H E A R I N G

BEFORE THE OIL CONSERVATION COMMISSION OF THE STATE OF NEW MEXICO.

Held in the House of Representatives,
State Capitol, Santa Fe, New Mexico,
at two o'clock, P. M., December 6, 1939.

PRESENT:

Hon. John E. Miles, Governor, Chairman of Commission
Hon. Frank Worden, Commissioner of Public Lands, Secretary
Hon. A. Andreas, State Geologist, Member of Commission
Hon. Carl B. Livingston, Attorney for Commission

J. O. Seth	Stanolind Oil & Gas Co.	Santa Fe, New Mexico
D. D. Bodie	Cities Service Oil Co.	Hobbs, New Mexico
J. D. Atwood	Cities Service Oil Co.	Roswell, New Mexico
Lloyd L. Gray	Gulf Oil Corporation	Tulsa, Oklahoma
P. H. Bohart	Gulf Oil Corporation	Tulsa, Oklahoma
Russell G. Lowe	Gulf Oil Corporation	Tulsa, Oklahoma
R. S. Knaffen	Gulf Oil Corporation	Tulsa, Oklahoma
S. G. Sanderson	Gulf Oil Corporation	Tulsa, Oklahoma
A. D. Curtis	Barnsdall Oil Co.	Tulsa, Oklahoma
J. S. Noland	Barnsdall Oil Co.	Tulsa, Oklahoma
W.M. Fleetwood,Jr.	Barnsdall Oil Co.	Tulsa, Oklahoma
E. P. Keeler	Continental Oil Co.	Hobbs, New Mexico
R. S. Dewey	Humble Oil & Rfg. Co.	Midland, Texas
W. E. Hubbard	Humble Oil & Rfg. Co.	Houston, Texas
R. A. Koenig	Ohio Oil Co.	Hobbs, New Mexico
Glenn Bish	Ohio Oil Co.	Hobbs, New Mexico
H. L. Johnston	Continental Oil Co.	Hobbs, New Mexico
H. B. Hurley	Continental Oil Co.	Fort Worth, Texas
D. R. McKeithan	Phillips Petroleum Co.	Bartlesville, Oklahoma
A. E. Willig	The Texas Co.	Fort Worth, Texas
Ira Van Tuyl	Gulf Oil Corp.	Hobbs, New Mexico
Ross M. Stuntz,Jr.	Gulf Oil Corp.	Tulsa, Oklahoma
S. P. Hannifin	Magnolia Petroleum Co.	Roswell, New Mexico
Delmer R. Guinn	Cities Service Oil Co.	Hobbs, New Mexico
Allen B. Gibson	Cities Service Oil Co.	Hobbs, New Mexico
D. A. Powell	Drlg. & Exploration Co.	Hobbs, New Mexico
Jack H. Rankin	Repollo Oil Co.	Midland, Texas
N. B. Larsh	Repollo Oil Co.	Midland, Texas
H. J. Summy	Repollo Oil Co.	Midland, Texas
Frank Gray	Anderson-Prichard Oil Corp.	Hobbs, New Mexico
Weston Payne	Anderson-Prichard Oil Corp.	Oklahoma City, Okla.
H. J. Kemler	Shell Oil Co.	Midland, Texas
O. D. Crites	Shell Oil Co.	Houston, Texas
M. T. Smith	Shell Oil Co.	Midland, Texas
F. E. Heath	Sun Oil Co.	Dallas, Texas
Harvey Hardison	Standard Oil Co. of Texas	Houston, Texas
Francis C. Wilson	Wilson Oil Co.	Santa Fe, New Mexico
Weldon Brigance	Rowan Drilling Co.	Fort Worth, Texas
R. S. Christie	Amerada Petroleum Co.	Fort Worth, Texas
C. G. Campbell	Tex.-Pacific Coal & Oil	Midland, Texas
O. F. Hedrick	Tex.-Pacific Coal & Oil	Midland, Texas
G. W. Selinger	Skelly Oil & Getty Oil	Tulsa, Oklahoma
Colin C. Rae	Skelly Oil Co.	Tulsa, Oklahoma

PRESENT: (Continued)

M. Albertson	Shell Oil Co., Inc.	Houston, Texas
R. G. Schuehle	Shell Oil Co.	Midland, Texas
E. W. Childers	Tidewater Assoc. Oil Co.	Midland, Texas
Edgar Kraus	Atlantic Rfg. Co.	Carlsbad, New Mexico
Lig Biddick	Samedan Oil Corp.	Ardmore, Oklahoma
J. P. Cusack	J. P. Cusack, Inc.	Midland, Texas
A. M. McCorkle	Stanolind Oil & Gas Co.	Fort Worth, Texas
G. H. Card	Stanolind Oil & Gas Co.	Fort Worth, Texas
Howard P. Holmes	Two States Oil Co.	Dallas, Texas
Roy Yarbrough	Oil Conservation Comm.	Hobbs, New Mexico
Rex E. Rader	Stanolind Oil & Gas Co.	Hobbs, New Mexico
R. W. Tesch	Stanolind Oil & Gas Co.	Fort Worth, Texas
Guy H. Woodward	Stanolind Oil & Gas Co.	Tulsa, Oklahoma
G. S. Bays	Stanolind Oil & Gas Co.	Tulsa, Oklahoma

The hearing was opened by Governor Miles.

Thereupon, at the request of Mr. Worden, the Notice for Publication for the hearing was read by Mr. Livingston, as follows:

"NOTICE FOR PUBLICATION
STATE OF NEW MEXICO

OIL CONSERVATION COMMISSION

"Pursuant to Chapter 72, Session Laws of 1935, State of New Mexico, by which Act the Oil Conservation Commission of New Mexico was created, investing said Commission with the jurisdiction and authority over all matters relating to the conservation of oil and gas in this State and of the enforcement of all provisions of said Act, notice is hereby given that a public hearing will be held at the Capitol, Santa Fe, New Mexico, on the 6th day of December, 1939, at two o'clock P. M., for the purpose of considering the following:

"Case No. 14.

The revising, modifying and amending the existing proration plan for Hobbs Field, Lea County, designated as Order No. 48 of the Commission, and the existing proration plan for Monument Field, Lea County, designated as Order No. 33 of the Commission.

"Any person having any interest in the subject of the said hearing shall be entitled to be heard.

"Given under the seal of said Commission at Santa Fe, New Mexico, on October 31, 1939.

OIL CONSERVATION COMMISSION

By (Sgd.) FRANK WORDEN
Commissioner of Public Lands

By (Sgd.) A. ANDREAS
State Geologist"

(SEAL)

BY MR. WORDEN: You have heard the reading of the Notice and we are ready to proceed. Inasmuch as we have two matters here, it would perhaps be better to handle them as such. One is known as the Hobbs Order and the other as the Monument. It might avoid complications if we handle them separately:

JUDGE SETH: We think that is the procedure to follow. First Hobbs, I take it, then Monument? There is a question here as to which company or which side of the controversy should go on first. The Stanolind, which I represent, wants a change in the existing regulations. I don't know whether the other gentlemen want a change or want to keep them as they are, and it seems to me that would determine the order in which the cases should be presented.

MR. WORDEN: It is the impression of the Commission that the companies that are for a change will be heard. I think the other side should express as to whether they want a change or want the existing regulations. Now, as to whether the Gulf wants to keep the existing regulations or wants a change we do not know, and would like to have a statement from them.

JUDGE SETH: I think it should be limited to those who will give evidence.

COL. ATWOOD: Cities Service, which I represent, does not want a change but is opposed to some of the changes that might be made. For the purpose of the record, we would like for those who want a change to so state so we will have something to shoot at, then those who favor the change, whether it be one way or another, could offer their proof in support of the proposals. Those interested who want to take part in the presentation of the case have the right to cross-examine the witnesses on the different points and have the right to offer counter-proof against a particular change or against all changes or in favor of all changes.

JUDGE SETH: I take it you mean those who are going to offer proof and participate in the hearing?

COL. ATWOOD: Yes, I do think it would be helpful to the Commission in order to find out whether there is general dissatisfaction with the system or with just a few of the regulations. I believe the operators represented here should be permitted to express their views as to whether they want the status quo to remain or are in favor of a change.

JUDGE SETH: I believe that should come toward the end of the hearing.

GOVERNOR MILES: I would appreciate that information. I don't care if it comes at the end or the beginning of the hearing, but I would like to know what the general opinion is.

MR. LIVINGSTON: Gentlemen, permit me to make a remark. This is a judicial hearing. The Commission is sitting in its judicial capacity and not in its capacity as a board of executives and this matter is a matter to be heard upon testimony. I really don't feel that inasmuch as this is a judicial hearing the general feeling among those present should be controlling in the matter, in that the testimony is paramount.

GOVERNOR MILES: Doesn't the Commission have the right to call any witnesses to the stand it desires, Mr. Livingston?

MR. LIVINGSTON: Yes, sir.

MR. R. G. LOWE: This, it seems to me, is a legislative branch of the Commission's powers. They are going to prepare rules and regulations which in itself is legislative. Now, after those rules have been promulgated, if a controversy comes up as to whether they are proper rules, the Commission could hear the matter as a judicial matter. I suggest that either these changes should be made or should not be made. We feel that perhaps the present rules are not working equitably among all the operators and should ppobably be modified as to lease acreage and potential.

JUDGE SETH: Gentlemen, might I read an opening statement which more or less covers the early history of the Hobbs pools. I don't believe all you gentlemen are familiar with the history. There are a few corrections to be made and I will then submit it in typewritten form.

MR. WM. FLEETWOOD: Mr. Chairman, I would like to make a statement on behalf of Barnsdall Oil Company. Barnsdall has no production in the Hobbs field and probably their testimony will fall under that belonging to Monument. However, in order to be fair to everyone, we feel very much like Gulf does, and we want to participate in this Hobbs hearing because it will affect the Monument.

COL. ATWOOD: As stated a few minutes ago, Cities Service has no objection to the maintenance of the present system. If there is to be a change, then Cities Service would be in favor of the proposals of Gulf and Barnsdall rather than those of Stanolind.

JUDGE SETH: The following is the opening statement which covers the early history of the Hobbs pools.

" S T A T E M E N T
PRORATION SITUATION, HOBBS FIELD, NEW MEXICO

"Following the passage of an act allowing cooperative development of oil pools, by agreement among operators, by the Legislature of New Mexico, in 1929, the operators of the Hobbs Pool, on June 11, 1930, entered into an agreement to prorate the market outlet of that pool by allocating to each 40 acre unit its proportionate share based upon 25% acreage-75% potential factors, the potential factor being the average potential of all wells on each unit.

"The Midwest Refining Company (later acquired by the Stanolind Oil and Gas Company), supported at that time a 50% potential and 50% acreage plan, but finally agreed to a 25% acreage-75% potential plan similar to one which had been in effect in the Yates, Texas, Pool for about a year.

"During the first eight months of 1932, exhaustive efforts were made to bring about unitization of the Hobbs Field but agreement finally failed because the most favored plan, of 42.5% structural position-42.5% potential-15% acreage would redude the allowables of some companies. A later plan of 37.5% structural position-37.5% potential-25% acreage also failed, for the same reason.

"Although the Hobbs Operators all accepted the 75% potential-25% acreage plan in June, 1930, by August, 1932, the majority were willing to accept 27.5 acreage-37.5 structural position-25% acreage. But on account of unanimous agreement being necessary for the adoption of any new plan, no change was made at that time.

"From the beginning of production, the Midwest Refining Company had maintained that potential should be given little consideration in any proration formula for a lime field such as Hobbs, and that structural position and pay thickness and acreage should far outweigh it. This policy has been maintained by the Stanolind Oil and Gas Company since taking over the Midwest properties.

"The fallacy of using potential in any proration plan, for any type of field, has become more and more apparent as production under proration has brought about more and more recognition of recoverable oil in place as a basis for equity.

"In March, 1933, acidation of the Hobbs Field was begun and continued up until October 1, 1934, at which time the operators agreed that potential tests of wells already completed and acidized after that date would not be recognized for use in the proration formula.

"On September 27, 1933, the proration agreement was modified, giving to wells making over 2% water an allowable based upon 40% acreage-60% potential. The modification of potentials by the use of bottom hole pressures was also introduced. This method of modifying potentials later proved to be erroneous and operated to cause great losses to Stanolind, as well as gains up to over 200,000 barrels to some companies. Stanolind vigorously opposed continuation of the 75%-25% method, but, due to the fact that Stanolind, as well as several other companies, had no pipe line facilities, they had no choice but to continue in the plan.

"On February 23, 1934, an N.I.R.A. Allocation Committee, representing Lea County operators, met at Artesia. The inequity of the use of potentials in a proration plan in New Mexico lime fields had become so apparent at that time that it was given no consideration, and allocation upon straight acreage was recommended. Representatives of Gulf and Stanolind met on April 17, 1934, and recommended straight acreage proration for Lea County, on a 40 acre unit basis, to the Allocation Committee, which adopted it, leaving the old Hobbs plan as the only one using potential. This plan was continued, as before mentioned, because unanimous agreement of the operators was necessary for change, and those operators having an advantage under potential refused to accept straight acreage, which became the rule in Lea County outside of Hobbs.

"In February, 1935, the New Mexico Legislature passed a conservation law forming a Conservation Committee, and establishing the proration of oil on the basis of recoverable oil in place as mandatory, except that proration by agreement plans then in effect could be ratified by the Commission and continued, should the Commission so choose.

"When this law went into effect it was no longer necessary to reach a unanimous agreement of the operators in a pool for the acceptance by the Commission of a proration plan. At a hearing of the Hobbs operators, on December 11 and 12, 1936, evidence was submitted by Stanolind to support straight acreage allocation for the field. The hearing continued for two days. During the intermissions efforts were made by the operators to reach an agreement. Finally, at the end of the second day, a compromise was reached on 40% potential and 60% acreage factors; Stanolind agreed that it might not be advisable to make too abrupt a change in the acreage factor at that time.

"After this agreement was reached, all evidence previously offered was withdrawn, and new evidence was put on both by Stanolind and the Gulf to support the agreed plan.

"The Commission, on December 29, 1936, promulgated Case No. 6, Order No. 48, Proration Order for the Hobbs Field, Lea County, providing for proration upon the basis of 60% acreage and 40% average unit potential. The order also provided for the adjustment of potentials each six months by use of a bottom hole pressure factor adopted and agreed upon by the Hobbs operators previously.

"On May 11, 1939, the Commission issued notice for hearing for the purpose of revising, modifying and amending the existing proration plan of the Hobbs Field, designated as Order No. 48, of the Commission. At this hearing no evidence was offered, but a Committee of engineers was appointed to investigate the various conflicting claims of the operators. The hearing was continued until October 23rd, and was subsequently continued from time to time.

"The Committee of Engineers was unable to agree upon any change in the proration plan, for the obvious reason that no change could be made in an attempt to satisfy Stanolind's claims without lessening the allowable of most of the other companies.

"Stanolind is opposed to the present proration plan for the following reasons:

"Too much weight is given to potential, which has little or no relationship to the oil in place beneath the tract.

"Stanolind, early in the history of the pool, lost great quantities of oil by water movement which swept across the upper pays of its properties, moving oil toward the crest of the structure where it was produced by other operators. The reason Stanolind lost this oil to other operators was that the upper pay section on several of its leases on the southwest flank was much more permeable than other leases around the water edge of the field; as oil was withdrawn from up structure, the water finding easiest access through the more permeable pays of Stanolind's leases, displaced oil therefrom rapidly. Stanolind set more packers than any other company in order that no waste would occur in the field, thus giving up its opportunity to produce this upper oil which finally moved on and was produced by other operators. If the loss of this oil for the sake of conservation cannot be compensated for to Stanolind, then the least that can be done is to allow Stanolind the same opportunity given operators in other Lea County pools, through the proper use of the acreage factor, to recover the remaining oil.

"Not only did Stanolind give up this upper oil through the setting of packers, but the packer wells were discriminated against in the erroneous method of correcting their potentials, through an adjusted bottom hole pressure factor, which cut the output from packer wells so that the allowable was reduced to a point where equity was no longer observed.

"Stanolind has further lost in its daily allowable over a period of years due to an inequitable use of the bottom hole pressure corredtion factor. The method of correcting potentials by this bottom hole pressure factor has resulted in a great many wells reaching a point of no potential, while at the same time able to produce many hundreds, and sometimes thousands of barrels of oil daily. On the other hand, many wells have gained increased potentials through the application of this bottom hole pressure corrective factor, although their bottom hole ressure steadily declined, a proposition impossible on the face of it. The Gulf Production Company has gained more than 200,000 barrels of oil due to the false correction in potential upward of a number of their wells, by use of this erroneous, inequitable, unengineering method of applying bottom hole pressure factor, while Stanolind, on the other hand, has lost.

"Practically all New Mexico fields are in a lime formation, cavernous in character. The caverns are irregular, with no particular uniformity in distribution. Frequently wells but one location apart will develop potentials varying from 10 to 1, or greater. Acidation has been found to increase the potential of the low potential wells in greater ratios than the high potential wells.

"The Hobbs field has been produced a number of years with an exceedingly high potential factor, i.e. 75%, in the proration formula. Gross inequities have occurred through these many years through the use of such a formula. Stanolind leases will never be able to recover the oil they lost during this period.

"It is the estimate of engineers that about half of Hobbs oil has been recovered. A large portion of this oil has been recovered under the basis of 25% acreage 75% potential, while a much smaller amount has been recovered under the 60% and 40% potential factors. If a straight acreage formula be put into operation during the remainder of the life of the field, it will have the same effect of a formula of 33.6% potential 66.4% acreage, over the whole life of the field, assuming that the field be half produced now. Although this is apparently true, it will not be true actually, because the final 20% or 30% of production will be upon a pumping or stripping well basis, which will not be affected by any proration formula.

"For more than the past five years the State of New Mexico's allocation among the various fields has been upon a 40 acre unit basis. This oil has been allowed to Hobbs on a basis of the number of 40 acre units in Hobbs. However, when the amount of oil earned by Hobbs in this manner is allocated among the leases in the field, straight acreage is no longer recognized, 40% of the allowable being given to the tracts on the basis of erroneous potentials corrected by an erroneous method of applying bottom hole pressures, and further modified, particularly insofar as Stanolind's leases are concerned, by drastic penalizing of the allowable given packer wells, which, on account of being fortunately placed in a highly productive part of the field were not allowed to take advantage of their situation and recover the oil in place, simply because the formation was so permeable that it offered easiest access to the water drive responsible for the production of the oil from the reservoir."

Stanolind's position is this. What we want is an opportunity during the remaining life of the field to have the same opportunity that every producer in every other pool in Lea County has - to have an allocation or production based on straight acreage. The Monument is 80% acreage and 20% bottom hole pressure differential.

Thereupon, the various witnesses were called and duly sworn by Mr. Worden.

Mr. G. H. Card testified as follows:

JUDGE SETH: Please state your name.

A. G. H. Card.

Q. What is your profession?

A. I am Division Engineer for the Stanolind Oil and Gas Company in Fort Worth. Petroleum Engineer.

Q. Will you please state your training.

A. I graduated from Stanford University in 1924 with a degree in engineering and economics and got a graduate petroleum engineering degree in 1932 from Stanford. I worked in the Hendrick Field in West Texas in 1932 for about a year and then went to East Texas for a year and then to Fort Worth as Petroleum Engineer where I did considerable petroleum engineering work on the West Texas and New Mexico fields. I was in our Tulsa office as a petroleum engineer for two years and also did a great deal of petroleum engineering work on West Texas and New Mexico Fields, and since March, 1937, I have been Division Engineer in Fort Worth, in charge of engineering work in West Texas and New Mexico.

Q. How many years has your work included the Lea County Field in New Mexico, including Hobbs?

A. For about five years.

Q. Are you familiar with conditions in the Lea County Pools?

A. Yes, sir.

Q. What is the general nature of the Hobbs pools? By that I mean from what kind of formation is the oil produced?

A. The oil in the Hobbs field is produced from Dolomitic limestone formation.

Q. And what is the formation in the Monument Field?

A. Same type.

Q. And the Eunice Field?

A. Same type.

Q. And is that generally true, with some minor exceptions, in all the pools in Lea County?

A. It is true with the exception of the sand fields east of the lime fields.

Q. Do you know how the allowable for the whole state after it has been determined by the Commission is allocated to the various pools?

A. It is allocated among the pools on the basis of 40-acre units.

Q. And is that true of all Lea County pools?

A. That's true.

Q. And does that have the same effect as an allocation on an acreage basis?

A. Same as a straight acreage basis.

Q. How is the production in the Eunice Field allocated among the various wells?

A. On a straight acreage basis. Each forty-acre unit getting the same allowable.

Q. Monument?

A. 80% acreage and 20% bottom hole pressure.

Q. Hobbs?

A. Allocated on 60% acreage and 40% potential. That is, 40% average unit potential with potential adjusted every six months with bottom hole pressure.

Q. In your opinion, is there such difference between the three pools as justifies any difference in the allocation of the allowable to the wells in each one?

A. No difference.

Q. Now, the New Mexico laws require this Commission to give each operator in the pool a fair share of the recoverable oil to the extent that it may be recovered without waste. Now, in determining this matter of fair share of recoverable oil, what factors are used in determining such matters, Mr. Card?

A. The factors used are acreage, pay thickness, porosity and percent of recovery.

Q. What does porosity mean?

A. Means the void space in the reservoir where the oil --

Q. Porosity is the measure of volume of oil that any particular underground reservoir will contain? Measure of quantity of oil?

A. Yes.

Q. What is permeability?

A. Permeability is the fluid conductivity factor of the reservoir. It is the measure of the flowing capacity - the ease with which the fluid can flow out through the reservoir.

Q. Permeability is the facility with which oil will flow through the ground?

A. That's true.

Q. Now, these factors you spoke of - acreage, pay thickness, porosity and percentage recovery, are they subject to quantitative determination?

A. Acreage is subject to quantitative determination. Pay thickness is subject to quantitative determination in a rough way. Porosity in limestone fields such as Hobbs is not subject to quantitative determination, because it has been impossible in the Hobbs field to obtain any cores through the porous producing section of the reservoir. Therefore it has been impossible to determine the porosity in many wells.

Q. Why has it been impossible to obtain satisfactory cores?

A. Because of the cavernous condition or nature of the reservoir.

Q. Is there a variation among the various wells in Hobbs in this matter of cavernous condition of porosity?

A. In each individual well and contiguous and adjacent wells - very wide variance.

Q. Can any fair average per cent of porosity be estimated in the Hobbs field in your judgment?

A. No, it cannot be estimated.

Q. And can this factor of porosity be used in determining the oil in place at Hobbs with any degree of accuracy?

A. No, not at all.

Q. Returning to the other factor you mention - percent of recovery. What factors enter into that?

A. The factors of permeability, method of production which includes conservation of energy in the reservoir and also the type of expelling force in the reservoir.

Q. By "expelling force" you mean water drive or gas drive, or whatever is present in a particular pool?

A. That's true.

Q. Mr. Card, what per cent of the oil in the Hobbs pool has been produced up to the present date, in your opinion?

A. About fifty per cent.

Q. Has there been any gas cap developed?

A. Yes, there has been a tremendous gas cap developed throughout the top of the structure.

Q. And is there a water drive?

A. Yes.

Q. And what effect has that had on the oil now left in place? By that I mean has it had any tendency to even up the oil remaining in place, in your opinion?

A. Yes, due to this development of the gas cap throughout the top of the structure it has leveled off so that at present the oil saturated section is more or less uniform.

Q. The gas cap and the water drive have more or less made the remaining oil and gas in place uniform throughout the field - sort of pancaked it and flattened it out?

A. That's true.

Q. For that reason would an acreage basis probably more fairly represent the recoverable oil than it would perhaps in the beginning of the production?

A. At the present time, yes.

Q. As to what is left there?

A. Yes.

Q. Mr. Card, going back to the various factors we have been discussing, is there any relationship in your judgment between porosity, that is, the volume of oil in a given area, and permeability?

A. The only relationship is quantitative. A given rock is permeable by virtue of its porosity. Obviously, a rock with no porosity could have no permeability, or a rock with a high porosity could be either slightly permeable, medium permeable, or highly permeable.

Q. Would it be possible for a rock to have numerous openings or cavities in it and have high porosity, yet if those openings or cavities were not connected, it would have no permeability whatever?

A. That's true.

Q. What bearing, if any, does permeability or the degree of permeability have on the amount of oil in place under a given area?

A. It has no bearing at all on the oil in place. It is merely the measure of the ease with which the fluid flows out from the reservoir.

Q. In other words, permeability means merely the movement and not the quantity of oil in the ground?

A. That's true.

Q. Is it possible to set a definite percentage of recovery in the Hobbs field?

A. No, I would say not. Due to the variation in the elements affecting this factor.

Q. Is potential a factor that can be used in calculating oil in place?

A. No, sir, it cannot.

Q. What does potential really measure?

A. Potential is a measure of the permeability, the pay thickness and the bottom hole pressure in a particular well.

Q. What has been the relation between ultimate recovery and potential in prorated and unprorated fields within your knowledge?

A. The relationship of these two factors in a prorated field has given ultimate recoveries to prorated leases entirely different than they would have received if the field had been operated under wide open conditions or under the law of capture.

Q. Do you know of any example of this in the limestone fields?

A. Yes, the Hendrick Field in Texas.

Q. That field is immediately south of the state line in Texas?

A. Immediately south of the state line, in Texas, on the same trend of the lime fields in New Mexico.

Q. On the same trend as Hobbs and Monument and Eunice Fields?

A. Yes.

Q. And it is a lime field?

A. It is producing from a limestone horizon.

Q. What has been the relationship in that field between potentials and ultimate recovery and the type of flow?

A. In the Hendrick field there has been practically no restriction of production and ever since development the field has been produced under wide open conditions. There has been found no relationship between the potential of the wells and their ultimate recovery.

Q. Has that field produced the greater part of its oil?

A. It is in its last stages of production at this time.

Q. Have you made up an exhibit indicating the relationship between initial production and ultimate recovery in the Hendrick field?

A. Yes, sir.

Q. Will you produce it, please?

(Exhibit "A" introduced into evidence.)

Q. Please explain what the scale on the left hand side of the figure means?

A. This scale shows the mean initial potential of the lease in barrels per day and the bottom scale is the mean or average recovery per acre in thousands of barrels per day for the lease.

Q. Will you take some of the wells and show whether the ultimate recovery agreed or was in conformity with the original potential?

A. For example, here are leases 28 and 26 with practically the same average initial potential of 2200 barrels per day and the recovery up to September 1, 1939, per acre widely varies. It is about ten or eleven thousand barrels per acre on lease 28 and about twenty-five or twenty-six thousand barrels on lease 26. You can take other numerous examples throughout this diagram and see how widely the average initial potentials of the various leases vary with their average recovery per acre. There are four or five other leases having an average initial potential of twice the average initial potential of lease 26 and their average recovery per acre is less than half that of lease 26.

Q. You gather from that, that was a lime field? And could you state that there is no relation between potential and ultimate recovery in that field?

A. In the Hendrick Field, very little or no relation between initial potential and recovery.

Q. If that field had been prorated under restricted outlet on potential, what would have been the effect on the wells?

A. The water would have controlled. The wells up structure would have drained the oil from the wells down structure where the water drive was coming from. There would have been regional drainage instead of local drainage, which was the case in the Hendricks field, produced in wide-open conditions.

Q. What do you mean by local drainage?

A. When a field is produced wide open, each well drains its local drainage area. The high potential wells go to water first after the oil is partially exhausted.

Q. That going to water - is that conducive to waste of oil?

A. Yes. It has been considered waste of oil due to operating under wide-open conditions leaving large quantities of oil underground.

Q. In the Hobbs field under the various proration formulas, what kind of drainage has that resulted in?

A. The Hobbs field has been producing under conditions of regional drainage.

Q. What do you mean by regional drainage?

A. Due to the restricted outlet under proration, the field produces much less than at its greatest capacity. The wells with high potentials produce large volumes of oil and drain oil from neighboring wells. Wells on the upper parts of the structure produce oil and have that oil replaced from edge wells which are subjected to a water drive such as on the Southwest flank of the structure.

Q. Have you some maps showing this manner of regional drainage?

A. Yes, sir.

Q. Are these maps of the Hobbs pool?

A. Yes, sir.

(Maps marked Exhibits "B", "C" and "D" introduced into evidence.)

Q. And do they represent conditions in the Hobbs field?

A. Yes, sir.

Q. Now, as to Exhibit "B". State what that is.

A. This is an idealized cross section.

Q. Can you show on the map next to it where the cross section is?

A. Right here. Along the north line of wells just south of the section line between townships 18 and 19 South.

Q. Explain what that exhibit shows?

A. Exhibit "B" shows the blanket encroachment of water across the upper zone. I might explain that the top line is the top of the white lime; the second line represents the impervious zone which represents the division between the first pay and the second pay, and the third line represents the sandy break between the second pay and the third pay.

Q. There are three zones that are pays?

A. Yes, sir.

Q. Are they separate and distinct?

A. Yes, sir. The water reached each one of the wells as shown by the vertical lines on the dates shown on the exhibit by those wells.

Q. Can you give some of the dates without much trouble?

A. Landreth State C-1, 1-22-31; Stanolind McKinley 6, 10-8-32; Sun McKinley 1, 2-27-33; Sun McKinley 3, 3-14-32; Stanolind State 8, 11-22-32; Stanolind Byers 8, 1-10-36.

Q. That shows the water encroachment in the upper pay?

A. The rapid advance of the water across the southwest flank of the field.

Q. Now, take the next pay.

A. This is the second pay. The water encroachment is not near as rapid because this pay is not near as permeable. The water encroachment in the upper pay has been much more rapid because of higher permeability. This rapid water encroachment illustrates what we were talking about a little while ago. This water encroached across this section of the field at a very rapid rate, displacing oil from the upper pay, pushing the oil on up structure and replacing the oil produced by the up structure wells.

Q. Now, take the next exhibit - Exhibit "C" - and explain what that is.

A. These two Exhibits "C" and "D" here are practically the same. The various lines show the water encroachment by years. Each color on Exhibit "C" shows the water encroachment for that year and the last color shows the water encroachment to 10/1/39. You can see how fast the water moved across Stanolind properties from 1931 to 1933.

Q. Now the other one - Exhibit "D" - will you please explain that?

A. It is the same. A water encroachment map, only colored differently, and the red circles are wells in which packers are set to control the water production. These water packers have been set here in the impervious zone between the first and second pays and in the sandy break between the second and third pays.

Q. The water packers are set between the pays, is that correct?

A. Yes, sir.

Q. And what is the purpose of them?

A. To shut off the water production from the upper zone in that well and also to conserve the reservoir energy of the field.

Q. If the packer were placed at the bottom of that first pay, would it have the effect of stopping production in that well from the pay above where the packer is set?

A. Yes, and there would be no more oil or water produced from that particular pay provided the perforations in the tubing were below the packer.

Q. How did the setting of these water packers affect the production of oil from these wells?

A. When the packers were set below these zones, these particular wells lost all chance of recovering any more oil from the particular section below which the packers were set, and this oil moved on up structure ahead of the water drive.

Q. That water coming in. Is that an illustration of what is known as water drive?

A. Yes, sir.

Q. Is that water coming in under pressure?

A. Yes, sir.

Q. High pressure?

A. Yes, sir.

Q. From the southwest flank of the field?

A. Yes.

Q. And after it comes in, what happens to the oil up there, if anything?

A. As water comes in, the oil surrounding the low structure wells is forced up structure, replacing the oil that is produced up structure.

Q. And the water coming in pushed the oil that was left there ahead of it, was that true?

A. Yes.

Q. Could those wells where those packers have been set still have been produced without packers?

A. Yes, they could have been produced without packers, but it would have been necessary to handle large quantities of water from these wells and this would have been injurious to the reservoir energy of the field, as it would have lowered the reservoir pressure because the maintenance of reservoir pressure is dependent on the water.

Q. And production from that zone after water came in would have resulted in many times as much total fluid production if packers had not been set?

A. Yes, many times.

Q. Would that have had a bad effect on the wells on up structure?

A. It would have reduced the pressure on the wells on the up structure. Many of these wells up here would be pumping today if packers had not been set in our wells, but they would not have as much oil as they have with the packers.

Q. Where is most of the water in the field being produced now?

A. Most of the water in the field today is being produced north of this section line between sections 24 and 25 and the east tier of sections. As a matter of fact, the report of the proration office showing water production for August, 1939, shows that 7186 barrels of water per day is being produced or 77% of the total water production of the field.

Q. How much in the yellow part of the map?

A. South of this black line here (indicating), in August there were 1329 barrels of water being produced, or 14.3% of the total water produced in the field.

Q. Have packers been set in the north end of the field? Other than you show there by red circles?

A. The red circles are the packer wells, and in addition two or three other wells have been plugged back to control water.

Q. What has been the effect of not setting packers in the north end?

A. You can see from the figures I have just given the water production up here is much greater than down here where packers have been set to control water.

Q. They are producing in many instances much more water than oil?

A. Yes, sir.

Q. What effect does that have on the conservation of oil and ultimate recovery?

A. It has a very injurious effect.

Q. Why weren't more packers set in the north end of the field?

A. It would appear that due to the proration formula that has been in effect, that is, the correction of potentials by bottom hole pressure, and the assigning of the field average pressure to packer wells, these wells would be assigned lower pressures after packers were set than they had before or would have if packers were not set, and therefore their potentials and allowable would be reduced.

Q. That part of the allowable based on potential would be reduced?

A. Yes.

Q. Do those maps, particularly Exhibits "B" and "C", show what you mean by regional drainage rather than local drainage?

A. Yes, sir.

Q. If there had been local drainage, would there have been water encroachment around each well rather than blanket encroachment?

A. Yes, sir.

Q. Do you know how many water packers have been set in the field there?

A. There have been 34 water packers set in the field.

Q. How many has Stanolind set?

A. Of these, Stanolind has 13. This is a far greater percentage than we have acreage in the field, as we have about 22% of the acreage.

Q. You talked about these maps showing the regional drainage. Is there some local drainage in the Hobbs pool?

A. Yes, I believe there are certain portions of the field operating under local drainage.

Q. What portions of the field are there?

A. I would say the extreme southeast section of the field in the low permeable area.

Q. Why is that section being operated under local drainage?

A. Because of the low permeability of that area. There is no drainage either to or from that area.

Q. The low permeability means the difficulty of the fluid to flow through the reservoir?

A. Yes, sir.

Q. Could Stanolind have produced from that upper pay after water came in for a considerable time, in your opinion?

A. Yes, sir, they could.

Q. Have you any reference to any literature on petroleum engineering which contains any reference to the relationship between potential and other factors used in calculating oil in place?

A. Yes, sir, I have one here. It is contained in the proceedings of the Third Pennsylvania Mineral Convention, Petroleum and Natural Gas Section, Bulletin No. 12 of the Pennsylvania State College, in a paper written by G. H. Fancher, J. A. Lewis and K. B. Barnes.

Q. Will you state who these men are?

Q. Mr. Fancher is one of the Petroleum Professors at the University of Texas. Mr. Lewis is operating a core laboratory which analyses cores in Dallas, Texas, and Mr. Barnes works for the Gulf Production Company.

Q. And what is the title?

A. "Some Physical Characteristics of Oil Sands."

Q. Will you read some of that?

A. On page 78 of this bulletin appears the following sentence:

> "A map purporting to show profiles of constant porosity was prepared by Rounds (139) for the Hobbs pool in New Mexico. The lines were established by connecting wells of approximately equal initial production. It would seem that such lines are lines of constant permeability rather than constant porosity and serves to illustrate the unfortunate confusion prevalent concerning the two properties."

Q. They speak of "lines of constant porosity." Does that mean lines of oil in place?

A. Porosity is a measure of oil in place.

Q. That would mean lines of equal porosity?

A. Lines drawn through equal porosity. However, the authors stated that these lines were really lines of constant permeability rather than lines of constant porosity.

Q. And was there considerable acidation of wells at Hobbs?

A. Yes, sir.

Q. Did that begin in March, 1933, and continue up to about October, 1934?

A. Yes, sir.

Q. Now, by acidation means that acid was pumped down these wells?

A. Yes, sir.

Q. And the idea is it eats up the lime?

A. Eats up the limestone formation in the producing section around the well.

Q. The idea is to make the oil come to the well more readily?

A. Increases the permeability.

Q. Does it reach very far back? The effects of it?

A. It depends on how much acid you put in and the condition of the reservoir when you put it in.

Q. And it doesn't cover large areas, like a forty-acre tract?

A. No.

Q. Was that acid campaign pretty general with Hobbs?

A. Yes, there was a large number of wells acidized.

Q. As a result of this campaign, do you know how much the potentials were increased on the acidized wells?

A. They were increased approximately from one million barrels per day to 1,900,000 barrels per day.

Q. Almost double?

A. Yes.

Q. As a result of this increase in potential, due to acidation, did the Hobbs Engineering Committee increase their estimate of ultimate recovery from the field?

A. No estimate was made whatever.

Q. Could acidation in any manner increase the total of recoverable oil in place under any particular tract of land?

A. No, in my opinion it would not increase the oil in place, but it may slightly increase the recovery factor.

Q. It might make it more easy to recover the oil?

A. Yes, sir.

Q. But wouldn't increase the oil under the land?

A. No.

Q. You testified, Mr. Card, as to the rapid water encroachment across the southwest flank of the Hobbs pool and across the Stanolind leases in that area. Have you made a calculation of the amount of oil that Stanolind lost due to this rapid water encroachment?

A. Yes, sir.

Q. Will you please explain how these figures were calculated and state your figures as to the total loss of Stanolind in that area?

A. The manner in which the calculations were made I will read from this page here. "The following data and assumptions were made in calculating the effects of water flooding on Stanolind wells in the Hobbs field, Lea County, New Mexico, to August 1, 1939:

1. <u>Wells Considered</u> - Only those wells which now contain water packers, or those producing an appreciable amount of water, were used. Where the migration due to water flooding appeared to be to other Stanolind properties, the well flooded was not considered.

2. <u>Original Recoverable Oil in Place</u> - The original oil in place was calculated on the ratio of the pay thickness of the unit to the total feet of pay in the field, and an ultimate recovery of 175 million barrels for the total field. (Pay thickness in the above means the intefval from the average top of the white lime for each unit to the -600 datum, below sea level.) The original oil in place was also corrected for the time the well was drilled by assuming that its unit had been depleted that percent which the production of the field at that time bears to the estimated ultimate field recovery.

3. <u>Fluid Zones, Original Recoverable Oil in Place and Division of Production</u> - It was also assumed that the original recoverable oil in place and the production from the flooded zones was in the ratio of the thickness of the flooded zones to the total pay thickness of the unit until either a packer was set or until the present if no packer was set.

4. <u>Rate of Encroachment and Percent of Zone Flooded</u> - The rate of encroachment is assumed to have been uniform from the time water first appeared in the well up until the time it was packed off, or up until the present if no packer was set, in which case the water producing zone is considered to be flooded the percent shown on the latest 24-hour individual well production tests. The zones encroached were taken from the latest revision of water encroachment maps for each zone.

5. <u>Other Date</u> - Byers NE/4 No. 33 - Only Zone 1 drilled. New Mexico's State Conservation Law became effective June 1, 1935."

According to these calculations, Stanolind has lost in this area, the southwest flank of the field, up to August 1, 1939, from the time of the development of the leases, 1,550,000 barrels and from June 1, 1935, up to August 1, 1939, which first date was the date the conservation law went into effect, Stanolind leases have lost 518,000 barrels.

Q. That is the result of your calculations made in the manner you have testified?
A. Yes, sir.

Q. And you believe it was a fair method of making the calculations?

A. Yes, sir.

Q. If you had based your calculations merely on acreage, would it have been more or less?

A. The loss would probably have been more.

Q. And, of course, it is a matter of judicial knowledge that the present proration plan for Hobbs is 60% acreage and 40% potential?

A. Yes, sir.

Q. And there is a provision made for adjustment of potential by bottom hole pressure?

A. Yes, sir.

Q. Will you please state that formula? How it operates?

A. The bottom hole pressure correction formula is the new well potential equals the old well potential times a fraction whose numerator is the new well pressure minus two-thirds the present field average pressure and the denominator is the previous field average pressure minus two-thirds of the present field average pressure.

Q. How often are these adjustments made under the present formula?

A. Every six months.

Q. Under this formula might a well increase in potential even though its pressure declines?

A. Yes, the way this bottom hole pressure formula works, as long as the well's pressure during any particular survey is above the field average pressure, no matter if the pressure on that well increased or decreased from the previous survey, the potential on the well will be increased; and, on the other hand, if a well's pressure is below the field average, whether or not its pressure has increased or decreased, its potential will be declined. For example, if a well had a pressure of 925 pounds and increased from one survey to the next to 950 pounds, its potential would be declined because its pressure is below the field average, which is now about 1180 pounds.

Q. And those that remain above the average of the field will get increases in potential, although there may have been a material drop in pressure?

A. Yes.

Q. How are packer wells handled?

A. Packer wells are assigned the field average pressure. It was thought at the time the pressure adjustment formula was put in that the packer wells should not be discriminated against because the packers were set to conserve the energy of the field and it was decided to assign to these wells the field average pressure. Also non-packer wells on which pressures are not taken are assigned the pressure of the closest well or the average pressure of the closest wells.

Q. And how long has this method of adjustment of potential by bottom hole pressure been used?

A. Since November, 1933.

Q. Up to January 1, 1937, it has operated on 75% of the allowable?

A. Yes, sir.

Q. And since January 1, 1937, it has operated on 40% of the allowable?

A. Yes.

Q. What has been the result of the application of this formula, bottom hole pressure business, to potential?

A. As a result of this formula, there are fifteen wells in the field which have been reduced to zero potential. Stanolind has eight of these wells.

Q. These fifteen wells that were reduced to zero potential, if the top allowable is 60 barrels, the utmost that they could allow to be produced would be sixty per cent?

A. That would be 36 barrels.

Q. What do individual well tests and over and short statements show regarding the Stanolind wells that have zero potentials?

A. Individual well tests show that the Stanolind wells which now have zero potential are capable of making their allowable greatly in excess of their allowable, and also over and short statements show that they are capable of making their allowable.

Q. Yet under the present formula they do not get any more than the 60% allowed them for acreage?

A. Yes.

Q. Have any wells had large increases in adjusted potential as a result of using this bottom hole pressure formula?

A. Yes, there are many wells which have had large increases in potential due to bottom hole pressure correction. There are about five wells in the field now which have rated potentials in excess of 26,000 barrels per day. I mention 26,000, as that is the highest potential after acid recorded in the field.

Q. Have these five wells had an increase in their adjusted potential since the present proration went into effect January 1, 1937?

A. Yes, they have had large increases in potential. This increase has ranged from 4500 to 7800 barrels per day in potential.

Q. And they have had the advantage of this increase for nearly three years on 40% of their allowable?

A. Yes, sir.

Q. Has anything happened that could have increased the oil in place under those leases?

A. Absolutely nothing that I know of.

Q. Do you believe this method of adjusting potentials by bottom hole pressure has been equitable?

A. I certainly do not. The erroneous potentials which it has created is alone sufficient to condemn it.

Q. There are fifteen wells, I believe you said, that do not get 40% of the allocation based on potential at all, is that true?

A. That's true.

Q. By assigning the field average pressure to packer wells instead of declining their potentials by the field average decline in potential in other wells, have Stanolind packer wells been penalized?

A. Yes.

Q. How much greater would the present potential now be if they had been declined according to the field average decline instead of by assigning the field average pressure?

A. The potential of Stanolind packer wells would now be 57,260 barrels greater than it is at the present time.

Q. In other words, Stanolind has suffered a considerable loss in allowable by setting packers due to adjustment of potential on packer wells, and has also given up large quantities of oil to up structure leases?

A. Yes, sir.

Q. Which company at Hobbs has benefited the most due to bottom hole pressure adjustment?

A. The Gulf.

Q. How much has their allowable been increased by bottom hole pressure over and above what their allowables would have been if the potential had not been adjusted?

A. Up to September 1, 1939, about 198,000 barrels, and at the present time it would no doubt be in excess of 200,000 barrels.

Q. That is the increase in potentials of the Gulf wells?

A. That is increase in allowable.

Q. In allowable?

A. Yes.

Q. Has that been in real oil produced during the period?

A. Yes.

Q. They have been given that many barrels by reason of this bottom hole pressure formula?

A. Yes, bottom hole pressure formula.

Q. Have you a diagram showing the relationship or lack of relationship between bottom hole pressure and potential?

A. Yes, sir.

Thereupon, Judge Seth suggested that the hearing be recessed, which suggestion was adopted, and the hearing stood in recess until 9:00 A. M. the following morning, December 7.

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I, Irene Kershner, hereby certify that the above and foregoing twenty-three and a fraction pages of typewritten matter constitute a true, correct and complete transcript of the shorthand notes taken by me at the hearing before the Oil Conservation Commission held in the House of Representatives, State Capitol, Santa Fe, New Mexico, on Wednesday, December 6, 1939.

I N D E X

CASE No. 14

To consider revising the Hobbs Proration Order, and the Monument Proration Order.

MORNING SESSION, DECEMBER 7, 1939

Pursuant to recess, the hearing in Case No. 14 was resumed at 9:00 o'clock, A. M. on December 7, 1939, all members of the Commission being present, the Honorable John E. Miles presiding, whereupon the following proceedings were had, to-wit:

BY MR. HUBBARD: Mr. Chairman: I am W. E. Hubbard, of the Humble Oil Company. I do not know whether our appearance has been entered here, but at this time we desire to enter such appearance.

