hole of a well and you take it through all those varying processes at different temperatures and pressures designed to get the result that the owner of that product wanted, isn't that right? A. Well, it is designed to separate the material in the products, yes.
Q It is designed to get the product which the owner of the original product wanted to get, now isn't that true? A. Well, it is one of the steps towards what he wants, yes. It is one of the steps, the separation.
Q Now, look, we get, from the treatment of the product that comes out of the well mouth, we get crude oil in the last analysis on these diagrams of yours, and in the interval we get butane and we get pentane,

and is there some other liquid we get in there? I thought I remembered three green blots.

MR. NOLAN: Propane.

Q MR. STEER: Propane, butane and pentane, and then we get dry gas, don't we? A. Yes.

Q Well, suppose that the owner of this product that comes from the earth wants to get a very rich wet gas and he wants to get the remaining crude oil, he simply cuts out two or three of those processes that you have described, doesn't he? A. Well. . .

Q He operates it at the temperature and pressure which would leave the butane, the propane and the pentane in the stream of gas? A. If he wanted what you call wet gas he would try to get most of the hydrocarbons into the gaseous phase.

Q And it is only in that sense that you can vary temperature and pressure and get liquid from this gas that you are saving that oil is condensed natural gas, is that right? A. I do not believe that was right. I was thinking more of the separator operation of a condensate field such as Turner Valley. The naphtha in that separator is condensed natural gas.

Q Well, you are not telling us, I hope, that the oil that is bored underneath the surface of the earth is condensed natural gas? A. No, not when it is liquid in the earth, no.

Q No. Then are you telling us that the natural gas which exists in the gas cap and the liquid that exists underneath the gas cap are two different substances?

A Well, they are two different materials, each of which is composed of a large number of constituents, and the same constituents in different concentrations.

Q Are you saying that they are the same or different substances? A. They are different in the sense that one is a gas phase and the other is a liquid phase.

Q Let us see what happens in the Viking-Kinsella field. You are familiar with that? A. Generally, yes.

Q A dry gas field, of which there are, as you say, many in the Province? A. Yes.

Q A man drills a hole there and he gets gas and that gas is piped into the City of Edmonton and burned as an article of commerce, am I right in that? A. Yes.

Q And then we go down to Leduc and they drill a hole there and they get oil mingled with gas at the surface, atmospheric temperature and pressure, am I right?

Q Well, they get oil and gas mingled. They are not at

atmospheric pressure normally at the surface, but the liquid results, it is liquid at atmospheric pressure, and the gas is conducted away at a pressure above atmospheric.

Q Now, I am not talking at the moment about that. I thought when they issued from the bore hole that they were at atmospheric pressure and temperature? I do not see how you can get away from that result, but perhaps you can tell us? A. If the material issuing from the earth is at atmospheric pressure the well would not flow. I mean, it is normally taken to a separator with some small back pressure, There must be a pressure at the separator in order to pour it into a stock tank. There is a small pressure on it.

Q There is a back pressure on it? A. Yes.

Q And there is a pressure behind the substance that is coming out of the hole, that comes out of the hole, is that right? A. Yes.

Q And if you want to get it anywhere else you have got to apply pressure to it, haven't you? A. Well, normally you permit the pressure that was on the fluids as they come from the earth to transport it first through the separation system and the tank, and, secondly, send the gas on the way to an extraction plant.

Q All right. Well, then, eventually you pass that substance through various pieces of equipment and you get a dry natural gas of the same character largely as you get in the Viking-Kinsella field, am I right in that?

A Well, it is wetter than the gas in the Viking-Kinsella field, but it is of the same character.

Q When it passes through this Leduc conservation plant, is it still wetter? A. You mean the residue gas or dry gas?

Q Yes? A. The dry gas that leaves the conservation plant is drier, in the sense, probably, that it contains less of the hydrocarbons than the Viking-Kinsella gas.

