OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

COPY

February 13, 1959

Mr. Oliver Seth
Seth, Montgomery, Federici & Andrews
P.O. Box 828
Santa Fe, New Mexico

Dear Mr. Seth:

On behalf of your client, El Paso Natural Gas Company, we enclose two copies of Order R-586-E issued February 12, 1959, by the Oil Conservation Commission in Case 728, which was heard at the regular hearing on January 14th.

Very truly yours,

A. L. Porter, Jr.
Secretary - Director

bp
Encls.

Order also sent to Jason Kellahin, Amerada & Bill Kastler, Gulf.
BP
2-13-59

El Paso Natural Gas Company

El Paso, Texas

November 28, 1958

Mr. A. L. Porter, Director
New Mexico Oil Conservation Commission
P. O. Box 871
Santa Fe, New Mexico

Dear Mr. Porter:

I have enclosed original and two copies of El Paso's application for the extension of the vertical limits of the Justis Gas Pool, Lea County, New Mexico. This replaces El Paso's Case No. 728 which was dismissed at the November regular hearing.

We request that this application be set for hearing as soon as possible.

Very truly yours,

Garrett C. Whitworth

Garrett C. Whitworth
Attorney

GCW:hsw

Encl.

BEFORE THE OIL CONSERVATION COMMISSION
OF THE STATE OF NEW MEXICO

IN THE MATTER OF THE HEARING
CALLED BY THE OIL CONSERVATION
COMMISSION OF THE STATE OF NEW
MEXICO FOR THE PURPOSE OF
CONSIDERING:

CASE NO. 1221
Order No. R-586-B

APPLICATION OF THE OIL CONSERVATION
COMMISSION UPON ITS OWN MOTION FOR
AN ORDER AMENDING THE SPECIAL RULES
AND REGULATIONS FOR THE TUBB GAS POOL
TO MAKE PROVISION IN SAID RULES FOR
THE REGULATION OF OIL WELLS COMPLETED
WITHIN THE DEFINED LIMITS OF SAID POOL;
AND FURTHER, TO CONSIDER THE DELETION
OF THAT PORTION OF ORDER R-586 WHICH
RELATES TO THE BYERS-QUEEN GAS POOL.

ORDER OF THE COMMISSION

BY THE COMMISSION:

This cause came on for hearing at 9 o'clock a.m. on March 14, 1957, May 16, 1957 and again on July 17, 1957, at Santa Fe, New Mexico, before the Oil Conservation Commission of New Mexico, hereinafter referred to as the "Commission."

NOW, on this 9th day of September, 1957, the Commission, a quorum being present, having considered the testimony and evidence adduced and being fully advised in the premises,

FINDS:

(1) That due public notice having been given as required by law, the Commission has jurisdiction of this cause and the subject matter thereof.

(2) That several wells have been completed within the defined limits of the Tubb Gas Pool which are capable of producing liquid hydrocarbons with gravities in the range which is commonly accepted to be that of crude petroleum oil, and that such wells should be classified as oil wells.

(3) That to classify, space, and prorate the aforesaid wells as though they were gas wells could be unfair to the royalty owners in the Tubb Gas Pool.

(4) That an oil well in the Tubb Gas Pool should be defined as a well which produces liquid hydrocarbons possessing a gravity of 45^{o} API or less.

(5) That an oil well in the Tubb Gas Pool should have dedicated thereto a proration unit consisting of 40 acres, more or less, being a governmental quarter-quarter section legal subdivision of the United States Public Land Surveys.

(6) That no acreage should be simultaneously dedicated to an oil well and to a gas well in the Tubb Gas Pool.

(7) That the limiting gas-oil ratio for oil wells in the Tubb Gas Pool should be 2000 cubic feet of gas for each barrel of oil produced.

(8) That the Special Rules and Regulations for the Byers-Queen Gas Pool as set forth in Order R-586 should be deleted since the production from the said Byers-Queen Gas Pool is no longer of sufficient consequence to warrant its continued prorationing.

IT IS THEREFORE ORDERED:

(1) That the Special Rules and Regulations for the Tubb Gas Pool, as set forth in Order R-586, be and the same are hereby amended to include the following rules:

SPACING AND OPERATION OF OIL WELLS

RULE 16. An oil well in the Tubb Gas Pool shall be defined as a well which produces hydrocarbons possessing a gravity of 45° API or less.

RULE 17. An oil well in the Tubb Gas Pool shall have dedicated thereto a proration unit consisting of 40 acres, more or less, being a governmental quarter-quarter section legal subdivision of the United States Public Land Surveys.

RULE 18. No acreage shall be simultaneously dedicated to an oil well and to a gas well in the Tubb Gas Pool.

RULE 19. The limiting gas-oil ratio for oil wells in the Tubb Gas Pool shall be 2000 cubic feet of gas for each barrel of oil produced.

(2) That the Special Rules and Regulations for the Byers-Queen Gas Pool, as set forth in Order R-586, be and the same are hereby deleted effective September 30, 1957.

DONE at Santa Fe, New Mexico, on the day and year hereinabove designated.

STATE OF NEW MEXICO
OIL CONSERVATION COMMISSION

EDWIN L. MECHEM, Chairman

MURRAY E. MORGAN, Member

A. L. PORTER, Jr., Member & Secretary

S E A L

ir/

BEFORE THE OIL CONSERVATION COMMISSION
OF THE STATE OF NEW MEXICO

IN THE MATTER OF THE HEARING CALLED BY THE OIL CONSERVATION COMMISSION OF THE STATE OF NEW MEXICO FOR THE PURPOSE OF CONSIDERING:

CASE NO. 1293
Order No. R-586-C

APPLICATION OF AMERADA PETROLEUM CORPORATION FOR AN ORDER AMENDING THE SPECIAL RULES AND REGULATIONS FOR THE JUSTIS GAS POOL IN LEA COUNTY, NEW MEXICO AS SET FORTH IN ORDER R-586, R-586-A AND R-586-B, AS AMENDED BY ORDER R-967, TO PROVIDE FOR 320-ACRE GAS PRORATION UNITS.

ORDER OF THE COMMISSION

BY THE COMMISSION:

This cause came on for hearing at 9 o'clock a.m. on August 15, 1957, and again on September 18, 1957, at Santa Fe, New Mexico, before the Oil Conservation Commission of New Mexico, hereinafter referred to as the "Commission."

NOW, on this 3rd day of October, 1957, the Commission, a quorum being present, having considered the application and the evidence adduced and being fully advised in the premises,

FINDS:

(1) That due public notice having been given as required by law, the Commission has jurisdiction of this cause and the subject matter thereof.

(2) That the Commission by Order R-586 dated April 11, 1955, established 160-acre spacing for the Justis Gas Pool.

(3) That the applicant, Amerada Petroleum Corporation, has proved by the evidence in this case that one well will drain 320 acres in the Justis Gas Pool.

(4) That at present, the Justis Gas Pool has not been so far developed as to prevent the adoption of 320-acre spacing in said pool.

(5) That the adoption of 320-acre spacing in the Justis Gas Pool will not cause waste nor impair correlative rights.

(6) That the adoption of 320-acre spacing in the Justis Gas Pool will prevent the drilling of unnecessary wells in said pool.

IT IS THEREFORE ORDERED:

(1) That any well which was projected to or completed in the Justis Gas Pool prior to the effective date of this order be and the same is hereby granted an exception to Rule 5 hereinafter set forth.

(2) That an increase in the acreage dedicated to any such excepted well shall become effective the first day of the month following receipt by the Commission of Form C-128, Well Location and Acreage Dedication Plat, provided said Form C-128 indicates that the acreage dedicated to such well has been increased in conformance with the Special Rules and Regulations for the Justis Gas Pool.