I would also like to say that we have no specific formula to offer for whatever may be worked out. However, Mr. R. S. Dewey, who since the inception of the Hobbs oil field, has been in charge of our engineering force in New Mexico, has prepared some data, of an economic nature, which is rather germane to this whole matter. I have asked the plaintiffs if it would suit them if we would inject this data at this time, and they have agreed. I would like to ask Mr. Dewey to give this matter in his own manner.

R. S. DEWEY,

being first duly sworn to tell the truth, the whole truth and nothing but the truth, was examined by Mr. Hubbard, and testified as follows:

DIRECT EXAMINATION

BY MR. HUBBARD: We have a number of exhibits here --

BY MR. WORDEN: For the sake of the record, I think Mr. Dewey should be qualified -- I take it he is offering this data as an expert.

Q Your name is R. S. Dewey?

A Yes.

Q You are an employee of the Humble Oil Company?

A Yes, sir.

BY MR. SETH: We admit his qualifications.

Q Exhibit No. 1 is presented to show the distribution of the higher gas-oil ratio of wells, as represented in the exhibit, in December, 1938. I understand corrective measures have been taken in two cases -- I think both are on the Gulf lands. This will be offered in evidence as an exhibit. (Map is displayed on frame, and marked "Humble Exhibit No. 1). I will ask Mr. Dewey to explain this map.

A The red color indicates the gas oil ratios in excess of 5,000 cu. ft. per barrel; the green color those gas oil ratios between 4,000 and 5,000 cu. ft.,; and the blue color those gas oil ratios between 3,000 and 4,000 cu. ft. per barrel. The upper black figures in ink indicate the monthly oil allowable. The middle black figure indicates the gas oil ratios, and the lower black figures indicate the monthly production of water.

Exhibit No. 2 consists of tabulated oil and water production by years for the period 1934 to 1938, inclusive. This data was compiled from the Hobbs Engineering Committee's annual reports. It consists of columns of figures giving the oil production, barrels of water, total barrels of oil, total fluid and water percentage.

On the map identified as Humble Exhibit 2-A, this information shows the year 1938. The upper figures in black ink is the total barrels of oil for the year. The little figures in red ink, the total barrels of water for the year 1938; and the lower figures in red ink is the water percentage of the total fluid.

Exhibit No. 3 is a tabulation of the various potentials adjustments which have occurred to bottom hole pressure adjustments under Plan 2A. In the first column the potentials have been shown. This column represents the potentials just prior to the adoption of Plan 2A. This column is not the last tested potential, as it contains some potentials which were modified under plan 1A. Plan 1A was in effect for only a short period of time. The last columns indicate the amount and the percentage that each potential has been increased or decreased by virtue of bottom hole pressure adjustments under Plan 2A. The summary sheet gives the amount of potential increase or decrease, by companies.

On the map identified as Exhibit 3-A the distribution of potential increase and correction, as the result of Plan 2A has been depicted. The green color shows wells that lost their entire potential. The yellow shows wells modified by field average pressure. The red shows units with assigned pressures, rather than actually taken on the February, 1939 survey. The white color shows units on which pressure was taken in the February, 1939 survey. The black figures show shut-in bottom hole pressures prior to the adoption of Plan 2A and on the February, 1939 survey. The percentage figures indicate the percentage of pressure decline over the period since the adoption of Plan 2A.

On the map identified as Exhibit 3-B, the yellow color depicts units with potential increase due to the operation of Plan 2A. The black figures indicate the amount of potential increase; and the percentage figures, the percenta ge increase of potentials due to Plan 2A. The white color shows units that lost potential due to the operation of Plan 2A. The red figures indicate the loss of potential; and the red percentage figures, the percentage of loss attributable to Plan 2A. The packer units have lost about 36% of their potential.

Exhibit No. 4 is a table in which the results of the various shut-in pressures have been compiled.

Exhibit No. 5 is a table entitled "Complete Report Acid Tests, Hobbs Pool, to December 31, 1934", which appears on the Hobbs Engineering Report for the year 1934, at pages 53A, 54A, 55A, 56A and 57A.

Exhibit No. 6 is a tabulation prepared by the Lea County Engineering Committee office at my request to supplement and continue the table identified as Exhibit No. 5. In the table in Exhibit No. 6 company tests are shown prior to acid treatment. As it is not known how these company tests were made, it is distinguished from the data in the column "Prior to acid treatment" in the table in Exhibit No. 5.

Exhibit No. 7 is a table compiled from the information contained in Exhibits Nos. 5 and 6. It may be noted that of the 263 wells in the Hobbs Field, three are very small wells which are permitted to produce four, five and six barrels, respectively. Of the 260 wells, seventy were never effectively acid treated to increase potential. Some of these wells were producing water wells or high gas-oil wells which the operators deemed it hazardous to acid treat. Some of them were packer wells; others were wells adjacent to water wells. In any event, acid treatment in the Hobbs field arrived at too late a date to permit these seventy wells being effectively acid treated to increase their potentials.

Seventy-five wells were acid treated with 1,000 gallons to increase their average potential 95%.

Twenty-five wells were acid treated with 2,000 gallons to increase their average potential 104%.

Fourteen wells were acid treated with 3,000 gallons to obtain an increase in potential of 241%.

And eleven wells were acid treated with 4,000 gallons, which resulted in a potential increase of 398%.

By platting the potential prior to acid treatment, against potential subsequent to acid treating, for 1,000 gallons, 2,000 gallons, 3,000 and 4,000 gallons treatment, a series of curves were obtained as shown on Exhibit 7-A.

For instance, for 1,000 gallons, 98 wells were used to determine the average curve shown. From this study it appears that up to an initial potential of about 4,500 barrels, there was a straight line relationship between the potential prior and subsequent to the acid treatment. Beyond this point a curve relationship existed which limited the percentage of increase progressively as the natural potential became larger, until a point was reached, at about a natural potential of 23,500, at which there would be no increase in potential due to the use of acid.

In similar manner, the curve for 2,000 gallons shows a straight line relationship there, similar or almost identical with the 1,000 gallon treatment, in the lower part of the curve.

This line broke into a curve a little farther to the right than that for the 1,000 gallon treatment. Seemingly, the up curvature of the line indicates diminishing returns from acid treatment of the larger wells. The 3,000 gallon straight line relationship then curved sharply upward and with the line projected, this curve passed relatively close to the 1,000 gallon curve through a point at about 23,500, and the 23,500 indicating the casing size limitation factor beyond which acid treatment would be ineffective in increasing potential. As the size of the well potential increases, the limitation of 7-inch casing and 3-inch tubing results in a limited potential.

The curve for the 4,000 gallons formed to coincide with the straight line, in the lower part of the curve, of the 3,000 gallon, but to extend farther to the right. With sufficient data, this curve might have shown an upward curvature present.

Three other curves from the test data, which is admittedly inferior to the official potential test date referred to previously -- a straight line or curve is drawn for the 12,000 gallon treatment. As to both the 4,000 gallon and the 12,000 gallon curve, the straight line relationship, the percentage increases within the limits of the data were 398 and 650%, respectively.

By platting the percentage increase against the number of gallons used, the curve identified as Exhibit 7-B was constructed, using zero-zero as one point. To do curves for 1,000, 2,000 and 3,000 gallons, there was no average percentage relationship that can be applied to this curve, and consequently the curve from zero-zero to 398 is indicated as a dotted line.

While the curves for the acid treatment are far from ideal, there does appear to be a relationship on the average between the acid treatment potential and the amount of acid used. Individual cases will show a wide variation from the curves as constructed. Several wide variations exist in individual wells and the various potential tests. These variations led to numerous potential tests in the area lying in the Hobbs Pool. This series of curves does afford a method of comparison of potentials with natural flow prior to acid treatment, or with 1,000 gallon acid treatment, or with 3,000 or 4,000 gallon acid treatment. By such adjustment of potentials to some common basis, it would be possible to compensate, to some extent, for the wide range of potentials which exist between the seventy wells never acid treated for potentials of the wells acid treated with 4,000 gallons or more to obtain a potential increase of 398% or more.

Should such a potential adjustment be attempted, it is suggested that the resulting potentials be fixed by averaging, by the method proposed by Mr. Albertson, of Shell, and described on page 99 of the Hobbs Annual Report for the year 1933. That part of the Hobbs Report is identified as Exhibit No. 8.

Exhibit No. 9 is the November Proration schedule for the Hobbs field, with particular reference to that part of the schedule which refers to the Landreth Production Corporation, State C Lease No. 1, which is believed to have a special allowance due to water at the present time.

Q From the study you have made, Mr. Dewey, would you say that the potential in the Hobbs Pool, subsequent to the acid treating you have described, would be more or less in relationship to the oil in place, than it would before acid treating?

A I think the oil in place was there long prior to anybody trying the acid treatment.

Q I don't think you quite get the point. For instance, you have certain relationship potentials in the edge of the pool, in the middle of the pool before acid treatment, and it so happens you have this relationship after acid treatment. I would like to know which relationship would more nearly represent the relationship between the oil in place?

A I just can't answer that.

Q Let me put it another way. Do you think the potentials taken before acid treatment more nearly represent oil in place than those taken after acid treating, in the Hobbs Pool?

A Under the current statute governing New Mexico oil in place, my conception of potential is merely a very poor co-factor, which might be applied with other factors to estimate roughly the oil in place. I believe that the natural potential prior to acid treating shows the natural permeability adjacent to the well bore better than the potential subsequent to acid treating.

Q Then, if you were to prorate on the basis of using potential as a factor, you would prefer, in the case of the Hobbs Pool, those potentials taken prior to acid treatment, rather than those taken subsequent to acid treating?

A I believe they should be adjusted.

Q Would you also state -- or could you also state that the use of potentials, if potentials were used which were taken before the adjusted potentials secured under Plan 2A, that a more equitable allocation would have resulted?

A I am convinced of that fact.

CROSS EXAMINATION By Mr. Seth:

Q You referred to Plan A2. By that do you mean the plan in effect at the present time?

A Yes, sir.

Q And what was Plan A1? Was that the plan in effect immediately preceding --

A The plan immediately preceding plan A2, and also based on bottom hole pressure.

Q Prior to January 1, 1937?

A I think Plan 1A was in effect the latter part of 1934.

Q Did I understand you to say that the potentials of the seventy wells, had they been treated with acid, their potentials might have been increased?

A The expectation would be, from all of the results obtained on wells which were treated, their potentials, on the average, might have been increased somewhere in the neighborhood of 95%.

Q I understood you to say the potential indicated the permeability immediately around the bore hole of the well?

A It is a co-factor, depending on several other factors, one of which is permeability. Permeability enters into the potential.

Q If it indicates the permeability immediately around the bore hole, it does not necessarily indicate the oil in place?

A No, sir.

BY GOVERNOR MILES:

Q Under whose supervision was this acid treating done?

A As I remember the history, the Atlantic had one well whose potential was apparently out of line with the potentials of the surrounding wells, and they asked the Operating Committee for permission to acid treat this well in order to see if they could not bring their potential up to the potentials of the surrounding units. The potential apparently was so much out of line at the time, and that permission was granted them. What was granted one operator became available to all operators, and started an acid treating campaign in the Hobbs Pool. It was expensive to all operators, and of course, resulted in a re-allocation of potentials among the operators. Prior to the Atlantic asking permission to acid treat this well, there had been a general agreement that no wells would be shot. Of course when one operator did it, it was done by all operators, and it has been the custom for everybody to acid treat their wells.

BY MR. BODIE:

Q I believe you stated a while ago you were of the opinion the potentials established previous to acidation represent more nearly the oil in place -- was nearer. Personally I would rather use it. Then you say in the case of the Atlantic well which was very much out of line, they were allowed to acidize, and in that case that brought it in line with the surrounding wells.

A On that point, I feel when potentials are so erratic, the natural and acid potentials are so erratic, some means should be employed, if they are to be used, whereby they could be smoothed out. That is why I suggest some method, similar to that proposed by Mr. Albertson and referred to as Exhibit No. 8, should be used. I think, if the operators, at the time the Atlantic seemed to be out of line, had averaged potentials throughout the field, it would never have been necessary to acidize that well. It could have been done by averages.

BY MR. HUBBARD:

Q Assuming that the potentials were to play a part in a proration formula as one of the functions, would more equity occur if these potentials were based on all wells being given an acid treatment of 4,000 gallons, or if some were given a treatment of 5,000, some 1,000, some 14,000 -- would more equity occur if potentials were based on approximately the same size shot?

A I think that is the case -- if all were on a common basis of 1,000 or 4,000 gallons, more equity in potentials would result.

BY JUDGE LOWE: So much data has been introduced, it will be impossible to cross examine this witness -- we would like to have his cross examination deferred until a little later in the proceeding. To cross examine him now would consume a lot of time and would be shooting in the dark --

BY MR. HUBBARD: I tried to make myself clear that we do not have any specific formula to offer as to the method of proration -- that we would give the history of proration, as we saw it, for use of the Commission, and for any recommendation either side of the controversy, or anyone else, might wish to make.

BY MR. WOODWARD:

Q Mr. Dewey, is it true that wells having the smaller potentials before acidation get a larger percentage of increase than the wells having a large natural potential?

A No, that is not true on the smaller wells acid treated up to 3,000 gallons. On the acid treatments above 3,000 gallons the limitations of the data are apt to cloud the issue somewhat. On those treated with 4,000 gallons or better, it seems they got the same percentage of increase.

Q Then the acidation, as used -- or if used on some uniform plan, would have resulted in evening out potentials in the field, or brought wells up to some uniform potentials?

A Yes, I believe that if everybody had the same opportunity to acidize with the same amount, the potentials would have been more uniform. Some operators have been prevented from treating their wells; other operators have used as much as 12,000 gallons.

BY GOVERNOR MILES:

Q Were they all on a uniform basis before that time?

A Well, no wells had been acid treated. All were on natural flow at that time.

Q That would vary?

A Yes.

Q Did this acidizing assist in bringing about more flow, or a uniform flow?

A The only idea I know of was to increase potentials by the operators who could increase their potentials in order to increase their allocations at the expense of operators whose wells were not available to be acid treated.

BY MR. WOODWARD:

Q Some wells in the field had very large potentials naturally?

A Naturally, yes.

Q Those wells are in a very permeable section?

A Yes, sir.

Q And some wells had very low potentials?

A Yes, sir.

Q And those wells are in a very low permeable section?

A That is right.

Q When acidation was used, is it true it brought about more or less uniformity in permeability underground?

A The low potential wells had their permeability increased relatively more than the larger potential wells could.

Q The high potential wells had been lucky enough to hit a cavernous spot, whereas the low potential wells hit a tight spot?

A That is right.

Q When you acidized in a tight spot, you went down in the well and hand-made a cavern, like nature had done in the other?

A Attempted to.

Q That was the tendency?

A That was the tendency.

Q The low potential well, having increased its flow by acidation, does that indicate to you it may have had as much oil in place as the well that happened to hit a cavernous spot naturally?

A No, that would not be conclusive proof of any same amount.

Q Of course not, but would it indicate the possibility of having it, having as much there as occurred possibly over here? (Indicating:.

A It would tend in that direction, but not conclusively prove, to my mind, that this tract (indicating) would have the same amount of oil.

Q Of course not. It does indicate the possibility to be as great in one as in the other, in certain cases?

A In certain cases.

BY MR. BOHART:

Q One or two questions. Oil in place and recoverable oil in place are not necessarily the same, are they?

A No. I don't think I have testified to that, that they are the same.

Q I am leading up to getting your opinion on a certain point. Now, isn't it a fact that recoverable oil in place is the important thing?

A From the operator's standpoint.

Q From anyone -- if you can't get it, it remains in place?

A That is right.

Q Isn't it your opinion, to a certain extent, in numerous cases at any rate, that acidation has aided in indicating the amount of recoverable oil in place?

A In some cases an acidation has been very helpful.

Q Let me give an example: I have in mind a well completed as a dry hole -- it did not produce. It was acidized and did produce. Without acidation there would have been no recoverable oil in place. With it, there was recoverable oil in place, so that the well produced for the benefit of the operator, the royalty owner and the state. There are such cases -- there are actual cases where acidation did assist in recovering recoverable oil in place?

A That is right.

Q Are you familiar with acidation in Michigan? I believe the consensus of opinion among operators is that acidation in Michigan, where the production is in the dolomite limestone --

A I am not competent to testify about Michigan at all.

Q Then I understand it is your idea, in numerous cases, acidation has been helpful in indicating the amount of recoverable oil in place?

A That is right. Lots of operators have been fooled by it, too.

Q Acidation is not wholly wasted effort?

A It is not an unmixed blessing.

RE-DIRECT EXAMINATION By Mr. Hubbard:

Q I don't believe you are attempting to say that acidizing has no place in the oil industry?

A Oh, no, it has its place; like any other tool, it can be misapplied.

BY COL. ATWOOD:

Q The fact that this dry hole was acidized and was then capable of producing oil, would indicate there was some recoverable oil around that hole?

A Undoubtedly there was recoverable oil around the hole. Without knowing the history of how the well was completed, we don't know what happened before acidation. It may be that another method of completion of the well might have made it a producer. You would have to know the circumstances.

Q I am assuming this well was completed in the ordinary way.

A You would have to know the spacing, for one thing.

BY MR. RAE:

Q On this matter of the seventy packer wells - I think you indicated that in your opinion they were not being fairly treated because they were not acidized. Was that your thought?

A That was my thought. Those wells could not be acidized, whereas the balance of the 260 wells in the field could be acidized, so those wells that were acidized naturally obtained some advantage over wells that could not be.

Q Is it true that those wells that run packers, that in most of them the upper zones have gone to water, and the reason for running the packer is to shut off the water in the upper zones?

A That is true. The operators had a general agreement that nobody should be penalized in potentials due to setting packers to shut off water or gas. That is the assumption I have gone on, that this gentleman's agreement is still in force.

Q Suppose we assume those wells did not have packers on the upper zones. Is it your opinion that with the upper zones almost entirely flooded, they could have gotten good results?

A There is no means of determining --

Q It may be true that packers being run will not allow those well s to carry their potentials, and that consequently the packer wells are injurbusly treated?

A I disagree -- my contention is that potentials that differ, there is a quality factor that can be used with oil in place to indicate to some extent -- perhaps to a minor extent -- the quality acre fee underlying it. What happens to the well subsequent to its having the packer is getting a potential on the basis of the law of capture, which I don't believe we want to consider.

Q I am not trying to have an argument. I am trying to have you point out why you claim, in packer wells, the lower zones having gone to water, and in spite of that the engineer allowed those wells to carry a potential which was made prior to the time the well went to water or gas, still you are trying to argue that when it has gone to water, and acid treatment would not do any good, that well is given lack of equity. I don't see any reason at all for packer wells to claim that they are injuriously treated. I think you distinctly stated the acid treatment would not help if you took the packer out --

A Where the well has gone to water, the chances are it would greatly increase the amount of water.

Q And probably the amount of oil would not be greatly increased?

A No, I think we are together, but not expressing ourselves the same way, Mr. Rae. If it is necessary to use potential in an allocation formula, I would prefer to see the potential frozen on the particular well, and carry on with that potential throughout the life of the well, and if acid treatment had been available at the time these seventy wells were drilled, before they had gone to water, and they could have had acid treatment and increased their potential, that potential could have been frozen and carried on. And that would have given more equity than we have at the present time, in my estimation. I don't know whether

I make myself plain --

Q I think you do. But still that does not explain why those wells have been injuriously treated.

A Wells that have not been acid treated, that had the ability to earn a greater potential --

Q (Interrupting) Wouldn't it be your opinion that wells in a field where there were less permeable areas than other parts of the field, the wells that greatly increased their potential were in that less permeable area, rather than those on top of the structure where there is a gas cap?

A I think the time factor would help those in the gas zone. They have a longer life in which to recover the oil than the edge wells do.

BY COL. ATWOOD:

A If I follow you clearly, you are not giving it as your opinion that potential should be disregarded entirely in the Hobbs Pool?

A No, I have no brief for or against potentials.

Q Your contention is that if potential is to be used, there are other factors that should be considered?

A I think there are certain inequities in the present use of potentials.

Q So your testimony is directed more at the method of computing potentials than the right to use potentials?

A That is right. I am not attempting to present testimony for or against potentials. Just trying to point out some things that seem to me to have become inequitable in the present use of potentials.

Q Then the present ratio of 60 on acreage and 40 on potential could still be followed, but so that the 40 on potential -- that is allowed for potential, it should be computed on the basis of the potential of the well when first drilled in?

A I prefer that.

Q Would you say that regardless of changes in the pressure in various parts of the pool, that that potential should be frozen clear on through?

A I prefer that way to what it is now.

Q Isn't it a fact that if any changes in bottom hole pressure come into existence in a pool, the result is a migration of oil which takes place from the high pressure areas to the low pressure areas?

A I have been unable to apply bottom hole pressure adjustments to potentials in the Hobbs Pool. I should say, in my own mind.

Q If migration takes place in a pool, what causes it?

A Pressure. Differences in pressure.

Q Higher pressure in one place and lower pressure in another, up or down the incline, it would drive the oil from the high pressure area to the low pressure area?

A As a general thing, I think that is right.

Q Is it a fair statement to say that any program for steadily developing a pool is to prevent migration of oil -- to hold it in place so that the owner of that deposit may recover the oil?

A I think that is the function of the Commission to determine. Under the state law they are charged with the duty of conserving the oil, and second, to allocate the oil. I think that is their function, and I would hate to try to allocate the oil in the Hobbs Pool.

Q I said, is it not the objective of any order to prevent the migration of oil and hold the oil in place to prevent migration?

A Theoretically, if you could build a fence around each well's property, to prevent any migration of oil across property lines, we would not have any proration.

BY GOVERNOR MILES:

Q If a company could prevent that, they would be interested in doing it?

A I don't know how they could do it.

BY MR. ATWOOD:

Q I am speaking about the objective. Is not that the objective, to hold the oil in place and prevent migration, so that each man takes the oil in place under his property?

A The state law, I think, covers that point.

Q Then it is a fair statement to say that any plan which is devised for proration, should be so devised to prevent migration of oil?

A I think conservation is a factor that comes in there too, besides allocation of oil among the operators.

Q Under our law it is recognized that every operator, royalty owner, owner of oil in place underlying their land, they have the right to recover the recoverable part of it. If that oil which is recoverable is permitted to migrate, the State of New Mexico is prevented from recovering a fair share of the oil underlying its land.

A I think it is the duty of any operator, who figures he is being drained by some operator, to present his case to the Commission.

BY MR. HUBBARD: Some of the questions are not quite in line. We have Mr. Dewey present, but he has not qualified on all of these points.

BY MR. ATWOOD: Somebody admitted his qualifications generally.

BY MR. HUBBARD: The only point I want to make, he introduced certain exhibits. These questions are somewhat afield from those exhibits. I admit they are good questions, but I don't think he has quite prepared himself especially well, except on the questions we presented.

Witness dismissed.

BY GOVERNOR MILES: The Commission will be in recess a few minutes.

MR. GEORGE H. CARD,

being recalled for further

DIRECT EXAMINATION By Mr. Seth,

testified as follows:

Q Mr. Card, this map at the extreme right (indicating map stand) Exhibit 3-A, you testified was the southern part of the field; that the present proration formula has deprived several wells, including Nos. 8 and 9, Stanolind, of all potential?

A Yes, sir.

Q Is that the area in green on that map?

A Yes, sir.

Q Are those wells, the majority of them, still producing oil?

A Yes sir.

Q But have no potential under the present proration plan?

A Have no allowable under potential.

Q They get the acreage allowable of 60%, and nothing more?

A That is true.

Q On that map the yellow indicates packer wells?

A Yes, sir.

Q Both wells, under the present proration formula, always had climbing potentials?

A Their potentials have declined. Packer wells have had steadily declining potentials, according to the way the pressure -- the field average pressure of the packer wells.

Q The field average pressure has always declined?

A Well, I believe there are a couple of surveys where the pressure increased, but the reason the packer wells declined more than the field average decline in potential, many wells in the field have increased in potential due to pressure adjustments.

Q The yellow wells, throughout the period, have lost potential?

A Yes, sir.

Q The areas in red represent areas where no pressure was taken, and they are assigned the pressure on the adjoining areas?

A That is true.

Q And the white indicates wells where the pressure was taken?

A Non-packer wells where the pressure was taken.

Q The white and red represent wells that have gained under the present system of adjusted potentials by bottom hole pressure?

A Not necessarily. You might have some low pressure wells down here (indicating on map) that have decreased in potential.

Q The ones gaining in potential largely are located in the white and red areas?

A There are also wells that have decreased in potential in the white and red, too.

Q But the yellow have lost -- they have lost steadily, being packer wells?

A They have suffered decline in potentials, yes, sir.

Q You spoke yesterday of some wells in the northern part of the field producing large quantities of water. Will you turn next to the one that shows water production. What number is that? (Witness turns to another map).

A 2-A.

Q Can you point to some wells in the northern part of the field producing large quantities of water along with the oil?

A This exhibit shows oil production for 1928 and water production for 1938, and the water percentage.

Q Take these wells here (indicating on map), Gulf, the one in the NW$\frac{1}{4}$ NE$\frac{1}{4}$ of Sec. 24; what was the water production?

A Oil, 18122 barrels; water, 83,322; water, 82%.

Q Does that mean that during the year 1938 the well produced four times as much water as oil?

A Approximately, yes, sir.

Q Come over here. (Witness goes over to map). Cities Service, what would that oil and water production be -- in the NW$\frac{1}{4}$ of Sec. 19?

A Oil, 20,808; water, 78,774.

Q Approximately four to one?

A Yes, sir.

Q And the well, the offset?

A Oil, 24,564; water, 67,980; 73%.

Q Immediately north, in the SW$\frac{1}{4}$ of Sec. 18, there are two wells in the S$\frac{1}{2}$ SW$\frac{1}{4}$ of 18; will you state their production?

A Oil, 20,589; water, 303,820 barrels; percentage, 93%.

Q Was that about fifteen times as much water as oil?

A About seven barrels of oil to 83 barrels of water.

Q The next one immediately east of that?

A Oil, 24,082; water, 461,258; percentage, 95%.

Q In those wells, Mr. Card, if that water were not produced, would it go on up the structure?

A Yes, sir.

Q What is the general effect of producing that large quantity of water, along with the oil, in the field on the pressure?

A It helps to decline the pressure.

Q If that water were packed off, would it improve the pressure in the field?

A It would help to maintain the pressure in the reservoir.

Q With that water they are producing oil and water together; is that correct?

A Part of the oil probably is coming from a zone that does not have water in it; the other part, the oil and water are coming together.

Q Suppose the Stanolind, down in the southwest flank of the field, had followed the practice of producing large quantities of water with the oil, instead of setting packers; would that have had the effect of holding the oil in place?

A If they had produced the water -- you would have had the effect -- that Stanolind could have produced the oil at that point by setting packers?

Q If they had produced twenty barrels of water for one barrel of oil, would that have had the tendency to have held back the oil in place under their leases?

A Held back the oil in place under the Stanolind leases?

Q Yes.

A Yes.

Q Would it have stopped the water from moving the oil up structure?

A Yes.

Q What effect would it have had on the pressure up structure?

A It would have lessened the reservoir pressure up structure.

Q Would it have lessened the production of oil up structure?

A By lowering the reservoir pressure you allow gas to come out of solution, making the oil heavier and more difficult to flow into the well bore and towards the well bore.

Q Now, will you state again, please, how the potentials of packer wells are adjusted by bottom hole pressure, under the present proration plan?

A Packer wells are assigned field average pressure for the purpose of adjusting potentials.

Q And are pressures taken in the wells?

A Pressures are taken in as many packer wells as possible, but the pressures taken are merely to calculate the field average pressure.

Q But they have no effect to assign pressures in the packer wells?

A No, none at all.

Q What has been the effect of the assignment of field average pressure on packer wells and on their potentials?

A It has had the effect of declining the potential greater than the decline of the average potential of other wells in the field, because of the fact that some wells increase their potential all of the time.

Q Why has this had the effect of always decreasing it, Mr. Card?

A Because of the fact that the pressure, in nearly every survey, has gone down, so if you assign the field average pressure to packer wells, it goes down, whereas wells in the field above the field average, their pressure increases; because the field average, when all wells decrease, the potential of the packer wells decrease because of the decrease in pressure on all wells in the field.

Q Is it the effect of the present proration scheme that a well that keeps above the field average in pressure gets an increase, generally, although its pressure may have declined?

A Yes, sir, as long as it is above the field average it gets an increase, whether or not the pressure goes down or not.

Q Has the potential of these packer wells, under this formula, been declined greater than the field average decline in potential throughout the field?

A Yes, sir.

Q Basing it on the field average has caused a greater loss in potential to them than the average loss throughout the field?

A The packer wells have suffered out of proportion to the other wells.

Q How many packers has Stanolind set?

A They have set a total of nineteen packers, gas and water packers.

Q How many packers altogether have been set?

A Has Stanolind set?

Q No, the number in the field. How many have been set in the field?

A I don't recall.

Q Was it fifty-eight or nine?

A Yes, sir. We have set packers in 33% of our wells, the Stanolind wells. I think we have fifty-eight wells -- our percentage of units in the field is 22.6, so we have set packers in the larger percentage of our wells than we have units in the field, which shows we have suffered more from packers in proportion to our acreage.

Q Did you give, yesterday, the amount of potential that Stanolind would have now -- I mean, how much larger potential Stanolind would have now than it has if the packer wells had been declined on average potential rather than average field pressure?

A We would have approximately 57,000 barrels more than we have at the present time.

Q When Stanolind set their packers, was it a low or high pressure area where they were set?

A High pressure area.

Q If packers had not been set in these high pressure areas in which they were set, what would have been the effect on Stanolind's potentials in those wells?

A Due to the fact of the high pressure area, the potentials, and, therefore, our allowables, would have been increased on every pressure adjustment period.

Q Mr. Card, the gentleman representing Skelly seems to think the setting of packers beneficial. What effect has the setting of packers had on Stanolind allowables?

A It has been very detrimental to allowables.

Q Will you state in what way?

A We have not the opportunity, the same opportunity of producing oil in those packers; we also gave up the opportunity of having potential increases by being in a high pressure area; as a result, potentials have declined.

Q Have you a diagram showing the comparison between the bottom hole pressure and potential in the Hobbs field?

A Yes, sir.

Q Will you produce it, please.

(Witness produces diagram, marked "Stanolind Exhibit No. E).

BY GOVERNOR MILES:

Q These three maps represent the same area?

A Yes, sir.

Q These all represent the Hobbs field? (Referring to three maps put in evidence by this witness on the preceding day).

A Yes, sir.

Q You were talking about up structure. Where is that on this map?

A Here is the low structure, and here the high.

BY MR. SETH:

Q I hand you Exhibit D, from yesterday.

BY GOVERNOR MILES:

Q Will you please state again where the low and high structures are located?

A This would be the low structure (indicating on map). The high structure for the field is through the center. The low structure would be around the edges of the field.

BY MR. SETH:

Q Will you state, for the record, approximately what sections are the high structure?

A It would be Sections 29, 30, 32 and 33.

BY GOVERNOR MILES:

Q What represents the packer wells?

A The water packer wells are colored red. The gas packer wells, in the center of the field, are not shown on that map.

Q In setting these packers in the wells, that had a tendency to push the oil up structure?

A They kept the water from being produced in those wells, and that pushed the oil on up structure.

Q These are not packer wells? (Referring to other wells indicated on the map).

A No.

BY COL. ATWOOD:

Q Generally speaking, where are the Stanolind leases?

A This section on the southeast side of the field, the yellow acreage (referring to map). These leases up here (indicating on map) are in a fairly good structural position.

BY MR. SETH:

Q This exhibit, Stanolind Exhibit E, is designated "Chart Showing Effect of Bottom Hole Pressure Correction Factor on Potential". On the left side are ten wells showing the largest gain in potential, is that correct?

A Yes, sir.

Q And on the right side are ten wells showing the largest loss in potential?

A Yes, sir.

Q Let us take this part first -- cut the chart in two in the middle I guess. (Chart is cut in two parts, and both parts displayed on map frame).

Now, Mr. Card, take the first well up there, Gulf Graham No. 1, Sec. 24, Over on the left is the scale. Explain what that means.

A The upper curves are bottom hole pressure. The scale is approximately 50 pounds to the inch. The lower lines are the potentials in thousands of barrels. The scale is approximately 5,000 barrles to the inch.

Q That is the bottom hole pressure scale (indicating on chart). Is that correct?

A Yes, pounds per square inch.

Q And at the bottom the potential in thousands of barrels?

A Yes, sir.

Q And at the bottom of the diagram those figures represent the years?

A Yes, each square is a year.

Q The Gulf No. 1 started at a bottom hole pressure of about 1375 in 1933. Is that correct?

A Yes,sir.

Q It has various ups and downs -- it is down to about 1235 in 1939?

A In March, 1939, yes, sir.

Q Falling off about 150 pounds?

A Yes, sir.

Q Take the potential of the well -- it started at about 3500 in 1933?

A Yes, sir.

Q What was that in March of 1939?

A The potential was about -- between 32,000 and 33,000.

Q It increased its potential eight or nine times?

A Yes, sir.

Q Along about the end of 1934 there is a straight up and down potential jump, from 7,500 to about 22,000?

A Yes, sir.

Q What was that due to?

A Due to acidation.

Q But since acidation the potential has increased about 10,000 a day has it not?

A Yes, about 10,000 barrels.

Q Although the pressure has fallen off?

A The pressure has fallen off.

Q Probably 150 pounds per square inch?

A Yes, sir.

Q In other words, that well, over a period of about six years, has had its potential increased eight or nine times?

A That is true.

Q Through acidation and through operation of the bottom hole pressure?

A Yes, sir.

Q Although the bottom hole pressure has fallen off fully 100%?

A 150 pounds.

Q The next one is Shell State D-2. That has had now much falling off in bottom hole pressure?

A About 165 pounds.

Q And how much potential increase?

A A potential increase from about 9,000 barrels to 23,000 barrels.

Q And the next, Grimes No. 2, there is a falling off in bottom hole pressure?

A Yes, about 125 pounds.

Q And how much potential increase?

A From about 16,000 barrels to 28,000 barrels.

Q Without going through all of these,-- this map was prepared under your direction?

A Yes, sir.

Q And they represent correctly the official data from the Hobbs field?

A Taken from the Hobbs operators report.

Q It looks like the Stanolind No. 33, and every one of these, the bottom hole pressure has fallen off?

A About 160 pounds on the Stanolind No. 33.

Q And the potential increased how much?

A From about 23,000 up to about 32,000, the highest.

Q Take one of the lower ones there (Indicating the lower half of the chart, as it was placed on the map form).
Take the first one, the Amarada State B-4, in Sec. 29. How much has the bottom hole pressure fallen off?

A About 150 pounds.

Q Has it lost any potential?

A Lost about 18,000 to 16,000 thousand barrels. This was probably acidation. From the time of acidation, 23,000 to 16,000.

Q The acidation covered the period from the end of 1934 and the first part of 1935.

BY GOVERNOR MILES:

Q How is a well's bottom hole pressure brought about?

A Production, by fluid.

Q What do you mean by fluid?

A Oil, water, gas.

Q In acidation, by acidation of the pool, does the well take less pressure? What makes the increase if the bottom hole pressure has decreased -- what makes the increase?

A You mean, the potential increase?

Q Yes.

A Because of the fact that any well with pressure above the field average pressure gets an increase in potential. If the well has a pressure below the field average, its potentials are decreased. The formula works that way.

Q That one over there (indicating the chart) shows there had been an increase?

A All the upper ones (right hand end of chart) show increased potentials. All below show decreased potentials.

BY MR. SETH:

Q Take the Amerada State in Sec. 29, it has had a decline in bottom hole pressure?

A Yes, sir.

Q And yet the Gulf potentials have increased eight or nine times?

A Yes, sir.

Q And the Amerada State has gone off two or three thousand barrels potential?

A Yes, sir.

Q Is that one reason why the Gulf, under the operation of that formula, under the inequitable operation, got two or three thousand barrels increase, and the Amerada got a decrease?

A Yes, sir.

BY GOVERNOR MILES:

Q Based on what?

A Based on the fact that the proration formula is based on the bottom hole pressure of the field, the pool relationship.

BY MR. SETH:

Q Take Stanolind No. -- Stanolind State A-1.

A This well has been a packer well, and of course, received the field average pressure.

Q It has declined in bottom hole pressure about the same as the Amerada State, has it not?

A Yes, about the same.

Q And lost in potentials, or probably gained at the beginning, but from the high point of potential, it has lost a great deal more?

A Yes.

Q Take the Humble Bower over here,- that has had a falling off in bottmm hole pressure substantially like the Gulf's?

A Yes, sir, about 170 pounds.

Q And how much has it lost in potential?

A About 12,000 barrels.

Q Mr. Card, during all the years up to 1937, January first, 75% of the field allowable was allocated on potential, was it not?

A That is true.

Q And since 1937 this inequitable operation of the potential applied to three-fourths of that area?

A About 75% of it.

Q And reduced that to two-fifths of the oil produced?

A Yes, sir.

Q Do you know of any principles of engineering, geology, or anything else that would justify any such operation of a formula of this kind, in the way it has operated?

A No, I do not.

Q Take the Gulf Graham, in Sec. 24, the first one, do you know of anything operating to increase the recoverable oil in place to justify an increase in its potential eight or nine times?

A No, I do not.

Q Has anything happened to increase the recoverable oil in place?

A No.

Q All have had a drop in bottom hole pressure?

A That is right.

Q And ten have had a decrease in potential?

A Yes.

Q And ten have had an increase in potential?

A Yes, sir.

Q That is just a group taken at random?

A These are ten wells showing the largest gain and ten wells showing the largest loss.

BY GOVERNOR MILES:

Q Where would they be located in the pool?

A They are scattered all over the pool. These up here (indicating on the chart) are in the north end of the pool; these down here towards the south.

BY MR. SETH:

Q Mr. Card, I don't know whether you have already testified to this or not: what will be the effect, in your judgment, on the ultimate recovery of oil from the Hobbs Pool, from these large withdrawals of water up in the north end?

A I believe it will lessen the ultimate recovery of the field.

Q It will weaken the water drive?

A It will weaken the water drive and allow the pressure to go down faster, thereby allowing the gas to come out of solution, making the oil thicker and hard to come out of the bore hole.

CROSS EXAMINATION By Mr. Bohart:

Q Mr. Card, I understood, in your testimony yesterday, that you stated that the encroachment of water constituted waste. Now, perhaps I am not quoting you literally or exactly. If not, would you please state that again?

BY MR. SETH: I think he said the production of water.

Q I believe you were asked the question, "if a property was going to water" if that constituted waste, and you said yes.

A I meant by that statement, the production of large quantities of water constituted waste.

Q This was made in a different place. Do you believe the encroachment of water itself, on a property constitutes waste?

A The movement of water from the edge of the structure up to the top?

Q Yes.

A No.

Q The mere encroachment of water does not constitute waste?

A No.

Q Mr. Card, then it is perfectly normal, as oil is withdrawn from a structure which, before discovery, in a static condition, no movement from one part to another,-- it is perfectly normal for water to encroach and occupy the space evacuated by the oil; is that correct?

A Yes, sir.

Q I perhaps misunderstood your answer to the question yesterday, and I wanted to be sure of your opinion on that point.

Yesterday you made the statement that certain properties of Stanolind, that formerly produced from the so-called upper pay, and in which packers had been set, had had the oil removed from them by water, and thereby you lost some of the oil -- either lost it or abandoned it, and were thereby deprived of it. Could you tell just what properties you referred to there?

A You mean properties where we calculated our losses?

Q Yes, have you got a map you can put up?

A We can put up the water encroachment map. (Witness puts up map). One of these wells is the Byers No. 8, in the NE$\frac{1}{4}$ of Sec. 4 -- this well here (indicating on map). Another well is the Byers No. 11 in the NE$\frac{1}{4}$ of Sec. 4. The Byers 26, in the NE$\frac{1}{4}$ of Sec. 4. The Byers No. 33, in the NE$\frac{1}{4}$ of Sec. 4. The McKinley No. 1, McKinley No. 6 and McKinley 26. State No. 8, in the NW$\frac{1}{4}$ of Sec. 4. State No. 11 in the NW$\frac{1}{4}$ of Sec. 4. State No. 26, in the NW$\frac{1}{4}$ of Sec. 4. State No. 33 in the NW$\frac{1}{4}$ of Sec. 4. State No. 3 in the SW$\frac{1}{4}$ of Sec. 4. State No. 11 in the SW$\frac{1}{4}$ of Sec. 5. Terry No. 8, in the NW$\frac{1}{4}$ of Sec. 9.

Q Now, for example, in which direction do you contend you lost oil from the McKinley property?

A On the McKinley property the oil passed up in this direction (indicating).

Q In what direction?

A North and east.

Q Mr. Card, what causes a liquid or gas in a reservoir to move from one place to another?

A Differential in pressure.

Q Generally speaking, a liquid or gas will move in the direction from the higher to the lower pressure?

A Depending on the permeability.

Q It would not move from low to high?

A No.

Q Then it would move from a higher to a lower. I do not have all of your figures available, but in making a spot check I find in December, 1931, the bottom hole pressure in your well in here, No. 5 West Grimes, was 1470 pounds. If you wouldn't mind, would you point out about where that is. (Witness points to well on map.) 1470 pounds, on the same date, or approximately the same date, that the Stanolind No. 6 had --

BY MR. SETH: Have you been sworn so that we can cross examine you? You are giving testimony.

BY MR. BOHART: I need this in order to ask a question.

BY MR. SETH: We might want to examine you on that.

BY MR. BOHART: I can ask if that is the pressure.

Q Do you have the statement, or would you tell what the pressure was in December, 1931?

A I don't have those pressures with me.

(Mr. Bohart hands witness a book).

BY MR. SETH: What are you reading from?

A This is the Hobbs Pool General Report.

(To Mr. Bohart): What wells do you want?

BY MR. BOHART:

A The Gulf No. 5 West Grimes, the December, 1931 survey?

A 1470 I believe, as well as I can see it.

Q What was the prėssure for the Stanolind No. 6 McKinley, at the same time?

A 1453.

Q Is that an offset, the south offset to the Gulf No. 5?

A Yes, sir.

Q And that is one of the properties you contend you have suffered a loss?

BY MR. SETH: In order that the record may be clear, is that the shut-in pressure or flowing pressure?

A Shut-in.

BY MR. BOHART:

Q And that is a difference of about 17 pounds?

A Seven pounds, shut-in; that does not mean that much in flow.

Q Seventeen, isn't it?

A That does not necessarily mean that much in flow pressure.

Q That relationship is static bottom hole pressure?

A Shut-in pressure, when not producing in the well.

Q What was the pressure in the No. 6 West Grimes on the same date of survey?

A It looks like about 1436 -- the figures are hard to read.

Q What was the pressure of the Stanolind No. 1 on the same date?

A 1458.

Q Well, at that time then, in the case of one pair of wells, there was a slight differential toward the south, the Stanolind?

A Measured by shut-in pressure test.

Q And on the other pair, there was a slight differential towards the north, the Gulf's?

A Yes, sir.

Q What was the pressure of the Gulf No. 5 West Grimes on October 23rd --

BY MR. SETH: We would like to have it shown that is shut-in pressure.

BY GOVERNOR MILES:

Q May I ask what is shut-in pressure and flowing pressure?

A When the pressures are taken, the wells are shut in for from 24 to 36 hours previous to the time the pressure is taken. That does not necessarily mean that is what the pressure is when the well is flowing. One well may have a much lower flowing pressure. The pressure test is when the wells are shut in.

BY MR. BOHART:

Q Mr. Card, isn't closed-in, static bottom hole pressure the pressure of the formation?

A Adjacent to the bore hole.

Q That is the pressure under which the fluid exists in the formation?

A Right adjacent to the bore hole.

Q When you take static bottom hole pressure the purpose is to close the hole a sufficient length of time to permit the pressure to build up to the maximum -- as much as it will build up?

A It takes some wells a good deal longer than others.

Q That is true, but isn't that the general purpose of taking a static bottom hole pressure?

A In a general way, it is, yes.

Q After that has reached a maximum, generally speaking, that represents the pressure of the formation surrounding the well?

A You don't know how far sourrounding it.

Q For some distance back?

A There is no way of knowing how far back.

Q It will not build up any more, so that it has reached equilibrium?

A Some wells will build up for a while -- leave them shut in and then they will build up.

Q When they have reached the maximu, the well has reached equilibrium, and that represents the average pressure of the field?

A Directly surrounding the well. I don't know how far.

Q And that indicates the pressure,- represents the force acting in the formation.

A It indicates the shut-in pressure, but not under flowing conditions.

Q The flowing pressure, or pressure differential while flowing is the drop in pressure from the bottom of the hole to the top of the hole?

A State that again.

Q The differential while flowing -- after oil gets into the bottom of the hole there is a certain differential of the pressure which must act to bring it to the top?

A Naturally the pressure is less on top than at the bottom.

Q If this well has a bottom hole flowing pressure of 600 pounds, and it is flowing on choke -- that is, flowing restrictedly, so that there is a pressure on the gauge at the top, the difference in the pressure is the pressure differential between the bottom and the top of the well?

A As far as the flow is concerned. That is not the differential in the reservoir.

Q What was the pressure in Gulf No. 5 West Grimes on October 23rd?

A 1380.

BY MR. SETH: Shut-in pressure?

A Yes, shut-in pressure, yes, sir.

BY MR. BOHART:

Q You are giving them all on the same basis?

A Yes, sir.

Q What was the pressure of Stanolind No. 6 McKinley on the same date?

A 1363.

Q What is the south offset to West Grimes No. 5?

A Which wells, 5 and 6?

Q What is the pressure of Gulf No. 6 West Grimes as of the same date?

A 1383.

Q What was the pressure of Stanolind No. 1 McKinley, as of the same date?

A 1364.

Q That is the south offset to Gulf No. 6?