Q So that the Viking-Kinsella gas contains a negligible proportion of the liquids for the purpose for which it is intended, namely, supplying gas to the citizens of Edmonton, is that right? A. The Viking-Kinsella gas contains low concentrations of propane and butane, but it does have some of those.

Q And the gas that comes from the gas conservation plant at Leduc is still drier? A. Now, I haven't examined to say whether it is drier.

Q You gave us that opinion a minute ago? A. The one I have here is drier.
Q They are approximately the same, shall we say that?
A Yes.
Q And both of those gases are supplying, or are used as articles of commerce, the one in Edmonton and the other in Calgary, to the inhabitants of those two cities for their industrial and domestic purposes, is that right? A. These dry gases are articles of commerce, yes.
Q And then in the course of the production of this well you have shown us in your diagram, we get a substance known as crude oil, is that right? A. Yes.
Q And that is another article of commerce, isn't it?
A Yes, the crude oil in the stock tank is ready.
Q And both of these substances, natural gas and crude oil, have weight, haven't they? A. Yes, they have weight.
Q And they have volume proportionately, in varying proportions to their weights? A. Yes, the crude oil has the volume.
Q And they are used for entirely different purposes?
A Well, now . . .
Q Perhaps not? A. They are both used as a fuel?
Q Quite so. They are both used as a fuel? A. That is right.
Q But the main use of this dry gas is for the heating of houses and industrial uses, and the main use of crude oil is to manufacture gasoline, lubricating oils, and other such substances which are used in an entirely different way from the natural gas. A. Well, one primary component of crude oil is fuel oil, and it is in direct competition with natural gas. I mean, many people use oil for heating their homes.
Q Oh, yes, we understand that. A. Yes.
Q We do not use it up here. When did you first come to Canada, 1944? A. No, I have forgotten the date. I believe it was in 1942, or '3 that I came to Canada.
Q I see. You came to Alberta for the purpose of assisting in the investigation of the Natural Gas Utilities Board? A. Yes.
Q Was that your first visit? A. I believe it was, yes.
Q I see. A. I contacted the late Dr. Boomer, and I am not positive whether it was with regard to the Conservation Board matters or the Natural Gas Utilities Board.

Q And since then you have been here very frequently?
A Several times.
Q And when you were engaged with regard to this litigation, you were told what the issue was, namely, whether or not petroleum included natural gas in the early part of this century, were you? A. Well, I was aware that there was a document that had the terms "all coal, petroleum and valuable stone", and that it was as of the date of 1906, thereabouts, yes.
Q And so you began to investigate that problem, as to the meaning of petroleum as of 1906? A. The reading I did at that particular time was in that connection, yes.
Q Quite so. And as I look over your list of authorities, I see no single reference to any Canadian authority, that is right? A. I do not recall any.
Q Take a look, please, and let me know. There is not a single Canadian authority in that list on page 25 of your exhibit 108, Dr. Katz. Will you take a look at it, Doctor? A. I am sure that none of the books was published in Canada.
Q And will you say that none of the books deals with the Canadian situation? A. Well, I was not aware that the Canadian situation was necessarily different than the English or the American.
Q Now, this is purely an Alberta problem, to be decided on under our Alberta law, that is correct? A. Well, it will be decided under Alberta law, I am sure.
Q And it is a purely Alberta problem as to the meaning under Alberta laws of this word as used in a document dated 1906? A. Well, I am not aware that you intend to use a distinctive language here as compared to the language we use in the United States.
Q I see. Well, suppose we do? Suppose the evidence is that we use a different language, and suppose the word "petroleum" has a different meaning in Alberta than the meaning that your technologists seek to give it in the United States, then all your evidence falls to the ground, does it not? A. Well, that is for my lordship to state, I believe.
Q You won't admit that? I am asking you to assume that from an examination of the same kind of document as you have referred to in Part II of this brief of yours, it is demonstrated that the word "petroleum" does not have the meaning which you in the box expressed the opinion that it ought to have. Now, make that assumption, and then I ask you, does not

your evidence fall to the ground? A. Well, the first thing that I know, as I understand it, which conflicts with what you are saying, is that the man who prepared this form, or this contract in question, was from Winnipeg, and this is a form from Winnipeg, so that I do not see how you can have it as exclusively in the language of Alberta. I just do not understand it. Of course, you are dealing with matters with which I am not familiar here.