(3) That Rule 5 of the Special Rules and Regulations for the Justis Gas Pool be and the same is hereby superseded by the following rule:

SPECIAL RULES AND REGULATIONS FOR THE
JUSTIS GAS POOL

RULE 5. (a) The acreage allocated to a gas well for proration purposes shall be known as the Gas Proration Unit for that well. For the purpose of Gas Allocation in the Justis Gas Pool, a standard proration unit shall consist of between 316 and 324 contiguous surface acres, substantially in the form of a rectangle which shall be a legal subdivision (half section) of the U. S. Public Land Surveys with a well located at least 660 feet from the nearest property lines;

(b) The allowable production from any non-standard gas proration unit as compared with the allowable production therefrom if such tract were a standard unit shall be in the ratio of the area of such non-standard proration unit expressed in acres to the area of 320 acres. Any gas proration unit containing between 316 and 324 acres shall be considered to contain 320 acres for the purpose of computing allowables.

(c) A non-standard gas proration unit may be formed after notice and hearing by the Commission, or by administrative approval under the provisions of Paragraph (d) of this Rule.

(d) The Secretary-Director of the Commission shall have authority to grant an exception to Rule 5 (a) without notice and hearing where a verified application has been filed in due form and where the following facts exist and the following provisions are complied with;

1. The proposed non-standard proration unit consists of less than 320 acres or where the unorthodox size or shape of the tract is due to a variation in legal subdivision of the U. S. Public Land Surveys.

2. The non-standard gas proration unit consists of contiguous quarter-quarter sections and/or lots.

3. The non-standard gas proration unit lies wholly within a single governmental section.

4. The entire non-standard gas proration unit may reasonably be presumed to be productive of gas from the Justis Gas Pool.

5. The length or width of the non-standard gas proration unit does not exceed 5280 feet.

6. The applicant presents written consent in the form of waivers from (a) all operators owning interests in section in which any part of the non-standard gas proration unit is situated and which acreage is not included in said non-standard gas proration unit, and (b) all operators owning interests within 1500 feet of the well to which such gas proration unit is proposed to be allocated.

7. In lieu of sub-paragraph 6 of this rule, the applicant may furnish proof of the fact that said offset operators were notified by registered mail of his intent to form such non-standard gas proration unit. The Secretary of the Commission may approve the application if, after a period of 30 days following the mailing of said notice, no operator has made objection to formation of such non-standard gas proration unit.

DONE at Santa Fe, New Mexico, on the day and year hereinabove designated.

STATE OF NEW MEXICO
OIL CONSERVATION COMMISSION

EDWIN L. MECHEM, Chairman

MURRAY E. MORGAN, Member

A. L. PORTER, Jr., Member & Secretary

S E A L

ga/

BEFORE THE
OIL CONSERVATION COMMISSION
STATE OF NEW MEXICO

IN THE MATTER OF THE APPLICATION OF EL PASO NATURAL GAS COMPANY FOR AN ORDER REVISING AND AMENDING ORDER NO. R-586 TO PROVIDE FOR AN EXTENSION OF THE VERTICAL LIMITS OF THE JUSTIS GAS POOL, LEA COUNTY, NEW MEXICO	CASE NO. ______

APPEARANCE

Come now Seth, Montgomery, Federici & Andrews, and enter their appearance as attorneys for the applicant, El Paso Natural Gas Company, in the above entitled proceeding.

SETH, MONTGOMERY, FEDERICI & ANDREWS

By [signature] Oliver Seth
Attorneys for Applicant,
Santa Fe, New Mexico

Docket Mailed
1-7-59 BP

OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

C O P Y

May 15, 1959

Mr. Jack Campbell
Box 721
Roswell, New Mexico

Dear Mr. Campbell:

On behalf of your client, Hamilton Dome Oil Company, we enclose two copies of Order No. R-586-F issued May 13, 1959, by the Oil Conservation Commission in Case No. 728, which was heard on April 22, 1959 at Santa Fe before an examiner.

Very truly yours,

A. L. PORTER, Jr.
Secretary-Director

ir/

Enclosures

B-1 Bully

PROPOSED RULES AND REGULATIONS
FOR THE ____________ GAS POOL,
LEA COUNTY, NEW MEXICO

WELL SPACING AND ACREAGE REQUIREMENTS FOR DRILLING TRACTS

RULE 1. Same as Order No. R-520, except substitute applicable Gas Pool Name.

RULE 2. Each well drilled or recompleted within the __________ Gas Pool on a standard proration unit after the effective date of this rule shall be drilled not closer than 660 feet to any boundary line of the tract nor closer than 330 feet to a quarter-quarter section line or subdivision inner boundary line. Any well drilled to and producing from the __________ Gas Pool prior to the effective date of this order at a location conforming to the spacing requirements effective at the time said well was drilled shall be considered to be located in conformance with this rule.

RULE 3. The Secretary of the Commission shall have authority to grant exception to the requirements of Rule 2 without notice and hearing where application has been filed in due form and the necessity for the unorthodox location is based on topographical conditions or is occasioned by the recompletion of a well previously drilled to another horizon.

Applicants shall furnish all operators within a 1320-foot radius of the subject well a copy of the application to the Commission, and applicant shall include with his application a list of names and addresses of all operators within such radius, together with a stipulation that proper notice has been given said operators at the addresses given. The Secretary of the Commission shall wait at least 20 days before approving any such unorthodox location, and shall approve such unorthodox location only in the absence of objection of any offset operators. In the event an operator objects to the unorthodox location the Commission shall consider the matter only after proper notice and hearing.

RULE 4. Same as Order No. R-520, except substitute applicable Gas Pool Name.

RULE 5. (a) The acreage allocated to a gas well for proration purposes shall be known as the gas proration unit for that well. For the purpose of gas allocation in the ____________ Gas Pool, a standard proration unit shall consist of between 158 and 162 contiguous surface acres substantially in the form of a square which shall be a legal subdivision (quarter section) of the U. S. Public Lands Surveys, provided, however, that a gas proration unit of less than 158 acres or more than 162 acres may be formed after notice and hearing by the Commission or as outlined in Paragraph (d) of this rule. Any standard proration unit consisting of between 158 and 162 contiguous surface acres shall be considered as containing 160 acres for the purpose of computing allowables.

(b) Any proration unit containing less than 158 acres or more than 162 acres shall be a non-standard unit and its allowable shall be decreased or increased in the proportion that the standard proration unit allowable bears to the number of acres contained therein.

(c) Non-standard units shall meet the following requirements:

1. Shall contain not more than 640 acres, the over-all length or width of which shall not exceed 5,280 feet, except in instances where the formation of a unit comprising four quarter sections results in a total acreage in excess of 640 acres; and in such event, the unit will be considered to be only 640 acres for proration purposes.

2. All acreage assigned a non-standard unit shall be adjacent or contiguous to the acreage on which the well on said unit is located.

3. All acreage included shall reasonably be presumed to be productive of gas.

(d) The Secretary of the Commission shall grant exceptions to Rule 5 (a) without notice and hearing where the following facts exist and the following provisions are complied with:

1. Application for non-standard unit has been filed in due form with the Secretary of the Commission.

2. Applicant has submitted satisfactory evidence that all operators of offset acreage have been furnished with a copy of the application for the unit.

3. There is no objection, in writing, to the formation of the non-standard unit received by the Secretary of the Commission from any offset operator within twenty (20) days after date of receipt of application by the Secretary of the Commission.

RULE 6. Same as Order No. R-520, except substitute applicable Gas Pool Name.

RULE 7. Same as Order No. R-520, except substitute applicable Gas Pool Name.

RULE 8. Same as Order No. R-520, except substitute applicable Gas Pool Name.

RULE 9. Same as Order No. R-520.

RULE 10. Same as Order No. R-520.