A Yes sir.

Q As that is south of Sec. 32, along that part of the pool the formation pressure, the static bottom hole pressure, was less to the south, on the Stanolind side, then?

A The shut-in bottom hole pressure was, yes, sir.

Q That is the pressure in the formation which is tending to expel the oil towards the bore hole?

A No, I would not say it was, exactly. You don't know what the gradient is out to the drainage area.

Q Even while a well is closed in -- assume the bottom hole pressure, which is not usually the case -- assume it is empty. You close the well in, and there is some forcex tending to push the oil from the formation into the evacuated area?

A Yes, sir.

Q In the last analysis, it is the pressure in the formation that tends to do that work?

A Yes, sir.

Q At this time there was not a pressure differential toward the north, at least in this area, as reflected by the Hobbs Engineering Report of bottom hole pressures?

A As reflected by conditions surrounding the bore hole. I don't know what they were a short ways away from the bore hole.

Q Well, the pressure could not have been less away from the bore hole than at the bore hole?

A No, probably higher.

BY DR. KNAPPEN:

Q If that is the case in December, 1931, the formation pressure around the wells, giving that 17 pounds difference in pressure, would tend to move the oil from the Gulf No..5 to Stanolind McKinley?

A Yes, sir, in this tabulation here it shows that McKinley No. 6 gained in oil during that year. These tabulations show gains and losses too.

Q And at the same time, according to your figures, there was a differential tending to move the oil from Stanolind No. 1 north to Gulf No. 6?

A That is, the pressure.

Q Do your tabulations show a loss for the Stanolind No. 1?

A In 1930 and '31 it shows a slight gain.

Q So that your calculations cannot be entirely correct, when you had a differential tending to take pressure away from you, when you show a gain?

A It was very small in those years.

Q In October, 1933, there was a pressure differential southward tending to move oil to Stanolind McKinley?

A 16 pounds. That is a pretty small difference for statin pressure.

BY GOVERNOR MILES: The Commission will be in recess until 2:30 P. M.

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Pursuant to recess taken, the Commission resumed the hearing at 2:30 P. M., December 7, 1939.

Mr. George H. Card on the witness stand for further cross Examination.

BY DR. KNAPPEN:

Q You are the same Mr. George H. Card who was on the witness stand this morning?

A Yes.

Q We were discussing bottom hole pressure -- I think you were making a distinction between closed-in bottom hole pressure and flowing?

A Yes, sir.

Q Can you explain to the Commission why closed-in bottom hole pressure has been taken throughout the last seven years, the life of the Hobbs field?

A The only reason I know, it was just the way we started.

Q Engineers generally agreed at the start that it was desirable?

A They have taken flow pressure on some wells, I believe.

Q But the bottom hole surveys report by the engineering committee are on closed in pressure?

A They are closed in pressure, yes, sir.

Q Why do they not report on flow pressure?

A I don't know.

Q You don't know why flowing pressure is of little significance?

A I think it is of significance.

Q But the engineering committee do not think it sufficiently so to ask for flowing pressure, nor do they think it sufficiently so to publish?

A They have published all that have been taken.

Q They have published all that have been taken?

A I believe so.

Q Do you know how many have been taken?

A No, not exactly.

Q Do you know how many closed in pressures have been taken?

A I don't know.

Q Would it be as much as 25 times, do you know?

A I don't know.

Q You have not paid much attention to flowing pressures in the Hobbs pool?

A Yes, to what was taken.

Q You have not urged it to be used?

A I don't think bottom hole pressure of any kind should be used alone.

Q That is a different attitude than that Stanolind had in 1932 when bottom hole pressure was introduced?

A It probably is.

Q Wasn't the bottom hole pressure introduced by Stanolind because they had high pressure areas in the field that were being drained?

A I don't know. I was not with the Stanolind at that time.

Q You have not studied your files enough to know whether that is correct?

A I don't know who urged it.

Q You don't know whether any Stanolind engineer urged that bottom hole pressure be used for adjustment of allowables in the Hobbs Pool?

A He may have done so.

Q You don't know whether he did?

A So far as I know, I think he was in favor of it.

Q Who was that engineer?

A Are you referring to Wahlstrom?

Q I am asking you. What was his connection with Stanolind at that time?

A I believe he was field engineer at Hobbs.

Q And he urged bottom hole adjustments in the proration plan for Hobbs?

A I believe he did, yes. At that time engineers knew very little about bottom hole pressure, and still know very little.

Q Do you know how the bottom hole pressures in the Stanolind wells along the north boundary of your properties compared with the bottom hole pressures taken on equivalent wells immediately north of the township line?

A For the most part, I think they have been as high or higher.

Q The Stanolind have been as high or higher?

A Generally speaking, they have been pretty close together.

Q If I were to tell you that in December, 1931, the north offsets of the Stanolind wells were two pounds higher than in the Stanolind wells, would you know that is correct?

A I would have to look at the maps.

Q You don't know what the relationship was?

A On most of the maps and surveys, especially recent surveys, our pressures have been as high or higher than those.

Q In recent years, yours are all packer wells, aren't they?

A No.

Q Your wells along the north line are not all packer wells?

A No.

Q I am talking now about December, 1931, the several surveys made by the engineering committee --

A I cannot remember individual wells.

Q And especially that pressure differentials increased to the survey of October, 1933 -- the pressure differentials at that time were ten pounds -- that is, the Stanolind wells were ten pounds less, on the average, than the north offset wells, taking the wells where actual measurements were made, not taking any assigned pressures or packer wells. Is that the true situation in 1933?

A I would have to look at the record of the two surveys.

Q Assume for the purpose of the question, that in the first survey the Stanolind wells were two pounds less in pressure than the north offsets, and two years later, ten pounds less. Would that indicate the oil was moving northward?

A I don't think it would indicate anything definite. In the first place, you cannot read bottom hole pressure charts within ten or fifteen pounds. In that case, you could have a variance of forty pounds, up or down -- that is, static pressure, you are talking about. You have got to know the pressure under flowing conditions.

Q Granted there may be an error in the reading of the charts involved -- there could be some error in the reading of any chart -- but if they were consistently lower, and another set of measurements, under static conditions, still showed they were lower, could an engineer say he could not tell with definiteness that those pressures were lower?

A One engineer can read a chart and get ten or fifteen pounds difference, higher or lower.

Q If the same group of wells were measured, if they constantly ran higher on the north, would that mean the engineer could not read the chart?

A I did not say he could not read the chart -- he might make a mistake.

Q If they constantly ran lower, would that mean the Stanolind wells had lower pressure than on the north?
A You are talking of static pressure?
Q Static, closed in. If the same group of engineers, reading the charts, constantly found the pressures higher in the wells north of the township line than south of it, would that indicate the closed in, static pressure in the Stanolind wells was less than in the wells to the north?
A It might be a general indication. It would be hard to say. There are many cases where you see the static, shut-in pressure running higher. That does not mean anything.
Q Would it be a coincidence if the error were always against the Stanolind on a whole series of surveys? I am not asking about those tests on wells where pressures taken --
A (Interrupting) What surveys are you talking about?
Q December, 1931 and October, 1933.
A I don't believe I have those.
Q It would take too much time to check up. I am asking if that situation is presumed to be correct, whether it would indicate the Stanolind wells had lower static pressure than those to the north?
A Any survey, or group of surveys, could make the same mistake, you mean?
Q Alright, I see you don't want to answer the question, so I will ask you another.

BY MR. HUBBARD: I don't believe that is called for.

BY MR. SETH: The witness is trying to get the data to answer the question of the gentleman. Evidently he does not want him to produce it.

BY DR. KNAPPEN: I am asking if that proposition were shown to be true --

BY MR. SETH: I think we ought to have the evidence. Let him produce the evidence that they are lower.

A You can look at just as many surveys and maps as you want, and see that the Stanolind wells on the north line were a few pounds higher, and then lower --

BY GOVERNOR MILES: You may produce the record.

BY DR. KNAPPEN: Mr. Chairman, I think we can get together and tabulate this data. It is scattered over a large chart. I think it might be best to pass that question for the present. With your permission I should like to consult with the witness and tabulate that data.

Q You introduced an exhibit, I believe Stanolind Exhibit D, was it not, which showed packer wells, the wells in which packers had been set in the Hobbs Pool?

A Yes, sir.

Q That exhibit showed only wells in which packers had been set to shut off water?

A That is true.

Q Many were set to conserve gas, were they not?

A That is true.

Q Do you know how many gas packer wells there are?

A I have a map here that shows it. (Witness produces map). There are approximately 43 gas packer wells.

Q And how many water packer wells?

A 35.

Q So there are more gas packer wells than water packer wells?

A Eight more -- I believe that 43 is correct.

Q I think it is very close to accurate. You did not show the gas packer wells on that map?

A No, that was a water encroachment map.

Q There are something like eight more gas packers set than water?

A That is true.

Q When a gas packer is set, the operator abandons the production from the formation above, in exactly the same way as with a water packer?

A It depends on whether there is any more water left in the area packed off.

Q My question was, does he abandon the formation in the same way he does with a water packer?

A Yes, there is less likelihood of any oil -- more that situation with a gas packer.

Q They abandon production in the same way as with a water packer?
A Yes.
Q When gas packers have been set, has every bit of producible oil been taken from that formation?
A Not necessarily. I believe under the conditions in the Hobbs Pool, there is more likelihood of the oil being depleted than with water packers.
Q There is some oil left behind, probably, or above the packer when a gas packer is set?
A It is hard to say -- maybe a small amount.
Q What is the reason for setting a gas packer?
A To reduce the gas-oil ratio.
Q The setting of a gas packer is a real conservation factor, is it not? The operator setting the packer is attempting to conserve gas for use of other parts of the pool, is that correct?
A Well, yes, the wells adjacent to the one he sets.
Q Certainly, on his own lease as well as others, but he is endeavoring to conserve the gas, for the benefit of production of other wells, his own as well as others?
A That is true.
Q When water packers are set, are they set to shut off water, or are they set because the operator can no longer produce his well unless he sets the packer?
A I don't think that is the case in the Hobbs Pool. There is no reason why he could not produce that water.
Q Have wells in which water packers have been set continued to produce their allowable up to the time of the setting?
A It probably has been necessary to pump some wells.
Q Any wells gone dead and had to be swabbed?
A Naturally, a well producing a lot of water would go dead occasionally. That is no reason it could not produce.
Q Many wells did go dead before water packers were set?
A I imagine they did.
Q Would it be safer for an operator to produce his allowable oil after setting a water packer than previously?
A You have got to take into consideration how much oil you are

going to get. I think the operators on many leases would have been ahead if they had set packers.

Q In terms of actual data on operation costs, would an operator's costs go up or down after he sets packers?

A It costs more money to operate a well pumping than a flowing well. You have got to consider the ultimate profit.

Q Forget the ultimate profit -- we are talking about operating costs. The setting of packers does result in saving operating costs?

A It should. If it does I don't understand why all operators in the north end have not set packers.

Q Any operator successfully setting a water packer does save in operation expenses?

A There should be a saving.

Q I agree. What determines the time when a water packer is set -- when an operator decides it is time to set a packer?

A Well, a lot of the wells make a small amount of water -- some a large amount of water --

Q What is the basis that you, as a Stanolind engineer, use to decide it is desirable to set a packer?

A Probably when they are having trouble treating the oil.

Q Take as an example Stanolind McKinley No. 26; do you remember the water percentage before setting the packer, was it 87% water?

A I don't recall exactly.

Q If it had been 87% would it have resulted in a saving to set the packer, in, after setting the packer, of having no water to produce from that well?

A We would not have to handle the water -- probably a small saving.

Q Do you know whether that well was making its allowable when you set the packer?

A I don't know.

Q Do you know whether that well was making its allowable, or making its allowable without swabbing?

A I could not say definitely. I know with the last two packers set, it was necessary to swab before setting the packer.

Q What does it cost to set a packer and pump at a depth of around 4,000 feet?

A That depends on the type of equipment used to set the unit -- probably $3,500.00.

Q Would that well, producing 50 barrels of oil and 17 times as much water -- if your well was making 87% water and producing 50 barrels of oil per day, how many barrels of fluid would that be?

A Nine barrels of water for every barrel of oil would be 450, approximately.

Q So you don't know the basis upon which you decided to set water packers on those packer Stanolind wells? Was it just a gamble, or when did they decide to do it?

A The last two wells, they were having trouble operating the wells. At the same time they started out to set packers others did too-- I think the Texas Company was the first one to set a packer, it was recommended by the Engineering Committee that a packer should be set there, and the Stanolind and other operators followed the same recommendation.

Q When did you decide, when a well was making 2%, 25%, 50%, or when the operating costs became excessive?

A A lot of packers have been set when I have been out of touch with the Hobbs field. I don't know exactly every one.

Q Water packers are set in order to reduce operating expenses, aren't they?

A And conserve the energy in the pool, yes.

Q Does the setting of a gas packer reduce the operating expense?

A Sometimes you set a gas packer in a well because it is making so much gas it is not making very much oil.

Q Does that involve operating expense?

A It involves revenue.

Q But does not involve operating expense?

A No.

Q Whenever a gas packer is set it is purely a conservation proposition, but a water packer is set purely to reduce expenses?

A I think it is just as important to conserve water energy in the

Hobbs Pool as gas energy.

Q This is an exhibit Mr. Dewey introduced (showing exhibit to witness) marked "H. Exhibit 2-A". That shows the daily oil production in barrels, by units, in 1938, and the unit water production in barrels?

A Yes, sir.

Q And the water percentage?

A Yes, sir.

Q There was some testimony this morning about some units where a rather high percentage of water was being produced. I notice Stanolind No. 8 Terry, in the NE¼ SE¼ of Sec. 9, Twp. 19 S., R. 38 E., that shows 50% water production. Would you think it desirable to set water packers there to conserve the energy in the field?

A Which well is that? (Exhibit is shown to witness). If a water packer would be set to do any good. There are two wells in this area where we have set water packers without any effect.

Q Stanolind No. 29 State, in the SW¼ SW¼ of Sec. 10, T. 19 S., R. 38 E., making 64% water, what about that?

A We set a water packer in that well, and then removed it.

Q Why did you remove it?

A We didn't get a good shut-off. We are going to do some more work on it. We set a packer in McKinley No. 26 three different times before we got an effective shut-off.

Q Is it possible there are wells in the pool where you could not set a water packer and not get good results?

A Where it gets into thick "pay". It depends on the pay.

Q What about No. 33 Byers, in the SE¼ NE¼ of Sec. 4? That shows 32.5% water. Could you set a packer in that well and shut off the water?

A The well would have to be deeper. It is only producing from the first horizon.

Q So that you could not set a packer in that and shut off the water?

A At the present depths, no. You could by going deeper.

Q If the water and oil are coming together, you cannot set a packer to shut off the water?

Q You can set a packer to shut off the water in most cases if you have oil in other "pays"?

If the water and the oil are coming together in the same pay?

A If all of the oil and water are coming in the same pay, you cannot.

Q So in the case of No. 33 Byers, all of the oil and all of the water coming in the same "pay", you cannot set a packer to shut off the water?

A Not until we have the well deepened.

Q Until you go deeper to get production in another horizon?

A Yes, sir.

Q What about some wells in the northwest end? Is not water and oil coming in the same "pay"?

A My understanding is that most of the water is coming in the second "pay".

Q Do you know that some companies have set packers repeatedly without shutting off the water?

A There have been packers set in the north end of the field that did not get a shut-off. I don't know how many times they were set. The thing is, the north end of the field is much thicker in section than down on this fringe here.

Q If you have set a packer and tried to produce from above, and have gotten water and oil, and below, and have gotten water and oil, when you tried to produce from ablve and below and still get water and oil, would you conclude that a water packer would not help?

A There are some wells they have not helped, and some wells they have plugged back.

Q Would you conclude, if you could not successfully shut off water in one well, that you could not in any well in that area?

A Not necessarily. It would look like the possibility was preggy good.

Q You would conclude, in the southeast end where you have set packers that have not shut off the water, that you could not set them in any well there, and yet you have criticized other operators for not setting them?

A I did not say that. I said we were going back in and try to successfully set them. What I was pointing out that in this section where these Stanolind wells are making a high percentage of water, the section is much thinner than in the north end of the field, and for that reason there should be a better chance of success.

Q Stanolind Exhibit B, which is a cross section of the Hobbs Pool along the township line between Townships 18 and 19 South -- I am not clear as to what the testimony was yesterday. The area in blue indicates --

A The blue section indicates water encroachment.

Q Does that cross section indicate the direction of the encroachment?

A Not necessarily. That is an east-west section.

Q So the water did not encroach from the left hand section across, but the water encroached at right angles?

A It probably came in from the southwest.

Q Would you infer that water appeared in this well (indicating on exhibit) before it did in this one? Is that the idea, that it gradually moved in this direction, but that the water appeared farther eastward?

A Not necessarily. I think one well farther east here is marked "1932" and the rest are marked "1933".

Q So the water appeared in this well marked "November, 1932" about three months before it appeared in the wells marked "February, 1933"?

A That is just an item. An east-west section of the field showed a blanket encroachment of water. It does not necessarily mean it came from the west to the east.

Q I got the wrong impression. Sorry. You have wells marked "March, 1932", and to the west, on the section, is a well marked "October, 1932". It means the water appeared in these wells some seven months earlier than in these (indicating on exhibit)?

A Yes, sir. The contours appearing on the water map shows that this well is in 9-32 and this one in 10-32.

Q Would you explain to the Commission how the water encroached?

A Well, from the record, these contours, the water encroached from that direction --

BY GOVERNOR MILES: (Interrupting) What direction is that?

A Northeast to southwest.

BY DR. KNAPPEN:

Q What do these contour lines along here indicate -- for the purpose of the record,-- in the western part of Sections 4 and 9, what are those contour lines indicated in the section?

A Section 4 appears to be moving this way (indicating).

Q Northwestward?

A Northwestward.

Q In the southern part of Sections 4 and 9?

A East.

Q It appears to be moving eastward. In the $N\frac{1}{2}$ $S\frac{1}{2}$ of Sec. 4, do those contour lines indicate the direction of the encroachment?

A There has not been any encroachment in Sec. 35. The reason those at the top are there, the wells to the north flow faster than on the south.

Q In the $N\frac{1}{2}$ of Sec. 4, the movement has been --

A (Interrupting) I think the water encroachment in that area has been to the northeast.

Q Then as the water has encroached in Sections 4 and 9, there has been a driving of the oil into the heart of the Stanolind block, and in the $N\frac{1}{2}$ of Sec. 4, part of the drive has been into the Stanolind block and part moving northeastward?

A I think you can say the water encroachment here has been across our part, and from the reports on wells, some of these show that some of this oil had gone to our own wells, we did not include that.

BY GOVERNOR MILES: We will be in recess for ten minutes.

----oOo----

Pursuant to recess taken, hearings were resumed in ten minutes, with Mr. Card still on the witness stand for further cross examination.

CROSS EXAMINATION By Mr. Sanderson:

Q Mr. Card, I would like to ask a few questions about the loss which you estimate Stanolind suffered over the past years by reason of the proration plan that has been in effect, and the water drive you talk about. Will you state again how much oil you estimate Stanolind has lost?

A Since the beginning of the development, 1,550,000 barrels. Since June first, 1935, 518,000 barrels.

Q Have you computed those losses by units or leases?

A By units, yes.

Q Will you refer there, please, to Stanolind Buyers lease, in the NE¼ of Sec. 4, and the NW¼ of Sec. 4.

A Yes.

Q Will you state there how much you estimate you have lost off of that lease?

A The list here is by units.

Q You don't have the total?

A Buyers No. 8, in the NE¼ of Sec. 4, 17,600.

Q What is the next?

A Buyers No. 11, in the NE¼ of Sec. 4, 13,400.
Buyers No. 26, in the NE¼ of Sec. 4, 7,400.
Buyers No. 33, in the NE¼ of Sec. 4, shows a gain of 98,600.
That is a high potential.

Q Take your Buyers No. 8 -- strike that. Take your Buyers No. 11, will you state what the allowable is on that unit now?

A I would have to have the proration schedule. (Witness is handed proration schedule).

BY GOVERNOR MILES: These losses stated, is that total loss?

A That is the total, yes.
Which well did you want, Mr. Sanderson?

Q No. 11.

A These columns must be mixed up -- under November Daily Allowable it does not show any figures at all. (Witness examines schedule). 53 barrels.

Q No. 26?

A 67 barrels.

Q No. 33?

A 75 barrels.

Q Do you know how much oil would be allocated to those units on a 100% acreage basis?

A In November the allowable was 46 barrels.

Q That would not be the allowable that would go to those wells if you were on a 100% acreage basis, would it?

A Forty-six.

Q What is the allowable for the pool, the Hobbs Pool?

A The total field allowable is 10,539.

Q How many units?

A A total of 250 units, but four of those have special allowables, 248 potential units.

Q Can you calculate quickly what that would be per well?

A Well, if Hobbs were on a straight acreage allowable, like other fields, it would be practically the same in the field.

Q What would that be, approximately, on the acreage basis?

A Approximately 46.

Q No. 11 is getting 53 barrels, and would get 46; 26 now has 67 barrels, it would bet 46 under your plan; No. 33 now has an allowable of 75 barrels. Under your plan it would get 46, on a 100% acreage basis?

A That is it.

Q Then, as I understand, you are proposing a 100% acreage basis to correct the situation which has existed in the past, which has caused you to lose amounts of oil, and every one of these units would get a smaller allowable?

A You have got to consider the whole picture. Some wells would be increased and some decreased.

Q Would you point out where those wells, or that lease is on the map?

A This is it (pointing).

Q Under the acreage plan, which Stanolind is championing, these wells which he has named would get 46 barrels of oil per unit, or per well. At the present time those wells have allowables of 53, 67 and 75 barrels, respectively, therefore, I am asking how the lower allowable of these wells would correct the situation under which Stanolind claims they have lost various amounts.

A You have to consider all of our leases.

Q Where would this oil go that you are going to get?

A It would be distributed among wells not getting as high as that.

Q Where are those wells? Just point to them.

A All the wells with allowables less than 46 barrels at the present time would be down in this section (pointing on map).

Q Under this plan you would actually lose on some leases, but you would gain enough more on other leases to more than offset the losses on those you say you have suffered losses?

A I think the balance on the NE$\frac{1}{4}$ of Sec. 4 show gains, on the NE$\frac{1}{4}$ of Sec. 4.

Q That would be true, but of the individual units?

A You have to consider this thing more or less as a whole.

Q Take State A lease, how much have you lost there, according to your estimate?

A There are quite a few along there -- which section?

Q Tract No. 1?

A What section?

Q Section 4, the NW$\frac{1}{4}$ of Sec. 4?

A The NW$\frac{1}{4}$ of Sec. 4, well No. 8, 5,400 barrels.

Q And the others?

A No. 11, the NW$\frac{1}{4}$ of Sec. 4, 16,200 barrels. No. 26, NW$\frac{1}{4}$ of Sec. 4, 12,800 barrels. No. 33, NW$\frac{1}{4}$ of Sec. 4, 27,300 barrels.

Q That is the total -- over half a million barrels of oil which you claim to have lost off that lease. Will you state from the proration records here what the allowable is on that lease at the present time?

A No. 8, 51 barrels. No. 11, 43 barrels. No. 26, 56 barrels. No. 33, 34 barrels.

Q That is a total of 184 barrels, or an average of how much per well?

A 184, that is 46 barrels per well.

Q On a 100% acreage basis, what would you get?

A Approximately 46 barrels.

Q The same amount of oil?

A Yes, sir.

Q This 61,700 barrels you calculate you have lost off of this lease, on the 100% acreage basis you would not be compensated for that?

A On that particular state lease we might not get anything. On other leases we would.

Q How much would it increase the allowable in the Hobbs Pool if the Commission adopted the 100% acreage plan, over what it is at the present time?

A It would increase about 3% over the total field allowable.

Q How many barrels would that be a day?

A About three hundred barrels.

Q So that the Stanolind, under this plan, would get 300 barrels more oil. It would go to the south end leases, would it not?

A Not necessarily. A lot of the leases on the southwest flank have allowables less than the top allowable.

Q You think this 100% acreage plan should have been in effect at the beginning?

A I think at the beginning of the field, some consideration should have been given to pay thickness.

Q If you adopted a 100% pay thickness --

A (Interrupting) I did not say 100%, I said some consideration.

Q But not 100%?

A No -- you mean at the beginning of the field?

Q I am just trying to find out when you think the 100% acreage would be good? Good now, but not previously -- when would the 100% acreage begin to be proper?

A I think at the beginning of the field, I think some consideration should have been given to pay thickness and some consideration to acreage.

Q But not 100% acreage?

A In the beginning of the field, no. I think the 100% acreage is the right thing at the present time, with possibly some modification.

BY MR. BOHART:

Q Is there any other operator that would benefit to that same extent by the adoption of the 100% acreage plan -- benefit to the same extent, -- 300 barrels?

A No, I don't believe so. I don't think any other operator has lost as much oil as we have.

BY MR. FLEETWOOD: I would like to ask the witness a few questions.

BY MR. WOODWARD: I want to let the record show that we object to the Barnsdall Oil Company taking part in this hearing; they have no acreage in this pool, and I would like the record to show that we object to their cross examining this witness.

BY MR. FLEETWOOD: Mr. Chairman, I am planning to ask some questions that apply to the Monument field. This is important to us. The notice of this hearing and the hearing in the Monument field were combined, these two fields, and Mr. Card testified that the Hobbs and the Monument fields were so similar that there was no reason for any difference in the proration plan. I think this is competent.

BY MR. WOODWARD: I understood they were taking them up separately.

BY MR. FLEETWOOD: We did too, but there has been testimony as to both.

BY MR. WOODWARD: There has been no evidence here that would have any bearing on the record in the Monument field.

BY GOVERNOR MILES: Has there been testimony here in regard to the Monument field?

BY MR. SETH: Merely that it was similar to the Hobbs field.

BY MR. FLEETWOOD: He proceeded further and said there was no reason for any difference to exist in any proration plans between the Monument and the Hobbs fields. Under the circumstances, when he has bound us in this way, I think we should be allowed to cross examine the witness.

BY MR. SETH: When the Monument hearing comes on there will be ample time to go into that matter.

BY MR. CUSACK: As I understood Mr. Fleetwood, he did not think there was any difference between the Hobbs and the Monument fields.

BY MR. FLEETWOOD: No, Mr. Card testified to that.

BY GOVERNOR MILES: The Monument case is coming up, so that no reference should be made to the Monument field in the testimony in this case, if he did testify to that -- make statements concerning the two fields, it should be stricken from this record. Mr. Fleetwood will be overruled at this time, and we will bar any testimony, comparing the two fields, from this record, and bring that up when the Monument field is being considered.

BY MR. FLEETWOOD: Did you rule that would be considered improper at this time?

BY GOVERNOR MILES: Yes.

BY MR. FLEETWOOD: Will you direct that Mr. Card be available for the Monument hearing?

BY GOVERNOR MILES: Yes.

RE-DIRECT EXAMINATION By Mr. Seth:

Q How much oil would the Gulf lose, under straight acreage, as compared to the present plan?

A I can't say for sure. I knew those figures several months ago.

Q You know it would be a considerable amount, would it not?

A It would be a considerable amount.

Q Two hundred barrels a day, probably?

A Somewhere in that neighborhood, I believe.

Q Now, you talked about the element of "pay" thickness. I believe you testified your own engineering committee estimated that Hobbs had produced about half of its total, is that right?

A Several years ago the engineering -- the Hobbs engineering committee estimated the ultimate recovery from the Hobbs field would be 150,000,000 barrels.

Q Of that figure, about half has been produced up to this time?

A There has been between eighty-seven and eighty-eight million barrels produced.

Q In working out an equitable formula for the protection of what is left, would the taking of the original pay thickness into consideration permit a lot of wells again to produce, or produce more than they are already producing?

A It would give them an allowable out of proportion to what the present pay thickness is.

Q The original pay thickness, as half of the field production, would give a decided advantage over what is left in the field?

Q That is true.

Q Some of the gentlemen that have examined you have assumed, or tried to assume that Stanolind pressures were two pounds, or seventeen pounds -- something of that kind -- less than the Gulf's. Have not many surveys showed that Stanolind's, in the wells right along that township line, to be higher than the Gulf's?

A Higher than the wells immediately north, static, shut-in pressure.

Q That is, on these pressures, static, shut-in pressure?

A The earlier actual pressure.

Q Some of the surveys show the actual pressure in Stanolind wells higher than those immediately north?

A Yes, sir.

Q They vary back and forth?

A Yes, sir.

Q I believe you testified the pressures perhaps are not accurate?

A I would say fifteen pounds -- probably now ten pounds.

Q Better now than at first?

A Yes.

Q At first they were notoriously inaccurate?

A About ten pounds, potentials, in reservoir pressure.

Q In early surveys, the possible error was greater?

A Yes, sir.

Q Now, what do you call the pressure when a well is flowing?

A Flowing pressure? Yes.

Q What is that pressure when a well is flowing, higher or lower than shut-in?

A Lower than shut-in.

Q At the bottom of the hole?

A Yes, sir.

Q It has to be lower or there could not be production unless it was lower?

A The pressure in the bore hole has to be lower than the surrounding formation.

Q The drop is considered between the shut-in pressure and the flowing pressure?

A Not necessarily. In some wells it is considered. Depends on the rate of flow.

Q How much lower would you say, roughly?

A That would be hard to say. You would have to know the well, you would have to know the conditions.

Q Vary fifteen pounds, up or down?

A Depending on the rate of flow, yes, sir.

Q Are the wells usually flowing the greater part of the time?

A Yes, sir.

Q The shut-in pressure is a built-up pressure, with the well not producing from 24 to 36 hours, isn't it?

A Yes, sir.

Q And that does not represent conditions while the wells are operating at all?

A Not adjacent to the well, or the boundary line between the wells.

Q Does shut-in or flowing pressure indicate conditions at the boundary lines?

A No, sir.

Q Merely indicates the condition immediately adjacent to the bore hole of the well?

A That is true.

Q Any drainage -- to determine whether drainage exists, you would have to know the conditions at the boundary line of the unit?

A Yes, sir.

Q Now, these gas packers, state whether or not they are usually set after the oil is almost entirely gone in that particular "pay" that is packed off?

A As a general thing, I would say the oil is pretty nearly depleted.

Q So much gas that in certain ones, the well would not produce the allowable in twenty-four hours?

A Not all cases. There have been cases like that.

Q In the case of the water packers, the oil is there with the water and could be produced?

A Yes, sir.

Q You spoke of an engineering report recommending the setting of water packers. Have you that available?

A Yes, sir.

Q Will you please state what it is, and read it into the record?

A This is the Hobbs Pool General Report, on page 57. The sentence is as follows: "The production of water reduces reservoir pressure the same as oil or gas production. For this reason, the Engineering Committee recommends the setting of packers as a means of maintaining reservoir pressures." This is the recommendation of the Engineering Committee.

Q This is the official report of the Hobbs Engineering Committee?

A Yes, sir.

Q Would you give the date of it?

A It was published in 1933.

Q And is there anything further in there when wells go on pump, in that same report, immediately following, isn't there something about that?

A No, sir.

<u>CROSS EXAMINATION</u> By Mr. Woodward:

Q The effect of setting packers, in the south end, reduces the total flow of fluid from the wells?

A Yes, sir.

Q You said a while ago that the difference in the bottom hole pressure when shut-in and flowing depends on rate of flow, permeability, and other factors? Is that correct?

A Yes, sir.

Q Does the pressure drop faster in these southern wells or in the northern wells?

A It would in particular wells.

Q When it drops, as a usual thing, there is drainage from the high pressure areas to the low pressure areas, isn't that the usual rule?

A The pressure is lower during flowing stages at the boundary line between units.

Q Where a well is producing great quantities of fluid, as those wells in the north, and in the south they are not producing so much fluid, the pressure would drop to the north because of the fact that the tendency would be a movement from the south to the north on account of the greater production of fluid there during the times the wells were flowing?

A We would have to know the flowing pressure of the wells to say whether that is true or not.

Q The greater the fluid production, the greater the drop in pressure?

A That is only true in individual wells.

Q There would be drainage to that well that had the low pressure?

A If they have a variation in pressure.

Q The greater pressure drop, the greater drainage possibility if the well pressures varied?

A Yes, sir.

Q In respect to setting gas packers, the accumulation of gas is due to the production of oil, isn't it?

A Yes, sir.

Q The setting of a water packer is due to the fact that the oil is pushed out and water comes in?

A Yes, sir.

Q That oil has been pushed on to some other place, and produced in some other well?

A In large percentage, yes.

Q The setting of a gas packer is to preserve and keep the oil there so that it may be produced in that well; the setting of a water packer is for the production of a well where water has pushed out the majority of the oil?

A The setting of a gas packer, as a general thing, there is very little oil above the packer -- very little oil left in the gas horizon. Usually quite a little oil can be produced from the well producing water where it is packed off.

Q With respect to this point, a great deal of time has been consumed asking you questions in regard to closed-in pressure. Mr. Bohart questioned you at length about the difference in pressures between the bottom of the hole and the top of the hole. Has that got anything to do with the production of oil in the field?

A Naturally, you have to have --

Q (Interrupting) Has it got anything to do with proration?
A No.
Q Have any bearing on the operation pressure, and the flow of the fluid through the sands? Some people believe one thing, and some believe something else, is that true?
A Yes sir.
Q Would you prefer theory to fact, where they have no fact?
A I would prefer fact.
Q Is it a fact that you know the water encroachment is from the southeast and towards the center of the field in a northeasterly direction?
A That is a fact.
Q Would that water, as a fact, push the oil ahead of it?
A Yes, sir.
Q Do you know of any way to keep the water flow from pushing the oil away?
A I don't know of any.
Q You know the water did push the oil up structure?
A Yes, sir.

BY COL. ATWOOD:

Q Will you state that this intrusion of water has pushed the oil to the northeast? Do you mean to say all the oil has been pushed out by the water?
A No.
Q As a matter of fact, the production of water --
A (Interrupting) It has been produced in the upper zones. We did not make any claim we had lost all of the oil.
Q As a matter of fact, you have no way of computing how much oil has been pushed away?
A Yes, you can calculate.
Q How can you if the oil has been pushed awa y by water encroachment, how can you tell how much?
A It is set out in the report I read yesterday.
Q Can you compute how much has been produced?
A You know the production, yes.
Q You don't know how much has been pushed away?

A You can make a very --

Q That is theory, not fact?

A You know the water has gone up over the field.

Q Did it go to take the place of oil removed at the surface, or did it go to take the place of oil that went some place else?

A Both, but mostly that had been taken out.

Q How much?

A It is easily calculated.

Q You know how much has been taken out?

A Yes, sir.

Q But you do not know with the same degree of certainty how much has been pushed away, if any has?

A You have got a pretty good idea.

<u>CROSS EXAMINATION</u> By Mr. Rae:

Q You made a statement that the setting of water packers was detrimental to the interests of the operator. Is that correct?

A I said that the operators on the southwest flank feel they have lost oil by setting packers.

Q I thought you made the statement, in answer to Mr. Seth's question, that the setting of a water packer was detrimental and not beneficial.

A I said the operators on the southwest flank feel they have lost oil.

Q I would like to ask you three questions: One is, would you, as an operator, desire to produce ten barrels of water for one of oil?

A If we could get more ultimate recovery.

Q Then what potential is assigned to that well,- what adjusted potential? Is that based on the production of the lower zone you are producing from, or based on the production of the upper and lower together, and the upper has been flooded out by water - is it based on the productivity of that particular pay, the production pay, or is it based on the productivity of the upper pay, now flooded out, plus the lower pay?

A Like all potentials in the field, it is based on the well's after acidation. It is true, you have packed off part of the pay. The operators in the north end there have probably found lots of water, it makes no difference whether it is north or south.

Q If your potential is based on the upper and lower "pays", your allowable must be; the present rules really allow you to produce both zones from that one particular zone?

A The engineers recommended that when water first appeared, to conserve energy.

Q The engineers were very generous to those operators and gave them allowables based on present fluid production, didn't they?

A The operators at the north end of the field, based on fluid production, their potentials are going up and ours are going down.

Q Do you think you could get a larger potential on those water packers than with fluid?

A The pressure would be higher.

Q Do you think it a reasonable statement to make that the water packer wells have not been given a lot of real consideration in allocation of oil?

A Due to the proration formula, they have had higher allowables than they have at the present time.

Q Most all wells took new potentials as water packers were set after acid treatment, didn't they?

A They would have had higher pressure and they would have had potentials increased by bottom hole pressure adjustments.

Q You say the water packers would have had higher --

A That is high pressure area.

Q A well making 95% water today, that was making clean oil a few years ago --

A (Interrupting) I am talking about adjusted potentials, not actual potentials. Probably not a well in the field is producing its potential.

BY MR. WOODWARD:

Q You read a reference from a report in the record. I believe I understood you to say you had operated in accordance with those recommendations?

A I believe we have.

Q You do believe in the maintenance of reservoir pressure where possible?

A I believe it is a good thing for the reservoir.

Q I infer from that, the engineers did not have in mind maintaining the pressure in any particular part of the reservoir, but the reservoir generally. Isn't that your understanding?

A That is it.

BY DR. KNAPPEN:

Q Referring, Mr. Card, to the water encroachment map, your Exhibit E, it is a fact that water has encroached across the area in which the red squares have been mapped showing the location of packers in wells, is it not?

A Yes.

Q Suppose it were physically possible to build a concrete wall along the township line, extending clear down from the surface, to say, 614 feet below sea level, so that all of Twp. 19 South would be completely shut off from Twp. 18, from the north, and the Hobbs Pool operated as two entirely separate pools; would water have encroached to within 313 feet of the concrete wall at any time during the productive life of that pool?

A You mean, half of the distance from the wells to the line?

A That is right.

A I think there are wells 330 feet from it.

Q Would water have encroached to those wells, assuming this concrete wall could be built?

A Water would eventually get to those wells.

Q We thoroughly agree on that. Mr. Woodward asked you a series of questions which he stated as facts. It is a fact that there was water in every one of the wells where packers were set?

A Yes, sir.

Q It is a fact that a large volume of oil has been withdrawn south of this concrete wall I am talking about?

A Yes.

Q It is also a fact, if that wall had been there, water would have encroached in the wells nearest to that wall?

A It would have taken a much longer time.
Q Water would have come in to replace the oil, wouldn't it?
A It would have taken a very much longer period of time.
Q Is that fact or theory, the longer time required?
A I thoroughly believe it, whatever you call it.
Q You know that where there is water in the wells, you know the water came in to replace the oil, but you don't know whether the water pushed any oil across the township line?
A Any way you want to calculate shows a loss of oil.
Q The facts are that the water would have encroached in those same wells, merely replacing the oil, if there had been no possibility of pushing the oil out?
A The higher withdrawals up in the center of the field, it is very reasonable to assume it pushed the oil out.
Q It is an assumption that the water pushed the oil across the township line -- you have made a statement based on assumption?
A You could make two or three different types of assumptions to show losses, varying degrees of losses.
Q I can set up a theory that no oil has moved across the well's boundary -- I don't believe that is correct. What I am getting at is the difference between facts and theory. The fact is that water has come in to replace the oil, and it is theory that the oil has been pushed ahead of the water --
BY MR. SETH: (Interrupting) I insist that Dr. Knappen be sworn if he is going to testify.
A How fast this water moved from -- during the years 1931, 1932 and 1933,-- how fast that water moved in those years, the production of oil could not possibly account for it.
Q Is that fact or theory?
A The production of oil south of the township line could not account for it.
Q You told the Commission you did not know the porosity -- you did not know what the porosity was, and therefore did not know how much oil there was. Perhaps it was limited and water simply replaced the oil as it came across.
A Based on calculations --

Q You assume average conditions throughout the field, and you have divided the 175,000,000 barrels by acre feet, and you found 110 barrels production per acre foot. You assume one acre foot has as much oil under it in Twp. 18 as in Twp. 19. That is theory.

A That is a pretty wide area, that water encroachment. It should average out as well as the rest of the field.

Q The average of the field, whether the flank or the top?

A No, I say that area covered.

Q Is the average porosity the same on top as on the flank?

A Nobody knows.

Q Has that always been the theory of the Stanolind and the Midwest?

BY MR. WOODWARD: If you had the concrete wall, you know the oil would not move up structure.

BY MR. GRAY:

Q You mentioned some gas packer wells had been unable to make their allowable prior to the time the packers were set?

A That is often the case. They are making so much gas they did not make their allowable.

Q Was that the case in any well in the Hobbs Pool?

A Right offhand I could not say definitely.

Q You do not know that some wells did not make their allowable?

A Not definitely. I would have to refer to the records. That is very often the case in any field, and probably true of some of the wells in the Hobbs field.

Q I don't want to prolong this cross examination, but I wish you would refresh your memory on that point. Stanolind State No. 11, in the SW¼ of Sec. 5, in 1932 didn't you start to plug back that well to shut off water?

A I could not say definitely. I have heard there is one well they started to plug back.

Q Did they finally plug it back to the point where the well would produce no oil or water?

A I do not know.

Witness dismissed.

ROBERT W. TESCH,

being called as a witness on behalf of the plaintiff, and being first duly sworn to tell the truth, the whole truth and nothing but the truth, was examined by Mr. Seth, and testified as follows:

DIRECT EXAMINATION

Q Please state your name.

A Robert W. Tesch.

Q What is your profession?

A Petroleum engineer.

Q By whom are you employed?

A The Stanolind Oil & Gas Company.

Q Please state your qualifications.

A I received the degree of Petroleum Engineer from the Colorado School of Mines in 1933. Shortly after graduation I was employed by the Stanolind Oil & Gas Company in the Permian Basin, where I have worked for two years. Since that time I have an office in Fort Worth, where I do sub-surface work.

Q You are about to conduct an experiment here. Will you state, in a general way, what you intend to do.

A I have two purposes: I wish to show with this experiment -- I have kept the experiment as simple as possible to save time and so that it can be readily understood. The first thing I want to show with the experiment is to show you can have two wells of the same "pay" thickness, and yet may have a variance in rated potential, and yet still have the same amount of oil in place. In other words, under certain conditions, potential is not any indication of oil in place.

Second, I wish to show that where you have two wells, one in a formation of high permeability and one well in a formation of low permeability, it is necessary for you to have a greater variation in flowing pressure in order for that well to have an opportunity to recover its oil. In other words, if you don't have that, that well will never recover its oil in place.

I have two tubes here (Here the witness sets up a frame holding two test tubes of glass filled with sand). We will say this is an oil well, and this is an oil well (indicating the two tubes) of relative porosity. That well happens to be drilled into a part of the formation that is very permeable. As a result, it has high potential. This well (indicating the other tube) is drilled into a part of the formation relatively impermeable as compared to the other, yet these two wells -- the two tubes -- hold the same amount of fluid. Both oil wells have the same amount of oil in place, but one well produces a greater amount in the same time. I am going to fill the tubes to show they hold the same amount. (Here the witness produces two other glass tubes, apparently of the same size, both filled with water. By the use of rubber tubes he attaches a water filled tube to each of the tubes filled with sand).

Q Is there a difference in the sand in the two tubes?

A Yes, there has to be a difference in the diameter of the sand grains to have a difference in permeability. You have fine grains of sand in this tube (indicating one tube) and large in this tube (indicating other tube).

BY MR. HUBBARD: You mean, one is tight and one is loose?

A Relatively speaking, that is correct.

BY MR. HUBBARD: When you say they have the same porosity, you mean one holds the same amount of oil in place, or water, as the other?

BY GOVERNOR MILES: Let me see if I understand. The two tubes are the same porosity?

A Yes, sir.

BY GOVERNOR MILES: But one is more permeable?

BY MR. SETH: Bigger grains of sand.

BY GOVERNOR MILES: And you claim both hold the same amount of fluid?

A Yes, sir. I am going to show that water runs through this tube (indicating one tube) much faster than through this one (indicating the other tube).

BY MR. SETH: Proceed.

A In the one case where the sand grains are larger, the openings between the sand grains are necessarily larger. In the other, the sand grains are finer and the openings smaller but many more of them, and the void places between the grains total up the same.

GOVERNOR MILES: Where the sand is finer, the grains are set closer together?

BY MR. SETH: Smaller openings, but more of them?

A Yes. That is a common source of misunderstanding, even among engineers -- that is the primary reason for this demonstration.

BY GOVERNOR MILES: Does it take more pressure in the one that has the finer sand to make the oil go through?

A Yes, sir. I am going to give both the same pressure, and as a result, this well will not flow as fast. You have to have a greater differential in pressure in order to get the oil. If you don't --

BY MR. HUBBARD: (Interrupting) What would determine the amount of oil in the tight one?

A Have a bigger potential. This is my source water (indicating the water filled tubes). It has 224 cubic centimeters of water. I am going to put the water into this tube first (indicating one sand filled tube). In a minute you can see the change as it comes up, and it will take a few minutes for it to fill. The water is going down here (indicating a water filled tube) as it fills. When it gets up to the top I will shut it off to show how much water has been displaced.

BY MR. HUBBARD: Is that the permeable one?

A That is the less permeable one. At the conclusion of the experiment I will take some of the sand out of each tube so that the difference in the grain size can be seen.

BY MR. HUBBARD: The area is the same?

A Yes. This one is now full. The reading is 176 (reading on water filled tube).

BY MR. SETH:

Q How many cubic centimeters does that make in the tube?

A 48. Now, we will fill this one (indicating the other sand filled tube). You will notice this is filling up much faster. (Tube is now filled). This tube here holds slightly less, about 46 cubic centimeters. They both hold practically the same. Both of these tubes are now full. I want to connect the two reservoirs and let the water run out and show you the relative production of both tubes. I am going to displace this area so that it will be even. I will fill this to the top. (Fills tube with water). I am going to run the water through into these tubes here, and will put in a little dye so that you can see (puts red dye in one tube and gree in other tube which will receive the water drained from the sand tubes). Now this tube here is low permeability, and this tube here is high permeability. I am going to remove the stoppers and let the water run (does so). Notice the production out of this tube -- they both started at the same mark.