Q You have gone far afield from my question, Doctor. You prefer not to answer it, I take it? A. I believe I do not understand it.

Q You have given us in the books today a meaning for the word "petroleum" as you understand it, is that right?

A Yes.

Q Now, you assume that in the Province of Alberta in 1906 and in the Province of Alberta today, the word "petroleum" has a meaning different from that which you have expressed, then I ask you, is your evidence in this case of any value? A. Well, I assume you use the English language in Alberta as we use it in the United States and England.

Q And you still prefer not to answer my question?

A Well, I am afraid I do not understand it.

Q Well, I see. Well, perhaps we will leave it at that. You have, really, in this brief of yours, reversed the order, Dr. Katz. As I was reading the first part of it, it struck me that you had assumed that petroleum included natural gas under all circumstances, and that is the correct view to take of this document you have filed, isn't it? A. Well, I have showed you that in my normal writings prior to the time I knew of this case, I used it in this manner, and you would not expect me to change my manner of usage when I wrote this document.

Q Now, look, you have misunderstood me, Dr. Katz. I am asking you whether in reading the first part of this document, Exhibit 108, you have taken for granted throughout that petroleum included natural gas? A. Yes, I believe that is right.

Q And you realize, of course, that the problem before the Court today is, Does petroleum include natural gas?

A Well, not with regard to my writing, but with regard to other documents.

Q Yes. With regard to the evidence that may be submitted to the Court, that is the problem with which the Court is faced, based on the evidence, including

your evidence, that is right, isn't it? A. Yes, but it is with regard to a particular document that the problem is to be decided.

Q Well, having assumed that your answer to the Court's question is the correct answer, then I understand that in the second part of your Exhibit 108, you proceed to give the evidence by which you form your own opinion that petroleum is inclusive of natural gas, is that the way this thing developed? A. Well, the second part is two portions. One of them is the way I have been using it, and the other is what I found in the literature concerning its use.

Q And that is the evidence that you want this Court to take as supporting your opinion which is expressed as a fact in the first part of your Exhibit 108? A. Well, it is a fact that I have been using it in that manner in other publications, and there would be no reason for me to change my language for this particular case.

Q Well, I suggest, Dr. Katz, that inasmuch as there has been some criticism here of the use of the word "petroleum" as liquid only, and the use of the word "petroleum" as including natural gas, I would suggest that your document should have been drawn without stating as a fact that petroleum includes natural gas, which is what you did in the first part of your document, is that not correct? A. Well, I have used the expression sometimes. I have used there expressions which are normal for expressing the things I have expressed.

Q Yes. Have you any knowledge of the extent of the Canadian literature on these questions of petroleum and natural gas? A. Well, not particularly, other than the literature that I would have available.

Q I see. And you did not have a single Canadian book available? A. Oh, I had Canadian books.

Q Of what nature? A. Well, I remember one away back in 1865, or something, and the title of it was "Oil in Canada", and I could not find any clear cut statement which would be of any value in this case, so that I did not refer to it.

Q So that you did not think it was worthwhile to refer to that precious volume that is to be had in some University libraries in this country? You did not think it worth while to refer to it? A. No, as there are lots of others that I did not refer to.

Q I see. And you are aware, I take it, of a book called "The Science of Petroleum" that was published in 1938?

A I am the author of one of the articles in it.

Q And I did not see that you included in your list of publications the article that you had written in Volume 5 of 1950? A. You mean the article with regard to the high pressure vapour liquid equilibrium?

