Principles of Unitization

Wallace E. Bakken

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PRINCIPLES OF UNITIZATION

A thesis
Presented to
the Faculty of the Department of Geology
University of North Dakota

In Partial Fulfillment
of the Requirements for the Degree
Bachelor of Science of Geology

by
Wallace E. Bakken

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ABSTRACT

In 1920, H. L. Doherty proposed the term unitization for the cooperative operation of an oil pool as though it were owned and operated by one party. The main methods of unitization are: (1) voluntary, (2) cooperative with divided interests, (3) complete with undivided interests, (4) compulsory. The petroleum geologist determines the outlines of the unit by correlating the assembled well data of each operator. After engineering studies have determined the reservoir characteristics, negotiations begin with royalty owners, many of which, not realizing the benefits of unit operation, refuse to permit consolidation of their interests. The state is a party to the formation of a unit and its conservation laws must be strictly obeyed.

The participation formula divides income and expenses among the members of the unit. It should be as simple as possible and yet cover all aspects which will determine future production of the reservoir. The "split" formula takes into account that oil fields have a primary and a secondary production; hence by use of this formula the economic adjustment is lessened by maintaining income at a stable level during the transition from primary to secondary recovery. The unit operator is appointed by fellow operators and carries out the orders of the operating committee.

The advantages of unitization are chiefly economic, through avoidance of competitive drilling, economic employment of personnel and marketing advantages. Engineering benefits include control of water incursion and reservoir energy, scientific well spacing, and coordination of drilling programs. Unitization tends to have a stagnating effect on the industry, cause restraint of trade, promote unequal distribution of royalty and be monopolistic.
Amerada Petroleum Corporation along with twenty other operators are nearly ready to begin secondary recovery operations in Beaver Lodge and Tioga fields in North Dakota. Water flooding, which is expected to produce an additional 125 million barrels of oil, cannot be initiated until eighty-five per cent of the royalty owners agree to the program. From past experience, the benefits of unitization of these two fields should exceed any which could be gained by competitive secondary recovery programs.
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I. INTRODUCTION

Unitization is the pooling of interests of the various operators, leaseholders and royalty owners for the purpose of operating an oil or gas reservoir as if it were owned and operated by one party.

The purpose of this thesis is to acquaint the reader with the principles of unitization including the background out of which it has grown, its theory, mechanics, advantages, and disadvantages. The chapter on Beaver Lodge-Tioga Unit Operation is intended to relate unitization to a local, familiar area and to cover the work the operators in that area have done to date in their proposed unit operation of the two fields. It is not intended to contribute to the knowledge of the geology of the area.

The many legal aspects of unitization could not be pursued due to limited space, hence only the necessary and related material is discussed. The portion on outlining the unit may have special interest to geologists in that it deals with some geological structures encountered in oil exploration and the problems in outlining a given area of a given structure.

Throughout the paper, unit operation and unitization are used synonymously.

The writer is grateful to Mr. F.D. Holland Jr., Assistant Professor of Geology at the University of North Dakota, for his helpful suggestions and cooperation.
during the preparation of this thesis. A demonstration on water flooding, given by Mr. H.A. Nedom of Amerada Petroleum Corporation on the University of North Dakota campus March 7, 1958, helped familiarize the writer with the engineering and geological problems of unit operation. This demonstration was of great help in writing the chapter on Beaver Lodge-Tioga unitization.
II. HISTORY OF UNITIZATION

As far as the petroleum industry is concerned the principal event of 1920 was the submission by Henry L. Doherty to the American Petroleum Institute of a plan for the unit operation of oil fields (Logan, 1930, p.137). Prior to that time, engineers and far-sighted administrative personnel in the industry were only beginning to "see the light" as far as conservation of natural resources was concerned. Logan (1930, p. 137) relates that in that same year Mr. Doherty presented two important proposals to the executive committee of the American Petroleum Institute: (1) a plan for cooperation by the entire industry to further the expansion of the use of petroleum products, and (2) a plan for the operation of oil pools as units. The second proposal has become known as the "Doherty Plan." It was Doherty, on account of his experience as an engineer, who was the first to do anything about the wastefulness due to drilling offset wells in newly discovered fields (Logan, 1930, p. 140).