BY MR. SETH:

Q Same pressure?

A The same pressure.

BY GOVERNOR MILES: In that calculation, the size of the grains of sand is taken for granted in each one?

A You would have to determine the effective diameter of the sand. You do that by screening.

May I call your attention to the fact that this one (in dicating) is allowing the water to drip through almost twice as fast as this one, but these both hold the same amount of water.

BY MR. ANDREAS: Is that the same procedure in both lime and sand?

A More true of lime than sand.

See, this tube here has produced about 21 cc. of water, while this tube has produced less than 10 c.c. This tube (indicating the first one) is twice as permeable.

BY MR. SETH:

Q While this experiment is going on, I would like to ask Mr. Tesch some questions. Is there any book or published authority on this matter of potential, what elements go to make up potential?

A Yes, probably one of the latest and best books that has been written is by Mr. Muscat, "Flow of Homogeneous Fluids Through Porous Mediums".

Q Is that Mr. Muscat sitting over there (indicating a man in the room)?

A They tell me that is who it is.

Q Have you that book?

A Yes, sir. Let me get it.

Q Would you read from Mr. Muscat's book and explain on the diagram that you have?

A On page 153 of his book, he has included a formula which shows the total fluid from sand to the well. I have taken that formula out of his book (indicating a chart which the witness has produced). (Marked Stanolind Exhibit F).

Q Is this Exhibit taken out of Muscat's book?

A Yes, sir, it is taken out almost exactly the same.

While we are doing this, this permeable tube has already recovered its oil in place (indicating tubes on the table).

Q Does this beaker hold the 50 c.c. originally put in?

A Yes, which is all this tube held.

(Turning attention to Stanolind Exhibit F): "Q" represents the well bore per unit of time; "K", which is permeability; "H" which is sand thickness; "P-1", pressure at edge of well; "P-2" the pressure of the well at flowing -- "P-2" has to be lower than "P-1" in order for the well to flow. Below the line we have "V", which represents viscosity of fluid; "R-1" represents drainage areas; "R-2" represents the radius of the well bore. In that formula -- it will be noticed that there is no schedule in that formula that has anything to do with oil in place. It is measured by the rate it will flow through that formation.

I have stated in the beginning, we have to assume that where you have two wells of equal thickness -- two wells of equal drainage radius, the tension at the well bore in that well is dependent upon the permeability of that section.

Getting back to the experiment again, everything is constant here except permeability. Both tubes hold the same amount of water, yet one you get twice as fast as the other.

Q What does that mean in respect to potentials?

A Well, it simply means this to me: The potential is no measure of oil in place.

Q In other words, this more permeable tube produces its oil in place more than twice as rapidly as the other?

A Yes, sir.

Q So that rate of flow represents potential?

A That is right.

Q This well, by having higher potential, would have gotten rid of its oil in less than half the time the other one would have?

A That is correct.

Q If it continued to produce oil, this well would have to get its oil from some other place?

A That is the only way it could.

Q It takes more pressure to get oil out of the less permeable well?

A It takes more pressure to get it out at the same rate.

Q If you produce the oil in the same elapsed time, it would take --

A Twice as much differential in pressure.

Q For this well to produce its oil in the same time, it would require a pressure drop of twice what this well of low permeability requires?

A Approximately.

Q Do you have anything further from Mr. Muscat's book?

A No, I think that is enough.

Q You can see this has gone down almost twice as fast (referring to the experiment).

A This tube of low permeability is still laboring along -- it takes a while longer.

BY GOVERNOR MILES: This diagram you speak of, has that been considered at all in the production in this field?

A No. In other words, it has always been taken in the past that potential is the measure of oil in place, which, to my way of thinking, under the conditions you have in the Hobbs Pool, is entirely wrong. If you will notice, this formula (Exhibit F) is taken from this book (Hands the Governor the book the witness has been using).

This tube has already recovered twice the amount of oil in place. This tube has only recovered slightly less than 80%. I would like to add this for the record: In a field like Hobbs, where you have such variances in permeability, that

that what I have shown here is more true than ever - even more reason why you should not use potential as a measure of oil in place.

BY MR. SANDERSON: Why don't you use two lime cores, rather than sand?

A I used this for the purpose of illustration. This is an experiment to show what can happen. We couldn't get cores from limestone.

BY MR. CHRISTIE:

Q If these two tubes were connected, as if on one reservoir, would you get oil from the lower permeability tube into the higher?

A You mean if they were connected up as one tube from the same reservoir?

Q Perhaps down the center of the tube somewhere, and had higher pressure in the higher permeability tube, would oil flow from the lower one into the higher one?

A I still don't get what you mean.

Q I think I can put it this way -- that would not be true if the pressure was higher in the higher permeability tube -- we have areas of low pressure and high pressure --

A I get what you mean -- rather that would drain that one?

Q Yes.

A It is possible, very.

Q Drain from the lower into the higher if the pressure was higher?

A You would probably, in general, you would have had the time element -- your potential is only taken over a two hour period.

BY DR. KNAPPEN:

Q I notice the level in the two graduates, or tubes, is very different at the present time.

A That is right.

Q The level is lower in this one because of excessive production.

A In a reservoir that would be the same, it would have greater differential, and --

Q (Interrupting) Let me continue. The fluid is lower in the graduate connected to the high permeability tube, is it not?

A That is right.

Q And the fluid level is lower because of the greater production through that tube?

A That is right.

Q The lower the fluid level, the higher the pressure on top of the high permeability tube than on top of the low one?

A That is correct.

Q If bottom hole pressure were introduced to pinch back the flow, you would get production on the two at the s ame time, if you pinch that back?

A The chances are it would be approximately the same in the reservoir.

Q The reason we want bottom hole pressure factor is to correct certain inaccuracies. Is that not what Mr. Wood has said, that potential is a good first measure of oil in place, but that potentials need to be rapidly corrected by bottom hole pressure. He has stated that if a well is allowed to produce at too excessive a rate, it drains the oil from adjoining lands --

BY MR. SETH: Is the Doctor testifying again?

BY DR. KNAPPEN: - - - - - then there would be no drainage. Is not that what Mr. Wood, Chief Engineer for the Standard Oil Company of Indiana, has written?

A I don't know.

This well has now recovered all of the water back -- 48 c.c. back; but in the meantime this tube has produced 136 c.c. In other words, this tube has produced twice as much. Obviously this water, or oil, has come from some place else, as it only had this much.

BY MR. SETH:

Q If you had bottom hole pressure on the two even, what would happen? The same thing?

A Approximately. As a matter of fact, if you keep the same pressure on this tube, you would have had greater production.

BY MR. SETH: That is all.

<u>CROSS EXAMINATION</u> By Dr. Knappen:

Q It is true the more permeable tube produced about two and a half times as much?

A Yes.

Q If bottom hole adjustments had been made on the potentials rapidly during the process of the experiment, so as to keep the bottom hole pressure equal, make adjustments to do that, the effect would have been to get just the amount of water in place in each tube at the same time.

A No, it could not, at the same time.

Q You made no bottom hole pressure adjustments. If you made them frequently enough, it would have been possible to produce the same amount of water from each tube.

A You mean by pinching back, that will be the result?

Q Yes.

A How would that change the head?

Q So that the pressure remained the same in the two tubes, then you would have kept exactly the same pressure.

A I don't see how that would happen at all in a reservoir.

Q If you had adjusted the fluid flow so as to keep the levels in the tube on top the same, you would have had identical production.

BY MR. LIVINGSTON: If the Commission may suggest, will the gentleman put his examination in the form of questions for answers, because this form would tend to confusion, making statements in the nature of testimony.

BY DR. KNAPPEN: I am sorry. I understood on cross examination that type of question was permissible.

BY MR. LIVINGSTON: If you put it in the form of an interrogation, something that the witness can answer.

Q Would it be possible to make fluid adjustments at the rate of flow from the high permeability sand so that the water level in the two graduates would have been kept the same?

A Yes, if you had increased the head on the other, and decreased it in this one, it probably would.

Q Would it have been possible to change the flow through the more permeable one to keep exactly the same head in the two graduates?

A It would.

Q Is not that exactly analogous to the bottom hole pressure -- to pinch back the production in the one which is producing at such a rate so that bottom hole pressure drops below the field average?

A No, sir.

Q Why?

A If you get a well of low permeability, you have got to have a differential in pressure.

Q Are you speaking of differential in flow pressure or static?

A Flow pressure.

Q Bottom hole pressure is made at static?

A Yes, that is why it is higher.

Q They are made at static?

A They have been in the Hobbs field, yes.

Q Is it your theory that a well producing at an excessive rate will produce a low pressure area around the well, so that the low pressure area will be compensated for by bottom hole pressure?

A On the other hand --

Q (Interrupting) Is that the theory of bottom hole pressure adjustments?

A I don't think so.

Q Will you explain to the Commission what it is?

A I am familiar with the scheme down in the Yates field. That bottom hole pressure adjustment there was to keep oil potential, as the bottom hole pressure of the well declined. It does not mean anything, but that is one of the purposes it has been used for.

Q What is the theory of bottom hole pressure in the Hobbs field?

A You have got me -- I could not tell. Many don't think there is one.

Q If you are familiar with the background and reasons for introducing it, you could not say what that theory is?

A I don't know what the reason was. I know it has not worked out at all.

Q I thoroughly agree with that. The bottom hole pressure has not been sufficiently severe.

A The whole theory is wrong.

BY MR. WOODWARD:

Q If you kept the level in the top of the graduates level, and gave the low permeability well an opportunity to produce its oil relatively in the same time as the other one, that would have been straight acreage, wouldn't it?

A I don't follow.

Q That would have been tantamount to straight acreage, equalization to get the same production?

A That is true.

BY MR. LIVINGSTON:

Q And would you have had the bottom hole pressure maintained the same?

A No.

Q Perhaps I should have said the differential pressure the same.

A Those are entirely distinct characteristics.

Q The bottom pressure in the reservoir would have been the same if you had equalized the potentials from the two sands?

A Yes, sir.

BY DR. MUSCAT:

Q Do you consider this field gas drive or largely water?

A Largely water.

Q That in spite of the large amount of gas there?

A You have produced the field slightly too fast.

Q At least, the water drive is not sufficient to maintain the pressure?

A It is not now. The rate is greatly reduced the last few years.

Q The pressure is still declining?

A Slightly.

Q So at least the water drive is not completely effective?

A Not 100%.

Q Isn't that true that the pressure in a field declines as oil is recovered?

A Not necessarily.

Q How many exceptions are there?

A I know in the Yates field there is no appreciable change in the pressure.

Q Do you know of any others? What about the Hendricks?

A The Hendricks was produced under the rule of capture.

Q The East Texas field?

A It was produced too fast.

Q In such a field where the pressure declined, would not a field be considered to be completely exhausted when the pressure falls practically to zero, or of very little value?

A You mean water drive?

Q Those having sufficient gas drive do decline.

A And have no water drive?

Q Those which are not completely water drive, because, if you cannot say, when such fields where the pressures do decline, when they decline to the approximation of zero, are they then not considered to be completely exhausted?

A Not unless the reservoir were exhausted -- that would be true in a field like Hobbs.

Q When the pressures have declined slightly?

A Slightly.

Q When the pressures have declined to low value, you will consider the oil has been recovered --

A No, sir.

Q The recoverable oil has not been recovered?

A I say it will not decline to zero. If it was you would be --

Q (Interrupting) At any stage does not the average value of the reservoir pressure give a measure of the oil content?

A The oil and gas content, yes.

Q Why does the pressure decline?

A The water is not keeping up quite as fast as the oil is recovered and the gas comes out of solution.

Q That gas comes out of solution only by virtue of pressure decline?

A That is right.

Q The more free gas space present in the reservoir, the more oil has been recovered?

A You mean the free gas formed after the reservoir begins production?

Q Yes.

A Surely, provided the pressure has not been declined too fast.

Q What else could that be due to?

A It may come out of oil still in the reservoir.

Q All free gas space was formerly occupied by oil. When you have great free ---

BY MR. LIVINGSTON: It seems to me Mr. Muscat makes statements, whereas an examination should be questions, rather than statements.

BY JUDGE LOWE: It seems to me they are progressing pretty well.

BY MR. WORDEN: Let him ask questions.

Q Is it not true that decline in reservoir pressure is the measure of the oil that has been recovered?

A To some extent, yes.

Q In those regions of a field where the pressure has declined, is that not an indication that greater amounts, or maximum amounts or greater relative amounts of oil has been recovered?

A What do you mean, what regions?

Q Those regions that have lost pressure?

A No, sir.

Q If all pressures were uniform at one time, and still one has dropped --

A (Interrupting) What pressure?

Q The reservoir pressure.

A How do you know what it is?

Q I am not talking about that -- assume, for the moment, you do know what the reservoir pressure is, then those regions which have declined by the maximum amount have recovered the greater proportion of the recoverable oil.

A I don't get what you mean. State it again.

Q Well, sir --

A Ask a direct question. You make it so long.

Q Is it not true that those parts of the field which have declined the most in reservoir pressure have been depleted of most of the original recoverable oil?

A If you knew what it was.

Q I am not talking about the reservoir pressure -- I am not referring right now to reservoir pressure --

A If you knew it.

Q It is true that -- isn't it true that the bottom hole pressures, as they have been measured, are lowest in the southeastern end of the field?

A As they have been measured, yes.

Q Isn't it also true, on average potentials, they have been lower than elsewhere?

A Yes, it is more impermeable.

Q They have recovered less oil than in the r est of the field?

A Yes, they have had lower potentials than the rest.

Q In spite of that, isn't it true that pressures have declined more than the rest of the field?

A I don't know.

Q Isn't it true that the measured static, bottom hole pressures have declined more than the rest of the field, in spite of the fact that withdrawals -- recovery has been lower?

A Yes.

Q If those measured bottom hole pressures do represent reservoir pressure, would that not be an indication that that region has had less recoverable oil in place?

A No, sir.

Q Why not?

A Because you can't measure, in a limestone like the Hobbs field, you can't measure reservoir pressure by bottom hole pressure --

Q (Interrupting) I said if the static, bottom hole pressure were to represent reservoir pressure, would it not be true that originally they had less?

A I said in the beginning you had to have greater differential pressure in these low permeability wells in order for them to recover the oil.

Q If you did know the actual reservoir pressure, and if that should have turned out to be lower in the southeastern end of the pool, in spite of the fact that withdrawals or recovery had been lower, would that not be an indication that originally they had less oil in place?

A No.

Q Why not?

A Because it is going to take them longer to get it out.

Q Wouldn't you say that reservoir pressure, if you knew exactly what it is, would (could not hear rest of question).

A If you had free gas formed, yes.
Q Didn't you have free gas formed?
A Not down there.
Q What is taking the place of the oil coming out?
A Down there?
Q Yes, in the southeastern end of the field?
A It has probably been, to a slight degree, water.
Q You have not drilled out to the edge of the field -- you have dry wells?
A Not every side of it.
Q In those wells that are still dry, that do not contain water, isn't it true in those cases, that gas must have come out of solution?
A To some extent.
Q Is there a vacuum left there?
A I don't think so, no.
Q For every barrel of oil taken out, there must be that much free gas left, if water has not come in?
A I am predicating my theory on the fact that the reservoir pressure away from the wells is much higher than at the well bore. I don't think what you measure at the well bore means much.
Q If you did know the reservoir pressure in the southeastern area, and if you found those to be lower than elsewhere, in spite of the fact that less oil had been recovered, and considering the fact that water had not come in to displace the oil recovered, wouldn't that be evidence of the fact that originally they had less oil in place?
A Go through that again. (Question is read to witness). I believe that is right.

BY DR. KNAPPEN:

Q Is the formula you have shown on this chart the proper formula for calculating the oil through permeability?
A Through the well bore, yes.
Q You believe the formula is satisfactory?
A For what?
Q Movement of oil. You have introduced it.

A Not entirely so.

Q You have introduced the formula.

A Not entirely so, because you do not know what the pressure is on the drainage area.

Q The formula assumes you know. If you do not know --

A I think your own man said so.

Q You think he is a competent petroleum engineer?

BY GOVERNOR MILES: We will be in recess until eight o'clock this evening.

Pursuant to recess taken, the Commission resumed the hea rings at eight o'clock, P. M., December 7, 1939, with Governor Miles, Mr. Worden and Mr. Andreas attending.

BY MR. SETH: We rest.

L. L. GRAY,

being called as a witness by the Gulf Oil Company, and being first duly sworn to tell the truth, the whole truth, and nothing but the truth, was examined by Judge Lowe, and testified as follows:

DIRECT EXAMINATION

Q State your name.

A L. L. Gray.

Q Where do you live?

A Tulsa, Oklahoma.

Q Who do you work for?

A The Gulf Oil Corporation.

Q How long have you been working for the Gulf Oil Corporation?

A Since 1928.

Q You are an engineer, are you not, Mr. Gray?

A Yes, sir.

Q I wish you would state your qualifications to the Commission.

A I am a Bachelor of Science --

BY MR. SETH: (Interrupting) We admit he is a qualified engineer.

Q Have you been associated much with the development of oil in the Lea County field?

A Yes.

Q For how long a time?

A Since 1931.

Q Have you been familiar with the proration plans in force since that time?

A I have.

Q Were you a member of the operators committee at the time of the committee's adoption of rules and regulations?

A Yes, sir.

Q Have you prepared a statement showing the history of that?

A Yes, sir.

Q I wish you would read it to the Commission.

A (Reading) The first well in the Hobbs Pool was drilled by Mid-west Refining Company on the State lease in the northeast quarter of Section 9, township 19S, Range 38E. The top of the Hobbs lime was encountered at 4065' and at total depth of 4220' the well flowed 700 barrels per day. Subsequent development was first southward where several relatively small potential oil wells and two dry holes were completed. The initial well was completed in December, 1928.

Rapid development of the pool did not begin until after the completion of Humble Bowers No. 1 located in the southeast quarter of Section 30, township 18S, Range 38 E, approximately three miles northwest of the "Midwest" discovery well. This well was completed in January, 1930, and encountered the top of the Hobbs Lime approximately 100' higher than the discovery well. It produced 7,275 barrels of oil per day based on a 23 day average.

Early during the year 1930 it became apparent from the falling crude oil market, the approaching chaotic condition of business generally, the rapid development in the Hobbs pool and the limited expected pipe line outlet, that p[illegible] n must soon be applied.

Discussions which lead to the adoption of the H[illegible] ration Plan were begun during May, 1930, about the ti[illegible] Humble Pipe Line was completed. The Atlantic Pipe Line under construction and construction of the Shell Pipe Li[illegible] which was to connect to the Texas Pipe Line was about to [illegible] started.

At that time four general types of proration plans had been operative in other states; (1) Deferred drilling plan, (2) The Potential Plan, (3) The Hendricks Pool Plan, and (4) The Yates Pool Plan.

The deferred drilling plan although attacking the problem of over-production at its source had the disadvantage of conflicting with the requirements of lease contracts. The plan usually provided for open production after the wells were completed so that it did not satisfactorily fulfill the requirements for control of the vast amount of over production as threatened the Hobbs Pool. In addition most operators believed that restricted flow would effect greater conservation than open flow from a lesser number of wells. Since the problem was to equitably distribute the available limited market and the conservation of reservoir energy, the deferred drilling plan was not given further consideration.

The potential plan which provided for districution of the market outlet in proportion to the potential of each well was favored by a number of operators. It was oppœed by other operators on the ground that short time potential tests would not reflect the well's relative ability to produce as accurately as open production so that a modifying factor should be introduced. It was also recognized that if the bool became a major producer and the apparent market did not increase there was danger of the smaller wells being prorated below the amount necessary to profitably continue their operations.

The Hendricks Pool Plan (Winkler County, Texas) provided for allocation of allowable to square 40 acre units; the and the limited expected pipe line outlet, that proration must soon be applied.

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The Hendricks Pool Plan (Winkler County, Texas) provided for allocation of allowable to square 40 acre units; the allowable being distributed 50% equally to the units and 50% in proportion to the total unit potential."

(Comment): This means if there are four wells on a 40-acre tract, it would be the total potential on all four wells.

(Reading): "The total unit potential was the sum of the potentials of all wells on the unit. In the opinion of most operators too much oil was allocated on a per unit or "so called acreage" basis and not enough on the ability to produce. Also, although a number of operators believed that one well per forty acres was adequate for efficient drainage the "total potential" clause resulted in many unnecessary wells being drilled merely to increase the total unit potential.

The Yates Pool Plan provided for allocation to 100 acres units; the allocation being distributed 25% equally to units and 75% in proportion to average unit potential. The average potential was the total potential of all wells on the unit divided by the number of wells on the unit. The average unit potential eliminated the bad feature of the Hendricks plan which tended to over-develop the unit but it did tend toward unequal spacing and density of wells. If the first well on a unit had a very high potential the operator was naturally hesitant about drilling more wells since if they had smaller potentials the unit's allowable would be decreased. If the first wells on a unit were low potential more wells were usually drilled in the hope that a very high potential well might be obtained with a resulting increase in the unit potential. The resultant well density ranged from less than 10 acres to 100 acres per well.

The Hobbs Pool operators then selected the best features of several plans. Agreement was reached on the following provisions:

(1) Allocation on the basis of 25% equally distributed to units (so called acreage) and 75% in proportion to average unit potential.

(2) The unit was fixed at a square 40 acres in accordance with regular subdivisions of sections by government surveys, this being the largest area most operators believed could be

efficiently drained by one well in any portion of the pool.

(3) A policy of drilling only one well per unit, but more than one well was not prohibited since it might conflict with contracts and lease provisions.

(4) A policy of conserving reservoir energy.

(5) The organization of a representative General Operator's Committee an Executive Advisory Committee and an Engineer Advisory committee.

(6) The employment of a Proration Umpire and staff.

(7) Miscellaneous minor operating features.

The initial Hobbs Proration agreement was signed by all operators, approved by the Commissioner of Public Lands and The State Geologist and became effective July 10, 1930.

The plan was extended and revised from time to time but the basic factors remained in force until December 31, 1936.

Initially all potentials were obtained by producing the well open through the casing, only a few of the wells being tubed. It was realized that a better gas-oil ratio could be obtained when producing the normal allowable production by tubing the wells. It was also the opinion of some that opening the wells for potential tests might encourage encroachment of water. For this reason it was decided to tube all wells with 3" tubing and obtain potential tests through 3" tubing. It was a practice at that time to take potential tests for each proration period of 15 days.

After further study it was found that the potentials taken through 3" tubing were not in proportion to the potentials taken through the casing such that the wells having potentials of over 6,000 or 7,000 barrels received a proportionately small potential as compared to open flow. In order to correct this situation tests were made of all wells through tubing alone and also through both tubing and casing. This information was plotted on cross section paper using the production through 3" tubing as the abscissa and the production through both tubing and casing as the ordinate. In general these points fell along a curve and a line drawn through average points were termed the experience curve and denoted the relationship between tubing and open flows. There were a number of points, however, that did not fall near the curve, but it was generally found that such wells were producing at higher than average gas-oil ratios. After further study it was found that a gas-oil ratio correction factor could be applied to the production through tubing so that the point would fall upon the curve. Both the tubing-casing experience curve and the gas-oil ration correction factor curve were then embodied in the proration agreement. The frequency of taking potentials was at first 15 days, was extended to three months, later to six months and finally extended to an indefinite period.

Water was encountered in six wells at the time of their completion but these were either edge wells or were drilled to a depth below the initial water table which was 600' to 615' below sea level. The first well to which water encroached was Stanolind State No. 11 in the southwest quarter of Section 5. This well began producing water in June, 1931. The water encroached rather rapidly. It did not, however, encroach evenly around the field. The water encroached most rapidly progressively up structure in the areas adjacent to Stanolind State No. 11 in the southwest of Section 5 and apparently followed the lines of lease resistance, which was areas having high permeability and porosity.

A gas cap quickly developed in the higher portions of the structure --

BY GOVERNOR MILES: What do you mean by "gas cap"?

A Gas cap is a term applied to the top area of the structure where gas has accumulated because it is the highest part of the pool. Where pressure is low, gas comes out of solution.

(Reading): "Initially there was either no gas cap or it covered a very small area. By August, 1931, it covered an area of approximately 500 acres and was still spreading.

The operators became alarmed by the rapid movement of water and spread of the gas cap and charged the Engineering

Committee with the responsibility of determining a solution for the problem. After several meetings and a concentrated study the Engineering Committee concluded that the only remedy would be unit operation. This conclusion was reached in August, 1931. From that time until early in 1933, the operators held a series of meetings in an attempt to reach an agreement on a basis for unitizing the Hobbs Pool. The Engineering Committee worked up innumerable plans which embodied acreage, potential, structural position, and attempts were made to modify these plans to take care of water encroachment and spread of the gas cap. A general potential survey was made of the pool in May, 1932, in order to have current information on the relative productivity of the basic units and in order to determine the rate of potential decline for these units. On several occasions it appeared that success was imminent in that the operators owning 95% of the properties agreed in principle. It was not possible however, to reach an agreement on certain details of the plans and the negotiations were discontinued in early 1933. The Plan which most nearly reached an agreement was one based on 42-½% potential, 42½% structural position (Thickness of producing formation) and 15% acreage.

Immediately following attempts to unitize the pool, one company proposed that the basic factors of the Hobbs Proration Plan be changed, suggesting that since water was encroaching up structure replacing the oil on edge properties a factor should be incorporated into the plan which would be essentially the inverse of structural position or thickness of producing formation. That is, the factor would allow an edge property to produce at a higher rate so that such properties would be more nearly afforded an opportunity to recover their oil in place before the water reached the properties. This company likewise objected to the apparent slightly lower pressures on offset properties than existed under their own properties. Another operator objected to the very low pressures in the southern portion of the pool. A few other operators proposed increasing the acreage factor. After a great deal of discussion, agreement was finally reached to allow, at the option of the operator, units that were producing water to be prorated on the basis of 60% average unit potential and 40% acreage. Units not producing water continued on the 75% potential and 25% acreage basis. In addition it was agreed to apply a bottom hole pressure correction factor to the potential.

The first bottom hole pressure adjustment plan was termed Plan 1A and was patterned after the plan which had been applied to the Yates Pool. It was to serve a twofold purpose; to adjust the potentials in order to eliminate periodic physical tests which was believed wasteful of reservoir energy and to reduce or eliminate differences in bottom hole pressure thus minimizing the underground movement of oil from one unit to another.

The bottom hole pressure adjustment in the Yates Pool changed the potential of each unit by a fraction: Present bottom hole pressure as the numerator and the previous bottom hole pressure of that unit as the denominator. It was provided the pressure would be obtained by taking regular bottom hole pressure surveys of the pool. The plan did not fit the Hobbs condition because it was generally agreed it was not drastic enough to materially change the pressure differentials in the reservoir. It was proposed that 1000 be subtracted from both numerator and denominator of the fraction in order to make it more effective. That is the fraction 300/400 would be less than the fraction 1300/1400.

One company objected to the plan because the 1000 subtraction was arbitrary and had no basis on experience and that when all bottom hole pressures had dropped to 1000 lbs. all potentials would be eliminated. It was pointed out, however, that from January, 1931, to May, 1932, there was a potential decline of 14% and the application of Plan 1A with the 1000 subtraction to pool average bottom hole pressures would have resulted in a decline of 16% which was within reason. With the understanding that the bottom hole pressure situation would receive the immediate attention of the Engineering Committee and the plan revised later, Plan 1A was accepted and incorporated into the Proration Plan effective November, 1933.

The Engineering Committee prepared a number of bottom hole pressure adjustment plans and after a thorough study recommended plan 2A. Since the bottom hole pressure adjustment had a twofold purpose, to decline potentials and to minimize bottom hole pressure differentials, the adjustment was made by applying two fractions as follows:

Present adjusted potential = Previous potential x

$$\frac{(\text{Present pool average BHP} - 1000)}{(\text{Previous Pool average BHP} - 1000)} \times \frac{(\text{Present Individual Unit B.H.P.} - 1000)}{(\text{Present Pool Average B.H.P.} - 1000)}$$

The first fraction was for the purpose of declining the potential. The second fraction was to effect increases or decreases in allowable depending upon whether the unit was maintaining its pressure higher than or depleting its pressure reserve faster than the pool average.

Plan 2A, bottom hole pressure adjustment was adopted and substituted for Plan 1A in the proration agreement. The plan still utilized the 1000 subtraction factor, but since it apparently was equitable when used with current existing bottom hole pressures in the pool and since no agreement could be reached on some other subtraction factor the operators believed it advisable to adopt the plan immediately in order that necessary and desirable adjustments could be made. Plan 2A is still in force except that in 1935 the subtraction factor was changed from 1000 to 2.3 of the previous pool average bottom hole pressure. In the beginning of the bottom hole pressure adjustment plan, surveys were made very three months in order that necessary adjustments could be made as quickly as possible. Only two bottom hole pressure surveys per year, however, have been made since 1936.

The first proration agreement provided that wells would not be shot except after receiving special permission from the general committee since it was the opinion of the operators that there was already too great a potential production in the pool. In 1933 acid treatment of lime and dolomite wells became a production practice for the purpose of increasing production. Special permission to treat one small potential well was granted the Atlantic Production Company in March, 1933. The treatment resulted in a potential increase from 2,981 to 6,350 barrels a day and later to 14,580 barrels. The success of this acid treatment changed the views of the operators and treatments were permitted on all wells. It was soon found, however, that large increases could be obtained on large as well as small potential wells. It quickly became a practice to treat wells not once but several times in order to compete with offset operations. The frequent acid treatments resulted in frequent potential tests and the operators frequently exercised their option of taking open flow potential tests rather than through the tubing alone. In addition operators generally made one or two tests before the official test in order to determine the manner in which they could obtain the highest potential. The frequent taking of potentials was believed not in keeping with true conservation and since most of the wells had been treated, in general, the relative potentials remained essentially the same although the actual potential of both large and small wells increased. The operators, therefore, agreed that effective January 1, 1935, the taking of new potentials would not be allowed except on newly completed wells or wells that had been drilled deeper. This agreement was reached in October, 1934, which left a period of three months for all operators to complete their acidizing program.

As mentioned previously gas began to accumulate in the higher portions of the structure soon after the pool was produced and the gas cap spread rather rapidly. Also water was rapidly encroaching in certain areas and some wells were threatened with early abandonment. In the interest of conservation efforts were made to reduce the production of gas and water by various means such as bottom hole chokes, positive chokes and the restriction of production to less than the normal allowable. Some of these effected temporary improvement but was not a lasting solution to the problem. In November, 1932, the Texas Company set a packer in McKinley No. 2 which shut off the upper producing zone. Although the well had previously produced more than 90% water, after the packer was set water free oil was again obtained. This definitely proved that the pay zones could be separated and offered a possibility of reducing gas-oil ratios. All of the operators favored conservation of reservoir energy but were reluctant to set packers because it would necessarily reduce the potential of the well, also large quantities of oil still remain in the zone it was necessary to pack off and the spread of the gas cap would eventually move this oil off the property. In order to promote voluntary conservation of reservoir energy and to afford the operator an opportunity to more nearly recover the initial oil in place under the property it was agreed that the existing potential at the time the packer was set would remain in effect except that in case there was a general potential survey the potential of packer wells would be declined in accordance with the average of tested wells.

When the bottom hole pressure factor was put in force it was agreed that packer wells potentials should be adjusted in accordance with pool average bottom hole pressure, that is, the packer well potential would be declined by the fraction having as a numerator the present average pool pressure minus 1000 and the previous average pool pressure minus 1000 as the denominator. This provision of the plan is still in effect.

In October, 1934, a special allowable which was greater than the normal allowable was granted to one well. This special allowable was granted because the well had produced for a long period of time at less than its normal allowable rate and because the well was on the edge of the pool two locations away from any other production and, therefore, could probably not drain other producing properties.

In the souther portion of the pool there were six wells on three units which had been drilled prior to the beginning of proration. Since these wells had been drilled prior to the time it was known there would be 40 acres square units and since there was 80 acres in the lease on which each unit was located it was agreed that these units would be divided along the long axis of the 80 acres instead of into the regular square 40 acre units. These wells were Repollo Crump Nos. 1 and 2, Walter Terry Nos. 1 and 2 and Stanolind State in Sections 15 Nos. 1 and 13. The change gave these companies one additional unit each and became effective October, 1934.

Shortly after the New Mexico Oil Conservation Commission was created a hearing was held in Santa Fe to consider Hobbs Pool Proration and essentially all features of the prevailing Hobbs Proration Plan were embodied in the Commission's subsequent order. There was still some dissension among the operators with reference to participation factors. Two companies favored an increase in the acreage factor, however, the majority of the operators opposed changing the plan.

A hearing was held in Santa Fe in December, 1936, and after a great deal of evidence had been presented the Oil Conservation Commission requested that all operators again attempt to reach an agreement on a plan. No agreement was reached and upon being so informed the Commission again requested that the operators again attempt to reach an agreement. At that time the 75% potential and 25% acreage plan of allocation had been in effect from the beginning of proration except for bottom hole pressure adjustment and the 60% potential and 40% acreage optional plan for wells producing water. In the opinion of the majority of the operators the plan in effect was most equitable, but since other methods of allocating production had not been used there was no supporting data to definitely prove their contention and since two companies insisted on a change, agreement was finally reached with the understanding that after it had been applied for a period of time information to support the various contentions would be available. The new plan eliminated the special allowable for water wells and changed the allocation factors to 40% for potential and 60% for acreage."

BY MR. HUBBARD: You didn't read the last three sentences (referring to copy which Mr. Hubbard has). Don't you have "Present information indicates --

A (Interrupting) I think you have an old copy.

BY MR. HUBBARD: Will you pardon me, please if I read that into the record? (Reading) "Present information indicates that certain features of the Proration Plan should be changed. In the beginning packer wells potentials were to be declined in accordance with the average potential decline of all the wells tested in the regular potential survey. No general surveys were made, however. When the bottom hole pressure method of adjusting potentials--" The sentence stops there.

BY JUDGE LOWE:

Q What was the packer adjustments the committee was in favor of?

A At the present time?

Q Yes.

A I believe packer wells should be adjusted in a different manner than they are at the present time. As stated, it was the intention of the operators to decline the potentials of packer wells in accordance with the average potential decline of all wells tested. When bottom hole pressure came along it was decided to use bottom hole pressure in order to decline potentials. The fraction used was the same as that used for the field average, that is, the first half of the fraction used for normal wells. The second half of the fraction was not applied. That feature has caused packer wells to decline more rapidly -- I believe packer wells have declined between thirty, thirty-five or thirty-six, and normal wells between five and ten. Since it was the intent of the operators, in the beginning, to decline packers in accordance with the field average decline in potential, I believe you can, in fact, adjust packer wells, from the time the packer is set, and decline these potentials with the pool average potential decline in that well, giving packers quite a little increase in potential.

BY JUDGE LOWE: Any cross examination?

<u>CROSS EXAMINATION</u> By Mr. Seth:

Q Are you also in favor of wiping out fictitious potential?

A We no longer have potential in the Hobbs Pool.
Q What do you have?
A We have what should be termed a pressure potential factor. Bottom hole pressure had no reference to potential -- it merely attempted to --
Q (Interrupting) Do you recall the first well shown on Exhibit E, introduced by Mr. Card? This was one of your wells which after acidation, its potential increased eight or nine times.
A Not from bottom hole pressure.
Q Bottom hole pressure declined a hundred and fifty or sixty pounds during that period, yet potential increased eight or nine times.
A No, not due to bottom hole pressure.
Q What justification is there for that increase?
A With the view that oil, or recoverable liquids, cannot flow against pressure, a well with high bottom hole pressure cannot drain another area.
Q You think that eight or nine times increase is justified?
A There has been no well in the field increased eight or nine times due to bottom hole pressure.
Q It was due to that and acidation?
A As shown, that well increased from 3,000 barrels to the present of about 32,000. The acidation increased it from 3,000 to 26,000 barrels.
Q And bottom hole pressure declined 150 pounds or more?
A Yes sir.

BY MR. HUBBARD:

Q Do you believe, Mr. Gray, that every operator in the pool should currently or ultimately have the opportunity to recover the oil in place?
A I believe he should ultimately be allowed to recover the oil.
Q Would you say the west edge operator in the Hobbs Pool would ultimately have a shorter life than on top of the pool,- the wells operated there?
A Yes, sir, but due to water drive from the west being stronger than on the top.
Q That being true, would you say the inclusion of potential in

the formula, would give the operator on the edge more or less chance -- opportunity to ultimately recover his oil in place, than the formula in which potential was not included?

A Are you speaking about all of the edge, or just the west edge?

Q Just the west edge now.

A I believe potential will help the operator in obtaining the oil in place ultimately.

Q I don't want to change the trend of thought too much, but there are one or two things I would like to find out. Would you say, in general, a pool which is flooded out by water has a more efficient oil recovery than one produced by the expansion of gas?

A I thin, in general, a water drive pool will recover a somewhat higher percentage than a gas drive pool.

Q Would you say materially or slightly?

A I believe as much as 100% higher in some cases. A ratio of 25 for a gas drive pool as against 50 for a water drive pool.

Q In that case it would appear we would have more efficient production of oil in the structure in Lea County, including Hobbs, if as much of the formation as possible were flooded out by water instead of having an expanding gas cap come down to meet it?

A I believe a field should be so operated to keep the pressure high and to keep as much gas from coming out as possible.

Q In the case of Hobbs, would we get a more efficient recovery if at the time the oil is depleted the original gas cap covered about the same area it did at the start of operations?

A I believe so.

Q It would be reservoir pressure operating a field. In that case if you attempt to keep the gas cap in the same area throughout the operation, and neither decrease nor increase it, it would be impossible to deplete the pool, and production would only dissolve the gas?

A Yes, I believe it would be if the pressure were maintained at original pressure, that would reduce the allowable to so operate it.

Q Assuming we are allowed an allowable that will allow us to produce at a profit?

A Yes.

BY MR. CUSACK: In your opinion, Mr. Gray, with the present formula that has operated in the Hobbs Pool, as to bottom hole pressure -- in your opinion is that a field formula that does do equity to all producers?

A I question whether it is perfect in that way.

Witness dismissed.

DR. R. S. KNAPPEN,

being called as a witness by the Gulf Oil Company, and being first duly sworn to tell the truth, the whole truth and nothing but the truth, was examined by Judge Lowe, and testified as follows:

DIRECT EXAMINATION.

Q State your name.

A R. S. Knappen.

Q By whom are you employed?

A I am employed by the Gulf Oil Corporation.

Q Since when?

A Since 1926.

Q I wish you would go ahead and tell what educational and practical qualifications you have to testify as an expert.

A I have the degree of Bachelor of Science from Southern Wesleyan; Master of Science from the University of Wisconsin --

BY MR. SETH; We admit his qualifications.

BY JUDGE LOWE: I want him to go ahead and state them anyway.

A Doctor of Philosophy from Columbia University; honorary Doctor of Science from Wesleyan University. In the course of that collegiate training I specialized in geology, although I took a good many courses in civil and mining engineering at the University of Wisconsin, some at Columbia. I was employed by the United States Geological Survey during the summers from 1913 to 1916, inclusive;

served overseas as Colonel of Engineers; at the close of the war I served as geologist with the Second Army, A.E.F.; returned to the United States and was employed by the Illinois Geological Survey in the summer time of 1919 and 1920, and then was re-employed by the United States Geological Survey, summer and part time employment during the next years from 1921 to 1926, inclusive. I resigned from the United States Geological Survey in 1926, and entered the employment of the Gulf Oil Corporation, and I have been employed by various Gulf companies since that time.

Q Have you taught in any schools or colleges?

A Yes, I was instructor in geology at the University of Chicago for a year; I taught in the University of Kansas from 1920 to 1925, in various grades from assistant professor to full professor. I taught at Stanford University as visiting professor the summer of 1923. I was visiting professor of geology at Harvard in 1925 and 1926.

Q You were teaching at Harvard when you entered the employment of the Gulf company?

A Yes, sir.

Q Since you have been with the Gulf, what has been the nature of your work?

A I was first a member of the Board of Directors at Pittsburg, paying special attention to engineering phases and geology; in 1928 I transferred to Tulsa, where I am Assistant to the Vice-President, and work on various problems of geology, production and engineering.

Q Have your duties included work in connection with the proration of oil in various pools?

A I have had a good deal to do with proration rules and regulations, and the application of rules and regulations.

Q In the course of your duties have you had occasion to examine production and proration of oil in the State of New Mexico?

A Yes, I have.

Q For how long a period of time?

A I was interested in the purchase of leases -- I was not in charge of lease purchases, but when we bought the first leases in southeastern New Mexico I sat in on all conferences; when the first leases were purchased I was consulted on design and other features of well drilling in New Mexico, and I have been familiar with the drilling of every well since that time.

BY JUDGE LOWE: I might ask the reporter to mark all the exhibits straight through. (Maps handed to reporter are marked Exhibit 0 to 12, inclusive.

Q Dr. Knappen, the first map is marked "Gulf Exhibit 0", you may state what that purports to represent.

A That is simply a map of the Hobbs field showing productive acreage within the pool, and is simply introduced as a convenient means of showing the location of the pool in Townships 18 and 19 South, Ranges 37 and 38 East. All of the yellow colored acreage is covered by the Proration Plan at the present time. All of the units colored yellow have production restrictions under the Proration Plan - the formula Mr. Gray described. The one pink unit, on the west side, has a special allowable. As I understand, the special allowable was granted when it was first drilled. It appeared unlikely it would produce enough oil to pay costs unless it were given a special allowable. The three units in green were unable to make their allowable, given to them under the Proration Plan, so those units were given permission to operate at full capacity. The other units all come under the provisions of allotting to units 60% allowable for pool distribution equally between the units, and 40% distribution on what is miscalled "potential basis" - actually it is a distribution on potential as adjusted by the bottom hole pressure - the 40% pool allowable is distributed among the yellow units adjusted by the bottom hole pressure.

BY JUDGE LOWE: I desire to introduce that in evidence.

Q Turning next to Exhibit - that is Exhibit -

A (Interrupting) That is Gulf Exhibit No. 1.

Q That map was prepared under your supervision?

A Yes, all of the maps were prepared under my supervision.

Q Go ahead and explain to the Commission what that map purports to represent.

A This map, like all the other maps we shall present, with one exception -- I am not certain of that exception -- are all on the same scale, four miles to the inch. This shows all of the wells drilled in the Hobbs Pool. This is simply the same map shown previously, but here we colored the acreage of the various operators in distinctive colors. I believe there are twenty-five operators and we ran out of colors -- one or two leases that have no colors. We have colored all of the leases belonging to an operator, where one operator has more than one lease, we have colored all of their leases the same. The Gulf leases are shown in green, scattered through the central and northern portion. The Stanolind are bright blue, concentrated largely in the southeastern part of the pool - this 160 acres in the W½ of Sec. 5. The bulk of their leases are in Twp. 19 S., extending up into 18 S. I can readily point out the properties of any other operator in the pool, and this map is introduced for convenience in locating leases.

Q Is that data as to ownership on record in Lea County?

A It was prepared from the Proration Report of the Conservation Commission.

BY JUDGE LOWE: I desire to introduce that exhibit in evidence.

Q You may explain Exhibit No. 2, that it is intended to represent and the information it is intended to convey.

A Gulf Exhibit No. 2 is the same map -- same scale. In this case we have drawn contour lines on the map as they have been drawn by the Engineering Committee. Contour lines, to an engineer or anyone accustomed to using them, indicate structural conditions. To make it perfectly clear, in this case we have a contour line on top of the white lime, the principal producing formation in the Hobbs Pool. It practically all comes in the white lime - less than one per cent comes in any other. A contour line is a line drawn through equal elevations -- the same distance above or below sea level; as it goes around, that contour is very easily followed. This line can be called the shore line (indicating a line on map). If everything above the pay at

Hobbs were torn away and the white lime exposed, this line (indicating) would be the ocean level, and this line (again indicating) would be 450 feet lower than the ocean level. Stand on the side of the Hobbs Pool, on the contour line of -450 feet, along the contour line which is most easily seen, with the green below and yellow above, and the ocean level lay beyond this line (indicating).

These contour lines are drawn 25 feet apart. Every contour line goes through a line of equal elevation. Where the contour lines are far apart, as they are along the southwest flank, through the center of the field, one must go down slope a considerable distance to reach the next one, which is another way of saying that one goes a long ways to go down 25 feet. Where they are bunched together it means one drops 25 feet in a very short distance -- the spacing of the contour lines in there (indicating an area on the map) is something like seven lines to a quarter of a mile, which means the slope is 175 feet to 1000 feet, about a 9° slope. The highest contour lines on the map are the producing area in Sections 32 and 33, 325 feet below sealevel. A number of wells inside that contour line reached the top of the white lime at that elevation, and has unquestionably identified the contour up slope and down slope. For instance, Cities Service No. 4, in the center of this area (indicating), that lies above the -400 foot contour line, and lies below the -375, so from the map you know it must be more than 375 feet below sea level, and less than 400 feet. This same contour appears between these lines in the same space.

I have taken some time to explain this contour map. This is a map on top of the white lime, shows the structure on top of the pay at Hobbs. From the center of the structure, the crest, to the northwest, the fartherest well would be 243 feet lower than the highest well on the structure, which lies at -312 feet. The drop from the highest well -- from the center of the structure to the southeast the slope is gradual, dropping down to the lowest, No. 1 Selman, which is found at -550, which is 238 feet lower than the highest well in the pool. To the northeast the slope is much steeper than either to the northwest or southeast, to the center of the pool. The lowest well for which we have any data is the Two States Oil Company No. 1, in Sec. 21, which is -583 feet, or 271 feet lower than the highest well in the pool. It is possible the Samedan have one still lower in Sec. 34, but we have no elevation on the top of that well, but the exact elevation is immaterial.