Q And it has retrograde in it? A. I believe that is the title. I just received it a day or two before we came up here.

Q Now, I wonder if you would agree with this, this is a sentence which appears in this book in which you have written articles.

"To be sure in each case which product may be concerned, it must be known with certainty the province and the country from which the product comes."

Do you agree with that? A. Well, I would agree in certain things, but I am not necessarily sure that that refers to the English speaking countries. The author is from Vienna, and, of course, if you are talking about the German language, or the Austrian usage, and if you are talking about the American usage, it is a different thing. It may be the Spanish usage. And obviously the terms may be mixed up, I realize that.

Q Well, this is 1938? A. And the author is from Vienna.

Q And the author is from Vienna. And he is considered to be sufficient of an authority to have his article published in the same volume as your own? A. That is right.

Q "The industry" - I am just going to read this to you -

"The industry of the production of crude oil and the distillation of mineral oil products which is spread over the whole world, naturally created different definitions for the various products according to their historical development whereby in some countries the same terms are used for different products."

I suppose you would agree with that, Dr. Katz? A. I am not quite sure what that last statement means, but I think it sounds all right.

Q Well, I am going to suggest to you that a large part of this large publication, which consists of four volumes like this (indicating) plus the adaitional one, isn't that right? A. Yes, that is right.

Q I am going to suggest to you that a large part of it has to do with nomenclature, what we ought to call these different substances? A. Well, I would say that they do call them these things in the articles,

but I do not think the main part of the volume is regarding nomenclature. Each person would use his own language at the various points.

Q Yes? A. In my article I did not go through a lot of things that I required to say what the language was. I simply used it that way.

Q Quite so? A. And my article was on natural gasoline, so that I talked about natural gasoline.

Q Yes. I notice here that the first fifteen pages of this volume are taken up with this question of nomenclature, and they emphasize the idea that different products are called by different names in different parts of the world. You have read it? A. Yes, I realize that. For example, petrol is used, as I understand, in England for gasoline, and we use the term motor fuel. And last night, I believe, the article in the paper said "gas", and we looked and found out it was not natural gas but it was gasoline that they were talking about.

Q Yes. Now, they go on to say here that in each case,

> "To be sure in each case which product may be concerned, it must be known with certainty the province and the country from which the product comes."

And you say that might apply as between Austria and the United States, but it would not apply as between the United States and Canada? A. Well, generally speaking, I would say that we spoke the same language.

Q Yes. Well, now, suppose we do not speak the same language Dr. Katz, and suppose a word in the English language by custom in Alberta has acquired a certain meaning different from the meaning given to that word in the United States, what meaning are we going to give it in Alberta? We have got to give it the Alberta meaning, haven't we? A. Well, I doubt if there is, if it can be shown that there is a meaning . . .

Q Well, Doctor, I would like you to answer the question, if you would. If it has a different meaning here than it has in the United States, should not our courts give effect to the Alberta meaning? You won't answer that? A. Well, I doubt the assumption involved, and if I doubt the assumption there is no reason for answering the question.

Q Please make the assumption, Dr. Katz. Please make the assumption and answer the question? A. I believe if the assumption were a fact we would not be here today.