When first proposed, the "Doherty Plan" was not acclaimed with equal enthusiasm throughout the entire petroleum industry. On the whole, the plan was considered a misconception by most of the leaders in the industry (Logan, 1930, p. 171). In the following years the merits and drawbacks of unitization were con-
sidered by the executive committee but its members did not agree with the plan. According to Logan (1930, p. 142) it was not until the fall of 1924 that the plan was presented to the public. In an address before the National Petroleum Marketers Association in Cleveland, Doherty stressed that an oil pool cannot be properly conserved for the benefit of all unless it is operated as a unit.

However, the disbelievers of unitization had just as good arguments against the plan as Doherty had for it. In 1924 A.L. Beaty, president of the Texas Oil Company, summarized his objections to unitization as follows: (1) the impairment of contracts and taking of property without due process of law if the plan was applied to established fields, (2) the difficulty of initiating activities under the new plan, (3) the difficulty of exercising rights held on non-productive leases if the plan should apply to existent leases, (4) danger of local politics, (5) the difficulty of apportioning royalty, (6) the revolution in the entire industry in order to fit it to the new system, and (7) the plan would eliminate the small producer and concentrate production in a few large companies (Logan, 1930, p. 183).

By 1926, discussions were still being conducted by the American Petroleum Institute concerning the benefits and drawbacks of Doherty's plan. In 1927,
Doherty again appeared before the executive committee with his plan. His objectives according to Logan (1930, p. 140) were: (1) conserve the oil resources of the United States, (2) stabilize the petroleum industry, (3) remove the necessity of offset drilling, (4) conserve natural gas for its fuel value and for its explosive power on the oil.

Keplinger and Wanenmacher (1953, p. 198) relate that it was not until near the start of the depression in 1929 that some operators began to feel the necessity of unitizing. Although not all leaders in the industry were in sympathy with the plan, they were in sympathy with the idea. During the early thirties the trend within the oil industry was definitely toward unit operation of fields (Avery and Miller, 1934, p. 1061). Most of the unitized projects at this time were for the purpose of sharing the cost of exploratory wells and in most instances the royalty interests were not unitized (Keplinger and Wanenmacher, 1953, p. 198). Gradually the geologist, engineer and practical oil operator began to realize and understand the physical principles governing the accumulation of oil and gas and the physical laws concerning oil and gas production (Fanning, 1950, p. 88). According to Myers (1957, p. 13) the seeds of unitization were thus planted, but the progress was slow. The oil man
of the thirties was an individualist and hence disliked surrendering the operation of his property to another company or individual designated as unit operator under the unitization agreement.

According to Uren (1950, p. 182), two decades ago, there were few who were willing to accept the unit plan, but today most of the recognized leaders in the petroleum industry give it their endorsement. In addition it has received the approval of the Federal Oil Conservation Board, the American Petroleum Institute, the American Institute of Mining and Metallurgical Engineers and the Mid-Continent Oil and Gas Association. As of July, 1953 there were slightly more than 1000 unitized projects in the United States (Keplinger and Wanenmacher, 1953, p. 198).
III. THEORY OF UNITIZATION

In a unitized oil field, it does not matter from which wells the operator derives his revenue. However, an injustice to royalty owners would result without unitization because oil would be forced from one tract to another (Brock and Landis, 1952, p. 220).

Basis for Unitizing

Sullivan (1956, p. 376) reports that all unit agreements follow a fundamental pattern but it is the physical characteristics of the pool; whether a new, partially developed, fully developed or depleted field that determines the agreement finally chosen. Even then the choice may be wrong, for not until the plan has been in effect for some time is its success or failure known.