To make it easier we printed the flanks of the structure in green. The area printed in green is where the thickness of the pay is less than 150 feet. The yellow is where the pay is more than 150 feet thick. The two breaks in the green printing is where no well has been drilled in the section of less than 150 feet. Not having a control, we did not carry the contour lines through that part. Similarly, in the northwest, there are no wells drilled in this part of Sec. 18, (indicating) of Sec. 18, T. 38 E., or these parts of Sections 13, 14, 23 and 34.

No wells in the less than 150 feet area does not mean the structure stops, but nobody has drilled out in that section where the pay has thinned, and we do not have anything to show the contour on production around the northwest end of the pool.

Q What do the colors indicate?

A The colors indicate the area where we know the pay is less than 150 feet thick, if it is green; or more than 150 feet thick if it is yellow.

Q What importance is attached to the position on the structure in the initial development of a field?

A If one knows where the top of the structure is, naturally he wishes to buy leases on top, which has the thickest pay and the longest time before water reaches it, and should have the largest volume of oil under the lease which he purchases. Accordingly every operator hopes his lease will be on top of the structure -- but many are disappointed in those hopes.

BY JUDGE LOWE: We desire to introduce this exhibit in evidence.

Q Exhibit No. 3 is the next?

A Yes, sir.

Q You may explain that map.

A Exhibit No. 3 is a duplicate of Exhibit No. 2, except we have not colored, on this map, the productive part of the pool. The contour lines are here. On this map are indicated a series of wells extending from near the northwest end of the field down to the southeastern end of the field. The wells have been selected so that we might, in the next exhibit, present a cross section of this field. If some gremendous giant, armed with a great meat cleaver, could sweep away the overlying formation from on top of the white lime on all of the territory southwest of the irregular red line, he would then stand off to the southwest, and looking northeast, see the white lime as it shows on the cross section in the next exhibit. We would like to have taken wells in a straight line, but lack of geologic information on some wells, and lack of other information on other wells, we had to select wells where we had available geologic and engineering data. The section shown on the next exhibit is not a straight section from northwest to southeast, but is a tolerably regular cross section which will, we hope, give a good idea of the character of the structure in the Hobbs Pool, in, of course, that direction. Other sections might have been drawn, but we felt this was all we could do with the geologic and other data available.

BY JUDGE LOWE: We wish to introduce the exhibit in evidence.

Q Now explain Exhibit No. 4.

A Gulf Exhibit No. 4 is, below the structure map shown on the previous exhibit, and here (indicating) it is repeated here but turned out at an angle so as to place the red line directly beneath the cross section.

Q The top of the lime, made with the giant cleaver?

A That is what is left after all above has been torn away on the southwest side -- if one stands on the southwest side of the field looking northeastward, he sees the top of the lime, following this irregular line, rising from the northwestern well -- not the highest well nor the most northwestern in the pool -- it rises from Samedan No. 3 -- rises from there to the top of the top of the structure, to 3 State A33, then drops off more rapidly to the southeast, to Stanolind No. 6, a dry hole at the southeast end of the pool. All of this section, shown on this exhibit, is supposed to have been filled with oil - the field as it is supposed to exist when the first well was drilled in the field. Certainly the higher portion was filled with oil, unless there was a very small gas cap right on top of the structure. A gas cap is a region in which gas has collected. All petroleum geology and all petroleum engineering is based on a very simple, well known fact, that oil is lighter than water, and gas is lighter than oil. If one would take oil and gas and water and put them in a bottle, or any other container, the gas would accumulate on top, unless it were all dissolved in the oil, and the oil would accumulate on top of the water. Over the period of geologic time in which oil and gas has been accumulating in the Hobbs Pool, the oil has separated from the water and flowed on the water field top on the Hobbs structure. The structure is very much larger than indicated on the map. We have simply indicated the oil production zone on the area. The northwest slope was toward the northeast, and somewhat less sharply to the southwest. The bottom of the oil zone is somewhat indefinite. Naturally no operator wants to drill a well until he encounters water. So far as we know, only one well inside the production area has been drilled down into the water underlying the oil. That well is Stanolind No. 1 State, in the NE$\frac{1}{4}$ of 9, Twp. 18 S., R. 38 E.

Q Indicate that.

Q It is shown at this point (indicating on map). Being the first well in the pool, the operator had no way of --

Q (Interrupting) Twp. 18 or 19?

A 19 -- I am sorry. Since it was the first, there was no way of knowing. The operator was dissatisfied with the oil production at shallower depths, and found water at 618 feet below sea level. The same operator drilled No. 6, right in Sec. 14, same township. That location was supposed to be outside the oil zone. It was drilled in very tight composition and at -614 they encountered water -- 614 feet below sea level. One or two wells along the southwest flank, between 600 and 614 feet below sea level, and it has been generally accepted and published in the reports on the Hobbs field that the bottom of the oil pay is at -614 feet -- 614 feet below sea level. That 614 feet below sea level marked the top of the original water, and the bottom of the oil in the structure. In so far as the upper space is concerned, perhaps oil is almost entirely up to the top -- there is some uncertainty as to whether there was a little free gas on top of the structure. I am in no position to express an opinion as to whether practically all of the gas in the Hobbs pool was dissolved in the oil, and the oil filling the upper space from the top of the structure, at 312 feet down to somewhere in the neighborhood of 614 feet below sea level, almost exactly 300 feet of oil pay in the central portion, with the thickness of the pay diminishing in all directions from the northeast corner of Sec. 2, Twp. 18 S., R. 38 E. While I have described that as being filled with oil, I certainly do not intend to leave the impression that there is oil in every cubic inch of rock -- much of the rock is too tight -- too dense to have liquid of any sort in it. The descriptions by various geologists of the Hobbs Pool, the reports of the company geologists, all I can learn from others about the pool, indicate there is at the top of the structure from 15 to 30 feet of very tight, impervious rock, in which little or no oil exists, then comes the first pay, then the prolific pay. It is exceedingly porous on top, and diminishes in porosity from the top, and becomes much less porous towards the southeast, northwest and down the northeast flank and the west side. The porosity of that pay diminishes outward from the highest point on the structure.

Probably the best article that has been written on this pool was written by two Midwest -- Stanolind engineers --

Q (Interrupting) Have you that article with you?

A Yes, I have. Mr. Ronald K. DeFord and Edwin A. Wahlstrom. Mr. DeFord was division geologist for the Midwest Refining Company at the time of writing the article.

Q Before proceeding, give the volume, the year, the name of the magazine, and the date of it.

A The magazine I have is the Bulletin of the American Association of Petroleum Geologists, Vol. 16, No. 1, of January, 1932. The article was written by Ronald K. DeFord, Division Geologist of Midwest, which, at that time, was 99% owned subsidiary of the Stanolind of Indiana, and Geologist and Engineer Edwin A. Wahlstrom, of the same company, the Midwest. The article is entitled "Hobbs Field, Lea County, New Mexico." Much of the geological data I am presenting here in their article have been checked by our company geologists and others. I might, at this time, make it perfectly clear that I have never been stationed in Lea County -- I have been there, but I am not so familiar with the details of operations as if I had been located at Hobbs. I have general information which I am trying to present of the general situation relative to oil and gas geology and production and engineering in the Hobbs Pool.

Q Are there any particular parts of that article you desire to read to the Commission?

A I think the Commission might be interested in a statement in this article as to the porosity of the white lime at Hobbs, page 76 (reading) "That the porosity of the 'White lime' at Hobbs is related to its structure is obvious. In general, the limestone is most porous on the crest of the anticline, less porous on the flanks, least porous beyond the limits of the oil pool.

Determinations of the actual porosities of limestone reservoirs are not practicable because the really productive openings are so large (ranging in size from 'mouse holes' to caverns) that core recovery is almost impossible. As previously stated, core loss is better indication of a limestone 'pay' than the recovery of porous material that bleeds oil. The only index of porosity in the Hobbs field is initial production of oil."

Then on page 70 and part of page 71, is a statement that there is a cavernous condition on top of the structure evidenced by loss of returns -- when mud is pumped down through the drill stem, if the formation is so porous as to take up all of the mud pumped down, the returns to the surface are lost. Then they speak of rotary tools suddenly drill downward in some wells without any apparent resistance, or cable tools drop as into an open space. That happened, they cite, at Midwest No. 33 Byers, in the NE$\frac{1}{4}$ of Sec. 4, Twp. 19 S., R. 38 E. -- this well about which Mr. Card talked today. This well was never drilled below the top of the pay, because when the Midwest was drilling the well, "the tools suddenly dropped the full length of the stroke and swung free. The drillers, suspecting the truth, ran from the derrick floor, and a few moments later the top of the control head was blown off by a great rush of oil that shot over the crown block. When the well was again under control, hourly gauges indicated a daily rate of flow of 21,249 barrels."

On page 77: (Reading) "The top productive member of the 'White lime' is cavernous on the crest of the structure, fairly porous on the flanks, and off structure is in places only very slightly porous, in other places somewhat porous."

BY MR. SETH: Did you leave out part of the sentence?

A In what I just read? I certainly did not. I read the entire sentence, beginning at the bottom of page 77, that paragraph.

Then again, on the development of porosity: (Reading)

"One not yet committed to any theory may reserve his judgment concerning the origin of the porosity in the lower part of the 'White lime', but the condition of the top porous member seems to significantly related to structure to be thus passed by. It is cavernous on the top, porous on the flanks, and off structure almost dense, and these remarks apply as well to the pre-Brown lime structure of the 'White lime' as to the present structure of that formation."

Q That article used the word "anticline". Explain the use of that term in application to this structure.

A An anticline is an elongated dome -- the dome on the ceiling here (indicating the dome in the room used for this hearing), if it were stretched out in one direction, would be an excellent illustration of an anticline -- a structure longer that it is wide, and sloping down in all directions from the crest. The crest is normally roughly horizontal for some distance, with the ends of the crest pinching off, in just the same way the dome in the ceiling might be stretched out to form a typical anticline structure, longer in one direction than in the other. So that Hobbs is a typical anticlinal structure. It is almost a text book structure. I suppose in years to come maybe the Hobbs Pool will be included in text books as an excellent illustration of such an accumulation of oil.

Q In your e xperience, is high porosity on the top usual or unusual?

A It is more usually the case. There are exceptions to the rule, but I should say that eight or nine times out of ten the highest porosity comes on the top of the structure, and, of course, the thickest pay is almost invariably on top. The only exceptions are where the pay is of uniform thickness and in impervious material. Most of the porous pay, and therefore, most prolific, normally comes on the crest of the anticline.

Q Is that the reason an operator tries to get on top of a structure?

A An operator, of course, desires to get the most oil for his money. Naturally, until the structure is well defined he does not know how far down the flank the oil and gas occurs. He tries to play safe and get clear on top. He has practical certainty of oil or gas if he is on top of the structure.

BY JUDGE LOWE: I desire to introduce the exhibit in evidence (Referring to Gulf Exhibit No. 4).

I notice it is five minutes of ten o'clock.

BY THE GOVERNOR: Proceed.

A One item I did not point out on this cross section -- that is the depths of the wells are indicated by making these lines, which go down to the proper elevation below sea level. The depth to which this well (indicating a well on the map) is drilled is indicated by drawing a line on the section down the proper distance below sea level. You will see these wells were completed at varying depths below sea level. These wells were completed, in general, 550 to 600 feet. An operator naturally desires to drill his well as deeply as he can without encountering water. He does not wish to drill into water production.

Q What is that middle line through the red section?

A That line marks the top of the sand break, a geological marker recognized by most of the wells in the section. The big pay lies above that big sand break; the second pay, on the southwest flank, also lies above it. The Capps, sometimes referred to as the lower pay, lies a short distance below the sand break. The various pays being separated, most probably all by tight, impervious material, there is gas, but no oil. Gas there which cannot make oil except by following some well drilled through.

Q Is the pay below the middle line available to all operators?

A No, not available to all operators. You will notice the sand break drops below -614 at this point (indicating on map), which is Stanolind No. 26, in the NW$\frac{1}{4}$ of Sec. 10. From that point southeastward there can be no production below the big sand break. The original water line lies above the place where the lower pay exists. No doubt the low pay is out in here (indicating) which contains water, as indicated by the discovery well and by the drilling of Ohio No. 1 State, in the SW$\frac{1}{4}$ of Sec. 9, all of which portray the lower pay, lower than -614.

Q Would you expect more oil or less than normal conditions where you have two pays?

A You have just twice as many chances if you have two pays instead of one. The chances are with two pays, the operators have two chances for pay production. However, a foot of pay in one horizon is a very different thing than a foot of pay in another. I would rather have a foot of pay in 35 feet of porosity than to have ten feet of pay in ten feet of porosity.

Q Will you turn back to No. 1 and indicate the section or area in which there is only one pay?

A Roughly the area in which there is only one pay is very narrow zone along the southwest side and a much wider zone at the southeast end, a narrow zone up around the flanks in the northwest end of the field. The highest wells drilled have been drilled where there are three pays. Probably wells might be drilled out here (indicating) that would encounter only one pay, but no such wells have been drilled.

BY MR. CUSACK: While we are on that northwestern edge, wasn't there a dry hole drilled in Sec. 14 -- didn't the Tidewater drill a dry hole up there?

A The Humble drilled a dry hole -- the Landreth in Sec. 7, the Shell in Sec. 14.

BY MR. SETH: On your Exhibit No. 3 -- or No. 2, my recollection is you said the reason you didn't draw the green area around that part of the field was because nobody had seen fit to drill out here (indicating). I just want to call your attention to this well (indicating a well on the map).

A We used this well down here (indicating).

BY MR. SETH: You did not show the thickness here?

A No, we used that well (indicating).

BY GOVERNOR MILES: Will you go back to No. 2 just a moment, because I am going to ask -- maybe you stated this before -- but how many companies are represented by those different colors? How many companies are represented in the field?

A There are twenty-five different operators in the pool. We ran out of colors, so we did not color this lease of the Getty Oil Company and the Two States Oil Company -- we left them in white as we ran out of colors.

BY GOVERNOR MILES: In acreage, that represented by the green figures what percentage of the total acreage?

A This tract down here, the Repollo -- there are four -- six out of 248 -- I miscounted -- there are two wells drilled in one forty that have been listed as one well -- another well in this forty (indicating on map) -- there are seven -- three units in here -- three units in Sec. 15, Twp. 19 S., R. 38 E.; four units in Sec. 28 of 18 S., R. 38 E. -- seven -- 2.48% -- just under 2% -- 1.97%. Does that answer your question?

BY GOVERNOR MILES: Yes.

A This is Gulf Exhibit No. 5 (turning to next map on stand), the contour map we have used in two or three of the other exhibits. This contour map has colored bands representing fifty-foot thicknesses. On this thin color the upper contour line is at 300 feet -- 325 feet, and the lower at 375 below sea level. The thin color is spread over an area fifty feet in depth below sea level. The green is fifty feet, from 375 to 425, fifty feet. The lavender is from 425 to 475. The brown is all the distance from 475 down to 600 -- 575 is the lowest contour down there. The depths of penetration of wells have been calculated within these zones. On the very top, where it would be level, the yellow is from 312 to 325. The wells are drilled at 217 feet below the top of the white lime. In the next zone, the geologists of the various operators recognized they would not have quite so much possible pay and the wells average 182 feet below the top of the structure. The zone of 375 to 425, the average is only 156 feet; 425 to 475, the average is 112. On the brown zone, the fringe of the field, the average is 60 feet, but that brown zone covers a full hundred feet, and that has been calculated, the two figures with 72 feet of penetration toward the top and 44 feet for the deepest penetration in the lowest and thinnest possible pay in the field. In other words, the operator who did not have the lucky wells, found out in the center, recognized there was no chance of getting oil at such depths, therefore drilled successively shallower depths in the southeastern portions of the field, the northeastern flank. In the northeastern and southwestern areas the average penetration is only 60 feet. The penetration increased to the top from 112 on up to 217 feet. The operator in the brown area had one foot of pay for every 3.5 feet of pay possible to the operator on top of the structure. In addition to having much greater thickness on top, you will remember DeFord and Wahlstrom said the pay is much more porous on top, so having the 3.5 to 1 advantage, I should say they had many-fold advantage on account of greater porisoty, which means, the more porosity, the more space to be filled with oil, which would mean more oil in place on top of the structure, and far more oil in place there than in the brown zone where the pay is thin and comparatively tight.

BY JUDGE LOWE: I desire to introduce Gulf Exhibit No. 5 in evidence.

Q What exhibit have you there?

A Gulf Exhibit No. 6 (turning to next map).

Q You may explain that exhibit to the Commission.

A This exhibit, map No. 6, is a bottom hole pressure survey made in the Hobbs Pool. It is a map of the pressure shown in the wells when the wells have been shut in from 24 to 36 hours, all pressure measurements being made at 400 feet below sea level, if that is possible, or if made at different depths, the correction formula was applied to ascertain the actual pressure at that level. I am sure you understand that before the first well was drilled, the oil, gas and water stands there under pressure. The water on the sides of the pool, and water coming up through the porous zones on the flanks would tend to push the oil to the top of the structure. There was impervious structure through which the oil and gas could not escape, and the oil was held there, and there being non-porous beds above, and flooded with water below, the pressure of the water balanced the pressure of the oil and the pressure would be uniform throughout the field. We have no pressure survey before the first well was drilled, but the oil had accumulated over a period of some hundreds or millions of years. If there were differentials in pressure in the various portions of the pool, those pressure differentials would have forced the oil to flow from the areas of high pressure to areas of low pressure, and the pressure differentials would have been equalized. When the first well was drilled into the pool, from the best evidence of pressure at a depth of 400 feet below sea level, which is the depth of the survey made by the Engineering Committee, that pressure was somewhere between 1500 and 1525 pounds per square inch. That pressure existed on all oil in the structure, and existed on the water around the flanks. When the first well was drilled, that pressure was available to push the oil into the hole, up the casing, up the tubing in the well, on up to the surface. As soon as some oil was produced from the first well, an area of lower pressure developed around that well. That is inherent in the production of oil from a structure. Removal of oil from the pay necessarily makes a place of lower pressure, to which the oil tends to travel from other parts of the field. As soon as the second well is drilled in the area, that is slightly reduced. If the permeability of the pay was high, then the pressure drop at a well would be very slight and oil would readily move into take the place of oil taken out and the pressure would be re-established. If the permeability was low, the removal of oil would require a greater time for the equalization of the pressure. But any time a low pressure area exists in a pool, there is a tendency for oil to move from the area of high pressure to this low pressure area. Movement of oil and water in any geologic structure is across -- over or across an area of low pressure. The same rule applies to the movement of water in a water distribution system -- it moves from the place where the pressure is exerted. In water supply mains, with a standpipe or reservoir, the water in the reservoir exerts the pressure, but if the water in the reservoir and standpipe is at the same level, the water pressure in the mains becomes constant --

BY MR. SETH: (Interrupting) Like this exhibit we had here this afternoon.

A Like the exhibit we had this afternoon. As long as he kept the water at the same elevation in the two tubes, he had the same pressure.

The Hobbs Pool was discovered in December, 1928, the official completion date. I believe the discovery of the first oil occurred in June or July of 1928, but the first well was officially completed in December, 1928, Stanolind No. 1 State, in the NE¼ of Sec. 9, T. 19 S., R. 38 E. Stanolind owned most of the acreage in the southeastern portion of the field. I should say the Midwest Company -- the Midwest Company was operating at that time and the Stanolind succeeded it -- they drilled wells in the southeastern area and production was found in a number of wells. A dry hole was drilled in Sec. 14, No. 6 Wright. It was not of any importance -- and on the map we did not use it. No great excitement until Humble drilled in No. 1 Bowers sometimes in 1930, in Sec. 30, T. 18 S., R. 38 E.

BY GOVERNOR MILES: What was the date of the first well?

A December, 1928, then the next well was January, 1930. The first big well was the Humble No. 1 Bowers.

BY GOVERNOR MILES: This first well drilled, was that considered a big well?

A No, it was not a big well. I do not remember the exact initial production.

BY MR. SETH: 700 barrels.

A Approximately 700 barrels was the figure I had in mind also.

Other wells were drilled after the first one, also of limited initial production because they were drilled in an area where the possible pay was thin. As it developed, Mr. DeFord and Mr. Wahlstrom pointed out, the porosity was poor as compared to the top of the structure. When the Humble No. 1 Bowars came in, it was immediately offset, and the Hobbs Pool developed at a rapid rate; in the course of the next fourteen months 140 wells were completed in the Hobbs Pool and the pool was fairly well outlined, although there has been subsequent development in the northeast and northwest sides of the field. The production outlet was poor -- in fact, the first pipe line was completed into the field in May, 1930, and the pipe line prorated the oil until July of 1930, when the operators united in a proration plan -- the Engineering Committee was established which Mr. Gray Has described, and the first bottom hole survey was made by the Engineering Committee about December, 1931. The Hobbs survey was made of a number of different wells, and naturally, as there was only one gauge at the pool, it had to be made on different days, and the making of the survey spread over a number of days, in December of 1931, and the data was all published in the January report of the Hobbs Engineering Committee. We produced that data on this map, platting equal pressure lines through those equal pressure wells, the same as making a contour map of equal elevations. All points along this line here were points where the shut-in pressure was 1425 pounds; all points along this irregular line No. 2 shows a pressure of 1425 pounds. The white areas which are enclosed by the pressure line of 1450 pounds -- that is to say, all points along the line enclosing the white areas had 1450 pounds per square inch; points inside the line had higher. The green area applied to areas having 1350 to 1400 pounds pressure. There are two sections of green in the northern portion and a rather broad band in the southeastern portion. The blue marks the zone of from 1300 to 1350 pounds pressure, and the muddy part is 1250 to 1300 pounds.

On that map of pressure differentials the lowest pressure well is the Stanolind No. 24 in the NW¼ of Sec. 15, the lowest pressure of 1275 pounds. The highest pressure is the Shell No. 1B Mc-Kinley in the SW¼ of Sec. 20, where the pressure is 1483 pounds. There is a pressure differential of 208 pounds. A pressure of 208 pounds will practically run a small locomotive boiler under low steam, and will tend to push the oil from the Shell well into the Stanolind well. The high pressure wells in Sections 33 and 34 and 4 and 3 to the south, the high pressure areas where the pressure is in excess of 1450 pounds -- I believe 1479 is the highest pressure within that area, so that from the Stanolind No. 8 State in the NW¼ of Sec. 4, there was a pressure differential of 204 pounds operating over a distance of roughly two miles, which would tend to push the oil down into the southeastern part of the field. Those pressure differentials were the result of the operations before the adoption of the proration plan. Before the adoption of the proration plan, every operator produced as the market permitted, as the pipe line could take it. The 25-75 plan was adopted in July, 1930. Unfortunately we have no survey as of that date. We do not know whether pressure differentials in the pool at the time the proration plan was adopted were greater or less than at the time of the first survey. This is the first time they knew how the pressure existed in the field and at that time there was a difference of 208 pounds, too much for a really satisfactory operation of the pool.

Q What does the yellow sections indicate, in general terms?

A The yellow sections indicate an area ranging from 1400 to 1450 pounds.

Q What are the ideal conditions under which oil could be produced in a field, in regard to bottom hole pressure?

A The ideal condition would be to have no variations in pressure across the field. Under those conditions there could be no movement across border lines from one lease to another.

Q What is the effect of the variance in pressure?

A The effect of the variance in pressure is to force the oil from areas of high pressure to those of low.

Q Have you any literature with you in regard to the ideal methods just stated?

A Yes, sir, I have.

Q Will you produce it?

A (Witness produces book) This is a report of the Committee of the American Petroleum Institute on the allocation of production. This was a committee appointed about 1929 and consisted of ten or twelve petroleum engineers who were instructed by the American Petroleum Institute to develop and recommend the most satisfactory method of allocating oil within a prorated pool, taking into consideration the best engineering information available. This is a revised progress report of that committee as published by the American Petroleum Institute on October 26, 1933.

Q What bulletin?

A It is a re-print from the production bulletin No. 212 of the American Petroleum Institute entitled "Essential Engineering Factors in the Allocation of Production."

Q Who wrote the report?

A The bulletin consists of a report by the Chairman of the Committee, Fred E. Wood, and a series of supporting papers in which various features are discussed of the recommendations of Mr. Wood in the general report.

Q Who is Mr. Wood?

A He is production engineer of the Standard Oil Company of Indiana,

Q Just read from his report.

BY GOVERNOR MIEES: We will be in recess until tomorrow morning at nine o'clock.

DECEMBER 8, 1939

9:00 o'clock A. M.

Pursuant to recess taken on December 7th, the Commission resumed the hearing in the foregoing matter at nine o'clock A. M. of December 8th, all members of the Commission being present, whereupon the following proceedings were had, to-wit:

BY MR. SETH: The reporter calls my attention to the fact that I did not offer in evidence Stanolind Exhibit E.

BY JUDGE LOWE: I think if either Judge Seth or I fail to introduce an exhibit in evidence, they can be considered as introduced.

DR. R. S. KNAPPEN

resumed the witness stand for further Direct Examination by Judge Lowe:

Q Mr. Knappen, when we adjourned last evening you were about to present an article prepared by Mr. Wood. Will you please proceed.

A I think I had given the title and date of the publication, stating it was a publication of the American Petroleum Institute and was a report of a committee appointed by the American Petroleum Institute to study the difficult and puzzling problem of the best method by which to allocate the oil within a pool. The committee was not attempting to determine how to allocate oil between operators, but simply over the pool. Under the old law of capture, each operator was permitted to produce oil as fast as he could. It depended upon the operator --

BY MR. SETH: What is the date of that last one (referring to book which the witness had).

A This is simply another copy. The date is October 26, 1933 -- I beg your pardon, this was originally prepared in October, the 26th, and revised November 14, 1934.

The introduction of proration made it impossible for an operator to produce except under definite restrictions --

Q (Interrupting) Are you reading from the paper?

A No, I am still explaining the background of the committee.

The restrictions naturally should be such as to give each operator the right to produce the oil under his land. That is the state law in New Mexico, I understand, but I do not mean to go into the law. The committee was appointed to study the proper type, and to recommend the proper methods by which the production in pools should be controlled so as to do equity between the various operators. The committee -- strike that -- the committee was composed of a large number of men, ten or twelve petroleum engineers. With no exception, I believe, they were all employed by major oil companies. Since the committee was to write a general report, not applicable to any one particular pool or to any one particular area, but just intended as a general report on the country as a whole, the report is couched in general terms, general rules which seemed fair to the various members of the committee. The Chairman of the committee, Mr. Fred E. Wood, is production engineer of the Standard Oil Company of Indiana, located in the home office of the company.

At a series of meetings we arrived at a general agreement on principles. Mr. Wood, as chairman, was asked to state the principles in definite terms, and present the report to the committee, which is the report I have in my hand. We thought the report certainly was not to question rules, but to elaborate upon them, and accordingly asked various experts to discuss various factors considered in the report of the committee. This pamphlet contains both the report of the committee and the series of papers written by different men at the request of the the committee, and indicate in the reports the different factors to be included in the proration order.

For instance, Mr. Albertson wrote a paper on "Acreage and Sand Thickness as Factors in Proration". Mr. R. B. Kelly, of the Pure Oil Company, wrote a paper on "The Potential or Productivity Factor in Allocation Formulas". Mr. R. D. Myckoff wrote on "The Relation of Well Potentials, Sand Permeability, and Well Pressures to Allocation of Production". Mr. T. V. Moore, of the Humble Oil, wrote on "Application of the Principle of Volumetric Withdrawal to the Allocation of Production". Mr. D. R. Knowlton, of the Phillips Petroleum Company, wrote a paper showing the effect of the application of this plan to Oklahoma City; his paper being entitled "Effect of Volumetric Withdrawal on Physical Waste in the Oklahoma City Field". Mr. Moore, of Humble, wrote another paper on "The Effect of Curtailment on Ultimate Recovery". I believe each of those gentlemen were members of this committee, as well as others.

At the present time I wish to read particularly from Mr. Wood's report, written for the committee and adopted by the committee as its recommendation. Of course, he discusses many things besides bottom hole pressure -- that is only one of the factors in prorating a pool, but since we are talking particularly about bottom hole pressure, I should like to invite the attention of the Commission to this part of his report, reading from the top of page 3, he writes:

"The total allowance of each well should be modified so as to favor substantially wells having low gas-oil ratios, in order to discourage inefficient production practices and minimize drainage toward inefficient wells. In pools with gas cap (where there is a market for the gas) the contents of the reservoir should be apportioned between the oil and gas areas so that relative volumetric withdrawals will not cause movement of oil into the gas sand, hereinafter discussed under 'volumetric withdrawal'. The principles of volumetric withdrawal may be applied where necessary to encourage low water-oil ratios".

Reading the fourth paragraph down, still on page 3:

"The committee recommends that an allowable computed under any formula should be subject to correction periodically, in order to decrease subsequent allowables previously found to be excess ive, or increase subsequent allowables previously found to be deficient."

Then reading the last para graph on the same page:

"Where there is more than one well to each proration unit, it is recommended that the productivity factors of all wells on that unit should be suitably averaged, and the result be used as the well productivity factor for that proration unit. Productivity is properly regarded as an indication of the producing quality of the strata within the drainage area of the well."

Reading still further, the paragraph headed in heavy black, bold faced type, entitled "Pressure":

"In most cases a formula for allocating production may well include the static bottom-hole pressure as a corrective factor. If, for any reason, the allowable assigned to a well or proration unit is larger than it should be, then the pressure in the well or unit should decline more rapidly than in the rest of the field; and at the next allocation period the inclusion of lower pressure in the formula will lower the allowable, and tend to correct the situation. Conversely, if the allowable assigned is smaller than it should be, pressure should decline less rapidly; and at the next allocation period the allowable will be increased as a result of the unit having a higher pressure than the rest of the field. Thus, by including the static pressure as a separate term in the formula, it will have no effect if the other factors in the proration schedule are properly balanced; whereas its inclusion will tend to correct the schedule if the other factors are out of balance."

I think perhaps, if the Commission wants me to read --

BY MR. SETH: I suppose you wish to introduce that as an exhibit?

A Not at present, anyway. I might note the revised report, the addition being dated July 15, 1936, printed on a blue sheet. The additions to the former paper have been printed in italics, and are additions which the committee felt should be made to the original report, and I call particular attention to the addition which the committee felt, after two years of study, should be added -- that is to say, after two years experience with the provisions of the paper, the committee felt should be added:

"If a well cannot produce its minimum allowable without waste it is highly desirable that the production of such well be subject to the principles of volumetric withdrawal as computed for the remaining wells in the field. The computation of volumetric withdrawl will reduce the oil production below the minimum allowable, but this is considered desirable as a conservation measure."

Q Has the proration plan in the Hobbs field been in accordance with the recommendations of the committee?

A The plan as written has been in accordance with the recommendations of the committee. The numbers that have been used in the plan have not been in accordance with the recommendations of the committee, because changes in the plan have been made which have increased bottom hole pressure, where the recommendations of the committee were that any changes should decrease bottom hole pressure. But the plan does follow the general terms of the recommendations of the committee. It provides the acreage be uniformally treated, and the allowable based on a forty-acre unit. It provided for the inclusion of potential in the formula, and it provided for the correction of that potential, because it was recognized that even though potential is the first yardstick you have of the amount of oil in a pool -- it is the first yardstick -- the first indication of whether you have prolific pay or poor pay, but that yardstick should be corrected by the bottom hole pressure. If an allowable is too large, the bottom hole pressure will show it is below the field average, and if it is too small, it will be above the field average. So that if the allowable is too large, the allowable of that unit will be decreased in the future. On the other hand, if the allowable had been too small, the bottom hole pressure will be too low, and it will be increased, and five that unit a chance to catch up with the average. It tends to drop the pressure at the top of the pool,to maintain uniform pressure conditions, because the oil, gas and water all observe the s ame rule, to move from an area of high pressure to an area of low pressure, and if the pressure is uniform, there is no movement.

Q I wish at this time you would explain to the commission what you mean by bottom hole pressure.

A To begin with, pressure is simply a force acting on any substance tending to push that substance in some direction. If I push down on this stick, I exert pressure on the floor. The floor pushes back, and there is no movement. On the other hand, If I apply the stick to the water glass, and the pressure exerted is sufficient to overcome the friction, the glass has to move along the desk. The pressure tending to move it exceeded, or is greater than the pressure holding it stationary.

In the case of a liquid, if I fill the glass with liquid, and move a spoon in it, there would be pressure against the water tending to move the liquid to one side -- the movement of the spoon in the water would increase the pressure on one side and decrease it on the other, and the water would apparently run around behind the spoon and fill in behind it, because the liquid would move from the area where the pressure was applied to an area of low pressure. As I push the spoon, there is higher pressure on the side of the spoon moving ahead, and the water runs around from the area of high pressure to the one of low pressure.

In the Hobbs Pool, oil and gas have accumulated in the porous zone, the white lime, on top and the pressure from the water below would, before the first well was drilled, keep the pressure uniform throughout the pool, the top the same as the rest of the pool. If it had not been the same, the liquid would have moved from the area of high pressure to one of low, and down to a balance. When I say pressure at the top of the pool, I am now, and throughout the discussion, assuming the pressure was the same in the same level.

So, referring to Gulf Exhibit No. 4, the cross section of the structure, all the pressures in the Hobbs Pool have been measured at a level of 400 feet below sea level. If they were not measured, then they were corrected to determine what it would have been if the pressure had been taken at that level. If we ass me the pressure was 1500 pounds at the level of 400 feet below sea level, that means a drop of oil standing at that level would be under a pressure of 1500 pounds per square inch, upward, downward and sideways. The pressure would be the same in all directions. A hollow container of any sort would be under crushing pressure and 1500 pounds per square inch would tend to collapse it. If we had a hollow box that had a capacity -- a cubic capacity of one inch, an inch on every side, and would put 1500 pounds of pressure on top of the box pushing down, 1500 pounds of pressure on the bottom pushing up, and on all sides, it would be an identical proposition. It follows if that bos were lowered from the -400 foot to the -500 foot level, the pressure would increase; it would be not only under the 1500 pounds at 400 feet, it would also be under the pressure of the liquid between 400 and 500 feet. For that reason, because pressures, even during absolutely static conditions in the pool -- because the pressure varies with the change in elevation, there has to be some horizon at which all pressures are measured. Otherwise, you might compare a pressure in this well at -500 feet and a pressure in this well at -400 feet, and you would see a higher pressure in the deeper well. The pressures would have to be measured at the same level. And that may be corrected if there is some obstacle in the hole, so that the pressure is taken at 300 feet, and to that pressure would be added as well an estimate from the pressure at 300 feet down to 400 feet, in order to determine the actual pressure at the 400 foot level.

That is what is meant by bottom hole pressure. It is a force exerted on the rock and on all liquid contained in the rock. The same force that acts on the liquid acts on the material containing the liquid, and tends to move the liquid from an area of high pressure to one of low. That is pressure measured by engineers as required by the report -- static pressure.

Static is the only measure of pressure existing in the formation. Static means standing still, and means when everything in the well is standing still you measure the pressure. At the instant when a well is shut in, the pressure in the well 400 feet below sea level will not be the same as the pressure in the formation 500 feet away. The well has been flowing and the pressure has been reduced in the well, because the liquid has been moving out of the well -- because there is a decrease in pressure inside the well as compared to the pressure existing in the rock outside. So at the instant the well is closed, the pressure in the well is less than the pressure in the surrounding rock. Closed in, the pressure at 400 feet rises, Liquid continues to move from the areas of high pressure, either side, above and below, the liquid continues to move to the point of low pressure. The movement then tends to equalize the pressure and when the pressure is equal, the movement stops. With a record -- I am getting a bit ahead.

The pressure in a well is measured with a gauge. A gauge is simply a device which determines the amount of pressure. Steam gauges attached to boilers are well known. The first bottom hole pressure gauge I know of was made by W. V. V. Eddy, of the Texas Company, and he used only the essential element out of a steam pressure gauge. He simply lowered into the well the inside workings of a steam pressure gauge to find out what was the pressure in the bottom of the hole. In principle, all bottom hole pressure gauges are the same as a steam pressure gauge. They differ in the method of measuring the pressure, but the principle is the same, to find out what is the pressure -- the force in the formation, the pressure in the formation. So the bottom hole pressure gauge is lowered into the well, and it indicates the pressure at the point where the gauge stops. The first pressure gauges manufactured showed only the maximum -- were what are called maximum indicating gauges. They had some type of device that showed the highest pressure to which the gauge was subjected. That was not entirely satisfactory. One thing we wanted to know was how the pressure was changing. Accordingly, a number of the oil companies developed gauges on which there was a chart of some sortk which had a record made on it by clock-works, the clock-works turning the chart to the point where it stood still, or the chart stood still while the automatic marker turned around, and the pressure could be read when the gauge was withdrawn from the well. The pressure the gauge exerted could be determined from the chart every minute the gauge had been in the hole. So looking at one of these records, which makes a record, not only of the pressure, the bottom hole pressure in the well which has just been shut in, the pressure immediately after shutting in, and leaving it in for a period of seventy-two hours, which is the common limit of many of the gauges, we will see that the pressure rises rapidly at first, then more slowly, making a characteristic curve which is known to all petroleum engineers working with bottom hole gauges -- the pressure rises rapidly at first which indicates there is considerable bottom hole pressure; then more slowly as the pressure begins to equalize, and finally reaches the maximum point, above which pressure does not rise because the pressure in the well and the surrounding ground has been brought to the same level. An engineer looking at the curve, can tell whether the gauge stayed in the well long enough to get the maximum pressure.

It is possible, by mathematics, to calculate how much more pressure would have been added if the gauge had been left in the hole for a longer time. In the Hobbs field there is high permeability so that practically in every case the gauge will come up to maximum pressure within a 24-hour period. There are a few places where the permeability is so slight it takes more time.

Under Mr. Staley's direction there have been more wells measured to determine what pressure will result over a period of time. The Engineering Committee, working with Mr. Staley, has rapidly checked that data. To the best of my knowledge, no engineer has objected that 36 hours is too short a time to take static pressure in a well.

I have said "static pressure" several times. I believe there has been some testimony as to the flowing pressure. The flowing pressure shown by gauge and record as set in the well while the well is producing. There is no proration plan in effect in any pool where the flowing pressure determines the amount of oil that may be produced from a well. The reason is, the flowing pressure means nothing except the resistance of the well to the movement of fluid outside.

When a well is flowing, the pressure inside the well depends upon the weight of the column of oil and gas, and perhaps water also, above the gauge, plus the friction of the tube through which the liquid is moving, plus resistance of the surface equipment, which commonly includes a choke and valve to restrict the flow, and the pressure in the tank into which the oil is flowing. The flowing pressure is entirely within the control of the operator, within limitations. You cannot reduce the flowing pressure to zero -- there will always be some pressure in the well -- you can take off the valve -- if it is flowing through a choke, it can be increased or restricted -- by maintaining a high pressure on the (   ) he can increase the flowing pressure in the bottom of the hole. By using different sizes of tubing he could increase or decrease the flowing pressure. The flowing pressure of a well varies from time to time, and may vary sharply within five minutes time as a result of a change in some condition. Flowing pressure means nothing except resistance of the well to the fluid out of the well. You cannot use pressure under control of the operator, that can be so easily changed, as a measure of the pressure existing in the formation, but by shutting in the well and letting the pressure equalize between the rock and the well, you can determine the pressure surrounding it. And if you maintain the pressure equally on adjoining leases, there will be no movement, and if the pressure is uniform, every lease will produce the oil underneath that tract, no more, no less, up to the limit of the recovery of the oil on the leases.

Does that cover the question on bottom hole pressure?

Q I think so. Have you a list of some fields in which the bottom hole pressure was considered by the various state boards allocating oil?

A I have a list which, I have no idea, is complete, because I know of no place I can look for a report of the proration methods at various pools. The various states of the nation simply write general information and announce it to the petroleum industry.

I know that in New Mexico, bottom hole pressure has been used in proration at Hobbs and Monument. That is why we are here today. In Texas it has been used in the Goldsmith Pool. It was first used in Texas in the Harts Pool; it was used at Rodessa Pool, over on the east side, and used in the Van Pool. I have no doubt there are many other places in Texas where bottom hole pressure is used in proration.

In Arkansas bottom hole pressure is used in five pools, Atlanta, Buckner, Magnolia, Schuler and Village.

In Oklahoma they use bottom hole pressure in prorating the South Burbank Pool, Moore Pool.

In Louisiana it is used in Cotton Valley, Lisbon and Sligo.

In the most important pool in California, Kettleman Hills, the basis of their formula is bottom hole pressure.

Bottom hole pressure is used to determine the potential in most of the wells in Kansas, under the requirements of the Corporation Commission for determining the potentials of wells in Kansas on which proration is based. We determine static bottom hole pressure, with rate of production of oil from the well. As far as I know, no operator has ever objected that static bottom hole pressure in a well in Kansas did not accurately measure the pressure in the surrounding field.

I have no doubt there are other fields, but those are the only ones with which I am familiar.

Q Are many of the major companies operating in the fields where pressure is used as indicated by you?

A Oh, yes, in Harts Pool we have the Standard of California -- of Texas, as it is now called, the Gulf Production Company, and a considerable number of other operators.

In the Van Pool, the Gulf, Humble and Pure. In East Texas I suppose every operator in the mid-continent area is interested, including every operator represented here this morning, as far as I recognize them -- I am not sure of Mr. Cusack, whether he has a well over in East Texas, but I think all of the rest have. Certainly East Texas has all the major operators in the mid-continent area, in addition to a vast number of small independents.

Q What information do you have that the bottom hole pressure taken by the umpire in the Hobbs Pool represents the formation pressure?

A By the fact that when the well is shut in it builds up -- the pressure curve rises rapidly, then more slowly, and finally reaches maximum, which indicates the bottom hole pressure in the well is the pressure in the formation. If the pressure in the well is less than the pressure in the formation, the pressure would gradually continue to rise in the well until the pressures were equalized.

Q Does the completion of new wells to offset old producers have any bearing on the formation pressure?

A Yes. One can determine pressure in a newly completed well midway between two old producers. If the pressure in the formation is greatly different from the pressure -- the static pressure in the wells which have been producing for some time, in a new well midway between two old wells you would find a much higher closed-in pressure than we find in the old wells. A good illustration of formation pressure and static pressure, as compared to pressure in adjoining wells is Continental No. 3 Grimes, which was completed June, 1935, in the NW$\frac{1}{4}$ SE$\frac{1}{4}$ of Sec. 28, Twp. 18 S., R. 38 E. Prior to its completion the north offset, Samedan No. 1 Grimes and the south offset, Continental No. 1 Grimes had both been completed. The pressure at that time in the Samedan well to the north was 1268 pounds. The pressure in Continental No. 1 Grimes, to the south, was 1293 pounds. There was a difference in pressure then between the two wells of 25 pounds. There was a pressure differential tending to move oil northward to the Samedan No. 1, a pressure of 25 pounds over half a miles of distance; that is, estimated from the static pressure in the wells. If the static pressure actually represented the formation pressure around there, when Continental No. 3 Grimes was drilled, midway between the other two wells, they should have found a pressure just midway between the pressure of the wells to the north and south. On the other hand, if static pressure does not represent formation pressure, then Continental No. 3 Grimes should have had a very high pressure, because drilling on the boundary between the two wells provided an exit. The average pressure of the wells to the north and south would have been

1281.5. That is the pressure to be predicted in Continental No. 3 Grimes. The actual pressure, measured by the combined pressure of the other two wells. In August, 1935, after the Continental Grimes No. 3 came in, it was 1285 pounds, a difference of 3.5 pounds from the pressure that would be predicted, a pressure difference that is within the accuracy of the gauge, and I think all engineers agree perfectly to the fact that the static pressure of the wells north and south were accurate pressures in the formation. Continental No. 3 Grimes, at the time the pressure was taken, had produced less than one-half per day of its potential, so that the production from the well, prior to the taking of its pressure, could not have seriously affected the pressure in that well.

I think that is as good an example as I could find of the relationship of pressure between the boundary drainage areas of wells and static pressure measured in the wells themselves.

Q Do you know of any fields where it is known the length of time it requires to build up the pressure after a well has been flowing?

A It is very difficult to state a time for a field, because if permeability is high, the build-up time may be very short. For example, in some wells where you have high permeability, we cannot find a difference between the flowing pressure and static, the drop in pressure is too slight to make any difference, if it is less than two pounds. In other wells in this pool, we have found it took as much as 36 hours to build up the pressure if it was during static conditions, and so, in any pool you might ask for, there will be some wells where the build-up is rapid, and others where the build-up is slow, but the rate of build-up depends on the permeability of the surrounding rock.

Q Return to Exhibit No. 7, I think is the next one. You may explain that map, what it is intended to represent.

A The last exhibit, No. 6, showed the first bottom hole survey that had been made in the Hobbs Pool. This exhibit shows the bottom hole pressure made under the umpire's direction in October, 1936 -- I beg your pardon -- October, 1933. The reason for selecting that date is that is the last survey made before the proration plan at Hobbs was changed. Up until October, 1933, proration was on the basis of 25% allowable, allocated as a flat allowable for every unit in the pool. The remaining 75% was allocated on the basis of potentials of the wells --

BY MR. SETH: What date is that?

A October, 1933.

BY GOVERNOR MILES: What determines a unit?

A A unit is forty acres. If more than one well is drilled on a forty acre unit, the potential of the wells is averaged.