RULE 11. Same as Order No. R-520.

RULE 12. Same as Order No. R-520.

RULE 13. Same as Order No. R-520, except substitute applicable Gas Pool Name.

DEFINITIONS

RULE 14. A gas well in the ______________Gas Pool shall mean any well within the vertical and horizontal limits of the______________Gas Pool:

(a) Producing gas and liquid hydrocarbons, the liquid hydrocarbons having a gravity of in excess of 45° API, or

(b) Producing gas and liquid hydrocarbons, the liquid hydrocarbons having a gravity of less than 45° API and a gas-oil ratio of in excess of 100,000/1.

RULE 15. Same as Order No. R-520, except substitute applicable Gas Pool Name.

RULE 16. Same as Order No. R-520.

RULE 17. Same as Order No. R-520, except substitute applicable Gas Pool Name.

RULE 18. Same as Order No. R-520, except substitute applicable Gas Pool Name.

BEHAVIOR OF GAS CONDENSATE RESERVOIRS

by

M. R. Dean and F. H. [illegible]

Research Division Report [illegible]

January 26, [illegible]

PHILLIPS PETROLEUM COMPANY
RESEARCH AND DEVELOPMENT DEPARTMENT
BARTLESVILLE, OKLAHOMA

Report 102-51-54R

PHILLIPS PETROLEUM COMPANY
RESEARCH DIVISION
BARTLESVILLE, OKLAHOMA

BEHAVIOR OF GAS CONDENSATE RESERVOIRS

The purpose of this talk is to discuss the fundamental behavior of gas-condensate reservoir fluids with particular attention given to explanations of the changes in the producing characteristics observed in the field, and thereby provide a basis for a better understanding of gas-condensate reservoir behaviorand to permit more reliable predictions of such changes as will occur in a particular reservoir.

How is the production from a gas-condensate reservoir recognized? Figure 1 lists the identifying characteristics. Items 1, 2, and 3 are those commonly observed in the field. They are not always sufficient for positve identification. Test No. 4 will be of value also. It can be made by sampling the separator gas and liquid, analyzing them and calculating the composite composition when they are recombined in the producing gas-oil ratio. Test No. 5 will furnish additional proof. Test No. 6, which can be made only in the laboratory, is the final proof.

Figure 2 shows the compositions of two typical gas-condensate fluids compared with a "dark oil" reservoir fluid.

Field experience has shown that the physical properties of gas-condensate production undergoes certain characteristic changes as the reservoir pressure declines. For example Figure 10 shows that the gas-oil ratio rises steadily, goes through a maximum then, if the pressure goes low enough, declines somewhat. Simultaneously the API gravity can be expected to rise somewhat.

These observations, however, do not explain what happens in the reservoir to cause such changes.

APR 5 1954

A major portion of this talk will be devoted to giving an explanation of what happens in the reservoir, how such events can be predicted by laboratory experiments and how the information so obtained can be helpful in finding the most desirable method for exploiting the reservoir reserves. In order to proceed in an orderly manner it is desirable to discuss briefly the basic science involved. For the moment let us discuss three simple terms which all of you use frequently. They are "gas", "liquid", and "critical temperature."

These terms were not coined, nor were the phenomena they describe first discovered by the petroleum engineer. The classical researches of physicists of the nineteenth century on the laws governing the behavior of pure liquids and of mixtures of liquids under pressure described the behavior which is observed in gas-condensate reservoir fluids today. It was not until the early 1930's with the advent of higher pressure reservoirs that the petroleum industry "rediscovered" the work of these nineteenth century scientists.

The terms "gas" and "liquid" as commonly used are only relative. "Gas" is normally thought of as a substance which can expand indefinitely to fill completely its container and a "liquid" as a substance adapting itself to the shape of its container but not capable of indefinite expansion. However, under the conditions of temperature and pressure found in gas-condensate reservoirs these definitions of gas and liquid are inadequate.

Figure 3 shows a typical pressure-temperature diagram. This one happens to be for propane. The diagram is shaded according to the density of propane for various conditions of temperature and pressure. It shows that only the paths which cross the vapor pressure curve show abrupt changes in density and that these changes become less as the temperature is increased and finally disappear at a certain temperature. This temperature is called the "critical temperature". Thus, we define the critical temperature as that temperature at which the density of the vapor becomes equal to the density of the liquid. It is possible to vary the temperature and pressure such that one can start in the gaseous region and proceed to a normally liquid state without passing through two-phase region. Thus, the terms "vapor" and "liquid" have significance only when they are in the presence of each other.

Figure 4 is the phase diagram of a mixture of two hydrocarbons, ethane and hexane. Note that this mixture has a critical temperature. However, in this case the transition from all gas to all liquid takes place over a range of pressure, for a given temperature, instead of at a single pressure value as is the case for a pure material, propane for example. Again note that it is possible, by varying the temperature and pressure properly, to cause the mixture to go from a gas-like material to a liquid-like material without going through the two-phase (gas-liquid) region.

Figure 5 shows the phase diagram of a complex mixture (a mixture composed of many different hydrocarbons). This diagram is similar in its general shape to the preceding diagram for the two-component mixture. It will serve as a model of the phase diagram of a gas-condensate mixture because such a mixture is composed of many different hydrocarbons. Note that again there is a critical temperature, a gaseous zone and a liquid zone. Figure 5 serves to show the important features of the phase behavior of a gas-condensate reservoir fluid.

A complete description, however, requires the explanation of one more effect. That effect is called "retrograde condensation". This phenomenon was first observed by J. P. Kuenen at the University of Leiden in Holland during the year 1892. He was the first to use the term "retrograde condensation". The term implies a reversal in the normal behavior or the direction of the condensation process. Thus, retrograde condensation refers to condensation of a liquid from a gas upon the constant temperature expansion of the gas. Conversely, "retrograde vaporization", would refer to the vaporization of a liquid by constant temperature compression of the mixture.

Again referring to Figure 5, if the pressure were dropped isothermally from point A to point B, the retrograde dew-point, liquid would start to appear. Further reduction in pressure causes continued condensation until point D is reached at which pressure the liquid volume becomes maximum. Further pressure reduction results in vaporization of the liquid until at point E, the entire quantity of liquid formed from B to D has been vaporized and the mixture is at its lower dew-point. The condensation from B to D is retrograde. From D to E normal vaporization occurs.

If the temperature of the mixture were increased sufficiently the pressure can be changed from very low to very high values without the appearance of a liquid phase. That is the relationship between reservoir temperature and the phase diagram of the gas comprising a dry gas field. On the other hand, if the temperature of this mixture were dropped to a value less than the critical temperature, and the pressure raised high enough to move into the single-phase region, where only liquid will be observed, the following events will occur as the pressure is progressively reduced at constant temperature. When the pressure reaches the upper curve a bubble of vapor will appear. This is called the "bubble-point pressure" or "saturation pressure". As the pressure is further reduced more vapor appears and the volume of liquid decreases until at the lower curve only vapor will be found with a trace of liquid. This is the relationship between the reservoir temperature and a mixture comprising a dark-oil reservoir.

Thus, the phase behavior of a given reservoir fluid is governed by the relationship between its phase diagram and the reservoir temperature (Test No. 6).

Let us return our attention to the case of the gas-condensate reservoir. The entire phase-behavior history during the production of fluid from an actual reservoir will take place over only that part of the diagram included along the line from B toward E, but usually stopping slightly below D.

The task of predicting the properties of the production at various stages during the producing life of an actual reservoir involves the use of a mathematical or a laboratory method which, in effect, vastly magnifies the changes taking place along the line BD.

We have tested the usefulness of the mathematical method and found that in order to obtain a result of requisite accuracy experimental data would first have to be obtained to feed into the equations since the necessary data do not exist. The task of obtaining those data would be greater than the task of performing a laboratory experiment which would give the answer directly. We prefer to use the laboratory method. It is that method which will be described briefly.