The principle thesis of unitization according to Wilson (1938, p. 1086) is that each oil producer and landowner is entitled to receive his fair share of the recoverable oil in the pool.

New Fields

In a new pool or field, unitization must be based on the estimated limits of production (Sullivan, 1956, p. 376). As the field is further developed the limits will become more evident.
**Partially Developed Fields**

According to Keplinger and Wanenmacher (1953, p. 188) most units in recent years have been formed after the field is partially or completely developed and in such instances royalty interests are unitized as well as leasehold interests. Partially developed fields, like new fields, are still under exploitation and dry holes have not been drilled around the entire structure, therefore the outer limits of production are unknown. In such fields, the various tracts are normally in varying stages of development; field pressures are depleted in varying degrees, different spacing programs have been followed, and the condition of equipment will vary on different properties (Uren, 1950, p. 185). In such cases, basing the relative interests of the property owners on acreage contributed to the unit would be unfair, hence a disinterested party must be called in to evaluate each tract before unitization can begin.

In partially developed areas, a provision must be included in the unit agreement whereby new tracts may be admitted to the unit when they have been proven productive and when the lease and royalty holders have signed the necessary agreements (Sullivan, 1956, p. 376).
Fully Developed Fields

Sullivan (1956, p. 376) states that the primary purpose of unitizing a fully developed field is pressure regulation to maintain reservoir energy. This is accomplished through gas or water injection. Fully developed fields, unlike the two previously mentioned types, have been defined by extensive drilling, hence the provisions of the unit plan are less complex. The negotiations are concerned with fixing leasehold and royalty owners percentages for various tracts and considering the mechanics of unit operation (Sullivan, 1956, p. 316). Keplinger and Wanenmacher (1953, p. 196) relate that most unit operations in recent years have been accomplished in fully developed fields as a preliminary to projects involving secondary recovery, pressure maintenance by water or gas injection, or by cycling gas condensate.

Depleted Fields

In depleted fields, the basis for unitization is secondary recovery (Sullivan, 1956, p. 376). Fanning (1950, p. 12) states that vast amounts of oil still remain in fields which were developed and produced before modern methods of production became general. If such fields had been unitized early in their life they might still be producing today.
The task of negotiating an agreement among property owners is much simpler in a depleted field than under any of the three previous types because the field is near abandonment and complete information is available concerning reservoir pressures in all parts of the unit (Sullivan, 1956, p. 376). Operators are generally more willing to enter into a unitization plan when their properties have reached this stage than in previous years when flush production was being realized and operation was on a competitive basis (Uren, 1950, p. 186).

Methods of Accomplishment

Nearly all students of petroleum economics agree on the principles of unitization but, according to Uren (1950, p. 182) there is no general agreement as to the means of its accomplishment. This might be considered analogous to the geologists' theories on the origin of petroleum. Most will accept an organic origin for oil but when it comes to explaining how it formed there are varied opinions. Many unit plans have been proposed, each with their own advantages and disadvantages. Some look good on paper but when it comes to actual operation, they fail, having not taken into account the uncertainties of human nature. Many operators have failed to recognize the great advantages that unitization would accrue and therefore
have not had sufficient confidence in their competitors to surrender certain rights to a unit operator (Uren, 1950, p. 182).

Although it has been thirty years since Doherty proposed his unit plan of operation, the agreements that have been made to put unit operation in force are very recent. The main methods of accomplishing unitization under competitive conditions are: (1) voluntary cooperation, (2) cooperative agreements with divided interests, (3) complete unitization with undivided interests, (4) compulsory unitization.

Voluntary Unitization

According to Sullivan (1956, p. 360) voluntary unitization takes place where the owners in a pool agree the area will be operated as a single unit, irrespective of property lines.