On this map there are two high pressure areas indicated. One is along the township line between Sections 31 and 32, in T. 18 S., R. 38 E., and the other between Sections 19 and 30, in T. 18 S., R. 38 E. -- the only two low pressure areas indicated, one of small extent in the northeast part of Sec. 36, and the three offset wells, and the other of considerable extent in the southeastern portion of the pool.

On this map -- on this survey, the highest pressure is 1383 pounds, in the Gulf No. 6 West Grimes in the SE¼ SW¼ of Sec. 32, and the lowest pressure is 1245 pounds in the Repollo No. 2 in the NW¼ NE¼ of Sec. 15. There is a difference in pressure of 138 pounds between those wells -- I regret I must change my testimony -- I had overlooked a high pressure well in the extreme -- I said two areas -- there is a third high pressure area in the southwest end of the field as developed at that time -- three high pressure areas. The highest pressure well on this map is the Amarada No. 3 Hardin in the NW¼ SW¼ of Sec. 18, T. 18 S., R. 38 E. The pressure in this well is 1395 in the northwest end of the field, and 1245 pounds in the southeast makes the pressure difference across the field 150 pounds.

The field, up to this time, had been operated on a basis of 25-75. I think this is so easy to understand there is no need to discuss that phase. It had so operated since proration went into effect in July, 1930, a little over three years under the 25-75 plan. From the first survey to the survey of October, 1933 there was a decrease in pressure differentials. There was a pressure differential of 200 pounds; now it is 150 pounds. Operation under the 25-75 plan acted beneficially on bottom hole pressure adjustments; the pool had approached uniform bottom hole conditions. There was less tendency at the time of the October, 1933 survey for oil to migrate from one lease to another than on any previous survey made by the umpire. The 25-75 plan apparently did do equity between the leases. It was tending to iron out inequities, to slow down the rate of pressure decline at the low points. Where there were five high pressure areas in October, 1931, as shown on that map, there are only three now. Where there were three low pressure areas in the 1931 map -- and the pressure differences had been reduced by one-quarter under the operation of the 25-75 plan.

BY JUDGE LOWE: We desire to introduce that exhibit in evidence. Start the next exhibit.

A I might at this time, if I may volunteer, call attention to the high pressure area shown -- this area at the bottom part of Sections 31 and 32 lies immediately north of Stanolind McKinley wells, from which, the testimony yesterday indicated, a considerable amount of oil had moved northward. With high pressure surrounding the well on the township line, to me, as an engineer, it is incomprehensible that oil can move from this low pressure area to this low pressure area (indicating on map). The high pressure area is an effective barrier against the migration of oil in that particular case.

The survey of 1931 shows a high pressure area around Gulf No. 5 Grimes. The position is reversed here in Gulf No. 6 Grimes and the south offset; shows a pressure differential of 17 pounds, in one case and 18 pounds in the other, in the opposite direction, so you will see, if you can say the pressure is in balance, the oil does not move under balanced conditions, one must have a difference in pressure to move it. We had a balanced pressure in 1931, and three and a half years later we find an increase in the pressure immediately north of the township line, as compared to wells to the south. Such movement as occurred had to go from the wells in the north to the south. That change, difference in pressure, is a suitable subject for bottom hole pressure correction.

Following the survey of October, 1933, there was introduced into the Hobbs plan for the first time a bottom hole pressure correction plan, which was a desirable addition to the plan. The correction allowed the continuation of the 25-75 plan, but at that time a feature was introduced that was unfortunate -- There was an allowance for water wells based on 40% for acreage and a 60% allowance for potential, as determined by the water coming in. That allowance was apparently excessive, because (turning to next exhibit), as shown by Exhibit No. 8, a bottom hole pressure survey made under the direction of the umpire, the survey of August, 1936, we find the bottom hole pressures nowhere near as uniform as they had been three years earlier. At this time the highest pressure is still in the northwestern part, Shell No. 2 State, in the NE¼ of the NW¼ of Sec. 24, T. 18 S., R. 37 E. The lowest pressure well was Repollo No. 1 with a pressure of 1000 pounds; the Shell well has a pressure of 1320 pounds, a pressure differential of 320 pounds, where it had been only 150 pounds three years earlier. Probably the 1000 pounds pressure, indicated in the Repollo well, is not the lowest pressure, because there are three wells south of it in which the pressures were not taken. Those wells have had lower pressures than the Repollo well, so the pressure differentials were probably greater --

BY MR. WOODWARD (Interrupting): What is the date of that map?

A August, 1936.

BY JUDGE LOWE:

Q Now, referring to Exhibit No. 8, it is colored. Explain that.

A This map has been colored as the other map was colored, using yellow for the most common pressure zone. The yellow represents pressures between 1300 and 1250 pounds -- 1250 to 1200 pounds; the blue, 1150 to 1200 pounds; the bluer from 1100 to 1150 pounds, and so on down until you get down to the pink, which represents pressures below 1000 pounds.

After this survey the Commission changed the proration plan at Hobbs to allow 60% on production of the pool to be distributed on the basis of acreage -- 60% of the pool's allowable distributed on units, acreage, amounts to only 40% of the allowable on the basis of potential. The bottom hole pressure adjustment factor to be applied to only 40%. Accordingly, a well might have a very low bottom hole pressure, and might be producing much more oil than the reserves justified. Bottom hole pressure might reduce the potential to zero, and the well might still produce more oil on the acreage allowance, so that the amount of oil produced on an acreage allowance might be more than the reserves justified. A test of a well producing more than the reserves justified was well stated by Mr. Wood in his report, that if pressures decline more rapidly than pool average, the well will produce too much, and in the amended committee report, made in 1936, it was their judgment the minimum allowable should be subject to bottom hole pressure adjustments, because it is unfair to everyone to draw across lease boundaries from other properties.

So I do not intend to criticize the Commission for its order of January 1, 1937, but the next map, Gulf Exhibit No. 9, shows the effect of the order of January 1, 1937, as well as the effect of the previous orders. The Commission had representations made to it that the 60-40 plan would be more reasonable, more equitable than the existing plan, and as there was no testimony to the contrary, the Commission accepted those representations, so that what I have to say is not a reflection upon the Commission, but the effect of that order, changing the acreage allowable from 25 to 60 -- perhaps I should say, or call it the unit allowable from 25 to 60, and reducing the effect of potential and bottom hole pressure from 70% to only 40% of the pool's allowable, is shown by the existance of a bottom hole pressure drop in the southeastern part of the field, and a somewhat less, but nevertheless a low pressure area developed on the northeast side of the field. And we have on this map the highest pressure of 1245 pounds in the Samedan Nos. 2 and 3 State, in Sec. 24, and the same pressure in the Continental No. 2 State in Sec. 13, 1245 pounds pressure, and the lowest pressure, 871 pounds in the Texas No. 1 Selman, in the most southeastern end of the pool. We have now a pressure differential of 374 pounds --

BY MR. WOODWARD: (Interrupting) Onwhat date?

A In September, 1939.

We have now a pressure differential of 374 pounds, and that pressure differential is a quarter larger than it was before the order of January, 1937 --

BY GOVERNOR MILES: I don't understand --

A The pressure differential is now 374 pounds across the field.

BY GOVERNOR MILES: Did that pressure differential decrease on an even percentage basis?

A It decreased more rapidly in the south than in the north. It has remained very nearly constant in the north. The result of the sharp pressure differential is a drop of 319 pounds in the space of three and a half miles in the southeastern part of the field, and the effect of the pressure differentials in moving oil, which varies with the distance, is that a 300 pound differential over two miles would cause the oil to move much faster than over six miles.

BY JUDGE LOWE:

Q I notice on the map, Exhibit -- the one you had before, there are a great many more colors on this map than on the others. What does that indicate?

A It means there is a much greater pressure differential. The pressure is declining, extending up into the first area, and becoming more accentuated -- there was a pressure differential of only about 125 pounds before 1933. With the change in the proration from the 25-75 principles to the principles we now have, the differential is 319 pounds across the same area.

Q Does that indicate excessive withdrawals in the southeastern part of the pool?

A Yes, sir, the withdrawals have been greater than the reserves justified for the southeastern part, as compared to withdrawals in the rest of the pool.

Q What is the effect of that on the migration of oil?

A The effect of that is that it causes the oil to move from the yellow area in the northwest to the southeastern part of the pool, in Sec. 4, T. 19 S., R. 38 E., the oil is moving from the yellow area into the area of low pressure.

Q That is the area that will always drain when there is increased acreage in the allocation?

A If there were an increase of the acreage in the allocation at this time, and the pressure differentials would be sharply increased under the conditions here, there would still be a greater tendency for drainage from the northwest into the southeastern area.

BY JUDGE LOWE: We desire to introduce the exhibit in evidence.

Q You may explain Exhibit No. 10.

A Gulf Exhibit No. 10 is a repetition of the cross section which was shown on Exhibit No. 4. The cross section is repeated exactly, but this time, instead of repeating the map underneath the cross section, we have introduced a chart showing the bottom hole pressure surveys on those four maps -- the bottom hole pressure maps we have just been discussing. The highest line on the chart shows the bottom hole pressure in the holes shown up above on the cross section. The highest line shows the December, 1931 survey, the first survey made. The line has certain irregularities, but in general it follows across at an average pressure of 1432 pounds. There are irregularities which, theoretically shoul have been flattened out, and I think could have been flattened out, but, in general, it indicates a satisfactory development, a satisfactory production from the pool, and because the pressure differentials are small, there is little drainage from one lease to another. Unfortunately pressures were not taken in the southeastern wells for the 1931 survey. I wish we had projected this line to show the estimated value, but we discussed the matter and decided to show actual measured values as shown by the umpire, and not inject any personal element. If that line had been shown, it would have shown low pressure, and this pressure line would drop down in some such fashion as indicated by this pencil -- pressures do drop down.

The second line presents the survey of October, 1933. It is more uniform than the 1931 survey, indicating that the 25-75 plan kept the pressures more uniform -- at any rate, there appears less variation than there was in the 1931 survey. And while there is a low pressure area in the southeastern part of the field, it is not so marked as in the 1931 survey. Conditions were getting better while operating under the 25-75 plan.

The third line shows the pressure in those wells as they were in September, 1936, after the large allowables had been given to water wells in the southeastern part of the pool, as well as water wells in the rest of the pool. The allowable was made to all wells producing water. It is, I think, apparent that the water allowables were excessive, because we find a sharp drop in pressure in the southeastern part, as compared to the slope of the line as it was in 1933.

The last line shows the survey of September, 1939. Through much of the pool there is a fairly uniform pressure, average bottom hole pressure now of about 1184 pounds. A correction, if I may -- this chart was prepared for the hearing in May, and it shows the February, 1939, rather than the September, 1939 survey. If the chart had been re-drawn to show the September, 1939 survey, which is the survey we showed on the map, it would have shown the same condition, except a greater drop which has resulted between February and September. Accordingly, the high rate of withdrawals in the southeastern area, compared to the reserves, has resulted in a steadily steepened pressure curve toward the southeast, and oil and gas flow down that course exactly as water comes down a gully. This difference in pressure, in two miles across the pool, has resulted in a steady migration of oil and gas into the southeastern area. If the straight acreage plan were adopted, that curve there would be still greater, with a greater loss of oil from the northeastern part of the pool. In general the slope across the pool is southeasterly, the general slope is in that direction, then breaks off quite sharply into the area of very excessive production.

BY JUDGE LOWE: We introduce that exhibit in evidence.

Q Exhibit No. 11 -- explain Exhibit No. 11.

A This is a map which shows the units which gained 20 barrels or more per day under the order of January 1, 1937, and the units which lost more than 20 barrels per day under that order. That order, dated sometime in December -- I refer to the order of January 1, 1937, that executive order. Under that order, which changed the 25-75 plan to 60% for acreage and 40% for potential, with bottom hole pressure adjustments, the red units are those which gained more than 20 barrels a day. The increase is largely concentrated in the southeastern part, with a few scattered units around the margins. The green units are those that suffered losses of 20 barrels or more a day, scattered through the central and northwestern parts of the field. Of course, there were changes on practically every unit in the field. We thought it would be interesting to see where the gains were concentrated under the 60-40 plan of January 1, 1937, and we found it gave a sharp increase in allowable where the bottom hole pressure was already low and drainage already existed.

Supplementing that exhibit, we have prepared Exhibit 11A, which is simply a repeating of parts of the previous exhibit. At the left we have a bottom hole pressure map, still of the southeastern part of the field as it was in October, 1933, showing a pressure differential not greater probably, not more excessive perhaps -- not more than would be expected in the operation of any pool.

Here in the center we have showed the location of the units which received large increases in production under the order of January 1, 1937.

Over at the right we show a bottom hole pressure map in September, 1939. This is not the February map I showed, but is, as you can see, a few sections of the map - the bottom hole pressure map of the same area. The increases of allowables in the southeastern part of the field have changed the pressure differencial across the southeastern area from 150 pounds in 1933 to 329 pounds in 1939, the present time. The order of

January 1, 1937 was not entirely, but largely, responsible for the large drop in pressure in the southeastern area. If we were to go to straight acreage, as has been recommended, there would be a large increase in this area. That is in the very units where potentials have been wiped out.

It is true, the wells in here can make several hundred barrels of oil per day, and I do not -- I am sure the Commission does not understand that because the umpire's books show no potential, no one would contend the wells have gone dry. It simply means the potentials have been absorbed by bottom hole pressure, or due to some other cause. But on only 40% of the pool's allowable, even though all that potential allowable is wiped out, there is too much oil being given for acreage, and the pressure differentials have increased and the wells are producing, in large part, producing oil not under the land originally, but under this 300 pound differential, they are draining part of the leases to the northwest.

BY JUDGE LOWE: We introduce the exhibit in evidence.

Q The next exhibit, please explain the next, Exhibit No. 12.

A So far we have been talking about bottom hole pressure, and have been theorizing from those as to the movement of oil. I have been drawing conclusions -- I believe that is competent -- that oil moves from an area of high pressure to an area of low pressure, and there must be some movement of oil into the low pressure area. The question is raised whether that could be quantatively determined.

That has been calculated on this exhibit. Three wells, extending in a northeast-southwest line, their location being in the SE¼ SW¼ of Sec. 3, the NW¼ NW¼ of Sec. 10, and the SE¼ NE¼ of Sec. 9, on which wells we have potential tests, low pressure tests, and from which --

BY MR. WOODWARD: Will you repeat the location of those wells?

A The SE¼ SW¼ of Sec. 3, Stanolind No. 26 Capps; the NW¼ NW¼ of Sec. 10, Stanolind No. 8 State; and the SE¼ NE¼ of Sec. 9, Stanolind No. 26 State. On those wells we had long time records of production, and productivity could be determined from the chart given in the Hobbs Engineering Committee's January report. We had pressures declining rapidly on the three north offset wells and the three south offset wells. To determine the rate of flow through porous formation, one has to use the formula introduced yesterday afternoon by Mr. -- Tisch -- Tasch, showing the drainage of oil, the amount of oil which will move through porous formation, known permeability, thickness and differences in pressures. The pressure differences are known every six months across that line. From those pressure differences the amount of oil moving from the northwest to the southeast, across the line, can be calculated. The volume of oil that has crossed the red line to the three 40-acre units, by that calculation, is 551,000 barrels of oil. That formula calculation does not include another production unit to the northeast, because we did not have the pressure measurements; it does not include two units to the southwest, because, again we did not have the pressure measurements, so to the north and south it would not be accurate mathematically to extend it.

It is not correct to say, because we have taken only half the line across which migration has occurred -- it is not correct to say that because the line across which there has been drainage is twice as long as the one studied, that the movement is twice as great, but certainly the movement must be greater than that calculated, because we have two units to the southwest and one to the northwest, but the exact migratory values are not known --

BY MR. WOODWARD: (INTERRUPTING) Did you mention the percentage of recovery there?

A I have not, but I will.

So across the red line the migration, based on information as good as we could get, has been 551,000 barrels and a somewhat greater amount because of the three units, in an equal length of line, which were not taken into the calculation.

During the time this portion of the pool has been under development, up to September, 1939, the production west of the red line has been 3,483,000 barrels; the migration of 551,000 barrels across that line constitutes 15.8% of the total amount of oil produced in that area.

The pressure differentials, which increase with the passage of time, with changes in the proration orders, migration across the red line, including the known extentions to the northeast and southwest, calculated under that formula, is 362 barrels every day.

BY GOVERNOR MILES: What is that township and range?

A T. 19 S., R. 38 E., the southeastern portion of the Hobbs Pool.

BY JUDGE LOWE:

Q That is the area that would be allowed more oil if we get the straight acreage basis?

A Yes, sir.

Q And the drainage would be greatly increased?

A The drainage would be greatly increased. That is the area in which potentials have been wiped out by the bottom hole pressure factor.

BY MR. BOHART:

Q Dr. Knappen, if we were not concerned with drainage as a matter of equity or obligation, which we are, we would be compelled to be concerned with it by law, would we not?

BY MR. WOODWARD: We object to that -- he didn't qualify as a lawyer -- nearly everything else, but not a lawyer.

Q If it is generally agreed that the factor influencing the movement of oil is pressure, then, as I understand it, from the testimony that has been offered, there has been some objection -- or at least, some distrust expressed of the instrument with which bottom hole pressure is measured -- the pressure itself was not, as I understand, challenged, but it was the accuracy with which pressure could be measured with an instrument, and also whether or not bottom hole pressures taken by the umpire represent formation pressure. Is there any reason that you know of, from your experience and knowledge of instruments, why instruments of this kind could not be built that would measure the pressure at the bottom of a well, as well as at the top?

A No, it is purely a matter of care in the design as you make the instrument.

Q Are we dependent on only one instrument, or are there more than one on the market?

A No, there are at least four. The Humble makes an excellent bottom hole pressure gauge; the Indian Territory Oil Company makes a bottom hole pressure gauge that is widely used at Hobbs because it is smaller in diameter and will go into the small tubes; the Geophysical Research makes an excellent one, and Amarada builds an excellent one,and modesty prevents me from saying how good is the Gulf gauge.

Q There are a number of gauges manufactured by different concerns?

A There are at least those mentioned, and there may be others.

Q Are all field instruments extremely accurate?

A No.

Q Is it necessary for all field instruments to be extremely accurate?

A No. Frequently you sacrifice extreme accuracy in order to secure greater ruggedness, the same as a watch. Sometimes it is desirable to have an instrument that will stand all sorts of abuse.

Q If the accuracy is in proportion to the work to be done with the instrument, is that sufficient?

A That is sufficient, if one remembers there is that degree of inaacuracy. The pressure gauges used in locomotives need not be nearly so accurate as bottom hole pressure gauges -- an error of ten pounds in a steam boiler gauge is not important.

Q Bottom hole pressure gauges are more accurate than some field instruments?

A Very much more accurate.

Q Hobbs is not the only place, I would understand, that bottom hole pressure gauges have been relied upon?

A Yes, there are listed some fourteen or fifteen places where they are used to correct the allowable, in various states. And of course, in addition to that, bottom hole pressure gauges are used by the engineers of the various companies to control their own operations, used to obtain information they need.

Q Is there any difference in the design and manufacture of gauges made for one set of conditions?

A Not in the essential principles. There is a difference in the gauges used under 100-pound pressure, as compared to 200-pound pressure, and again for 400-pound pressure the gauge is different.

Q Does that mean the manufacturer has attempted to build for the specific purpose for which it is to be used?

A That is it. He modifies the instrument to get the most satisfactory results for the pressure under which it is to be used.

Q Have you any information in regard to the gas-oil ratios?

A Yes, sir, I have.

Q You may state what it is.

A A table has been prepared from the reports of the proration office in Hobbs showing the gas-oil ratios in the southeastern portion of this pool, approximately the area colored in red on this map (indicating), covering thirty wells southeast of a general line following the red line shown in Gulf Exhibit No. 12. In December, 1936, according to the records of the umpire, the gas-oil ratio was 1520 cubic feet per barrel of oil. By July, 1939, the gas-oil ratio had increased to 2742 cubic feet, an increase of 1222 cubic feet of gas for every barrel of oil produced in that area.

To see whether that was a reasonable increase, we took the records of all the rest of the pool, clear up including the northwest end, making no deductions for the water lifted by the gas in many places, and the gas-oil ratio in the central and northwestern part of the pool -- all the rest, except the thirty wells already mentioned. In December, 1936, the gas-oil ratio was 1629 cubic feet per barrel. In July, 1939, the gas-oil ratio in that same area, on the rest of the pool, was 1872 cubic feet. In the southeastern end of the field the increase in the gas-oil ratio was 1222 cubic feet; in the rest of the field the increase in the gas-oil ratio was only 243 cubic feet. The increase in the southeast end is five times the increase in the rest of the pool, over the identical period, from December, 1936, the month before the start of operations under the 60-40 plan, up to July, 1939 -- in that period the gas-oil ratio in the southeastern part of the field was 5 to 1 as compared to all the rest of the field.

BY JUDGE LOWE: The information given was obtained from the umpire's office?

A Yes, sir.

BY GOVERNOR MILES: We will be in recess for five minutes.

Pursuant to recess, hearing was resumed, with Dr. Knappen on the witness stand:

BY MR. SANDERSON:

Q Dr. Knappen, will you refer, please, to the Exhibit No. E -- Stanolind Exhibit E, showing the increase in so-called potential for the Gulf Graham No. 1. Will you explain what caused the increase in the first part of the curve?

A Gulf Graham No. 1 -- or Gulf State No. 1, in Sec. 24, according to the exhibit -- and I have no reason to think the figures inaccurate, although I do not want to testify to their accuracy until I have had an opportunity to check them, was completed with an initial production of 3,000 barrels -- my recollection is it should be about 3,500 barrels -- that is immaterial. The potential increased, to February, 1934, to 7,000 barrels. That may have been bottom hole pressure adjustments, or it may have been the first acidation of the well. The potential increased again in September or October of 1934 from 7,000 barrels to 23,000 barrels as a result of acidation. A new potential test was made after the well was acidized and the new test showed a capacity to produce 23,000 barrels of oil daily. After that time there was a series of adjustments up and down, mostly up, which, I assume, were all made as the result of bottom hole pressure correction factor. I am confident that is the reason for the adjustments up and down from 23,000 barrels to about 32,800. That is a high pressure well in danger of being drained by low pressure units in the rest of the pool, and the bottom hole correction factor required the upward adjustment of the potential in an effort to have the allowable overtake the increase in pressure in that well to the relative pressure in the pool as a whole.

Perhaps I should say, in this connection, the pressure in that well has declined from the original shown at 1375 pounds, to the present pressure of about 1225 pounds, but the pressure in that well is higher than the average pressure in the pool, and according to my recollection, has been higher on each pressure test; and so long as it is higher, there must be drainage from that well. The potential has been adjusted by the bottom hole pressure factor to give the present potential. No one would contend this is a 32,000 barrel production well. You might just as well have left the potential at the last figure, and added a certain percentage to allowable because of the high pressure. That might have eliminated some confusion if it had been handled in that way. The umpire's report shows the adjusted potential. I am certain no one thinks that is the actual potential. I think all recognize it is the potential with adjustments made to that number so that the allowable will be increased because the pressure in this well is higher than the average, and consequently in danger of being drained.

Q That large decline in bottom hole pressure, that does not indicate a relative decline -- or rather, other wells in the pool were also declining at the same time that decline occurred?

A That is true. The pressure decline was about 150 pounds, where the decline in the pool, or correction, was 200 to 250 pounds.

Q It did not decline as much as the average of the pool?

A It did not decline as much as the average of the pool.

Q That large increase in potential was brought about by acidation?

A Correct.

Q And every other operator in the pool had the same opportunity to acidize their wells?

A That is true.

Q And had the opportunity to drill more wells?

A No legal restriction.

Q Whatever was done there, it was not done out of disregard for any other well -- they had the same opportunity?

A On the contrary, we were forced to acidize a lot of wells to keep up with the other operators who were also acidizing their wells; if not, we would have suffered very serious losses in potential and closed-in pressure.

Q Gulf did not start it?

A It did not.

Q This quite large increase in potential due to bottom hole adjustments, do you know how many barrels of oil per day that adjustment has increased the allowable of wells at this time? In other words, how much more oil is Gulf getting today than it would have gotten had there not been any bottom hole pressure adjustments?

A I am not certain whether the adjustment from 23,000 to 25,000 is due to the second acidation or bottom hole pressure adjustments -- if 25,000 -- the last three potential tests, it has been increased approximately 8,000 barrels in that well; the adjustment result from the last proration allowable is about 2.2 barrels per thousand for that well, increasing it about 17 barrels.

Q At the present time?

A At the present time.

Q Do you know whether some of the Gulf's wells were reduced in allowable by that adjustment?

A I cannot testify as to that; I have not checked it up.

BY JUDGE LOWE:

Q Part of the article introduced yesterday purports to have been written by Mr. Barnes, an employee of the Gulf Oil Corporation. Was Mr. Barnes an employee of that company at the time the article was written?

A He was not at that time, no, sir.

Q What is he commenting upon in the part introduced?

A He was commenting upon an article in the Oil and Gas Bulletin written by M. A. Rounds.

Q Do you have that quotation?

A Page 78, Pennsylvania State College Bulletin, No. 12: "A map purporting to show profiles of consistency of porosity was prepared by Mr. Rounds for the Hobbs Pool in New Mexico. The limes were established by connecting wells of approximate equal initial production. It would seem that such lines are lines of consistent permeability, rather than consistent porosity, and serves to illustrate the unfortunate confusion which prevails concerning the two properties". Then he gives the quotation from Vol. 29, Oil and Gas Journal, page 70 and 110 of December 18, 1930.

Q Dr. Knappen, there has been considerable evidence introduced in regard to the installation of packers, and the number of packers installed by Stanolind, but no information as to packers installed by other companies. Is Stanolind the only company that has installed packers?

A No, sir, packers have been installed by most, if not all, of the major operators.

Q Do you know how many Gulf has installed?

A We have set twelve packers. We have twenty-two wells, and have set packers in about 50% of our wells.

Q You testified at some length. As a result of your investigations and the evidence you have given, have you any definite plan to propose for the future?

A It would be my recommendation to go right back to the 25% acreage; that is to say, 25% of the pool's allowable to be distributed equally between the units, which would give each unit enough to pay operating expenses; and distribute 75% on potential with adjustment for bottom hole pressure, to be made every six months, in an earnest effort to equalize pressure throughout the pool and to prevent drainage of the oil from one lease to another.

Q You do believe some adjustment of packer wells should be made?

A I believe some adjustment should be made as outlined by Mr. Gray last night. It was the intention of the operators that the operator who set a packer would not be penalized, as setting a packer to shut off gas was making a very real contribution to the pool. The pool would then give them the right to produce the well's former allowable from a pay which represented only part of the original formation. The arithmetical adjustments has been worked out that a man who sets a packer is penalized. The packer wells were not intended to be penalized. I think the plan should be changed so as to give the packer wells the benefit originally intended to be given to them. The change in the packer well plan will cost the Gulf Oil Corporation some twenty barrels of oil daily, but it is the fair thing and the carrying out of the original intention, and I think the change should be made.

BY THE GOVERNOR: In packer wells, what is the object in setting a packer? What is to be accomplished by that?

A If all production, Governor, is coming through the same part of the formation, oil and gas and water are coming into the well at the same place, there is no way a packer will do any good in that case. But if we have two production horizons, as indicated by the chart and the pamphlet which I hold here, and if gas is present in the upper horizone and oil in the lower, a packer may be set around the tube between the upper and the lower formations, then if there are holes in the bottom part of the packer, below the packer, or the tube is open below the packer, oil will come in from the lower formation and pass up through the tube. The gas tries to come in, and the casing head closed in so that the gas cannot escape, and the gas saved benefits the pool as a whole.

It is precisely the same condition if there is water in the upper formation and oil in the lower.

I think without exception every operator produced his well until the time came he was producing so much water the operating costs were wxcessive, the operating costs equaled the value of the oil recovered, and in most cases the well went dead, and the operator was then faced with the problem of plugging and abandoning the well or setting a packer. If the water was confined to the upper horizon he could set a packer in the upper and produce from the lower, and the water would be shut off -- not come out at the top. If the water was in the lower horizon, he could plug off the lower part. If the undesirable fluid was coming from below he could set the packer in the impervious zone and the fluid would be shut off.

So setting a gas packer is a real conservation measure, and conservation of gas is needed for the pool, and the operator is looking out for his own interests, as well as the interest of the pool. He will get the benefit as well as some other well -- some other lease. The operator who shuts off water does nothing but make it possible for him to operate that well.

If oil and water are both coming in the same horizon, the setting of a packer will not shut off the water. If they come together, they must be taken out together.

BY THE GOVERNOR: Bottom hole pressure adjustment, when do you mean by that? Do you have some method of making that adjustment?

A An adjustment is a calculation made in the umpire's office. If a well has a pressure higher than the average of the pool during a previous survey -- and surveys are made every six months -- then the potential of a well is increased by a percentage corresponding to the amount the pressure is above the pressure in the previous survey. If the pressure is below the average in the pool, then the potential is reduced below that, with the result that the potential, by a series of successive subtractions, may be reduced and finally may be completely eliminated. The calculation is made by algebra and is complicated, as I think Mr. Staley understands -- it is a calculation made in his office, the correction is made in his office, and if a well has too high a pressure, it is decreased, and if it was too low, it is increased.

BY MR. BOHART:

Q There has been a great deal of evidence as to whether potential is an indication of oil in place. Technically -- I would be interested to know, and I am sure the Commission would, as to whether there is any practical recognition of potential as an indication of oil in place, and it occurs to me the evaluation reports, might give us some information on that point. Have you ever made up evaluation reports, and studied them?

A I have made a great many evaluation reports in connection with the purchase and sale of property and the exchange of interests.

Q Is it a common practice, in making up an evaluation report, to study the report and give weight to the potential of wells?

A The potential of the well is about the third item considered. The first item is the description; the second, the number of the wells; the third item is potential; the fourth is the present daily production; and the fifth is the reserves.

Q People, in buying and selling, actually study and consider a well's potential?

A I never knew of any sale of producing property where potential is not given very serious consideration. Potential is not the only yardstick, the only thing considered, but one of the very first items looked into.

BY MR. WOODWARD: You say potential is the second item?

A The second item is the number of the wells, in our evaluation report.

Q Then the purchaser of a producing property is primarily interested in the oil under the property he may recover?

A From the potential and other data, he calculates the reserves under the property which can be recovered.

BY JUDGE LOWE: You may cross examine.

BY GOVERNOR MILES: We will be in recess until 1:30 this afternoon.

Pursuant to recess, the Commission resumed the hearing at 1:30 in the afternoon, with Dr..Knappen on the witness stand.

BY JUDGE LOWE: I have one additional question I would like to ask.

Q Dr. Knappen, you reviewed the history of production in New Mexico. What are your views as to the efficiency with which this pool has been operated?

A This pool has been operated more efficiently than any pool in New Mexico, and more efficiently than any pool in the United States. There are minor inequities abainst which we are protesting, but on the average, it has been especially well operated.

Q There was one correction you wanted to make in your testimony this morning?

A Yes, in the number of packers the Gulf has set. My memory failed and I used the wrong figures. The Gulf has set ten packers and has twenty-three wells, so the number of wells in which packers were set is 42% or 43% of its wells. That was a mis-statement when I said twelve.

There was also another mis-statement on my part, or a misunderstanding as to one other statement, and I would like to correct that. I am told I said all of the wells in the Hobbs Pool would come up to maximum pressure in a thirty-six hour period. A great majority came up to maximum in a 36-hour period, and all of the wells, in thirty-six hours came up to the point where the maximum could be calculated -- not all came up to 99½% in thirty-six hours, for a few of the wells did not reach maximum pressure within the thirty-six hour period.

CROSS EXAMINATION By L. H. Rankin (Repollo)

Q I believe it has been stated there is a gas cap on the Hobbs Pool at this time?

A That is true.

Q Could you roughly outline where it is?

A In a general way, it lies in here (indicating on map); that is to say, in Sections 32, 33, a portion of 29 and I believe a part of 28.

Q Would you explain to the Commission again the cause of a gas cap?

A A gas cap has been formed by the release of gas from solution in the oil. The oil contained all the gas it could hold in solution at a pressure of 1500 pounds per square inch. Now that the average pressure has dropped 20%, the amount of gas is released -- necessarily a certain part of that gas has come out of solution in exactly the same way gas dissolved in ginger ale or soda pop comes out when the cap is taken off.

Q The drop in pressure, I understand, is caused by excessive withdrawals?

A It is caused by the removal of oil faster than the water keeps up.

Q There are a number of Gulf leases in this area under this gas cap?

A Oh, yes, the Grimes.

Q Is there a gas cap down here (indicating on map)?

A I don't know. There is a great deal of free gas in the pay. I don't know that there is any separation in the gas above the oil in the southeastern part of the pool. There is free gas in that area. It may be present filling some cavaties, or it may be present as a gas cap in that area (indicating on map).

Q Turn to Exhibit No. 12, Dr. Knappen. About four years ago contour maps of the Hobbs field were terminated at about this point, Sec. 24, T. 18 S., were they not?

A I don't know that they were.

Q Isn't it true that the development of Sections 13 and 24 was a subsequent development?

A That is true.

Q At that time, sometime about the year 1934, the contours in Sec. 24 and Sec. 18 were terminated -- that is, T. 18 S., 37 and 38 E., were terminated in much the same manner as in Sections 6, 8 and 9, T. 19 S., R. 38 E.?

A I don't know that that is true of four years ago, but certainly that is true that the contours could not have been drawn for the north end of the field until it was developed.

Q We have a production slope of -583 sub-sea?

A Yes, that is true. The Ohil well in Sec. 9, T. 18 S., R. 37 E., and the Two States Company well in Sec. 21 -- I beg your pardon -- The Ohio well in Sec. 9, T. 19 S., R. 38 E., and the Two States well in Sec. 9, T. 18 S., R. 38 E. had the white lime at -583.

Q As a geologist, wouldn't it have been reasonable to suppose that development would be contiguous, and project a line parallel with the last known contour?

A It would have been reasonable to draw a contour roughly parallel. It xxxxld was not done because there was no development in there and on account of the irregular slope immediately north of Sections 5 and 4. Where you have an irregular slope it is dangerous to project --

Q Would it deface your map too much to parallel the -425 foot contour which has been established, with the -575 foot contour?

A No, I am perfectly willing to do that.

Q Would you make a light line?

(Witness makes a line with pencil).

Q From such a line as that it would be reasonable to estimate the position of that line?

Q Can you tell -- first, there are a number of dry holes between the -475 and the -525 foot contours the way you have projected the lines?

A In the area of Sections 5, 6, 8 and 9 of T. 19 S.

Q So that area is not good production?

A I wouldn't care to drill in it.

Q According to your formula, the average Lea County well is 45 barrels per well?

A I thought it was 46 or 47.

Q According to your formula, one-fourth of that would be allocated only on properties falling within your average thickness map, not 60%?

A No, one-fourth of the allowable of the Hobbs Pool would be divided equally between the production units.

Q But if a well had no allowable, it would be one-fourth of 45, or 11.5 barrels?

A That is approximately correct.

Q You would not drill a well for 11.5 barrels?

A I don't believe you could drill a well in that area and get that.

Q According to your map, which you have referred to in your testimony, you have wells lower sub-sea than that?

A Certainly. I don't believe there is commercial oil in that area, at the present time. If I had known the field in 1929 I would have been willing to recommend a well there at that time, but certainly not today.

A No, I would not today. On the basis of that formula?

A No, on the basis of water encroachment.

Q You know the water is coming from this direction, through this area (indicating on map).

A I believe --

Q (Interrupting) And not through here, from the southwest to the southeast?

A I think from the southeast to the northeast in that particular area, as Mr. Card said.

Q How many undeveloped units in the blank space, as outlined here? (Indicating on map).

A About twenty.

Q What percentage are state units?

A I am not certain, but I recognize four -- there may be more.

Q 20%?

A Four out of twenty, -- yes, 20%.

Q You just definitely condemned that area?

A Yes, I certainly would not drill in that area.

Q There is the area that Mr. Cusack drilled, you dondemn that, in Sec. 34, T. 18 S., R. 38 E., is that capable of making its allowable -- the average Lea County allowable?

A I don't know that you would condemn that. That does not have the same producing conditions. The Samedan Turner lease does not have the same producing conditions as 5 and 6. There is no water encroachment approaching from the east side of the field -- if one had knowledge Mr. Cusack's well was high enough on the structure.

Q If it was a low well?

A If it was a low well there would be no reason to expect water encroachment, as there is on the southwest side.

Q Assume someone came along that does not know that area as we do -- what would it cost to drill a well?

A A well or a dry hole?

Q A well.

A $30,000.00 to $35,000.00.

Q And gravity is 34 to 36?

A Yes.

Q The average price of pipe is 37¢?

A That is right.

Q And we assume the lift will cost 37¢?

A That is far too high for flow.

Q It may make a little water? Could he make a net of 80¢?

A That is not unreasonable.

Q And of that eighty cents, ten cents, or one-eighth goes to the royalty owners?

A Yes, probably eleven cents.

Q Well, eleven cents. So can you figure with a net profit of seventy cents a barrel, and an allowable which would be established by your formula of eleven barrels a day, how long it would take to pay out $35,000.00 before he would get a cent of revenue back?

BY JUDGE LOWE: I don't like to object, but I don't know what this has to do with the program we have before us, how long it would take to pay out at a certain price.

BY GOVERNOR MILES: I don't know what he is going to show. I don't know enough abo t it to follow the lead as to what his thought is.

BY MR. RANKIN: I am trying to show whether there is a possibility, in Dr. Knappen's estimation, or whether there is no chance to get production in this area; and I am trying to show the effect the proposed formula would have on development and possible future investigation in that area; and I am trying to also show how long it would take to pay out on a well under that formula, the drilling of which would result in sonservation measures, as far as oil is concerned.

A You want to assume bottom hole pressure would be so low that there would be no potential?

Q We would naturally assume bottom hole pressure would be so low that no credit would be given a well for potential.

Q That might be your assumption. Certainly it would not be mine, because bottom hole pressure was originally 1500 pounds; there is no reason to expect a lower pressure unless there is drainage from the area. If that is an oil producing area, the pressure should be at least as high as the average, perhaps higher. If, on the other hand, if this should be an area in which no potential were allowed because the pressure was so low, and it was draining oil from the rest of the pool, then the well would take between ten and eleven years to pay. But such a well has no business to be drill d if it is dependent on draining oil from other parts of the field.

Q How many places in the United States -- or in Texas, or in New Mexico, that if the acreage was so low as you set out, would pay t e cost of operation? You say 25% on acreage will pay the cost of operating a well?

A I didn't say pay the cost -- I said that figure was set up in 1930 to pay the cost of drilling and operating a well.

Q I think this morning you set out a formula of 25% on acreage and 75% potential, corrected by bottom hole pressure every six months?

A That is correct.

Q I think you went further and said the 25% on acreage would pay for the operation of the well.

A I did not say that. I said that was the thought when the plan was put into effect at Hobbs. If conditions change, it may or it may not.

Q I thought that was included in your formula?

A It was not intended to be.

Q Exhibit No. 8, now. In your opinion, do wells in an area of low permeability have as rapid a build-up as wells in an area of high permeability?

A No, they do not.

Q And bottom hole pressure measurements are made on the basis of the record in the bore hole in a given length of time?

A That is true.

Q In an area of low permeability it would take much longer for fluid to build up to a given point?

A That is correct. Don't overlook the high permeability over here (indicating on map). It will build up in half an hour in many wells. Where they are down in lower porosity, it will take thirty-six hours.

Q And it might take longer?

A And it might take longer. Hobbs, in a 15-day shut-down, made a series of tests. I took the bottom hole pressure in seven wells in the southeastern area. The wells had been shut in for from six to nine days -- the average was seven days. During the seven days the wells built up to within an average of three pounds in each well. That indicates that at the end of thirty-six hours those wells had practically come --

Q (Interrupting) That is a reflection of permeability?

A What is a reflection of permeability?

Q The fact that it took them so long to build up?

A No, it will build up -- they were within three pounds of maximum in thirty-six hours. The remainder of the three pound build-up probably was the result of drainage of more than 360 barrels per day, the condition in the northwestern and southeastern part of the field.

Q Where is the exhibit with the red line across it? (Witness turns to Exhibit No. 12). Where did you derive the information on the 367 barrels?

A A calculation of the productivity of the three wells along the line and the difference in the pressure in the three north offsets and the three south offsets, the pressures being determined by the six months surveys.

Q How did you arrive at the figure of 360 barrels?

A The result of the formula introduced yesterday by Mr. Tasch, applying the differences in pressure between the southern line of wells and the northern line of wells and their production.

Q And Mr. Tasch derived that from Dr. Muscat?

A From Dr. Muscat's book.

Q Have you ever been interested in pipe lines - the pressure in pipe lines - those laid in a straight course as compared to lines with a considerable number of angles per mile?

A Yes, sir.

Q My understanding is that in a linear mile, that if there were sixteen angles, turned in the manner pointed out here (indicating), one angle -- two angles -- three angles -- sixteen of them to a linear mile, it amounts to a plugged line.

A I don't know about that --

Q I have talked to pipe liners, and they have said that in a field of that sort it would break the line before they got anything through.

A Those sixteen angles will greatly reduce the possibility of a line. Every time you put an angle in a pipe line, you reduce the capacity of the pipe line. The pressure is reduced every time the oil goes around an angle, and at the next angle it is reduced again -- it seems to me quite practical, as the oil moves up to the angle, it will be slowed down to go around --

Q (Interrupting) But a much less rate?

A At a slower rate. Every time you throw an angle into a line, you decrease the amount of oil that will go through it.

Q That number would not plug it, but tends to move it so slow it is the same thing?

A You can't get any through with the line plugged.

Q I believe you quoted two pressures -- I believe you said there was a large differential in pressure between the north part of the field and the southeast part (pointing to map). Which were those two wells you mentioned?

A The highest pressure shown was in the December, 1931, survey, at the Shell No. 1 McKinley, 1483 pounds. That is the highest well on that map, and the only well that had that pressure.

Q What is the lowest?

A The lowest was 1275 in the Stanolind No. 24 State, I believe is the name of the lease. At any rate it is No. 24 in the NW¼ of Sec. 15.

Q That was a difference of 208 pounds?

A That was a difference of 208 pounds.

Q In what distance?

A Approximately five miles.

Q Let us assume you have a pipe line running right straight from the Shell well down to the Stanolind, with a head up stream side of 208 pounds, with delivery pressure zero. What influence would the pressure have on resistance to flow --

A There is less oil movement through a two-inch line over five miles than one mile.

Q Would it be asking too much to ask Dr. Muscat to figure that?

A I don't have the tables for a five-inch line under 208 pounds pressure. I should think the delivery scale would be in the neighborhood of 800 barrels a day.

Q And a two-inch line under that pressure?

A That is almost --

Q (Interrupting) It would be very little through a two-inch line under 208 pounds?

A That is true.

Q Isn't that a far more ideal condition? You would have oil migrating through an area of very low permeability and porosity, would you sill have a transfer of oil over a distance of five miles, from this point, the Shell well, down to this Stanolind? Wouldn't the resistance to flow be far greater in the formation than in a pipe?1 Could you have a transfer of 800 barrels?

A I am not certain how much greater. You will have a band a mile wide, two mil s wide in places, and of unknown width in places. I have not said there was a transfer of 800 barrels from the northwest to the southeast end of the field. Our calculations along the red line do not indicate any such figure. Your two-inch line under that pressure would probably bring more oil down than came, in '31 under these conditions.

Q You would not get much?

A Depend on whether you think 800 barrels is much or little. A two-inch, five mile line -- I don't know. We estimated any such movement as 600 barrels across the red line at that time. At that time you will notice you have a pressure differential of 200 pounds in two miles, from the Stanolind No. 8 State, in the SW$\frac{1}{4}$ of Sec. 4, you have 200 pounds pressure, which is almost equivalent to 208 pounds.

Q You have 208 pounds from this point down to the Stanolind well - 208 pounds?

A That is correct.

Q Right in the center of the field you only have a differential of 200 pounds?

A Correct.

Q I fail to see how there could be drainage of oil down to the Stanolind area.

A There is probably no drainage from the northwest end of the field -- perhaps from the high pressure area in 31. Such drainage as occurred in the southwest end of the field undoubtedly was coming from this area (indicating on map).

Q Take the Stanolind wells in the SW$\frac{1}{4}$ of Sec. 10, T. 19 S., R. 38 E. Those are in an area of remarkably low pressure?

A Yes, sir.

Q But it is also in an area of rather low permeability?

A You are speaking of the southwest of ten?

Q Yes.

A Yes, that is an area of low permeability.

Q As you get away from the well bore to the center of the property, the pressure must necessarily go up?

A Not more than two or three pounds two or three pounds higher than the static in the well after a 36-hour period.

Q Wasn't there testimony this morning about some well up in the northeast part of the field?

A Continental No. 3, completed between three producers; in the NW¼ SE¼ of Sec. 28 -- was completed between two producers a quarter of a mile to the north and a quarter of a mile to the south. The producers had already been on production for some time. There was something like 26 pounds difference in pressure between the northern and the southern well. The Continental well was midway between, and should have given a good measure of the pressure at the boundary. One would anticipate the pressure to be between the two, which, as I remember, would be 1381.5. It measured 1385, a difference of three pounds.

Q Do you have a later bottom hole pressure map than that (indicating the exhibit)?

A Yes, turns to Exhibit No. 7). This is a bottom hole pressure map nearly two years later.

Q The only thing I want is the permeability in this area (indicating). Have you compared this well, No. 3 Grimes, in Sec. 28, T. 18 S., R. 38 E., with the pressure and permeability in the southeast part of the field?

A It could be done. I have not made such comparison.

Q However, if bottom hole pressures are a reflection of permeability --

A (Interrupting) Bottom hole pressure is no measure of permeability.