Figure 6 shows a cut-away drawing of the steel pressure vessel which is the "heart" of the laboratory equipment. It is referred to as the "equilibrium cell". The cell has a volume of about seven-tenths gallon. It is equipped with a pair of glass windows through which the hydrocarbon contents can be seen. The contents can be compressed to the desired pressure by injecting mercury above the piston forcing it downward. Samples of gas and liquid are obtained from a field separator through which production from the reservoir to be studied is flowing. The samples are obtained preferably as soon as possible after the reservoir is discovered and the production has stabilized. The separator liquid and gas are charged into the cell in their producing ratio. In most cases this operation reconstitutes the flowing vapor phase in the reservoir. The pressure and temperature are adjusted to be the same as exist in the reservoir. The contents are viewed through the windows to see if any liquid phase exists. Usually there is none. The absence of liquid indicates that only the vapor phase is flowing to the well bore. A sample of the vapor phase is withdrawn for analysis with consequent reduction in pressure. This procedure is repeated from 8 to 15 times until the cell is depleted. Each time a sample is withdrawn the volume of the liquid phase created by virtue of the retrograde condensation effect is measured by viewing it through the windows while injecting a measured volume of mercury into the base of the cell thus floating the hydrocarbon liquid past them.

The laboratory procedure does not constitute a scale model of the reservoir. The reservoir fluids in the cell go through the same phase changes that they undergo in the natural reservoir.

Figures 7, 8, and 9 show the types of data obtained in the laboratory study. Figure 7 shows how the concentrations of the various components of the vapor phase in the reservoir change as the pressure declines. Note that the concentrations of the butanes and all the heavier components decrease steadily as the pressure declines. This is due to the retrograde condensation phenomenon. Figure 8 shows the volume percentage of the pore space occupied by the retrograde liquid phase for one reservoir. That reservoir can be classed as a "rich" reservoir. The average gas-condensate reservoir is "leaner" and the volume percentage will be less. The important point is that even for very rich reservoirs it is unlikely that the volume percentage will reach the 20 per cent or so that is needed for the liquid phase to flow toward the well bore. This brings us to the characteristic of the gas-condensate reservoir which makes it basically different from the dark-oil producing reservoir. That is, the stock tank liquid content of the reservoir is contained in the vapor phase, and all the liquid which retrogrades out in the reservoir will usually never be produced by the process of producing the gas. This is exactly opposite from the dark-oil reservoir where the liquid is usually produced into the well bore concurrently with the gas. To use the scientist's terminology, the gas-condensate reservoir is unique because the characteristics of the production are controlled by the thermodynamic properties of the vapor phase whereas in the dark-oil producing reservoir it is the dynamics of the flowing fluids which control.

The laboratory results can be assembled to show the extent of the retrograde condensation losses. Figure 9 shows a typical example. In general the richer the reservoir fluid the greater will be the percentage loss.

It is appropriate to ask, "How dependable are these laboratory procedures for predicting gas-condensate reservoir behavior?"

The problem of proving the soundness of the laboratory technique requires a great deal of patience. Whereas only 10 to 15 days are required to complete a "production history" in the laboratory on a particular reservoir fluid, we must wait the usual period, measured in years, for the natural reservoir to complete the same degree of pressure depletion. However, the comparisons we have been able to make so far indicate that the laboratory method gives reliable results.

Figure 10 presents an example of another use of the laboratory method. A comparison was made between the actual gas-oil ratio history of a gas-condensate reservoir and the gas-oil history calculated from the results of a laboratory study of the type just described. Note that the laboratory study predicts a uniformly increasing gas-oil ratio resulting from retrograde condensation of the heavier hydrocarbons in the reservoir. The field history, by contrast, showed the gas-oil ratio history to follow a rising trend but at a much slower rate. This reservoir included an oil rim. Other information gave support to the idea that there was a liquid phase saturation present of just the right degree to give it an incipient mobility. Thus, the liquid which retrograded out of the gas, flowed to the well bore and helped to maintain the gas-oil ratio. However, as the pressure continued to drop the natural shrinkage of the liquid phase finally became large enough that it exceeded the additional liquid being contributed by retrograde condensation. This resulted in a decrease in the liquid phase mobility to nearly zero. It is now expected that the gas-oil ratio history will follow the laboratory prediction for the remainder of the reservoir's life. From the standpoint of the producing mechanism in this reservoir it can be said that during its early life the dynamic characteristics of the two flowing fluids, gas and liquid, controlled and during its later life the thermodynamic properties of the vapor phase will control. Time does not permit a discussion of the usefulness of such a study in making an economic-engineering appraisal of a particular reservoir with regard to the value of pressure maintainance. However, such use will be evident to you.

MRD/FHP/wlb

FIGURE I
CHARACTERISTICS OF A GAS-CONDENSATE RESERVOIR

1. GOR GREATER THAN 10,000
2. TANK OIL GRAVITY ABOVE 48 API
3. TANK OIL COLOR, STRAW TO COLORLESS
4. COMPOSITION RICH IN METHANE
5. MOLECULAR WEIGHT OF HEPTANES + FRACTION BETWEEN 120 AND 170
6. PHASE STATE OF THE RESERVOIR FLUID IS AT THE RETROGRADE DEW-POINT PRESSURE OR ABOVE

FIGURE 2
TYPICAL COMPOSITIONS FOR GAS-CONDENSATE AND DARK-OIL

	COMPOSITIONS IN MOLE PERCENT		
	CONDENSATE RESERVOIR FLUID		DARK-OIL RESERVOIR LIQUID
	RICH	LEAN	
METHANE	72.4	82.4	18.1
ETHANE	9.6	10.7	11.8
PROPANE	5.4	3.1	12.7
BUTANES	3.7	1.3	9.2
PENTANES	2.1	0.7	6.0
HEXANES	1.8	0.6	5.8
HEPTANES +	5.0	1.2	36.4
	100.0	100.0	100.0
HEPTANES + MOLECULAR WEIGHT	150	130	220