Q And that is your answer? A. Yes.
Q I cannot get an answer "yes" or "no" to that simple question, eh? Very well. I am reading again from this same article,
"The raw material, namely, the crude oil, is known in the United States as 'crude oil' or 'petroleum'."
Do you agree with that? A. Yes, it has been called crude oil.
Q "The raw material, namely, the crude oil, is known in the United States as 'crude oil' or 'petroleum'".
A Is this the gentleman from Vienna?
Q That is right. Now, then, before you ventured your opinion in Exhibit 108, did you look at any of our Canadian or Alberta law, and, if so, what? A. No, I did not look up any Canadian or Alberta law.
Q You did not go back to look at the Statutes of Canada which controlled petroleum and natural gas up to 1930, is that right? A. I did not.
Q And you did not look at any of the regulations dealing with natural gas and petroleum in those years? A. I did not look at them in connection with this case.
Q Yes. And, consequently, you did not look at any of the statutory provisions or regulations of the Province of Alberta from 1930 on? A. No, I have not looked at them in connection with this case.
Q Yes? A. I have looked at them on other occasions, but not in connection with this case.
Q And if you had thought that there was anything significant about them, I suppose you would have gone and studied them? A. I have looked at them for other purposes.
Q You just did not think there was anything significant about them? A. Well, I did not look at the regulatory measures in any of the States either.
Q I see. And have you looked at any of our lease forms?
A No, I have not.
Q Have you looked at any of our conveyancing from the beginning of the century on? A. No, I have not.
Q Do you think those would be pretty good sources of material to go to for the purpose of determining the meaning we give to a word which is used in those documents? A. Well, I do not know if they would or not.
Q I see. Now, I will ask you, Dr. Katz, if you will assume this - you are reluctant to make assumptions, but perhaps you would not mind making this one. We will assume that the test which the Court is going

to apply to this problem is, what is the meaning, in common speech, of the word "petroleum" in Alberta among men who are in the mining business, seeking for oil or gas, among business people dealing with oil or gas, and among men who desire to sell or buy interests in oil or gas. Now, we will assume that that is the test. Does your evidence as to the meaning among technologists of the word "petroleum" have any bearing, even if that is the modern meaning?

A Well, all my evidence was not with regard to technologists. One or two of the recent references were in the language of the common man, and were so written.

Q One or two of the references of your United States' authorities. I am coming to those, some of them, Dr. Katz, in a moment. Do you know a decision of Chief Justice White in the United States in a case called Indiana Oil and something - I am sorry, it is Ohio Oil against State of Indiana. Do you know that decision? A. I don't believe I have seen it.

Q Here is a sentence which is . . .

MR. HELMAN: What is the citation of it?

MR. STEER: . . . which is pretty pungent. It is in 177 United States Supreme Court, page 190, and the passage I am referring to is at page 210.

Q Are there cases of divided title of oil and gas in the United States? A. Yes, there have been cases.

Q Many of them? A. Well, I do not know how many cases there have been. I know there have been many pieces of land in which there have been divided titles between oil and gas rights.

Q And how many pieces of litigation, you do not know?

A No. I know there have been several.

Q A lot? Many more than several, I suggest to you?

A Well, there could have been.

Q I suggest one of them was in which Chief Justice White has this to say,

> "On the other hand, as to gas and oil, the surface proprietors within the gas field all have the right to reduce to possession the gas and oil beneath."

Then he goes on to say,

> "They could not be absolutely deprived of this right which belongs to them without a taking of private property."

You have got your constitutional provision which

protects property rights. And then he goes on,

> "But there is a co-equal right in them all to take from a common source of supply the two substances which in the nature of the things are united, though separate."

And I ask you to say whether or not that is an accurate description. . .

MR. HELMAN: What is the date of that?

Q MR. STEER: ...of petroleum and natural gas?

10 A Well, he might have understood it, Mr. Steer, from what I heard, I wouldn't know.

MR. HELMAN: What is the date of it?

MR. STEER: It is called "Oil Fields of Texas, Louisiana, Gulf Coastal Plain", Dr. Katz, and which of your documents is that? A. That is Reference 11.

Q Reference 11? A. Yes.

Q I wanted to look at that for a minute with you, Dr. Katz. Reference 11, on page 25 of Exhibit 108.

20 This is the paragraph,

> "These simple theoretical conditions are, however, seldom, if ever, realized in nature. It is evidence that the oil and gas in the Texas-Louisiana pools are not sharply separated by a plane surface. Some of the wells on Spindletop, it is true, have yielded only gas."

That, I take it, is an area that resembles Viking-Kinsella, and our other dry gas fields, am I right?