Q In other words, in your opinion, the pressure would build up just as quickly there as in a permeable area?

A No, you asked if bottom hole pressure was a measure of permeability.

Q Are they a reflection of permeability?

A Bottom hole pressure in a well is no reflection of permeability. The build-up in a well is a reflection of permeability.

Q What causes the well to build up?

A The difference in pressure between the formation -- the equalization of the pressure between the well and the formation.

Q If that oil can run through bigger holes, rather than through small holes, it would reach the well bore much sooner?

A Certainly.

Q And big holes are in areas of high permeability, and small holes are in areas of low permeability?

A Yes, sir.

Q So the build-up in quicker in the well in an area of high permeability? Is that not true?

A But the wells, in areas of low permeability, the build-up is just as high in time, and as I say, in areas of high permeability in all pools, you could get a complete build-up sooner; if a well has low permeability, you would have to wait 24 to 36 hours. The rate of increase of the bottom hole pressure is the measure of permeability, but actual static bottom hole pressure is not the measure of permeability. Do I make the distinction clear?

A No --

A Bottom hole pressure in an area represents the pressure under which fluids exist, the static bottom hole pressure in the well. When the pressure has reached its maximum, it is the same pressure in the well and in the surrounding area, because if the surrounding area had a higher pressure, then the pressure would continue to build up in the well.

Q You mean to say there is only -- in this area down in here (indicating on exhibit), there is only possibly three pounds difference in the bottom hole pressure in the center of the lease and the edge of the lease?

A After the well had been shut in and had built up to the maximum, I would not expect more than a three-pound difference between the margin of the lease and the well.

Q From the center of the lease is approximately 800 feet. Do you think you could construct a tube 800 feet long, having perfect porosity, of say 33%, and very effective permeability, or effective porosity, and have a three pound pressure up stream side, and still, going up stream side, have oil come out of that tube 800 feet away?

A Certainly.

BY MR. RANKIN: That is all.

BY MR. RAE: I believe you made thestatement that bottom hole pressure was used in the allocation plans in other pools, did you not?

A I did.

Q You have property in the South Burbank Pool, a nd are familiar with the plan there?

A No, I am not familiar with that plan. I know that bottom hole pressures are used in adjusting pressures in the pool every six months.

Q You probably know the plan was designed by the Engineering Committee of the pool?

A I assume it was. I do not know.

Q You are probably familiar with it enough to know that the plan designed by the Engineering Committee had certain penalties, and that those penalties were cut one-fourth of their original effect by the Secretary of the Interior, after due hea ring?

A No, I am not familiar with that. I don't deny it, but I do not know it as a fact.

Q The only point I was making, as an engineer, the number of corrections to be applied, and how often, and the type of corrections -- that you have no hard and fast way to compute the time of the correction, the amount of it, and other factors as applied to an allocation plan to be put into use?

A As an engineer, I would say the more often the correction is applied, the more equitable -- the more closely you correct, the more equitable --

Q (Interrupting) If I were to tell you the Secretary of the Interior changed the number of times the South Burbank made corrections, that he said they made them too often, that probably the engineers were too enthusiastic, would you say the Secretary of the Interior was wrong?

A He and I have differed on engineering matters frequently.

Q Of course, you realize the Secretary of the Interior's decisions were made by technical men with hom you are probably acquainted, and he simply acquiesced in the decision?

A It is not becoming in me to attack or defend the decisions of the Secretary of the Interior. I do not know the situation -- I do not know why he made the decision. I am in no position to attack or defend the Secretary.

Q You think bottom hole pressure can quickly be recognized in the field, so they might be nullified?

A Might be gradually reduced. With tremendous bottom hole pressure as set up in the Hobbs Pool, that is not going to be wiped out in sixty days or six months.

Q Would it be more important to wipe out bottom hole pressure, or allow every property to produce the oil in place?

A I think you should allow the property to produce if there was not movement of oil from other leases.

Q I believe the maps show, under the present Hobbs plan, that the pressure decline is slightly faster around the edge of the pool?

A They are declining much faster in the southeastern end of the pool, and declining less rapidly in the northwestern end.

Q What would be the life of the pool at the edge, compared to the life at the highest point?

A It would depend on the part of the edge.

Q Do you have any way of knowing at this time from which side of the pool, and the amount, the water encroachment will come?

A Not with great precision. We do know there is water in the central southwest side, and the northwest end, and to a less extent around the southeast end. There are certain areas on the northeast side where water has not come in at all.

Q Suppose the northwest end would only have a life of eight years, and the top would be fifteen years, knew that was a reasonable estimate. Would you still say you wanted to go along and have such adjustments as would tend to equalize every one over the pool?

A Yes, I would, because you cannot in any other way prevent drainage at the east boundary.

Q How can you give a man the oil under his property unless you allow him to produce over a term of years that will allow him to recover the oil under his property? To put it in another way, suppose you had a property on the northwest side that had a lower bottom hole pressure, and only had a life of eight years, compared with properties on top of the structure which had a life of fifteen years. Would you think it reasonable to commence to decline the low pressure property and not allow it to produce its oil before it is wiped out?

A Not at all. It would not have a lower pressure today -- it has a lower pressure only because of over-production.

Q You would not give that property the oil under it? You would not allow each property to produce at a rate that will allow it to recover the oil under it?

A Certainly, because there is no migration across the boundary if pressures are equal.

Q You might have low pressure and have water?

A You are saying low pressure, and I am saying they start at equal pressure.

Q That is right, start at equal pressure.

A Both properties would produce in proportion to the reserve if you keep the pressure equal, there will be no pressure -- differential pressure.

Q I would say that property on the edge of the pool, the advance of water is caused by the oil field in general, not that property, but with water sweeping across that property, the life may be seven or eight years as compared to twenty-five years on top.

A We are overlooking the fact that water sweeping across a property, that water build up a higher pressure. A man might be entitled to produce more and keep the pressure down level with his neighbor.

Q There are certain parts of the field where the water builds up pressure?

A No, I know of no evidence that water builds up any pressure anywhere in the pool. Let me explain -- the water comes into the pool only as oil is removed. The water comes in and takes the place of the oil. If water comes as rapidly as the oil is taken out, the pressure is high, and the well should be allowed to produce more rapidly. We are learning a lesson from hydrostatics; fluid moves only under different pressures; if you keep the pressure the same, there can be no movement across the property lines, then the lease which is against water may produce at a much higher rate than the lease that is removed, but if you do keep the pressures the same, then there is no differential in pressure.

Q We will assume the pressure on the edge lease is the same as the rest of the pool -- we are assuming the water encroachment is not caused by the production of that lease alone, but on the structure the water continues to replace the oil taken out --

A No, I have not said --

Q (Interrupting) If you have a water drive it will move along and gradually move up structure, and the water tends to advance according to the differential in pressure?

A Certainly.

Q It displaces the oil higher in the structure and the effect is felt on the edge leases?

A Certainly.

Q Assume the pressure is even -- take, for example, the Cusack lease; suppose water goes over that lease and wipes out the property after eight years of production life, as compared with fifteen years up structure. How are you going to give a man his oil unless you give him a reasonable allowable compared to the other leases?

A The man on the edge will be allowed to produce at a higher rate. He will get his oil out in eight years, where the man farther up will not get his out so quickly.

Q I thought your map showed lower pressures around the edge of the pool?

A No, I specifically pointed out places where excessive production and water had caused higher pressures. The highest pressure is in the northwest end of the pool, right up against the water, in most of the maps.

Q Wouldn't you say that the large operator would be able to average up his edge wells, the loss of oil recovery, that his high wells would give him his recovery, but the small operator, with wells only on the edge of the pool, he would consider that short life a much more serious factor than the large operator?

A I would take care of the operator on the edge of the pool, whether large or small -- as has been said, every lease must stand on its own feet. There is no reason that you should be allowed an advantage if by producing that lease you have to take oil from your neighbor. Every lease should be handled as a separate unit. Everyone should make bottom hole pressure tests frequently, and you do produce your edge leases in shorter time, at a faster rate, and you get all off the edge lease through the wells on that lease.

Q Suppose, or assume you are able to have uniform pressure over the pool, and uniform pressure on all leases, the production -- allowed production to be equalized; what is there in your formula to allow for the fact that the wells have a shorter time, or life on the edge leases?

A Nothing.

Q Wouldn't you think the higher wells, using the same pressure, would produce a much greater volume of the oil underground than the edge lease would in eight years?

A I don't think because of the accident of location, any lease is entitled to take from other leases; you recognize a man's oil is under his own lease.

Q Anything in your plan to protect the edge wells, which have a shorter life? Assume they are going to be produced to keep an equal pressure? Is there anything to compensate for a shorter production?

A They wouldn't need any compensation.

Q Are they allowed to produce three times as fast?

A They would be if bottom hole pressure were properly applied; they would be allowed to produce three times as fast if that were necessary to maintain equal pressure.

Q I suppose you know that in East Texas some of them got together and gave the edge of that field additional pressure so that they produced, in the lifetime of the wells the oil under the lease?

A Yes.

Q I still can't see, in your formula, how every lease would be allowed to produce the oil under it.

A It will figure out if you make the bottom hole pressure equal, and maintain it; if the pool has no differential in pressure there can be no drainage across boundaries.

BY MR. LIVINGSTON:

Q Would that be true of adjoining properties if the permeability were different on each property?

A Yes, sir, the high permeability property would have high potential, would be allowed to produce more oil on the potential basis, than the low permeability. If the potentials do not properly adjust them, then the bottom hole pressure will adjust it, so that if one is allowed too much on the basis of potential, the next time a survey is made, you will find it low, and it will be cut. If one is not allowed enough, the pressure will be high, and the next time it will be increased, permitting that well to produce faster.

Q But does not adjusted pressure, with different permeabilities, involve a larger element of time?

A I am not certain I understand the question.

Q Stating it in different words, in the experiment we witnessed yesterday, from one tube the liquid, under apparently equal pressure, flowed faster than it did from the other, said to be tighter. I understood you to say the pressure will equalize notwithstanding the variability of permeability. But now, what I have in mind, does not that equalization take into consideration the element of time? In other words, down to twenty-four hours, or perhaps thirty-six hours, in the course of time, would the matter not be taken care of with sufficient time?

A Perhaps I can answer in this way: In the experiment yesterday, he started with equal pressure on the two tubes. Had the fluid level in the two graduates up on top,-- had the water level been kept the same; if that had produced what corresponds to six months in a well, and the fluid level lowered every time to the level of the fluid in the tube for the high permeability, that would correspond to a going well -- where you find the bottom hole pressure low, then Mr. Staley would say this well is producing too fast, and he would apply a pinch-off on it to slow it down, the rate of production for that well, until the fluid level in the two graduates were the same. That would have brought about what corresponds to equal bottom hole pressure. And then he would operate those two wells so as to keep the fluid level the same level, which would correspond to the same bottom hole pressure. If he had done that, and the porosity was the same, they were entitled to the same volume of oil production. So by the repeated making of corrections, when you find the bottom hole pressure too high, increase the rate; when you find it too low, decrease the rate, and in that way keep the bottom hole pressures alike, then the oil cannot migrate from one property to the other. You must shut in each well occasionally to find out what the pressure is, and long enough to let the well reach the maximum. In some wells, two or three hours is sufficient -- in some wells, half an hour is sufficient. Other wells, thirty-six hours might not be sufficient to give the maximum, but sufficient so that the engineer can calculate it. If you do leave the well shut in a sufficient length of time, with a good engineer, you will find his calculations within a few pounds of what it would reach.

BY MR. DEWEY:

Q Is it safe to infer from your testimony on pressures, that out in a field where the wells are drilled in the center of each forty acres, and all completed at approximately the same time, that you would only need one factor to prorate that field, shut-in bottom hole pressure?

A Let me repeat that to be sure: You are assuming equal spacing of wells, simultaneously completed, within reasonable limits, and you are asking whether, with those conditions, if bottom hole pressure alone is sufficient for proration in a pool?

Q To obtain recovery of the oil in place.

A Yes, that is true. Perhaps I might elaborate on that answer and read a statement by W. S. Farish, of the Standard Oil Company of New Jersey, as presented to the Temporary National Economic Committee, commonly known as the T.N.E.C. I am reading from the statement as published in the Oil & Gas Journal of October 26, 1939. Mr. Farish's statement so accurately explains this point to petroleum engineers and petroleum executives that it has been widely circulated. Mr. Farish says: (Reading)

"Optimum production may be defined roughly as 'the most oil at a reasonable cost,' that is, the most oil that can be obtained without spending more on the addition to the supply than that addition is worth. The concept therefore embraces economic aspects as well as considerations of physical waste. The idea of optimum production involves several things: (1) The most economical recovery for a pool as a whole should be established at a rate that will maintain the bottom-hole pressures. (2) There should be proper well spacing to avoid unnecessary drilling costs. (3) Withdrawals of oil should be made ratably from each property owner's holdings, protecting correlative property rights and maintaining equilibrium within the reservoir. Under a condition of optimum production as thus defined, it will be possible to avoid almost entirely the injurious consequences of the rule of capture. This is the job of proration."

BY MR. WOODWARD: What was that first one?

A (Reading) "The most economical recovery for a pool as a whole should be established at a rate that will maintain the bottom-hole pressures."

Q You mean to say maintaining the pressure and equalizing the pressure are the same thing?

A It is possible to maintain pressures in part of a pool and not equalize the pressures -- going ahead with No. 3 (Reading)

"Withdrawals of oil should be made ratably from each property owner's holdings, protecting correlative property rights and maintaining equilibrium within the reservoir."

Q You mean to tell me the maintenance of the reservoir pressure is equalization?

A Exactly, equilibrium means equal balance.

Q You would not suspect he means acreage?

A Perhaps if field pressures are identical throughout the pool when you drill the first well.

Q With respect to the gas in solution --

A (Interrupting) Certainly, he wants equilibrium -- he has stated that far better than I could.

BY MR. CRAUSE:

Q Dr. Knappen, getting back to the allocation to individuals within the Hobbs Pool, you think the Hobbs Pool has been operated and regulated to obtain conservation?

A As a whole, yes, sir. There are exceptions to that rule, but as a whole it has.

Q You think the operation and regulation is better than the average pool in the United States?

A I think it is better than the average.

Q Have you any recent information to indicate the pool has been over-produced?

A I don't know what your definition of over-production is.

Q At such a rate that water encroachments are not keeping up with withdrawals?

A Certainly water is not encroaching as fast as oil is withdrawn.

Q Is that serious?

A I think not.

Q Have you any information that it is serious?

A I have no information indicating it is serious.

Q There is some positive information that is available, that is, the bottom hole pressure tests that were made?

A I know a number of tests were made.

Q Do you know what they show?

A Yes.

Q Will you tell us?

A They showed the pressures in the various parts of the pool were different, exactly as they were different on the surveys shown there (indicating map).

Q Any great difference at the beginning of the shut-down and the end of it?

A An increase in pressures in the southeastern end, as a result of drainage from the northwest.

Q Take an average.

A I don't know that there was.

Q Any great change?

A No great change that I know of.

Q Would that indicate that the water was keeping up, before the shut-down, at some reasonable rate, for the pool as a whole?

A I don't see that you can draw any conclusion from a seven-day test. The pressure did show a slight increase, but they were small. Certainly you would not expect, in seven days, to have water come in to make up for all the oil production of eight or nine years.

Q If the pool was currently over produced, as a whole, would there not have been a great increase in bottom hole pressure during that seven days?

A If there were serious over-production I would have expected pressures to increase considerably.

BY MR. RANKIN:

Q You told us that during the seven days, in this area, the pressures had increased three pounds?

A I told you the average was some three pounds.

Q As it ran, you mean?

A It may have been more in some places.

Q And you just got through telling us the seven day shut-down showed drainage from the northwest to the southeast?

A Yes.

Q You would not say the water, during the seven days, tended to increase, rather than the migration of oil from the northeast to the southeast?

A I don't believe the water drive in the southeastern area is very effective. The water encroachment map Mr. Card submitted showed it was slow.

Q Would you not think oil with gas in solution, coming from the northwest to the southeast, would encounter far greater friction, going through porosity, than the water in adjacent properties would have coming into the property itself?

A There is greater friction resistance with gas --

Q (Interrupting) You would say water is the prime mover?

A I don't think I said that, but it is true that water holds the oil in the pool to begin with -- water provides the original.

Q If you were going to drill an oil well, you would get as close to an oil well as possible?

A I would want to.

Q If you had a property with a well producing on it, and you wanted to drill another well, you would get just as close to the oil well itself as possible?

A No, I would move a reasonable spacing distance away.

Q That is the policy here. We have water abutting our property, and it is natural to suppose that water, as you say, traveling far more easily than oil, is going to travel down here, so that --

A (Interrupting) If you had the same pressure, if you equalize the pressure to the average?

Q The formation pressure would depend upon the water drive.

A No, because the water drive is not keeping up with the removal of oil.

Q Is that the reason the average field pressures have dropped?

A That is the reason the average field pressures have dropped.

Q In order to keep the pressures up, the water drive is to be considered the force that keeps the pressures up?

A I don't know to what extent, due to the policy at the present time, it is maintaining it, or whether it is simply residual pressures; both are factors.

Q I think we understand each other pretty well. Will you refer to this map (Exhibit No. 4). Will you please identify in this cross section wells Nos. 16 and 17?

A No. 16 is Repollo No. 1 Crump, and No. 17 is Repollo No. 2 Crump, in the NW¼ NE¼ of Sec. 15, T. 19 S., R. 38 E.

Q Now, we will take each well going up structure from Repollo Nos. 1 and 2 Crump. I believe practically all of the wells have allowables greater than either No. 1 or No. 2?

A I don't remember the allowable of each well. I doubt if the Stanolind, in the SW¼ of Sec. 10, has any greater allowable. I think most of the other wells have a greater allowable. Before I testify I will consult the record (Witness consults records). Your question was whether all the wells northwest of the two Repollo wells had more than the minimum allowable. The answer is that three wells have the minimum allowable, Stanolind No. 24 State, in the SW¼ of Sec. 10; Stanolind No. 26 B. L. Thorp, and Stanolind No. 8 in the SW¼ of Sec. 10. All the wells southeast of where I hold this pencil (indicating on map), all the wells southeast of the southeast corner of Sec. 4, on that section, have the minimum allowable. The wells northwest of that point have greater than minimum allowables, so far as I remember, and as I remember all do have more than minimum allowables.

Q The two Repollo wells produce from one zone?

A I believe that is true.

Q The rest of the wells to the northwest are higher on the structure, and also participate in that structure?

A That is true.

Q Every barrel taken out to the northwest, going up structure, it must necessarily, in a perfect water drive field, be replaced by a barrel of water coming in on the Repollo property?

A Not necessarily. The water may be coming in over other property to replace the oil.

Q You think the bottom hole water coming up when a number of wells have been completed, the water would not come into these wells?

A None of the water in the lower horizons, but in all of the wells farther northwest drilled in the lower horizon -- the water has not yet reached the bottom of the wells in the lower pay.

Q But you can say that wherever the thirty barrels the Repollo Oil

Company takes from their property alone, there must necessarily be thirty barrels of water to replace it, as they are on the edge?

BY GOVERNOR MILES: The point has been repeated, and the witness has answered. You should interrogate the witness and not argue with him.

BY MR. RANKIN: The only point I was trying to bring out, that every well along this profile is participating in the oil underneath the Repollo lease, and for every barrel of oil taken out, a barrel of water must come in to replace the oil, and that water comes on the Repollo lease, and therefore those wells should have a greater allowable than the wells higher up the structure.

Q Do you agree?

A I certainly do not, because oil does not move from areas of low pressure to high pressure areas. You do not have oil moving from a lease which has 900 pounds pressure up on to a lease with a pressure of 1100 pounds.

Q I am not trying to argue, but I fail to understand, if there is migration -- there was some testimony to the effect that there was high bottom hole pressure in this area, and I cannot understand why they continue to decline as they are, if they are replaced by migration.

A The answer is that migration is too slow through this area. You are taking oil out, 900 barrels per day. Well, calculate that the movement into this area is 360 barrels per day, and in addition to taking out more oil than you calculate is moving into the area, you are also taking out far more gas, and the pressures continue to drop, even if the oil comes in as fast as you take it out.

A I will admit there is slow migration, even of water, into the property, due to the fact it is so impervious, which accounts for the fact the bottom hole pressures do not build up any faster than they do.

BY GOVERNOR MILES: We will be in recess for five minutes.

BY MR. CUSACK: We have a lease owned by J. P. Cusack, Inc., which is carried on the proration sheet under the Samedan Oil Corporation. It is carried that way for the reason that the Samedan is operating the property, but have no vested rights.

My purpose now is to make clear my reason for making any statement, which reason is that on the NE¼ of Sec. 28, T. 18 S., R. 38 E., when the potentials were originally taken, we had potentials there as the yardstick of 3500 barrels. Under the present formula, as used by and at the instructions and instigation of the Committee, it is now 1500 barrels. J. P. Cusack, the individual, is not here to complain about the present set-up. It simply comes to my attention at this time how unfair we have been treated by the present set-up. I will plead guilty to my share in that.

After listening to this testimony, which, in itself, is confusing -- you can take one side or the other, and -- and disadjust any fact. I am not a Harvard graduate or an engineer who can disadjust any fact -- it is just a question of belief in the testimony, but one thing I know, the bottom hole pressure has been unfair -- I think that has been admitted by everyone here, with the possible exception of the Gulf. I think Mr. Gray's testimony said it was questionable. That, in itself, means he doubts the formula. If you will take bottom hole pressures out, and put potential back, the 1934 formula, which was in effect at the time bottom hole pressure was brought in, so far as J. P. Cusack, Inc., is concerned, we are agreeable.

We are not contentious in the matter, but if there is an error, we certainly do not want to freeze that error. There are some here who seem to like to freeze things that are unfair.

The second problem, as I see it, is this: With the majority of the testimony and the fact that you can take these things and wind them around and do what you want through the engineering factor and more glib terms, and that is not very helpful -- is to place all on an equal basis. This may not be admissible. I am not testifying, but I believe at some place, at some time, these various companies that are here today, have given all of these matters consideration, and have agreed to a flat allowable. On that basis, the leases on the edge of the pool, when they have gotten their allowable, and have been wiped out, it will show that the water pressure will drive the oil up to the top of the structure, and when the leases are wiped out, those companies who have been fortunate enough to get leases on top will still have oil in place after we have been wiped out on the edge. On the other pools they may agree to that, but if their testimony in prior meetings -- if their testimony was right then, it must be wrong now, or if it was wrong then, and right now, we should try to find out what should be done.

I thank you.

BY JUDGE LOWE: We think the principles we are advocating are sound and practical, and we are willing that they should be initiated in every pool in the state.

DR. KNAPPEN,

on the witness stand for further Cross Examination:

BY MR. WOODWARD:

Q Dr. Knappen, when did you say you went to work for the Gulf?

A In 1926.

Q And prior to that time you had been teaching school?

A I had taught at various universities from 1919 to 1926.

Q Prior to 1926 you had had no experience in the petroleum industry?

A If I might state -- I had been employed by various universities and by the United States Geological Survey and in the petroleum section of the Illinois Geological Survey, in the economic geological section, which includes oil and gas operations.

Q Since you came with the Gulf, what has been your experience with respect to production?

A I have been in the geological department at the home office in Pittsburgh for a period of slightly less than two years, and I was occupied particularly with the relationship of engineering and geological problems. In 1928 I was transferred to the executive department at Tulsa, and I have been occupied with the scientific aspects with respect to production and pipe line operations.

Q Have you, during any of that time, been in the field?

A I have visited the field for conferences about problems. I have not been stationed in the field.

Q The principles you have announced here today, with respect to drainage, are principles well established by the text books and experts have given them a great deal of study?

A Including petroleum engineers who have worked in the field.

Q The soundness of the theory respecting drainage from high pressure areas to low pressure areas are generally admitted?

A That is correct.

Q Then, if there are any conditions in the Hobbs field which do not make that true, all the testimony you have given here is for naught?

A Why for naught?

Q Let me repeat the question: If there are any conditions in the Hobbs field that would prevent drainage from high to low pressure areas, then all the testimony you have given is for naught?

A That is not true.

Q What value is it in respect to the Hobbs field?

A Facts are facts; science is science, and truth is truth. You may have conditions in one particular place that is not taken into consideration.

BY MR. WOODWARD: Will you read the question to the witness?

(Reporter reads question).

A The answer is, that is not true.

Q You think the Commission should accept it and use it?

A I think the Commission should accept it and use it until some evidence -- until evidence is introduced to show conditions are not as I have said, are not true.

Q If it is established that there are conditions in the Hobbs field which would prevent drainage from high to low pressure areas, will you agree to the Commission that you are wrong about it?

BY JUDGE LOWE: I object to the manner of the question, what his testimony is worth -- he is asking him to pass on his own testimony.

BY MR. WOODWARD: I am asking a hypothetical question.

BY GOVERNOR MILES: It would seem to me that the testimony is the sworn statement of the witness, the testimony to the Commission, and it would be up to the Commission to determine whether it was of any value to them or not.

BY MR. WOODWARD: That is true. The point I want to make is that if facts are shown which make the application of the principles practically impossible of application, then I wanted to know if the witness would agree that the formula is wrong.

BY GOVERNOR MILES: If you prove that to the Commission, then this is not necessary.

BY MR. WOODWARD: Whatever the witness might say would not have anything to do with it.

Q Dr. Knappen, I want to draw your attention to your Exhibit No. 6, (Witness turns to map, Exhibit No. 6).

Now, Dr. Knappen, you drew a comparison between the Shell well in Sec. 20 and with the Stanolind in Sec. 15. Is that correct?

A Yes, sir.

Q The pressures you have assigned on your Exhibit No. 6 to the two wells in question is 1483 pounds pressure for the Shell well, and 1275 for the Stanolind well. Where did you secure those figures?

A From the reports of the Engineering Office at Hob s.

Q For what period?

A For the survey shown there, I believe is December, 1931.

Q Will you produce that report? (Witness produces report). Will you point out for me the Shell well, McKinley B-1.

A I have it here. It shows a pressure on December 10, 1931, of 1483 pounds.

Q Will you point out the Stanolind well?

A Would you give me the name and number of the well?

A The Stanolind Leach No. 24.

A The pressure was 1275 on November 19, 1931.

Q Is that -- will you check that sheet again, Dr. Knappen? Is that in the '30 column or the '31 column?

A Is which?

Q The Shell well first.

A The Shell well was taken December 10, 1931.

Q What column appears at the top -- what number?

A Column 1-A, dated 12-11-31.

Q Check the top of the column in which the Stanolind well appears.

A The column reads 11-16-30. The date "11-16-30" is apparently a mistake, because there are three prior surveys in 1931, and opposite the Stanolind is the date "11-19-31", twenty-one days earlier than the Shell McKinley.

Q Then you attribute that to an error in the column?

A Yes, sir.

Q I am inclined to agree with you. I believe you testified last night that there was drainage from this well to the Stanolind?

A I do not believe I made that statement. I said there was drainage from the area in the northwest to the low pressure area, but I doubt very much if the drainage from the northwestern end of the pool, say Sections 29 and 30 and 19, I doubt very much if drainage from Sections 19 and 20 passed the high pressure area in Sections 33 and 4. There was only eight pounds difference in pressure between that high pressure area (indicating) and the high pressure area in Sections 33 and 4, so that at that time I do not believe there was drainage from that area.

Q Do you want now to chan e your testimony and say there was not drainage from that area?

A No, I am not changing my testimony. I previously testified I did not believe there was drainage from the northwestern end of the pool to the southeastern end at that time.

Q Do you think there is drainage now from the Shell well to the Stanolind?

A Yes, in this way. I am not sure that any identical barrel of oil has drained from Sec. 19 to the southeastern part of the field, but oil has come from Sec. 4 to the southeast, and the oil from Sec. 4 has been replaced by oil from Sec. 33. I am not certain that any barrel of oil has drained from that point to this point (indicating on map), from the northwestern end to the southeastern end, but oil has drained from Sec. 4, and replacing the oil from Sec. 4 has been oil from Sec. 33, and

and the oil going out of Sec. 33 has been replaced with oil from Sections 29 and 32, and the oil moving from Sections 29 and 32 has been replaced by oil from Sections 19 and 20.

Q You do not claim any direct drainage?

A Not direct drainage, not by directly moving a barrel of oil clear to the southeastern end. The oil coming from Sections 19 and 20 may not have gotten past the south line of Sec. 30. It has moved into that territory to replace the oil goingfarther southward, and in that way the southeastern area has drained the northwestern territory.

Q Dr. Knappen, I will ask you if you know what pressure is reflected by the last survey of the wells along the south line of Sections 32 and 33?

A There is only one pressure shown along the south line of Sections 32 and 33, the Gulf No. 5 West Grimes -- 1242 pounds.

BY JUDGE LOWE: What date?

A In September, 1939.

BY MR. WOODWARD:

Q I will ask you what the bottom hole pressure of Continental State No. 3 is?

A The Continental State 3-B, in Sec. 33 had a pressure of 1210 pounds at that time.

Q Drop half a mile south and tell what the pressure was in Stanolind State No. 26?

A 1220 in Stanolind State No. 26 in the NW¼ of Sec. 4.

Q I will ask you what the pressure was in Stanolind Byers No. 8?

A The pressure is not shown -- I beg your pardon, I was looking at the wrong well - Stanolind Byers No. 8 is 1210 pounds.

Q It has the same pressure as the Continental well?

A It did.

Q And the Stanolind state lease is ten pounds higher?

A It was.

Q How could oil jump over or under that?

A Because of the lower pressure -- Byers No. 8 and Stanolind No. 26 had 1200 pounds pressure, in Sec. 29, to the SW¼ NW¼ of Sec. 3, there is a ten pound pressure across there.

Q That is south of this well?

A Alright.

Q This pressure - higher pressure here is also -- what did you say, 1210 pounds pressure. Certainly on your theory the oil would not move past the low pressure against the high pressure?

A No.

Q It would not move against the high pressure?

A No, it would not move against the high pressure. It moved in the direction of this pencil (indicating on map) from the northwest to the southeast. At the same time the oil was moving straight south from the Byers No. 8, and at the same time oil was moving eastward from Stanolind No. 26, and you would have a low pressure area draining from the higher pressure leases.

Q Dr. Knappen, according to your theory, the oil just drained around the high pressure wells?

A Oil never moves from low to high pressure, naturally.

Q Moving from this high pressure down to the low pressure, with these high pressure wells in between, would you have it moving around the Stanolind No. 26 well some way to get down there?

A In moving from the Continental No. 3-B it would not pass through or close to that area (indicating).

Q Who owns those wells?

A Stanolind, Texas, Repollo, the successor of Shell.

Q And if there is any drainage, it was from Stanolind leases on to those you have mentioned?

A So far as the movement south from Stanolind it was to Stanolind or the others, and there was also drainage --

Q (Interrupting) I don't understand how it drained around that well.

A There is a general differential pressure between Continental 3-B and Stanolind No. 29 Byers; that passed here, this mark between here (indicating) some 1800 feet away from the Stanolind well, which is shown by the high pressure here (indicating).

Q Let's look at the 1935 pressure map.

A I have 1936 and 1933 -- (looking) We don't seem to have it here.

Q May we put the 1935 pressures on the 1939 map in pencil?
MR. CARD: Reading: Continental State No. 6, Sec. 33, 1270 pounds.
Q Continental State No. 5, in Sec. 33?
A 1280 pounds, putting it in in pencil.
Q Gulf Grimes East No. 1, in Sec. 33.
A 1258 pounds.
Q Stanolind Turner No. 29, in the SW$\frac{1}{4}$ of Sec. 34.
A 1308 pounds.
Q Stanolind Byers No. 8, in the NE$\frac{1}{4}$ of Sec. 4.
A 1283 pounds.
Q Stanolind Byers No. 8 in the NW$\frac{1}{4}$ of Sec. 3.
A 1280 pounds.
Q Stanolind Byers No. 26 in the NE$\frac{1}{4}$ of Sec. 4?
A 1282 pounds.
BY MR. WOODWARD: addressing Dr. Knappen:
Q Drawing your attention to the map, do you find that Continental State No. 6 is 1270 pounds, and State No. 5 is what?
A 1280 pounds.
Q The Gulf No. 1 East Grimes is 1258. Let us drop below the north line of Sec. 4, and we find Stanolind Byers No. 8 is what?
A 1283.
Q Is that higher or lower than any above the line?
A Lower than any of the wells --
Q You mean 1283 is --
A It is higher.
Q State No. 26 Stanolind, 1282, is that higher or lower than the wells above?
A It is higher than any of the wells you have indicated in Sec. 33.
Q Take Stanolind Byers No. 8 in the NW$\frac{1}{4}$ of Sec. 3, 1280 pounds. Is that higher or lower than any of those wells?
A 28 pounds more than the SW$\frac{1}{4}$ of Sec. 34.
Q Take Stanolind Turner No. 29?
A 1308 pounds.
Q Is that higher or lower?
A Higher than the south offset by 28 pounds.
Q Dr. Knappen, why didn't you prepare an exhibit of the pressures

in 1935?

Q We prepared four exhibits, showing the time when the proration plan was changed, and we were afraid more would tire the Commission.

Q You did leave out the 1935 survey?

A We left out many surveys. There was a survey made every six months.

Q Explain how the oil gets down to the southeast end of the field, does it go over or under this high pressure area?

A From over here in this high pressure area (indicating).

Q You mean to say the oil comes way around here (indicating)?

A No, I don't mean the oil travels through this, to the low pressure area down in here. There is a high pressure area on the north line of Sec. 4, the northwest corner of Sec. 3, at the time.

Q It does not come right across that?

A It does not come in a straight line. It always moves from high pressure to low.

Q Let us turn back to the map with the hump (Witness turns to Exhibit No. 10).

You are familiar with the wells that have set gas packers?

A In a general way. I have prepared a map showing the gas packers, if you would like to have it.

Q Could you approximately outline where the gas cap comes to by the gas packers?

A No, I couldn't without the data. I will have the gas packer map in a minute. (Produces map). There is a map which shows the gas packers and the water packers.

Q Let us go to this big hump, now, from your map --

BY GOVERNOR MILES: (Interrupting) Is this map which you are reading from now been introduced as an exhibit?

A No, it has not. I did not intend to show that. It may be material and we may enter it as an exhibit.

BY MR. WOODWARD: It may become very material.

A We are perfectly willing to introduce it as an exhibit.

BY JUDGE LOWE: We have no objection.

Q From your packer map, will you indicate in the record what kind of a map you call it?

A A verticle section.

Q Will you indicate on that vertical section the Shell McKinley No. 4 in the W½ of Sec. 19?

A It is not on that section.

Q You have the wrong cross section. (Witness turns to Exhibit No.4). Now can you locate the approximate location of the McKinley No.4?

A The Shell McKinley No. 2 is the offset to Shell McKinley No. 4.

Q Will you make a dot there?

A Whatever you say.

Q Now, at what sub-sea depth is the packer set in that well?

A We don't possess that data. I don't know.

Q Do you have that data with you, Dr. Knappen?

A I am not certain whether we have it or not. It is in the report of the Hobbs Engineering Committee.

BY MR. CARD: I have a map showing it, if you want to accept it.

A I am not sure --

BY MR. WOODWARD: We will leave it subject to your inspection.

For the purpose of this examination I am not asking you to agree or disagree with facts.

A As soon as I am satisfied they are facts, I will readily agree. I never disagree with facts.

Q Have you got McKinley No. 4?

A The depth of the first setting or the recent setting?

Q The last?

A The last was set at -474.

Q Will you put a dot on that map approximately where that falls?

A (Making dot) Approximately there.

Q Take McKinley No. 3.

A McKinley No. 3 is the diagonal offset to this same McKinley No. 2.

Q 476 sub-sea depth?

A Only two feet different than the other numbers. The packer, according to our record, is -533.

Q Let us turn to Humble Bowers A-1, in the SE¼ of Sec. 30, is that No. 1 or A-1?

A It is A-1 and B-1.

Q The $NE\frac{1}{4}$ of 30 -- the $SE\frac{1}{4}$ of Sec. 30, that should be No. 5 -- A-5. The Bowers A-3 in the $SW\frac{1}{4}$ of Sec. 29, the sub-sea depth is 461?

A 461.

Q This one was 471 (indicating on map). Now, Stanolind State No. 26, in the $SE\frac{1}{4}$ of Sec. 33?

A 459 feet.

Q Correct. Now, Dr. Knappen, we will lay a straight-edge across this cross section of yours where the packers have been set. Does that mean everything above here is gas? Is that all gas up above there?

A In the particular wells where packers have been set it has been abandoned for oil production, yes, sir.

Q This gas cap, standing up here at the top, has pretty well cut this off?

A No, I would not say that, because you have this here (indicating).

Q I asked if the gas cap had not pretty well leveled this formation off? Here the gas will cut off everything above the gas?

A Not the adjoining wells.

Q Where there is gas, everything above that in adjoining wells has been cut off?

A Not the neighboring wells.

Q Where the packers have been set, everything above the gas, then?

A Still not in the neighboring wells.

Q Everything above in that well the gas has cut off?

A Not in the neighboring wells, that one yes.

Q In the production section, down here, past the center, toward the south, are the production sections toward the north in these wells, it is approximately the same, isn't it?

A I am not sure I know what you mean. That the production section is approximately the same on the south and north?

Q Yes.

A The total thickness of that pay is approximately the same, yes.

Q That is better. What is the matter with straight acreage then?

A If you mean to say that because the thickness of the producing pay is the same, you are ignoring the quality of the pay. The quality of the pay is very different in different wells. The only way to determine that is --

Q (Interrupting) Just answer my question.

A As an expert witness I have a right to explain an answer. To say the same thickness of pay will produce the same amount of oil is to make a mis-statement, and I will not do that.

Q The productiom section is approximately the same?

A I told you it was, but the quality is different.

Q I thought you said it was, but the quality was not.

A The production section is approximately the same thickness, but not the same quality.

Q You have extended this section out here to the Stanolind dry hole. What was the closest producing well to that inside of your cross section?

A The first producing well is the Repollo No. 2. The closest producing well is the Texas No. 1, south.

Q That should have been cut off right along there (indicating on map) to stay within the production area?

A Yes, that is quite true. It is entirely possible the bottom of the section should have been drawn to 595, producing a cross section at this level (indicating on map). That was drilled in tight, impervious section. At that time, at the same level, it is entirely possible there was oil production. We have been generous and drawn the line here (indicating).

Q This map would be an inch and a half too long, taking this dry hole?

A No. As I tried to explain, when you would not listen, the exact position of the water line is not known. In No. 1 State they found oil at 610 -- I don't mean that is the highest where oil was found --

Q (Interrupting) Wait a minute. This is a cross section?

A From the northwest to the southeast.

Q This is the length -- this represents the length (indicating)?

A That is lying vertically.

Q You kept on going until you hit a dry hole?

A Surely.

Q What is the scale of this cross section in length?
A The horizontal scale, measured sideways, is one inch to 1500 feet.
Q What is the scale, the perpendicular scale?
A One inch to 25 feet.
Q If you put the horizontal scale on the same basis as you did the perpendicular, how long would this be (indicating cross section)?
A It would be sixty times as long as it is now.
Q Are you sure of that?
A Sure.
Q Would it really be that long? How long is it here?
A Roughly, two feet -- two feet -- 26 inches.
Q Sixty times that would be 120 feet long?
A That is right, if the vertical were the same as the horizontal.
Q If these bumps were stretched out sixty times this long, would that be reduced (indicating cross section)?
A No, the difference would be there.
Q This difference that you have, that would not be the true condition?
A It will be the true condition as a geologist would draw a cross section. I said last night that the slope is only four and a half feet in two miles and a half, it is so flat the slope is only one degree to the southeast, a slope so gentle it is barely discernable.
Q In the field?
A I made no point of these particular bumps.
Q In the field there is a very, very regular thickness of the pay section?
A No, sir, not at all. That is what I pointed out.
Q You testified this --
A (Interrupting) They pay section only occupies a portion of this. You keep going back to the bumps. There is a very uniform slope to the southeast, very gentle -- this is greatly exaggerated in this section. The slope down from the crest to the southeast end is one per cent, barely perceptible. From the northwest it is one third of one per cent, only a man with his eyes trained could see it.

Q If you have uniformity in the production section, would you say that acreage would be entirely wrong in allocation?

A No; if you have uniformity in quality you would have uniformity in bottom hole pressure.

Q What makes the variation in uniformity?

A Variation in porosity in the pay -- variation in the porosity and permeability.

Q Is there varying porosity in this field?

A Tremendous.

Q How do you measure the porosity in a lime field?

A By taking cores of rock.

Q Did you ever see a core from the Hobbs field?

A I have not.

Q Did you ever take a core here (indicating)?

A I have not.

Q Did you ever take a core here (indicating)?

A I am inclined to think there were a few cores taken in the northwestern part, and no cores taken here (indicating).

Q Don't you know, as a geologist and a scientist, that you can't take cores in a lime field?

A No, sir, we can.

Q That represent porosity?

A We average an 80% recovery in a limestone core. It has been said you can't take cores in limestone, but the Gulf does. We do.

Q You are better than most then.

A Perhaps you would like to have me make an explanation.

Q If you can.

A You cannot get a core from a cavity. When you have a cavity four feet across, you get no core. Accordingly there are sections where you get no core; but with an area of this kind, we will get two cores out --

Q (Interrupting) Then you say there are cavaties through the field?

A I said there were cavaties on top, not the flanks.

Q How do you go about taking a core in one of the caverns?

A I just explained you could not. I said where you have caverns, you get no core.

Q How do you know there is uniformity in porosity throughout the top of the structure?

A I don't know there is. I have testified repeatedly there are variations in porosity and variations in permeability in the top of the structure.

Q The more cavernous a formation is, the more permeable?

A Yes, assuming the caverns are connected, and they almost always are.

Q Would you say permeability has anything to do with porosity?

A Not necessarily. Permeability is the measure of the composition of the rock to permit fluids to move up through it. Porosity is the measure of the open spaces. It is possible to have high porosity and low permeability. Pumice may have so much porosity it will float on water, but have no permeability. Nor is high permeability associated with high porosity.

Q I take it from what you say it is possible to have just as much oil in the tight sections as in the porous sections up here (in dicating on map)?

A As a theoretical proposition, it might occur. Bottom hole pressure shows --

Q (Interrupting) What do you say bottom hole pressure is?

A The pressure of the fluid in the reservoir.

Q What causes bottom hole pressure in the Hobbs field?

A Originally it was caused by the water on which the oil floated. The pressure at present is caused by the pressure of water from the flanks and pressure of gas escaping from solution.

Q Then we have a gas cap pressing down from the top and water pressing in from the edges acting to maintain the pressure in the field?

A That is true.

Q We find on this section there are different parts of the field where you find differant bottom hole pressures?

A Correct.

Q What does the bottom hole pressure represent, any portion of the original pressure?

A If that has not been destroyed by the removal of oil - they have been restored by the movement of oil and gas.

Q What causes pressure to be greater in spots than in others?

A As a general rule, if you have wells of equal depths, near one another, the well with the higher pressure -- the well with the high pressure has removed a smaller percentage of the oil around the well.

Q Wouldn't you say the water coming in from the edges and the gas pressure would cause that?

A They are things that maintain the pressure. That, and also a great deal of residual pressure that has been there since the field was opened up.

Q You do not have an intrusion of water or an expansion of the gas cap until the oil has been removed?

A No.

Q Isn't it reasonable to suppose that the well that has removed the most oil would have the higher pressure?

A No more reason to suppose that than to suppose the opposite -- the one removing the most oil; other things being equal.

Q Let me call your attention to this, in applying a pincher to a bottle, as in the experiment here, the bottle does not have outside pressure, and that is where your theory falls down?

A That is not where the theory falls down -- you have distribution of pressure through the field. That is the reason you have migration of oil. The pressure is all the time attempting to move the oil from the areas of high pressure to those of low. Down in this area (indicating) you are taking the oil out faster than the oil and water will come in, and they are making an area of very low pressure.

Q Permeability is the measure by which a fluid will move through a porous medium?

A That is correct.

Q Then the more permeable a well is, the more readily water will come in?

A The more readily any fluid will move through it.

Q We are talking about water.

A That is only one factor affecting water encroachment.

Q The more fluid that moves in, the greater the pressure build-up?

A No, water is not coming in fast enough to build up the pressure.

Q I call your attention to the southwest flank?

A You are overlooking the distinction between maintenance and build-up. Water is not coming in fast enough -- the encroachment has maintained the pressure to some extent.

Q The fact that water comes in more easily, the pressure will be maintained, and you said it came into the more permeable well easier?

A Yes.

Q Then it must be so that wells with high permeability have the highest bottom hole pressure?

A Not necessarily.

Q What is the supposition?

A The bottom hole pressure in the well is a question of what percentage of oil has been removed and how much drainage there has been to or from it.

Q Therefore, the more oil you take out, the more water will come in, and the easier it comes in, the more pressure you have got in the bottom of the hole?

A If you have an adequate supply of water to come in there. As I tried to explain, the operator being flooded must take the oil promptly. Therefore, the bottom hole pressure is high, and he is entitled to take the oil faster, but he is not entitled to take the oil from below his neighbor and he should not be permitted to take oil from his neighbors. He is entitled to get the oil before water encroachment floods his property.

Q You said the permeability is no measure of the oil in place?

A That is true.

Q If it is no measure of the oil in place, why should a high potential well, a high bottom hole pressure well have any greater allowance than a low one?

A Because the oil moves to the area of low pressure from the high, to equalize the pressure. The high pressure property is entitled to produce the oil and reduce the bottom hole pressure to an equality with the rest of the field. That is true whether it is permeable or slightly permeable.