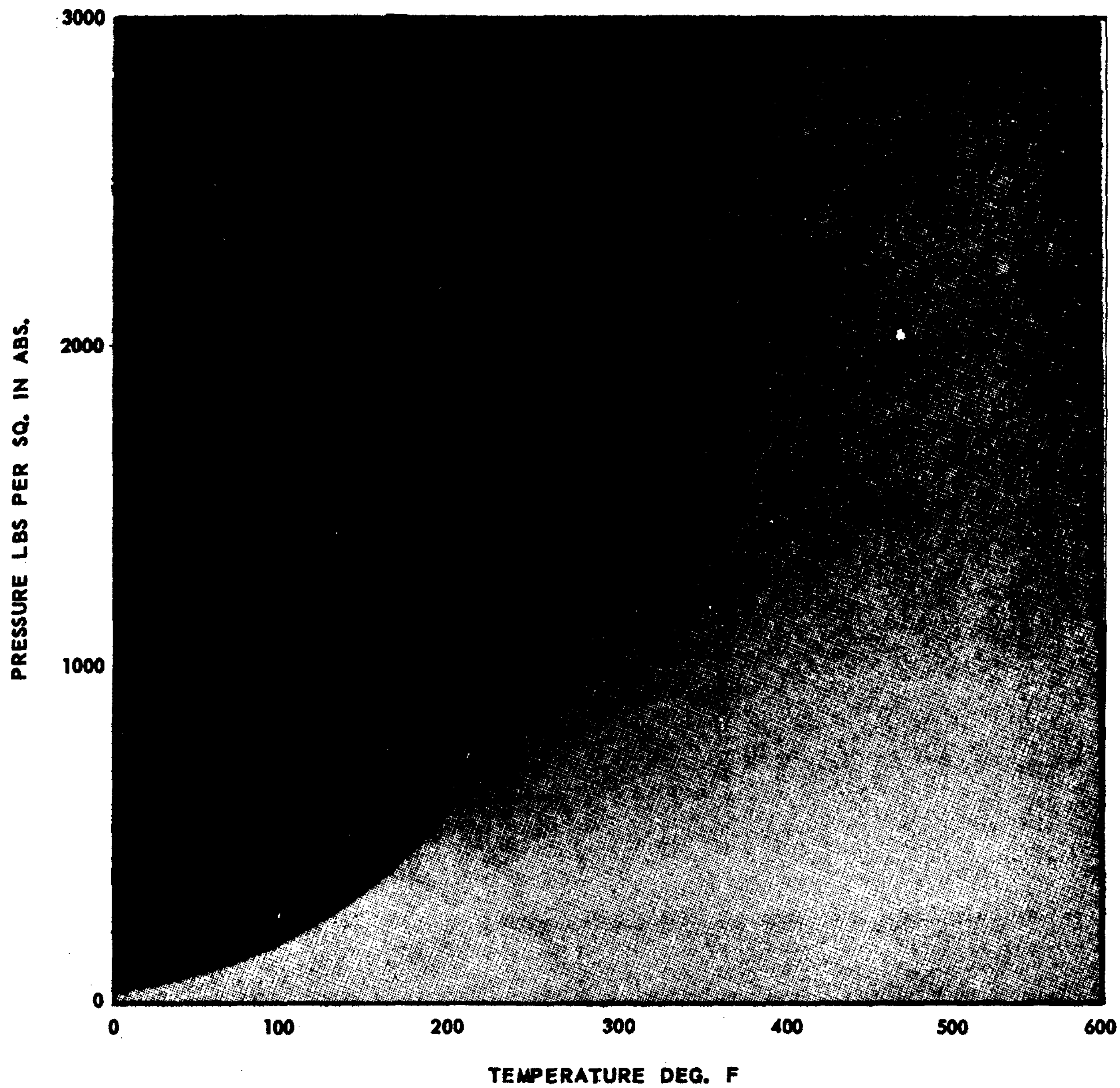

FIGURE 3 CONTINUITY OF GASEOUS AND LIQUID PHASES

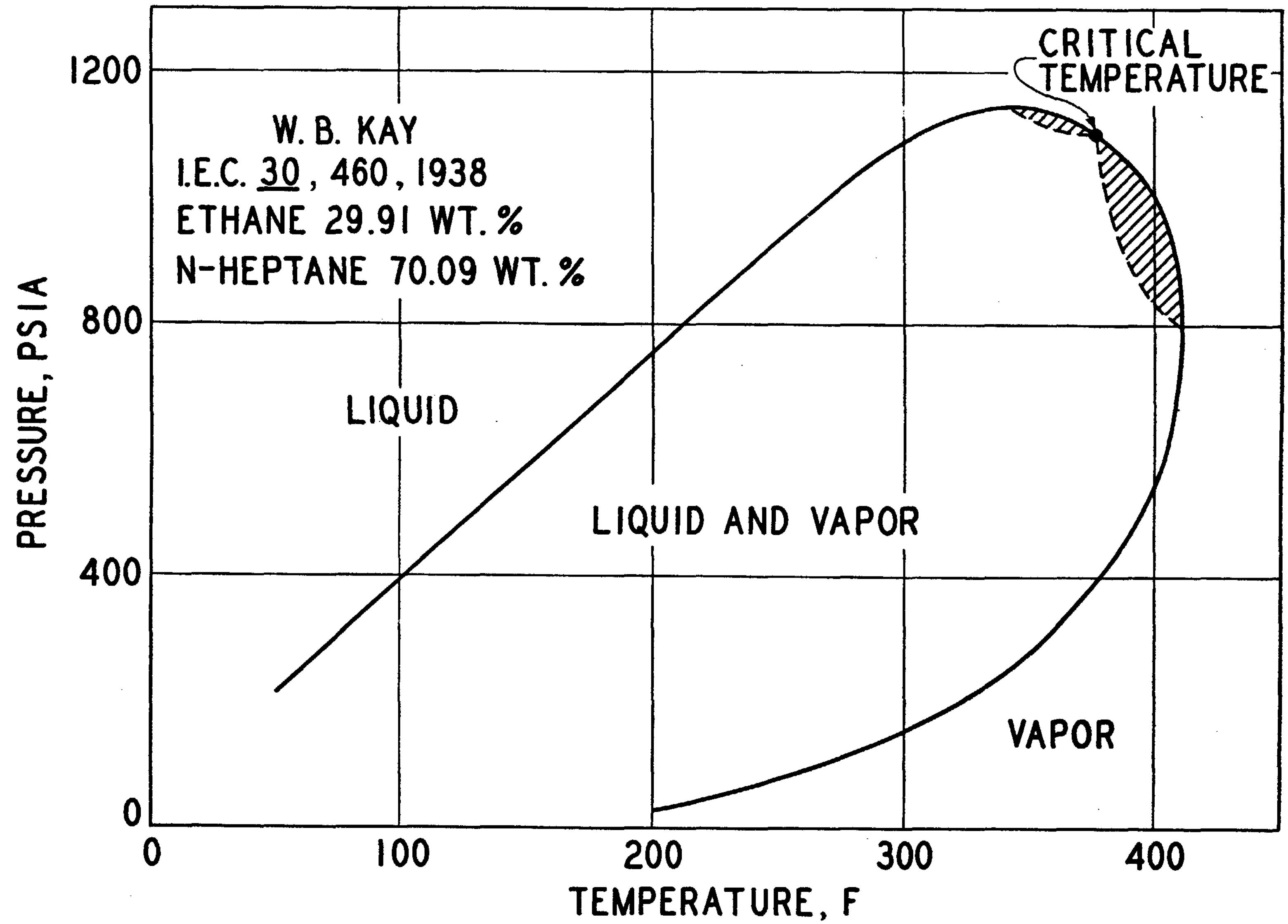

FIG. 4 PRESSURE-TEMPERATURE DIAGRAM FOR ETHANE-N-HEPTANE MIXTURE

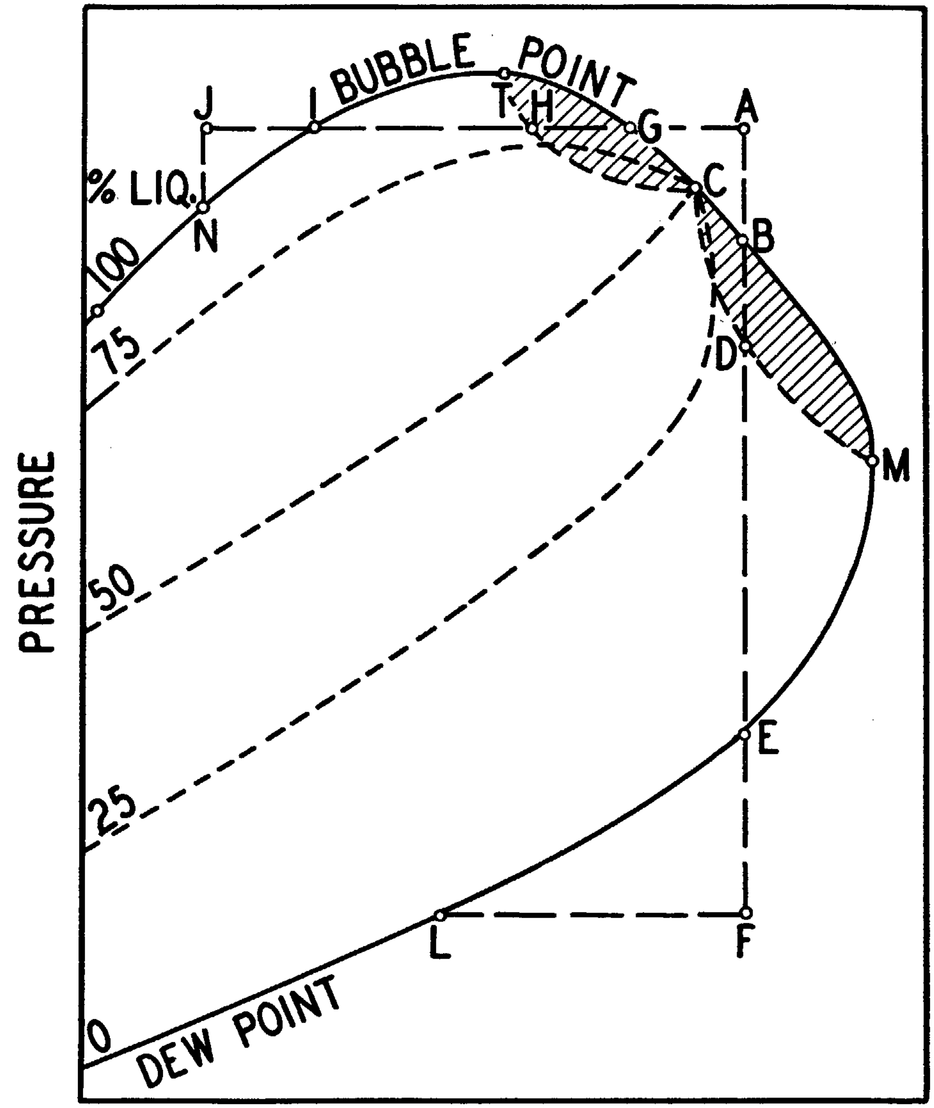

FIG. 5 PHASE DIAGRAM TO ILLUSTRATE NOMENCLATURE OF RETROGRADE CONDENSATION

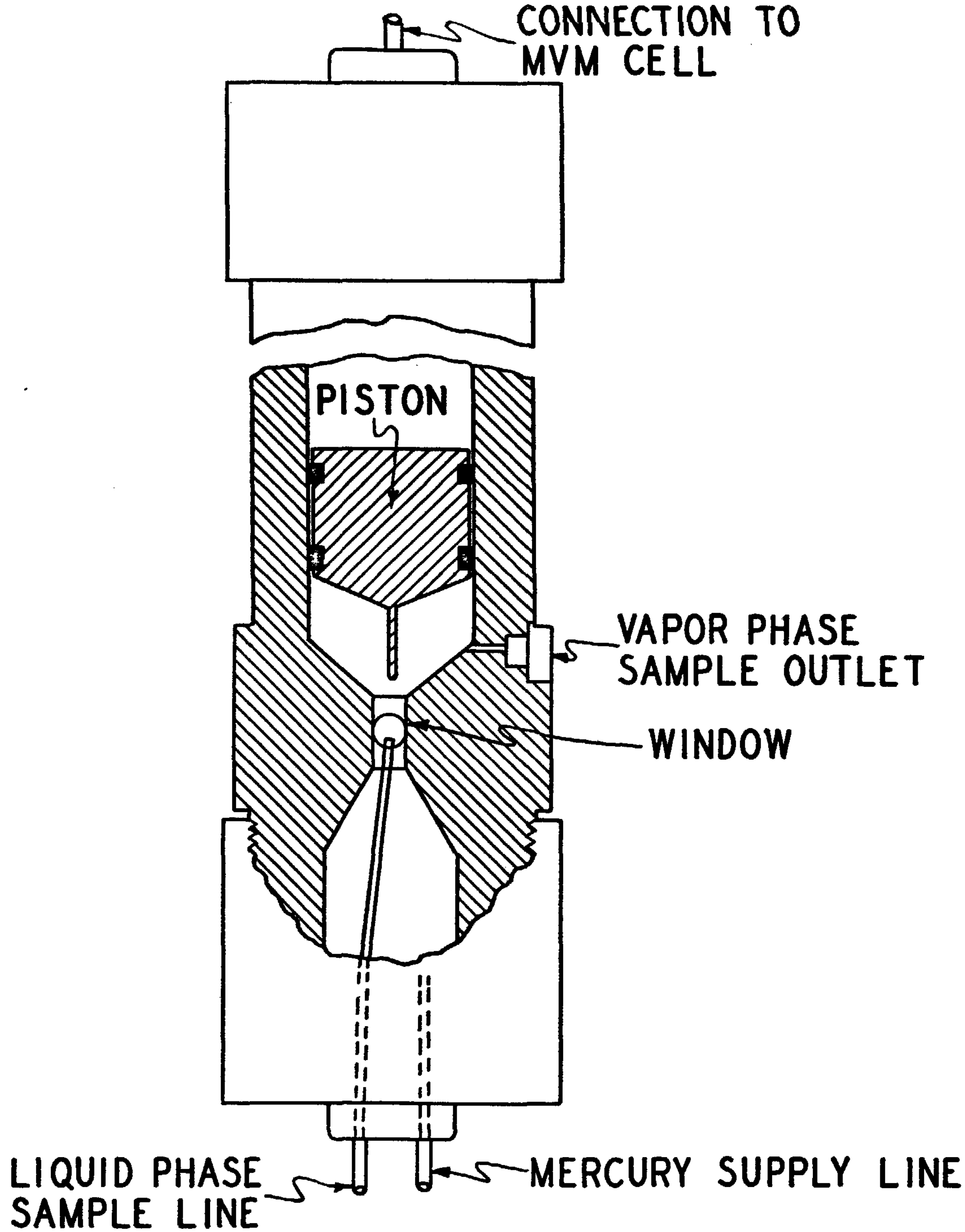

FIG. 6 PISTON CELL

PHILLIPS PETROLEUM COMPANY
RESEARCH DIVISION REPORT 102-51-54R

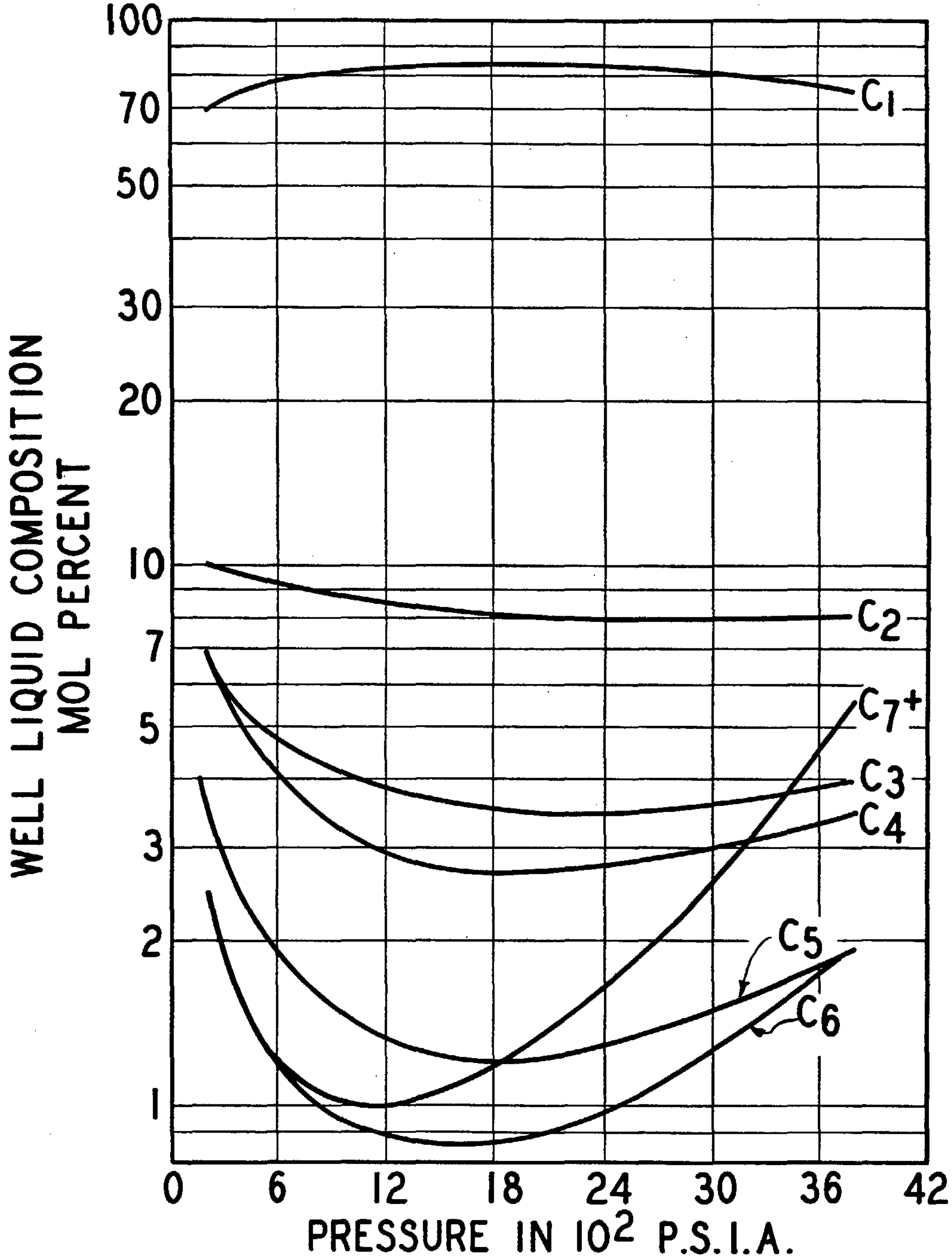

FIG. 7 COMPOSITION OF PRODUCED FLUID AS A FUNCTION OF PRESSURE DURING PRESSURE DEPLETION