Varying degrees of unitization are possible through this method according to Uren (1950, p. 183), ranging from simple spacing agreements to complete merging into single operating organizations. Uren (1950, p. 183) goes on to say that if a voluntary plan is to be used, it must usually fall short of complete unitization since unanimity among operators and royalty owners is difficult to attain. A field may go ununitized for its entire life, merely because a minority was unwilling to sign the unit agreement.
Unitization in North Dakota is on a voluntary basis (Grand Forks Herald, Feb. 12, 1950, p. 1).

Cooperative Agreements with Divided Interests

The theory involved in this method is that agreement is easier to attain among a few operators than among many. The few operators according to Uren (1950, p. 183), usually two or three, will agree to develop their properties according to a predetermined plan. The results will not be as successful as if the entire field had been unitized but the few who pooled their holdings will usually get a greater ultimate recovery than their unaccommodating neighbors. This method has a voluntary aspect to it in that each operator is free to join the group or remain outside of it.

Uren (1950, p. 183) relates this method is employed chiefly where a few operators own the entire acreage in a field.

Complete Unitization with Undivided Interests

Complete unitization where the interests are undivided is employed in prospective fields which have not yet been drilled (Uren, 1950, p. 184). In such areas, land titles are divided among several owners. All these owners agree to pool their holdings, each accepting an undivided interest in the entire acreage. Each owner shares in the cost of drilling additional
wells in the unit in proportion to the ratio of his acreage to the total acreage (Uren, 1950, p. 184).

A difficulty involved in this plan is that of determining the amount of acreage to be included in the unit. According to Uren (1950, p. 184) a tract must be proven productive before being admitted to the unit. If there were many of these tracts it might serve to defeat one of the purposes of unitization, that of lessening the drilling of unnecessary wells. The individual tracts are operated by a single party, the unit operator, who is free to exploit the field as he sees fit.

Compulsory Unitization

Compulsory unitization according to Williams and Meyers (1957, p. 42-43) is the bringing together, as required by law, of separately owned tracts into a unit to be operated by a single operator. Sullivan (1956, p. 401) believes the word compulsory is a misnomer since before such a plan may be initiated there must be agreement among the majority of lessees and royalty owners in the area. The actual compulsion is exerted upon those who seek to block the majority from unitizing. If a few tracts are withheld from the unit, it may defeat the unitization plan (Uren, 1950, p.187). These "holdouts" have obstructed unit agreements so frequently that many operators are urging legislation
to compel unitization. Varying degrees of compulsory unitization have been suggested ranging from enforcement in all fields by national legislation to milder ideas in which the individual states could compel operators in a field to unitize (Uren, 1950, p. 187).

Sullivan (1956, p. 401) relates that Arkansas, Louisiana, Oklahoma, and Washington have statutes providing for compulsory unitization. In addition to these four, Williams and Meyers (1957, p. 42) add Nevada and Alaska.

How far the matter of compulsory unitization will get is yet to be known. According to Uren (1950, p. 187) the Federal Oil Conservation Board and the American Bar Association have expounded on the idea and believe the federal government is outside its authority in legislating on the matter. Instead, they believe it should be left up to the individual states. It is evident that compulsory unitization is unconstitutional and therefore the writer doubts that it will ever be achieved, at least not on the national level. Political favors would also enter into determining which fields should be unitized if unitization should ever become a national law. According to the attitude of oil companies toward the recent natural gas bill, they also would disapprove
of compulsory unitization on any level. It is likely that more and more states will form and pass laws compelling an operator to manage his property in accordance with the desires of the majority in the field.
IV. MECHANICS OF UNITIZATION

Forming the Unit

The discussion of the formation of any unitization program must start from the time one or more of the operators in the field suggest that unitization is necessary for efficient operation of the reservoir and as a means of obtaining the greatest ultimate recovery.

Outlining the Unit

A field must be outlined before unit operations can be initiated.