30 A Not the Spindletop area, but the gas may have resembled your gas.

Q But this says that some of the wells on Spindletop, it is true, have yielded only gas. A. The Spindletop is also known for its crude oil production too.

Q Yes, but what I am asking you is whether the Spindletop wells which produced only gas resembled the dry gas that we have in this province. Will you answer that?

A Yes.

Q They do? A. The dry gas would be similar to

40 your dry gas, yes.

Q Yes. "Some of the wells on Spindletop, it is true, have yielded only gas, and certain portions of the reservoir must, therefore, contain only that form of hydrocarbon." Is that right? A. That is right.

Q Yes. I wonder why they did not use the word "petroleum" there? A. Well, the hydrocarbons is another name we use for the substances in petroleum.

Q "Certain portions of the reservoir must, therefore, contain only that form of hydrocarbon as shown on the diagram; but these gas wells are not all shallower than some which have yielded oil and hence the two substances are not separated by a horizontal plane."

Now, whoever wrote that regarded oil and natural gas as two separate substances, didn't he? A. Well, he was uncertain as to whether they were or not, to my mind.

Q Well, I will read it again:

"But these gas wells are not all shallower than some which have yielded oil, and, hence, the two substances."

What does that mean? A. It means oil and gas. Would you read the remainder of that while you are at it, because it clarifies the question you are asking me.

Q ". . . the two substances are not separated by a horizontal plane".

I am going to read the rest of it.

"It is probable that under the pressure existing in the oil reservoir, the liquid hydrocarbons . . ."

That is an expression for which you would substitute "petroleum", am I right? A. Or "crude oil".

Q Or crude oil. Indifferently, it does not matter, Doctor? That is right? Is that right? A. Well, I used several names for these things.

Q Crude oil, (1); petroleum (2); hydrocarbons (3); anything else? A. Well, I called it "reservoir crude oil" when it was in the reservoir.

Q Oh, yes, I see. You did.

"It is probable that under the pressure existing in the oil reservoir, the liquid hydrocarbons absorb a very large volume of the gaseous compounds, and it may be that the expansion of this absorbed gas is the principal agent in causing the oil to gush."

I would say the man who wrote that thought of oil and gas as two separate substances, wouldn't you? A. No, I would not.

Q I would also say that the man who wrote that thought that a comprehensive term that would include oil and gas was "hydrocarbons", would you agree with that?

A Well, he used the term "hydrocarbons", I believe,

with that inference, yes.

Q Now, among the Canadian literature is a report made in 1914 by Frederick G. Clapp, and others, for the Department of Mines in Ottawa. Now, I suppose, perhaps, you have never seen this report, Dr. Katz?

A I do not think I have.

Q I would like to call your attention to a passage in it and ask you what you have to say about it. It is a passage at the bottom of page 2, which reads this way,

> "Petroleum (from the Latin meaning rock oil) is the best known of the various natural hydrocarbons of the bitumen series. It is the erdol or steinol of the Germans and the petrole of the French and other nations of Southern Europe. The relation of petroleum and natural gas to allied bitumens is indicated in the following classification",

and then he gives the form of substance, and he gives the English word, and he gives the corresponding German, French and Spanish, and I will just read the English ones,

> "Solid, asphaltum; semi-fluid, maltha; fluid, petroleum and naphtha; gaseous, natural gas."

I suggest to you, Dr. Katz, that the man who wrote that regarded natural hydrocarbons of the bitumen family as a comprehensive term that would include all these substances. Would you agree with that?

A They used the term "bitumen" to include all the substances that we have included when we use "petroleum".

Q That you have come to include when you say "petroleum", the natural hydrocarbons of the bitumen series. And then he gives various natural hydrocarbons, and he uses "petroleum" as one of them, and he uses "natural gas" as another, is that right? A. That is right.

Q And he regards them as two different substances?