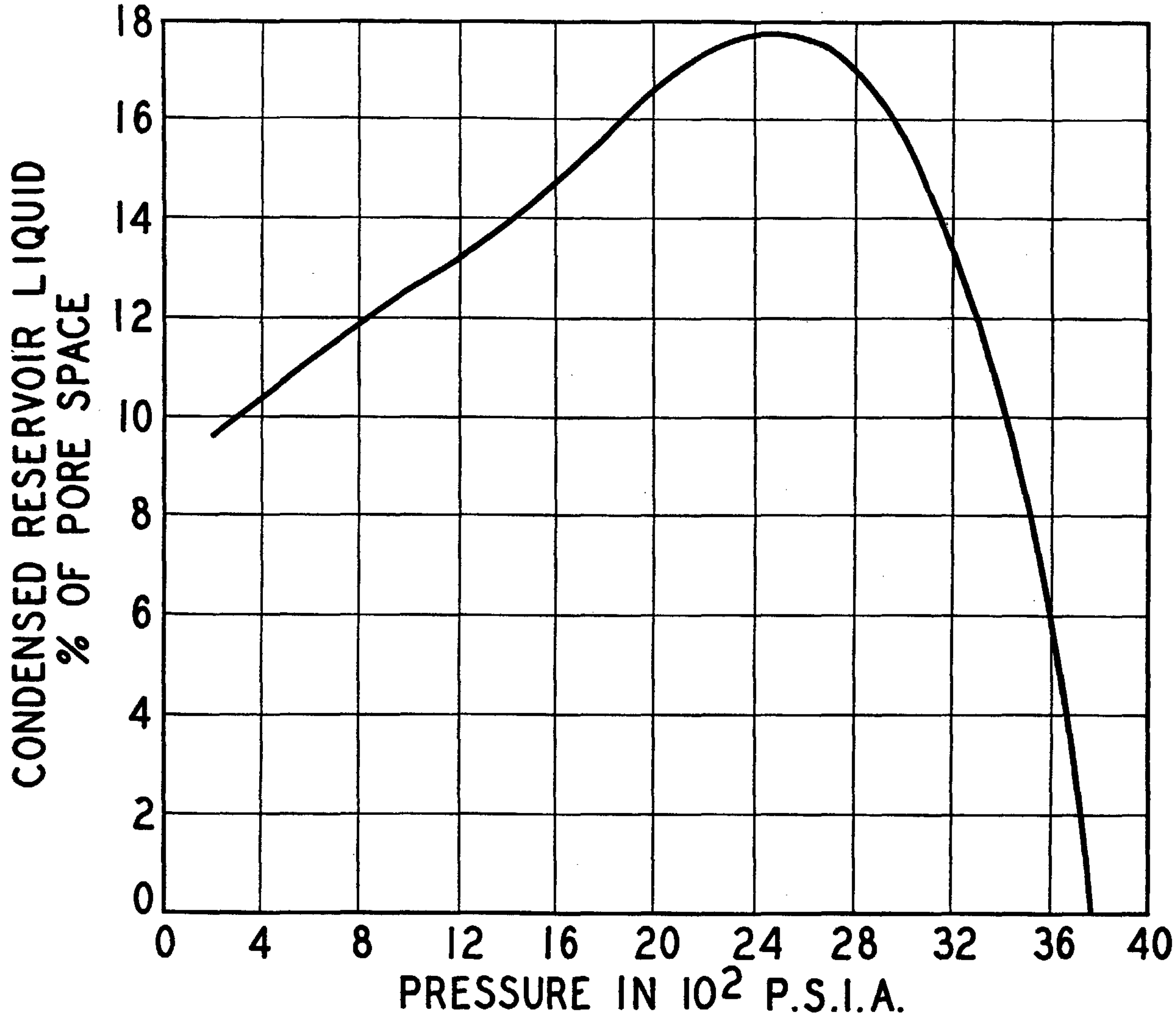

FIG. 8 CONDENSED LIQUID IN THE RESERVOIR AS A FUNCTION OF PRESSURE DURING PRESSURE DEPLETION

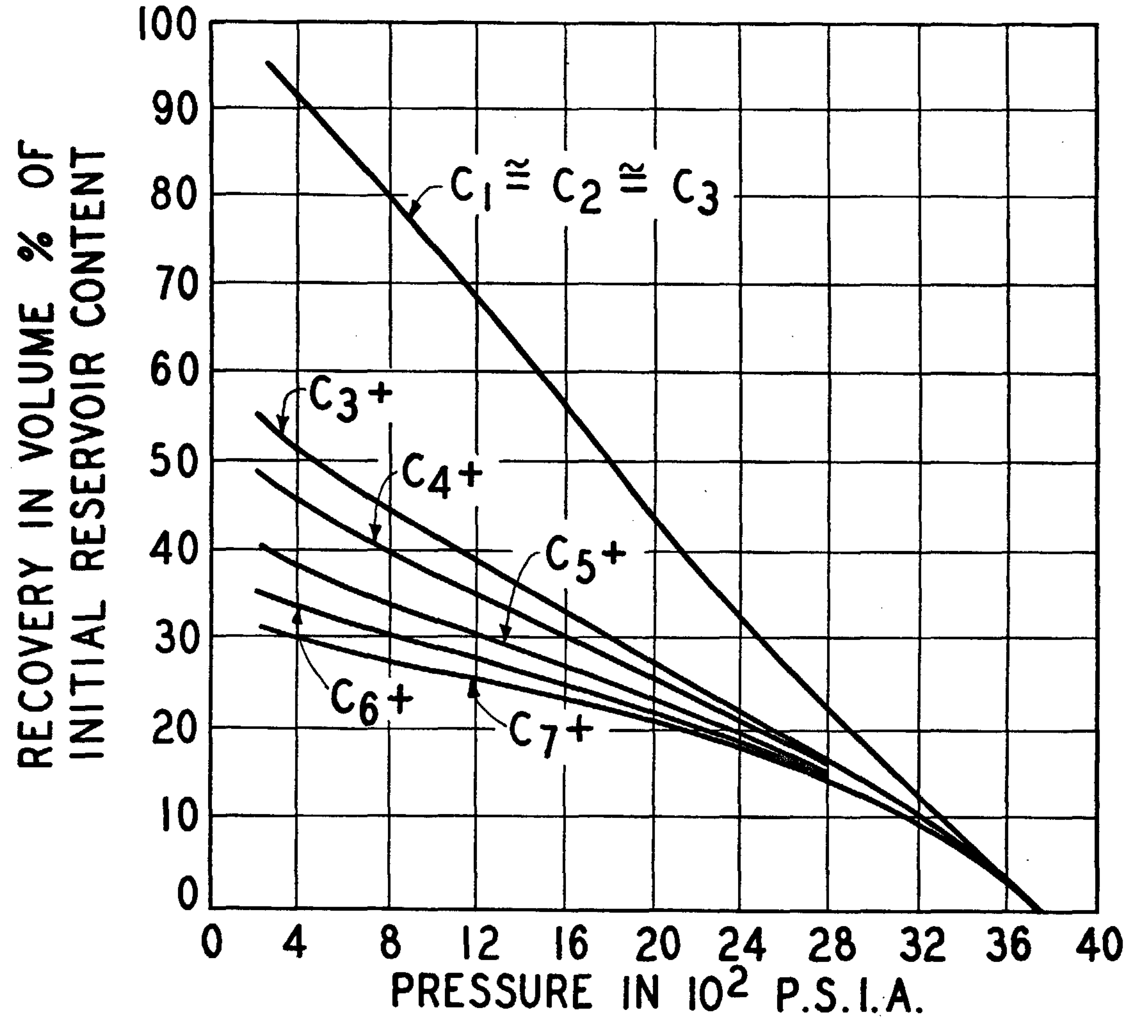

FIG. 9 CUMULATIVE RECOVERY BY PRESSURE DEPLETION PER UNIT OF RESERVOIR VOLUME AS A PERCENTAGE OF ORIGINAL CONTENT

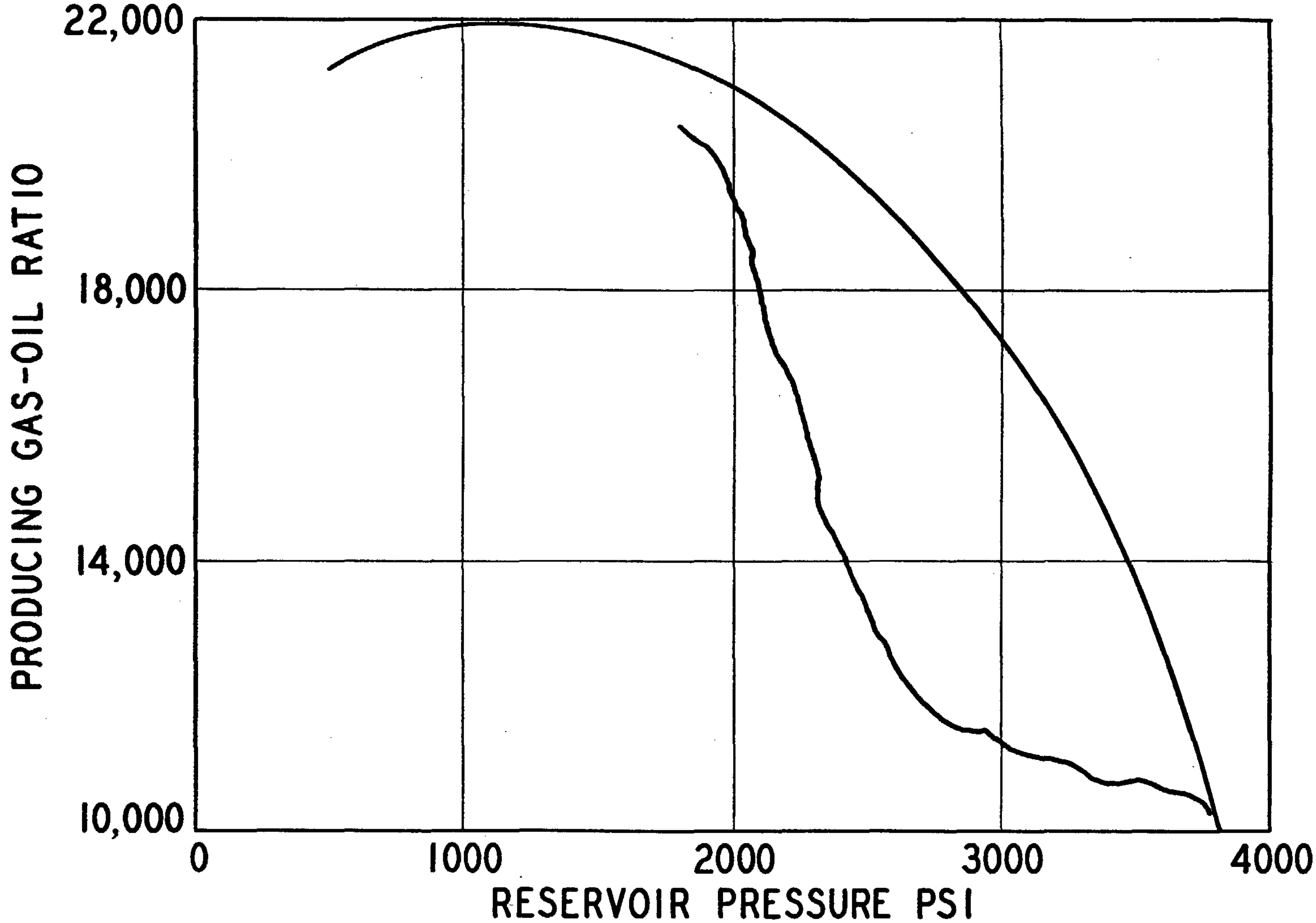

FIG. 10 COMPARISON BETWEEN LABORATORY PREDICTION AND EXPERIENCE IN AN EXCEPTIONAL FIELD

Cheyenne

MAIN OFFICE OCC

8:20

Monterey Oil Company

430 STATLER BUILDING | 900 WILSHIRE BOULEVARD | LOS ANGELES 17, CALIFORNIA

February 24, 1956

Mr. W. B. Macey
Oil Conservation Committee
Box 871
Santa Fe, New Mexico

Dear Mr. Macey:

Please send by parcel post, COD, the Exhibits by Gulf Oil Corporation for Case No. 727 and No. 728. If prints are not available, we hereby authorize you to duplicate same.

Very truly yours,

Stafford Park

Stafford Park
Chief Petroleum Engineer

SP:t

OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

March 8, 1956

COPY

Monterey Oil Company
430 Statler Building
900 Wilshire Boulevard
Los Angeles 17, California

Attention: Mr. Stafford Park

Gentlemen:

Enclosed please find the exhibits of Gulf Oil Corporation in Cases 727 and 728. We do not have an extra set of these exhibits and since we do not have adequate reproduction facilities here in Santa Fe, we are sending this set to you for your duplication.

We would appreciate your returning these exhibits as soon as possible.

Very truly yours,

W. B. Macey
Secretary - Director

WBM:brp

<u>CERTIFIED MAIL</u>
<u>RETURN RECEIPT REQUESTED</u>