Q You have admitted a high pressure well would not have any more oil in place?

A No, I didn't admit that. I said theoretically it was true if you have high permeability. I don't know what the facts are. The only measure of bottom hole pressure, if you take oil out, the pressure must go down. If you take more than your share, if my bottom hole pressure is greater than that of my neighbor, the oil goes there.

Q Someone questioned you about the intrusion of water from the edge, and I think you said there was no intrusion there of water?

A No, I said it was slow, I did not say there was not any intrusion. All of these wells in the southeastern part of the field produce large volumes of water. To correct that, to hold your well's equilibrium, it is necessary to set packers, therefore it is possible to produce water as fast as it intrudes, and that is the reason the water is not moving across the field. That often happens.

Q Dr. Knappen, which will move through the formation more easily, oil or water?

A If you are trying to start an oil well, and if the oil occurs with the water, it will move through more easily.

Q We do have some water intrusion down here? (Indicating on map).

A Certainly.

Q Why dosen't the water come into the field from the southeast flank?

A It may be you are producing water just as fast as it comes in. We have a number of pools where it is produced just as fast as it comes in, and the water has not advanced across the pools.

Q Do you have high or low permeability?

A Low permeability.

Q As a matter of fact, isn't it true that with low permeability, that the water will not come through as fast as the oil?

A No, I will not say that. It will not come through much faster.

Q If the water will not flood this area (indicating on map) until this oil comes down here (indicating) you have one type of permeability --

A I do not say you have the same sort of permeability on Sec. 10 The permeability is higher on the north, therefore you have a better chance for the oil to come in than for the water.

Q I don't quite understand. If this is so low in permeability that the water will not come through --

A (Interrupting) We are assuming it is the same permeability all across there (indicating on map).

Q I am talking about the southeast end.

A That is not true.

Q Is there any great distinction in permeability in the southeast area?

A Yes, sir.

Q How far up?

A There are very high potential wells on the south line of Sec. 4, and the south line of Sec. 3. I don't mean 20,000 barrel wells, but you do have ten and fifteen thousand barrel potentials, while a mile south you have one to five thousand.

Q Weren't these wells acidized?

A Yes, I presume they were.

Q Do you know what the potentials were before acidation?

A I don't know as to the particular wells. I know the acidation campaign was very unsatisfactory because the permeability is so low.

Q It is a fact we did not get as large potentials by the use of acidation as the more permeable wells?

A Certainly.

Q There was a greater percentage of increase in the low permeability well than the high?

A Oh, yes, when you add a thousand barrels to a thousand barrels you have a greater percentage of increase than if you have 20,000 to start with.

Q By acidizing these wells, you made from your three to five thousand barrel wells, twenty to some, approximately, 23,000 barrel wells?

A You say three to five thousand barrels?

Q Yes, and by acidizing they were from three to five times as good?

A You say three to five times as good as the best wells. You see you have different permeability along the south line, low permeability, as compared to the high permeability along the north line.

Q Dr. Knappen, I want to ask you this question: If the oil had not been in place when you used the acid, how could you increase the potential? If the oil had not been down in the ground, how was it possible to increase the potential?

A You couldn't.

Q The oil was there?

A Certainly.

Q When you used acid you increased the permeability?

A Increased the permeability immediately around the hole.

Q The potential is a measure of permeability?

A Potential is a measure of permeability, yes.

Q Then when you prorate that field on potential, you are prorating it on permeability?

A Surely.

Q And permeability is no measure of the oil in place?

A No. Let me explain that. If the well potential is not satisfactory as a yardstick, and needs to be corrected by bottom hole adjustments, you may get too high a potential, that is the reason you do not prorate any pool on potential alone.

Q Do you say, Dr. Knappen that permeability is not a measure of bottom hole pressure, or bottom hole pressure is not a measure of permeability?

A No.

Q Tell me why, then, when this pool is shut in, all the pressures do not equalize?

A They will if it is shut in long enough.

Q If permeability has nothing to do with bottom hole pressure?

A Give it time and you will have the same pressure. In twenty years you will have very fair bottom hole pressure. High permeability simply gives an opportunity for bottom hole pressure to equalize. Do you get the distinction?

Q I get the idea, as in this room, the more windows you open, you get more wind blowing through?

A Yes, sir.

Q And the more pressure you will have in the room?

A That depends on what windows you have on the other side.

Q And in this case, the more permeability, the more pressure?

A No.

Q If that is not true, and permeability has got nothing to do with pressure, why isn't --

A (Interrupting) May I say, permeability provides the opportunity for the pressure to equalize. When a well is producing, and you reduce the pressure in and around the well, if the permeability is high, the pressure will equalize at the intake quickly; if it is low, it may take twenty-four, thirty-six, forty-eight hours for the pressure to equalize. As between two areas a mile apart, it takes the maximum to equalize across a distance. Where the permeability is high, the pressure equalizes more rapidly.

Q Because the pressure will work more easily?

A It will drain off from high to low.

Q It will --

A (Interrupting) The wind will never blow into a room where there is a pressure trying to force the air out.

Q Dosen't that presuppose permeability is a measure of bottom hole pressure?

A No, you are confused. Permeability is a measure of the rock the fluid can travel through, if the fluid traves through easily, it has high permeability. You could drain every drop of fluid out of a structure, and your permeability would remain exactly the same, but bottom hole pressure would be tremendously different.

Q You are familiar with the 15-day shut-in they had at Hobbs?

A I have heard of it.

Q Are you familiar with the bottom hole pressure measurements made at Hobbs?

A I know a number were made.

Q You know it to be a fact that a great deal of difference was found in those pressures?

A Surely.

Q Why didn't they equalize?

A Because fifteen days is far too short a time for the bottom hole pressure to drain the oil from the northeast down to the southeast. Doing the best it could, 360 barrels a day is not enough to make up for the 900,000 barrels produced over the past five years.

Q You have an average of a three-pound build-up?

A On some seven or eight wells.

Q What was the equalization up on the higher permeability?

A No difference after the first twenty-four hours.

Q They built up much faster in the permeable area?

A Yes, on the west line lease, high permeability, we have had wells we cannot discern the difference by the bottom hole pressure in a shut-in. There must have been one pound difference to bring the oil into the well, but this was so slight when it was producing it was not discernible.

Q You did have high pressure?

A Yes, sir, and we had an awful lot of oil.

Q You did have a high permeability section?

A Yes, sir.

Q You still say permeability is not a measure of oil in place? You could have a tight section and have as much oil as you had in this section?

A No.

Q The porosity then?

A You cannot have as much oil in porous rock as you can in a cavern, if you have 100% floor space, you would have more space to be filled in than if the room were filled with furniture. We may have had more than you could have had in any rock of low permeability.

Q You have calculated this drainage down into the Stanolind area, you calculated that as 518,000 barrels?

A 551,000 barrels.

Q On what basis did you calculate that?

A On the basis of the differentials in pressure of the wells north of, and the wells south of the red line through the wells previously described. The differences in pressure which show consistently on every pressure survey that has been made, showing the tendency of the oil to move from the north to the south across the line, using the formula Mr. Tasch explained to the Commission.

Q You used the formula in Mr. Muscat's book?

A That is right.

Q Isn't it a fact that formula is confined to homogeneous fluids?

A No, I don't know it is.

Q Isn't it a fact that the same book of Mr. Muscat's says the problem is determined the same way to determine the flow of hetrogeneous fluids --

A (Interrupting) We have used the formula on the basis of flow through rock, on the assumption that the oil did not carry a large volume of gas. We reduced it from 1.8% to 1.25% so as to take care of possible gas coming out of solution.

Q Your figures are on the basis that that oil coming down structure had no gas in it?

A I did not say how much oil -- I said the drop in pressure would move the oil.

Q As an engineer, wouldn't you say that gas had come out of solution?

A Yes, it probably was coming out.

Q Some gas in the solution?

A Certainly.

Q Would you say there were any other properties mixed with the oil?

A You can't mix properties.

Q Would you say any other fluid was coming down structure with the oil?

A There was no indication there was any water in that.

Q Then what you did was apply the formula which is designed to determine the flow of homogeneous fluid?

A That is right.

Q I want to ask this: We determined all the upper part, in certain wells is gas?

A That is true.

Q That is, in the upper formation?

A Perhaps I should qualify that and say that primarily the gas operates as a shut-off.

Q This shut-off operates so there is no possibility of the oil ever passing to the lower formation and being produced through that?

A That is true.

Q If this upper formation is primarily gas, how could you drain the oil down to the southeast part of the field?

A This upper formation is continuous. The oil is contained in the formation on the northwest side, around the northeast flank and on down the southeast part of the pool.

Q You don't claim the fluid moves through the cas cap?

A No.

Q The movement is around it?

A The movement is around it, and part travels through the wells from the upper to the lower, and moves over into the low pressure area. Unfortunately we do not have a map that shows that exactly.

BY GOVERNOR MILES: We will be in recess for five minutes.

(Dr. Knappen continues on witness stand for cross examination)

BY MR. WOODWARD:

Q Dr. Knappen, did I understand you to say a moment ago that in calculating the amount of drainage you claim from the north to the south, to the Stanolind leases, you had made some adjustments in permeability because of gas in solution?

A Yes, sir.

Q What adjustments did you make?

A We reduced the productivity factor from 1.8 to 1.25 -- approximately a 33% decrease.

Q How did you calculate that reduction?

A Experimental curves, in laboratory work, which showed there would be a 75% decrease at the maximum decrease for such conditions, as compared to the initial condition in the pool. The productivity was determined after a drop in pressure of 20%. Normally, a 20% drop in pressure should correspond to such a decrease. We thought we should make a 37% adjustment. We made a 65% to be sure.

Q Has there been any published or accepted formula?

A Dr. Muscat published a paper on the change in permeability of gas and oil sands saturated with gas and oil, after the préssure is reduced and the gas comes out of solution.

Q These calculations you made from laboratory experiments represent conditions as they exist at Hobbs?

A As closely as we could, yes.

Q Now, if you were positive those conditions were accurate in the laboratory, why did you put in this additional factor?

A Because, as I said, we wished to be generous and set the figure plenty low.

Q You were not sure of the figures obtained from the experiment?

A Not precisely, no, we did not know, we had no way of knowing what percentage of the original oil in place had been produced from the formation.

Q Then the figures you obtained must be more or less guess-work?

A No, not guess-work, engineering calculations.

Q You have given an additional factor, over and above the laboratory work, to make sure of being generous. If you were sure of your figures, it was not necessary to give that additional factor so generously?

A Every capable engineer puts a factor of safety into their work to take care of any possible flaw.

Q Dr. Knappen, when you multiply two by two, do you put in any safety factor?

A No. Do you?

Q Now, Dr. Knappen, with respect to drainage that we were tàlking about a moment ago, from north to south, which you said could have gone around the northeast edge --

A (Interrupting) If I might interrupt right there -- I was not entirely fair. I said it had gone around the northeast side. It could also have gone over the top, because you will see the oil in this area, the northwest part of the field, it is higher than the top of the sand break in the central part of the field. This section (referring to map) is not drawn to the highest part of the field. If it had been drawn so, we would have shown the northwest end of this section at a point indicated by my finger (pointing on map), and we would then have had our oil shown some 80 feet higher than the top of the sand break in the highest part of the pool, although there has been so many wells set with packers, there is nothing to prevent the oil migrating through the lower portion of that.

Q It did not migrate through the gas cap?

A It could very easily, while a packer has been set at such a point as this, 450 feet, it does not mean that area is barren of oil. As a conservation measure, if it was abandoned, shut off from production, as shown, it may still have had 50% of the original oil when it was abandoned.

Q Isn't it a fact that packers have been set, either for water or for gas, along the center of the field, from east to west, directly north of the north line of Sections 4 and 3?

A What is that?

Q Isn't it a fact that packers, for either oil or water, have been set in wells, from east to west, along the north line of Sec. 4?

A Yes, that is true, and along the north line of Sec. 5 there are packers in every well.

Q And part of Sec. 3?

A No, there are no packers in the three offsets, according to my information.

Q The Samedan well out on the edge, Terry Nos. 1 and 2, I should say are high pressure wells, aren't they?

A There is a little too much detail to remember (looks at records). In one the pressure is 1225 pounds, and the other the pressure is 1185 pounds, on the last survey.

Q It isn't likely there has been very much drainage through those packer wells, or around to the extreme northeast edge of the field, is there?

A Not through the packers. There will be drainage through all of the forty.

Q Does the fact that packers have been set indicate a gas cap?

A Gas or water.

Q And there is very little oil to be drained?

A No, we have set packers when we were producing 10,000 cubic feet of gas with one barrel of oil. We may have agandoned a formation when we have less than 50% recovery of oil. We do not want to waste the gas in the pool; it is for the benefit of all. We may have left large amounts of oil in the gas cap. The northwest end of the pool is higher than the sand break in the center, and under the influence of the higher pressure, there may be a large migration of oil above the packer, through the lower portion of the gas cap.

Q You agree with me that the oil did not move from here clear down to here (indicating on map)?

A I said no single barrel of oil had moved from the northwest to the extreme southwest.

Q Now you say it will?

A I have not said that. I said if oil moves a mile, and that oil is replaced by oil that has moved from there, and that has gone on consecutively, you have taken oil away from the extreme northwest to the extreme southeast.

Q The only migration of oil that may have gone out of the gas cap is oil abandoned by the operators?

A It has been in that particular well. In the West Grimes lease we have set a gas packer, and we are producing from that same pay horizon. It has been abandoned because of too high gas-oil ratios, and we are still down on the flank recovering the oil.

Q Therefore, there was no drainage from your wells up structure?

A In that particular case they were taking part. The well pressures were still too high, and there is still drainage to the low pressure areas.

Q Going back to pressure, I call your attention to the exhibit of Stanolind. There are twenty wells represented there on the exhibit. I believe the testimony showed ten wells had an increase of potentials, and ten wells had decreases, although all twenty wells had decreases in bottom hole pressure. (Referring to Stanolind Exhibit E).

A Oh, yes, the average pressure in the pool has declined and I know of no wells that have maintained their original prèssure.

Q You testified that bottom hole pressure was used in some 12 to 15 pools you were familiar with?

A I happen to know those, possibly there are many more.

Q Do you know of any pool where potentials are increased in the face of dropping bottom hole pressure?

A Yes, sir.

Q Where?

A The South Burbank Pool, and it was done on a few leases in the Moore Pool.

Q Don't you know the present plan is that bottom hole pressure in the South Burbank and Moore will be discontinued?

A I know they will discontinue it and that your company is in favor of the plan and it was of great benefit to the Gulf in the Moore Pool.

Q As to the proration formula you suggest, 75% potential and 25% acreage, would that not increase the allowables of the high potential wells at the north end of the field where large quantities of water are being produced?

A I presume it would.

Q Wouldn't that lead to waste?

A No, it is the only means of operating the high pressure wells so the operators could recover the oil under the property. There is no place those operators are draining oil, and the only way they can recover the oil is to take it before the water comes in. The only fair thing to do with a high pressure property wherever you have one, is to give it an increased allowable so that the operator can secure the oil before another operator drains it away.

Q The more water you produce, the more reservoir pressure you lose, isn't that a fact?

A No.

BY MR. WOODWARD: I believe that is all for the present. I would like to have the opportunity to ask Dr. Knappen some more questions tomorrow if we find it necessary.

BY GOVERNOR MILES: In view of the fact that we have another nearing on the oil and gas ratios set for tomorrow at ten o'clock, whihc it is necessary to hear -- I know Mr. Andreas has to leave, and some of the others here -- I doubt whether we are going to be able to finish all the testimony. How much longer do you think it is going to take in this particular case?

BY MR. WOODWARD: I have two or three other questions to ask after consulting with the engineers here, and if anyone else has any questions to ask, I would suggest that we go ahead.

BY GOVERNOR MILES: You would be able to finish from nine until ten o'clock in the morning?

BY MR. WOODWARD: I can finish tonight.

Q You read from an exhibit last night in which, I believe Mr. Wahlstrom and Mr. DeFord were discussing the physical charatter-istics of the Hobbs Pool. Do you have that?

A I believe I have, or a copy of it.

Q Will you turn to page 77? You will find a paragraph which has this statement, "It may be said it was the most productive member of the White lime". Dr. Knappen, will you read to the Commission the paragraph on page 77 which commences "The top productive member of the White lime --"?

A I am reading from page 77 of the article by Ronald K. DeFord and Edwin A. Wahlstrom, published in the January, 1932 Bulletin of the American Association of Petroleum Geologists, the article being entitled simply "Hobbs Field, Lea County, New Mexico", on page 77 you will find the paragraph I am reading:

"The top productive member of the 'White lime' is cavern-ous on the crest of the structure, fairly porous on the flanks, and off structure is in places only very slightly porous, in other places somewhat porous. On the flanks, the lower pprous member, particularly the 'Caps pay((all relatively unim-portant on the crest), generally yield much more oil than the top member."

Q Now, Dr. Knappen, you read the same paragraph yesterday, didn't you?

A I am not sure I read it. I may have. I read a number of paragraphs.

Q The record will show. Why didn't you read the last sentence of that paragraph?

A I said I don't remember whether I read that paragraph or not.

Let's see -- I introduced the exhibit for the benefit of the Commission. I had no intention of omitting the last sentence, "On the flanks, the lower porous members, particularly the 'Caps pay' (all relatively unimportant on the crest), generally yield much more oil than the top member." The Capps pay was unimportant. The acidation of the Capps pay on top of the structure has tremendously increased the pay on the top zone. I had no thought of misleading the Commission. If I did, I am sorry.

Q I believe you claim, Dr. Knappen, that bottom hole pressures are not indicative of oil in place. Do you claim that?

A Bottom hole pressures are not indicative of oil in place, except if you have high bottom hole pressure, as compared to a neighboring area, that indicates that the area has not produced its fair share of oil. A low bottom hole pressure would indicate it had produced more than its share. Obviously that refers only to pay. One might drill a water well off structure and have a very high bottom hole pressure, but if you have very high bottom hole pressure with all water, he would never get an allowable.

Q You do not contend that because a well has high bottom hole pressure, it does not have any more oil than the low?

A It is not a measure of the amount of oil, but the percentage of the oil one will produce in comparison to what another will produce.

Q Is it not a fact that instead of being a measure of the oil produced, it has been a measure of the oil and water and gas that has come out of solution?

A No, it is not a measure of those things. Remember, bottom hole pressure simply indicates the oil being drained underground and from high to low areas.

Q What compensating factor do you have for the water produced?

A I don't think any compensating factor is necessary. When the operator produces all the oil under his land, he will plug in the hole.

Q Wells are still producing oil and have produced a large amount of water; how have they been compensated?

A In part by the bottom hole pressure adjustments, but it has been applied to only a small part -- if it were applied to 75% of the allowable -- we do not have the pressure map of Hobbs survey as made in 1939.

Q It is true the relationship -- rather say, there is no relationship between the oil in place and the shaft pressure adjustments?

A At the present time -- when you say "shaft pressure", you mean bottom hole pressure?

Q Yes.

A At the present time bottom hole pressure is negated, and we have developed low pressure areas with drainage of oil from the rest of the pool. I am not sure I have answered the question.

Q The think I am trying to bring out is the fact that you are contending for bottom hole pressure adjustments?

A Exactly.

Q But you make no compensation for the great amount of fluid produced previously?

A I see no reason. It is the present bottom hole pressure as compared to other areas. If the pressure is too high, oil is being drained.

Q Do you want to give every property the opportunity to recover the oil under it?

A Just as far as we can, and the only way we can -- the oil is never going to come from low pressure areas and move against high pressure.

Q You seem to be in the minority among engineers I have talked to.

A Perhaps they would like to testify.

Q You testified this morning respecting factors used in determining the value of properties for purchase?

A I named a few, not all by any means.

Q Do you, as a purchaser of property, do you consider and inquire into what the shut-in pressure may be of a lease or property?

A Most certainly.

Q How much weight do you give that?

A It depends on the property and the pool. Shut-in pressure frequently gives the best measure of the recovery reservoir under the property. I don't mean I apply that to every property -- there is a wide difference between pools. We do certainly investigate the shut-in pressure.

Q You know the west side leases, in East Texas, have the highest pressure?

A I think --

Q And you know the western, or west side leases have the least oil in place?

A Certainly.

Q It would not work in that case?

A I did not say --

Q You would not work with that alone?

A I would use shut-in pressure as one factor.

Q You would work ~~with~~ bottom hole pressure either way?

A No, not either way. The west side leases in the East Texas Pool are entitled to produce at a higher rate; the oil is leaving the west side properties, and they are entitled to a higher rate of production a day. If they don't get it now, the oil will get away.

Q The same thing is true of the edge of the Hobbs pool?

A If a lease's history is one in which the pressures are high, those leases must get the oil shortly, or they will lose it. I tried to say to Mr. Ray that some properties may be depleted in eight years, some in twenty-five, and the man whose property will be depleted in eight years should be allowed to keep down to the pool average. Nobody should be allowed to put pressures below the pool average.

Q That was not the case with the Stanolind, on the southwest flank, they were not given such pressure adjustments?

A I don't know the application of the proration rule. They should have been given a pressure adjustment factor if the pressures were higher than the pressure in other leases in the pool.

Q You know by setting packers, we did not have the advantage of the pressure adjustments you have been talking about?

A I testified, or Mr. Gray testified the packer adjustment has not been sufficient to take care of the packer wells. I testified adjustments should be made, though it will lose the Gulf money.

Q You don't know how much?

A The Engineering Committee has a definite formula. It will cost the Gulf some oil, but it is the fair thing to do and should be done.

BY MR. WOODWARD: I believe that is all.

BY COL. ATWOOD: Cities Service does not desire to avail itself of the opportunity to cross examine this witness, or to recall the witnesses who have gone before. We are anxious to save time and get the matter to a close. After hearing the testimony submitted here by the proponents of the different plans, I am authorized to state that Cities Service has receded from its position of wanting the status quo maintained, and now favors the plan proposed by Gulf, of 75-25%.

BY MR. FLEETWOOD: I would like, for reasons of expediency, to ask if I could be permitted to state one question -- I will guarantee that it will be only one question, because of the objections here, I would like to state the question and have the Commission pass on whether Dr. Knappen may answer.

BY GOVERNOR MILES: We will allow you to state your question.

Q Dr. Knappen, eliminating all reference to the testimony heretofore given at this hearing as to this particular field and the characteristics of the Hobbs Pool, and asking you to keep in mind only the general characteristics of oil in place, bottom hole pressure differentials, drainage, migration, thickness of pay, porosity, permeability and desirability of the proration formula, we wish to ask if the general geological, engineering and production facts to which you have testified here, are they applicable to other pools to the same, or similar degree as they are to Hobbs, and if so, would they apply to a pool such as the Monument Pool in New Mexico?

A Certainly the general principles that I have been discussing apply to Monument, Eunice, or any other. Some of the factors present at Hobbs are not present in some of the other pools. There are geological variations, and variations of various types which, to the best of my knowledge, are present in all pools. However, the potential, ownership of the oil and the geological principles involved in proration are just as applicable to Monument, or any other pool, and I think they should be applied.

BY JUDGE LOWE: If applied to Monument, would it be necessary to take open flow potentials before thinking of a plan?

A No, sir, it would be entirely satisfactory at Monument to make tests to determine the productivity factor; that is, the number of barrels of oil which a well will produce for every pound of pressure in the ground. They would give the same information, and such tests would be recommended for a pool like Monument.

BY MR. RANKIN:

Q Do you know of any field in Lea County that is of the same structural shape as the Hobbs Pool?

A No, I do not.

Q It is the only one in Lea County of that type, to your knowledge?

A That is true.

Q In the Hobbs Pool, in the crest of the structure, one zone is gas drive, and another zone is water?

A Yes, the northeast side, you have no water encroachment because the formations are tight. You do have water encroachment in the southwest. So that is surely gas at the northeast end.

Q I believe you said the water level around the anticline sometime was level, just like, or something like a dome with the rim of the dome being water?

A So far as water in the pay, but on the northeast side the dolomite changes to anhydrite. The pool, especially in the dolomite on the northeast side of the field, the anhydrite and clay are found to such an extent there is no water drive on the northeast side. There may be some places where the water is coming in.

Q There probably is water around the structure?

A I am not at all sure. Such evidence as we have indicate there probably is no water along much of that northeast side.

Q We will assume this is the apex of the structure right down through the middle (indicating on map). This side of the apex (indicating) you wouldn't have a very effective gas drive, whereas to the other side of the apex you do have an effective water drive?

A No, sir, you have an effective gas drive, but on the northeast side it is not driving it up toward the crest, but down toward the flank. The gas cap formed on top there pushes the oil down into the low pressure areas.

Q As a geologist, would you say there is any relationship in the structural conditions between a text book anticline and this Hobbs reservoir to the other pools in this area?

A There are many similarities.

Q The structural conditions are not the same in any way whatsoever?

A I would not say they are not the same in any way whatsoever.

Q You could not compare the production characteristics of both types of reservoir as being identical?

A No, sir.

Q You could not use the conditions at Hobbs as a --

Q (Interrupting) No, your statement is too sweeping. Many of the conditions and many of the suggestions I have made about Hobbs could be used elsewhere.

Q Anywhere else where oil and water and gas are in it?

A Exactly.

Q The structural conditions are not at all identical?

A They are not identical; there is some similarity.

BY MR. WOODWARD:

Q Do you know of any field where bottom hole pressure is used, where you have ascending potentials and descending potentials, although you have decreasing bottom hole pressure?

A I think in most places, instead of increasing the potentials, they increase the allowable. We have, in the Hobbs Pool, increased the potential by adjustments for bottom hole pressure in order to increase the allowable. Most pools have not changed the potential numbers, they have changed the allowable.

Q You know of no place where bottom hole pressure is declining and some wells get an increase and some a decrease?

A Yes, that is what bottom hole pressure adjustments are for.

Q You don't get the question. Do you know of any pool where you have both a declining bottom hole pressure and one well gets an increase and another a decrease?

A Yes.

Q Where?

A Kettleman Hills and Yates. You said where you had a declining pressure. You didn't say declining at the same rate. I know of no place where it is declining at the same rate, where both started from the same level, but I do know many where they are not declining at the same rate. That is what bottom hole pressure adjustments are for. Both will start at a different level, and one will decline and one will persist above the average of the pool, --

Q Wait a minute --

A You wait a minute. You keep talking about potentials. The umpire does not say "potentials", he sayd "adjusted potentials". It is the old original potential after adjustments for bottom hole pressure have been made. Nobody claims -- in a well with 10,000 potential, nobody claims that is actual potential.

Q Adjusted potentials is what you want to base allowables on?

BY GOVERNOR MILES: Is this testimony pertinent to Hobbs?

A Yes, sir.

Q Don't you know, as a matter of fact at the Yates pool, that any time there is an increase in bottom hole pressure, they get an increase in allowable?

A Exactly.

Q And decreased in the same way?

A That may be because the pressure is maintained very uniformally. Just as soon as Yates pressure begins to drop, you will find the same thing.

Q They are both decreasing at Yates?

A I don't know.

Q What is the pressure formula at Yates?

A I don't know. I testified that bottom hole pressure is used at Yates.

Q You testified it operates like this one.

A I don't think I testified to that exactly. I testified the

the allowable is changed as the pressure went up and went down.

Q What is the formula at Kettleman Hills?

BY GOVERNOR MILES: It does not seem to me this is necessary.

BY MR. WOODWARD: I want to make this statement. He has been testifying positively about these things --

BY GOVERNOR MILES: He has been testifying about the conditions in the Hobbs Pool.

BY MR. WOODWARD: He said Kettleman Hills had bottom hole pressure, and I want to show he does not know what the formula is. That is all.

BY MR. HUBBARD:

Q I would like to ask one question. Dr. Knappen, you are acquainted with what I presume is the rather erratic distribution of adjusted potentials in the Hobbs Pool?

A I am familiar with adjusted potentials, yes.

Q Would you, or would you not call the distribution of potential extremely irregular, not to say erratic?

A No.

Q Same pay thickness on the same contour?

A It may easily be that some people would call it erratic. I would say that adjusted potentials have not been adjusted fine enough to take care of the wide differences in bottom hole pressure; that means there must be an erratic potential. We know we had erratic porosity to start with.

Q Would you or would you not say that to achieve your stated end, of equalizing pressures over the Hobbs Pool, that the goal could be reached much more quickly if your true potential were used entirely, and start adjustments based upon bottom hole pressure?

A If you make sufficiently large bottom hole pressure corrections, yes.

Q Then, as a matter of fact, to achieve your end, you would prefer using potential with the same weight as bottom hole pressure, and thus throw out potentials?

A No, not with the same weight.

BY MR. HUBBARD: That is all.

BY GOVERNOR MILES: I want to be sure -- is there someone who wants to bring out any other points? I don't want to close off any testimony.

BY MR. HARMS (Two States Oil Company):

Q I would like to ask a series of questions leading in the direction of the practical operation of a plan, thinking primarily of the problem of water. We are in the northeast section of the pool. You testified you thought it probable that was sealed off. On the other hand, I think the water must be encroaching across the north end of the field?

A It is coming from the northwest and moving southeast.

Q We have very real interests in that direction. As I understood, you said you did not approve of a flat allowable plan, or the same allowable for all wells?

A No, certainly not.

Q In a water drive field, would you consider it advisable or practical to let the water drive work, to use the water drive as a source of energy?

A Certainly.

Q Under your theory of production, is it desirable to keep the bottom hole pressure as high as possible?

A As high as possible without having any inequalities between different leases.

Q Under your theory of operation, is it desirable to keep all leases with constant equal bottom hole pressure?

A So nearly as that is possible, yes.

Q This stops oil moving across boundary lines?

A This stops oil moving across boundary lines.

Q Would you attempt to do this actually if permitted to use your theory?

A Certainly.

Q Why?

A Because under operation as it is at present, a great many inequalities have developed, and vast quantities of oil have been moving from one lease to another. The only way an operator can secure the oil that remains under his land is by bringing his pressures to an equality, to a substantial equality, a 50 or 75 difference over the pool is probably as close as one could hope for.

Q I would like to make this thing specific, and my remarks are directed to the northeast and northwest corners of the field, where, I understand, we do have water drive, and still have high bottom hole pressure; have we any reason to believe water is moving into the structure from the southeast?

A Yes, that is true.

Q Which leases are first exposed to that water?

A The west side of the pool, the northwest side of the pool.

Q We are said to have normal high bottom hole pressure -- or high bottom hole pressure, is that a normal condition?

A I am not sure of what you mean by "a normal condition".

Q Would you expect that to be so?

A I would not expect to have so high a pressure as they have if they had been adjusted by bottom hole pressure.

Q Where will this arrangement be able to reduce the bottom hole pressure, to bring the pressure down to an equal basis?

A By giving a greater allowable.

Q Of oil or water?

A Allowable in terms of oil.

Q And how much fluid will have to be produced to hold, or to reduce the bottom hole pressure?

A I don't know; that would depend on each individual well.

Q Instead of using a well, let us use it as an area. In other words, to make it a line of wells, or a section in which the wells have water, would you be able to answer that question?

A No, I could not tell.

Q Would it be reasonable to suppose they would have to produce as much water as had encroached for that day, plus their allowable oil?

A They would have to produce as much water as had encroached that day in order to keep the pressure constant. They must, therefore, produce more fluid than the volume of water coming on to the lease, to reduce the pressure.

Q We have two factors, as I understand, working in our favor; we have the factor of the gas cap, which is released gas due to reduced pressure; that is a displacement item, is it not, takes up some room?
A- It takes up room. I don't know that you would call it displacement.
Q I am trying to remove that from the question. The other item, in order to maintain anywhere near equal pressure, is the amount of water encroachment?
A If you are going to maintain the pressure constant, yes.
Q That means, therefore, that subject to this gas displacement, if any, we must have water encroachment of some kind?
A I don't see why it is necessary. Necessary to what?
Q You must have water displacement when you remove the fluid, to take up the space and hold that pressure, you must have something to maintain it?
A Oh, yes.
Q And that source of maintenance is encroachment of water, is it not?
A Yes.
Q Now, to get back to your theory, we have assumed that that well, to reduce its pressure, must produce more water than encroached on the lease that day?
A That is correct.
Q Then as to a line of wells -- whatever it may be, they must, in effect, replace the oil which has been -- it must produce the oil -- if they must produce as much oil as would encroach on that lease every day, that goes back to the previous statement of yours -- if the water were produced, what would the encroachment or displacement factor be?
A I don't know what you mean.
Q What I am trying to do is to fill a void, a void created by withdrawals.
A When you take out a barrel of oil, you must fill the space with gas or water, or seal it off.
Q The only way to fill it by gas is to reduce the bottom hole

pressure?

A You do reduce the bottom hole pressure when you take out a barrel of oil.

Q Getting back to the perfect working of your theory, we arrive at the point where this line of wells must produce all of that water to maintain their relative position with the rest of the pool, and if we produce all of the water we have taken away at least one of our sources?

A All of the water? You mean during that day?

Q Yes.

Q You wouldn't have to produce the water. You can produce an equal volume of oil.

Q That is correct. The factor then works to the effect that these -- we have to come to another assumption -- the water encroaching would displace production to certain portions of the field, and probably in several parts there is an encroachment or increase of water?

A Several places water is coming in to replace the oil taken out.

Q However, if one produces the fluid, whether it be oil or water, the withdrawal of that fluid for those leases would equal the total production of all the rest of the field, would it not?

A No.

Q Modified by the space taken by the released gas?

A I think I see what you are meaning. Yes, every barrel of oil taken out of the field must be -- the space must be filled by water or expanding gas, or gas coming out of solution. Every barrel of oil taken out must be replaced by water coming in or gas coming out of solution.

Q Then to make -- we are the edge lease owners -- to make my point clear, you have stated that bottom hole pressure factor is not adequate, if you are going to work upon that basis. On the other hand, that would mean certain wells were being flooded, and certain wells are being currently flooded, and as the factor comes across here, those wells, under your theory, must be allowed to produce an equal amount of oil with the lease -- with the rest of the field?

A No, not an equal amount.

Q Of fluid?

A No.

Q Would that be approximately so?

A No, nowhere near that.

Q What would be the condition?

A You have a vast gas cap that can and will expand to replace that.

Q Then we run into the offsetting disadvantage, that by these tremendous withdrawals, if we gave half of that oil to that area, we have a pool allowable, and the middle section immediately gets penalties to make up for these washed over leases?

A That is right.

Q Then if we do anything less than that, the bottom hole pressure, on the average in the pool, will drop?

A Yes, they have been dropping right along.

Q If I actually attempt to handle the water in the northeast corner of the pool, in which, as I understand -- I believe your own testimony said that -- the oil and water are coming in together.

A I believe that is true in the northwest.

Q So that we will have to handle oil and water. We are handling fluid instead of oil, whatever that may be, and if we do not adjust the big pressures daily, at the rate the fluid is withdrawn, which means the water taken out and the oil taken out, then we will have a resultant general loss of energy for the pool?

A Well, the energy used to raise water and oil to the surface.

Q You have assumed the gas cap would expand. We have to protect the washed over leases. That is what we are attempting to do, and when the lease has been washed over --

A (Interrupting) It has produced the oil there.

Q As long as the water is from that direction and is washing the oil with it?

A I would not say that as long as a lease is producing oil, it has not produced all the oil.

Q We get to this point: This lease gets where it must necessarily produce a lot of fluid, whether oil or water, to keep its relative position; if it be water, and if we attempt to maintain an equal rate of flow per well, in the middle of the pool, we are going to be withdrawing fluid more rapidly than now?

A That is what I have been urging from the high pressure property.

Q What you are trying to do now is keep a balanced pressure?

A Yes.

Q With the result that the gas cap builds up and the bottom hole pressure goes down and the field is injured by all this water before it gets into the field. I question whether that be conservation. May I ask this question: the water drive is here; shouldn't we use it in the interest of conservation, and if we do, wouldn't we get into an impossible situation in the ultimate working of the theory, from the standpoint of conservation, and if so, why pick on the specific point, 25-75, or 40-60, or 50-50? Why that particular one, 25-75?

A There is no magic in that number. It is the percentage that worked satisfactorily before. You could use a different set of percentages, if you would make the bottom hole pressure take care of the difference. But the smaller you make that figure, purely on the unit basis, the larger you make the adjustment figure, the more quickly you stop migration of oil from high to low pressures.

Q You would not assume, under the proposed plan, you would level out pressures?

A Oh, no.

Q My question here is, you would make no such assumption, if there is a certain amount of slippage in it, then why name a percentage?

A What do you mean?

A In other words, it gets down to a question of what is practical, and there are lots of factors involved in what is practical, among them being the economic factor, the production of the lease. Can we logically assume, that is -- have we any absolute control on the percentage as picked out?

A In order to apply the principle the Commission must use certain numbers. As I said, there is no magic in my numbers, 25-75. It might be 10-90, 20-80 or 70-30. The smaller they make the amount of oil on a flat unit basis, the more quickly t ey will stop inequities. Some number must be written. I would not presume to dictate, and couldn't if I would, and would not if I could.

Q Practically, my questions all derive from protection for the edge wells against the big middle, with equity to them, in that they are allowed to produce their oil; if you don't go the whole way, there is an amount of slippage, and those wells or property is being damaged.

A Amount of slippage? I am not sure --

Q I mean the difference between being theoretically perfect and positive operation, or practical operation.

A I don't want to be unfriendly, but I don't understand.

Q What I am trying to say is this, the theory perfectly worked, whatever its ultimate result with regard to what the leases produce, the oil, would maintain positive pressure as among all units?

A Positive?

Q Constant, equal pressure between all units?

A That is true.

Q When we commence to get into the question of practical application of the plan, we must vary from the perfect theory in some respects?

A Certainly.

Q And when we get away from this perfect theory, in operation, we immediately get away from perfection, in operation, as soon as we depart from perfection?

A We are no longer --

Q (Interrupting) The difference between perfection and operation -- as shown by actual operation under any plan which may be used, that is what I call slippage.

A Now I understand, Perfect, theoretical perfection would mean no allowable in the pool on the basis of acreage, and all allowable would be distributed on bottom hole pressure. I would not recommend any such plan. Theoretically the wels there would have absolutely no protection. Things might be set up, theoretically desirable things to most quickly achieve a uniform pressure throughout the field which would be absurd in practice. 25-75 was the ratio or percentage under which the pool operated for a period of six years and gave quite satisfactory results. We thin, if we would go back to that, we would again move closer to the thought of equity. It would not give absolute equity; there would still continue unfair drainage to lower areas.

Q As between wells, or properties, even with this system, we would not attain absolute equity, but we would, in your opinion, approach it?

A We will approach absolute theoretical equity. Absolute equity would require the shutting of all the low pressure areas until the high pressure drops down to their level, and of course, that is impossible.

BY MR. WOODWARD: Would you recommend pulling the packers from those wells to get equity?

A I would not recommend it --

Q (Interrupting) They would still have high pressure? The only thing a man can do that has set packers is to pull them out and get a big potential on his well?

BY MR. RAE:

Q Speaking about the value of potentials, does the amount of gas available near a well have anything to do with the amount of oil that the well flows?

A Certainly.

Q May it not be true that the Gulf's high potentials are due to the fact that they are near the gas cap and had enough available oil to make an abnormal flow?

A I think not. If they are in the gas cap, they have so much gas coming out of solution that the oil will not come.

Q I suppose you understand that with 20 or 30 feet of gas, and if the well is drilled two or three hundred feet lower, the natural consequences might be that it would add to the flow, enough to give a better flow?

A It would assist in giving a larger flow.

Q Those big wells do have a great porosity in the upper zone?

A Both in the upper and lower zone.

Q I think all statements indicate the upper zone is more porous?

A More porous.

Q You think, in this area, the gas is forcing the oil down toward the flanks, and that it is possible the Gulf leases are really somewhat depleted?

A It is unquestionably true that a lot of oil has been taken out of the upper pay in all wells where packers have been set.

Q In reference to the part of the packer pays, suppose you require the Gulf to produce from the zone in which the packer has been set, from the gas zone. Isn't it true that the high gas ratios would cause the Gulf pressure to decline very fast, and the reason the pressure is high is simply due to the fact that the Engineering Committee allowed the Gulf to shut in the gas, which kept them from knocking the pressure down, and at the same time, take oil from the lower zone, and not being penalized, but using the field average; that you consentrated on the second zone -- isn't it possible that some of the wells have really lower pressure than the field average, and are getting oil from other leases?

A If you were to open up production above the gas packers, we could produce oil from above the gas packer.

Q And your pressure would decline?

A Surely, but we would waste a terriffic amount of gas and decrease the field pressure.

Q Wouldn't you assume the gas-oil ratio would prevent waste, abnormal waste?

A I hope there would be a control.

Q If that would happen, you would not be able to waste that gas, and it might not be possible for the Gulf to produce enough gas to make its allowable?

A No, because we have low gas-oil ratio.

Q With packers set in the wells, which are keeping you from producing your allowables in the depleted zones from which you have established potentials?

A True.

Q Wouldn't you think it fair to force operators to produce from the zone they are supposed to come from, and not from another zone? If bottom hole pressure is so important, we would make each lease ride on its own feet.

A You wouldn't want to try to set packers?

Q I certainly don't want to go bottom hole pressure entirely. The point I am making, the Engineering Committee have done a great deal for the operators in allowing them to produce from the lower zone, and if the pressure goes down, they are not penalized. Then if you are going to use bottom hole pressure to build up potential and the field is put on a basis of 75 potential to 25, I would say you should compel the operators to produce the oil from the particular zone on which pontentials were extablished. We know that with high gas-oil ratios, the pressure would decline. I think if the operators were compelled to do that, the high pressures would quickly disappear. If you are setting bottom hole pressure as the measure, the oil should come from the zone where the potentials have been set up. Suppose you have a gas-oil ratio of 2,000 feet per barrel, and the Gulf would try to make its allowable --

BY JUDGE LOWE: Are you questioning the witness or making a statement?

Q Then the condition set up in the various parts where you have built up potential, that would be insufficient. I have agreat deal of doubt whether there is oil left in the upper zone. The Stanolind wells have largely gone to water in the upper zone. That has pushed the oil up. Your statement was those that have gone to gas have pushed the oil down, and I thin, if we are going to bottom hole pressure, probably, Dr. Knappen, you might say, or give your opinion as to whether you are getting undue credit for potential, or getting credit for the higher pressure, that you should be compelled to produce oil from the zone in which the pressure is set up.

A I don't think that would be fair. If I were to speak for the company, I would be glad to eliminate the advantage given by gas packers. We have only four or five gas packers, and if I were to speak solely from a company point of view, we could pick up 25 to 50 barrels a day allowable if we were to eliminate that advantage given to packer wells. If that were done, we would find people operating wells without packers, we would find a terrible waste of gas. I think the program the Engineering

Committee has followed, of giving some advantage to the well for setting packers, is conservation engineering, and conserves the energy and the gas in the field. I think the program is a reasonable program. I don't know if we can balance out on every well and say how many barrels -- but setting packers is the same situation as trading anything -- it may be a good trade for us. The operators have made a trade among themselves. We have said we want to conserve in this field, and we will, therefore, give an advantage to any man who sets a packer, give him an advantage for setting a packer.

Q That is the very point I was making, the reward for setting the packer has been given the owner of the well, in letting the operator produce oil from the lower zone. Then after that operator has been duly rewarded, then he comes in again and wants additional advantages --

Q (Interrupting) The pressures are not taken in the packer wells.

Q You wouldn't want them taken there, if reserves are drawn on severely and the pressures are lower.

A I frankly don't see, if pressures are not taken --

Q (Interrupting) You are producing oil from an entirely different zone from which it is supposed to come from, and have been rewarded for that.

A And that is the trade made.

Q What you are asking for is a reward for setting a packer, which is given to you, and an additional reward as you were producing oil in the zone from which it should come from, you would have lower pressure.

A I am afraid I don't follow you.

BY MR. RAE: I wish to offer in evidence, in view of the articles which were put in evidence by Mr. Wahlstrom, the testimony given by Mr. Wahlstrom at a hearing on December 12, 1936, in case No. 6 -- I think that is on file with the Commission, and let that record be submitted as part of this case.

BY MR. WOODWARD: If the Commission please, in view of the nature of the testimony offered here, I know it will take the Commission some time to consider it and digest the matter, and I would like to ask the Commission for a substantial time to file a statement with the Commission before they decide the matter.

BY MR. DEWEY: Is it proper to have all reference to Monument stricken from this record?

BY GOVERNOR MILES: Yes, if that is agreeable to all operators.

BY MR. SETH: Could we have fifteen days after the transcript is prepared?

BY (Reporter could not get the name): There are a number of companies whose representatives are not here now, and in view of the representations made, they would like to be heard. Could we recess until nine o'clock in the morning, at which time a full quorum of the operators in the Hobbs Pool would be here?

BY GOVERNOR MILES: Any other statements to be made? If not, the Commission will take the matter under advisement until tomorrow morning, and the Monument case will be heard at nine o'clock, and then the oil-gas ratio hearing will be at ten o'clock, and the Commission will take this matter under advisement until then.

DECEMBER 9, 1939

Pursuant to recess the Commission reconvened at nine o'clock, A. M. on December 9, 1939, whereupon the following proceedings were had:

BY GOVERNOR MILES: The Commission has decided that this matter is closed. If anybody has any objections, they can write to the Commission. I don't think we want to consider further testimony; they can make their statement in writing, and the testimony that has been put in in this case will be all that will be considered in this case.

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C E R T I F I C A T E

I hereby certify that the foregoing and attached two hundred and twenty pages of typewritten matter are a true, correct and complete transcript of the shorthand notes taken by me on the 7th and 8th days of December, 1939, in the hearing before the Oil Conservation Commission, in Case No. 14, to consider revising the Hobbs Proration Order.

Witness my hand this 3rd day of January, 1940.