A Well, he uses the term "petroleum" for the liquid portion of it, and the term "natural gas" for the gaseous portion.

Q MR. STEER: This volume I read from, I think I said was published in 1914, did I?

MR. NOLAN: Yes.

MR. STEER: And I said it was the Frederic G. Clapp report?

MR. NOLAN: Yes.

Q MR. STEER: Then you gave us a photostatic

copy from Redwood's book of 1886, Dr. Katz. That is from his 1886 book? A. It is the one which is in the lecture form.

Q And is that in the book? A. It is my understanding that it is in the book form, but it is published as lecture form where he uses the first person.

Q I see. I was struck by this passage,

> "In considering historically the subject of these lectures, it will be convenient to accept the name petroleum (which is obviously derived from the two Latin words, petra, rock, and oleum, oil) in its broadest signification, as embracing not only the liquid oils which flow from the earth in various localities, but also the solid or semi-solid forms as well as the gaseous forms."

Now, the thing that I want to call your attention to there is that the author says,-

> "it will be convenient to accept"

that meaning of the word "petroleum", and I am going to suggest to you that that is the definition of the word "petroleum" which this author wants you to take as being his meaning when he refers to the word "petroleum", is that right? A. Yes, I would say it was, and I feel that back in 1886 when a person thought of the derivation of the word, and he uses this enlarged meaning, that he had to have some expression.

Q I would think that probably he would. And it is very much like our Legislature when in two or three places they use "petroleum, in addition to its ordinary meaning shall include" certain other substances.

A Well, my answer to that is that Sir Cunningham Craig, in his reference that I read to you, that he received his definition from Sir Boverton Redwood, and apparently it was received with consideration.

Q He may have been relying on this very first paragraph, which is what Sir Boverton Redwood said was his definition. He said it would be convenient to accept it. Now, Cunningham Craig, you were relying on that paragraph from him. I am sorry, I mean Cunningham Craig may have been relying on that paragraph, may he not?

A I have never seen the particular booklet for a number of years, so that I did not rely on it in that at all.

Q Well, Cunningham Craig may have? A. He said he did. He does not refer to this particular article,

but he says that he relied on Sir Boverton Redwood's definition.

Q Yes. And then he goes on to say,

"In addition, the similar products obtained by the distillation of boghead coal, bituminous shales, brown coal and peat."

Do you think that petroleum is got from the distillation of boghead coal, bituminous shales, brown coal and peat? A. No, I would not take it that way.

Q But the man who said that you may take "petroleum" as including natural gas did think so. I just want to refer you to this one. What is the number of this Universal Cyclopaedia, Number 8, is it? A. Reference 8.

Q And in this one it is stated that petroleum and natural gas appear to be inseparably connected.

"Wherever large supplies of the one exists, the other is in almost all cases not far distant."

Now, do you think that is a correct statement, Dr. Katz?

A Yes, I think it is.

Q Do you think if you came up to Alberta and saw fifty or sixty dry gas fields, that you could say because those gas fields exist, that oil is not far distant? And, if so, what is the meaning of "not far distant", 100 miles, 200 miles, 10 miles? A. Well, more likely he means that within the same formation there may be some oil, and it is not commercial. "Not far distant" could well mean within the same formation.

Q And that formation extends over this whole area to the Rocky Mountains from the Eastern border of the Province? A. Yes, the sedimentary rocks.

Q The sedimentary rocks? A. Yes.

Q I do not know whether we have had them described in this case, but we have had them described elsewhere. That is all, thanks.

MR. NOLAN: No questions, thank you, my lord.

THE COURT: All right, thanks very much. Next? All right, Mr. Helman.

MR. HELMAN: I am not going to make an opening of the case for the C.P.R., my lord, except to say that I rely on the statements that were made by Mr. Nolan with regard to the Imperial Oil, except that we have certain necessary changes having regard to the changed situation of the parties, and I would like to call as my first witness Dr. Fancher.