Geological Aspects

The type of structure, magnitude and extent of folding, and the dip of the flanks and axial line are all important considerations in determining the outer limits of a field (Uren, 1956, p. 34). According to Avery and Miller (1934, p. 1482) the petroleum geologist is trained in subsurface geologic methods and should be consulted before any unitization project is formulated. Failure to do so results in complications and needless expense. Even among experienced geologists there is not universal agreement on details of outlining the unit; however on fundamentals there is usually agreement, therefore their suggestions should be given careful consideration. Reliable geological
information is essential to the operation of any unitization project (Avery and Miller, 1934, p. 1482).

Logan (1930, p. 181) reports that each of the operators in a unitized pool usually reveal the geological information in their possession regarding the field including the results of core drilling.

**Structure Determinable.** - Where structural conditions of the strata are apparent, an agreement as to the total area to be included in the unitization project is not difficult to achieve. According to Avery and Miller (1934, p. 1455) the structure contour map is the primary tool for outlining oil producing structures.

For outlining anticlinal fields, the axis of the limiting syncline is obviously the extreme outer limit of acreage over which unitization can be accomplished (Avery and Miller, 1934, p. 1484). For partially developed anticlinal fields the practice usually employed is to include lands within the lowest closing contour which includes a known producing well.

An asymmetrical anticline or variations of that type of folding pose numerous problems to outlining the area. Usually the field must be further developed in order to help determine the outer limits of production. Avery and Miller (1934, p. 1488) state that in most unit agreements a provision is made whereby when and if additional acreage proves productive it may be
added to the unit.

Structures Indeterminate. - Avery and Miller (1934, p. 1483) relate that where structures are concealed beneath unconformities, where pools exist because of some condition other than structure, or where the surface expression is impossible to decipher the geologists advice is considered superior to any guess made by one not familiar with the scientific principles involved. No definite rule can be laid down for determining the outlines of the unit under such conditions. As in the case where structures were evident, additional acreage may be added later to the unit if development shows a greater extension of the pool than was expected.

Avery and Miller (1934, p. 1483) state that oil deposits formed due to lensing, variations in porosity, concealed faults, or to unconformities constitute the most difficult case confronting the geologist who has the responsibility of recommending the area as a unit. Therefore under such circumstances, the geologist's decision must be based on his knowledge of the rest of the area or of similar conditions he may have experienced in other areas. Since an oil pool is a geologic phenomenon, it falls to the geologist the task of deciding the acreage to be included in the unit.

According to Avery and Miller (1934, p. 1489) any structure contour, fault, combination of structural
boundaries, or any arbitrary line agreed upon by the parties concerned may be selected as a unit boundary.

Engineering Aspects

After the geologic limits have been deduced, the pool must be organized into an engineering unit in order to carry out the unitization project (Logan, 1930, p.129). The production engineer, economist and administrative officers are important participants in the preliminary work of formulating a unit. According to Levorsen (1954, p. 378) the changes in reservoir pressure that accompany production are of great importance to the production engineer. In general, pressure declines with fluid withdrawal and the rate of this decline furnishes the petroleum engineer with some of the best data on which to base estimates of the type and amount of reserves and the best locations for future well sites (Levorsen, 1954, p. 378).

The engineering studies may be made by company engineers, consulting engineers or both. According to Sullivan (1956, p. 371) all data pertaining to the area is analyzed by the operators to determine the probable future benefits under the unit plan of operation. After the operators have agreed in principle that unitization would benefit all concerned, the obligations of each company are set and discussed by company representatives (Sullivan, 1956, p. 371).
Negotiations must be conducted concerning the basis of participation, type of operation to be used and the type of business and accounting procedures to be employed.

After engineering and geological studies have been made and the operating companies believe it economically feasible and practical to unitize, negotiations begin with royalty owners and state authorities.

**Negotiations**

**Royalty Owners**

The results of the engineering study discussed previously are placed in the form of a report and submitted to the royalty owners. According to Keplinger and Wanenmacher (1953, p. 200) such a report should include the following:

1. A summary of statistics and factual data.
2. Conclusions and recommendations.
3. Estimates of increased recoveries.
4. An economic analysis listing anticipated operating expenses and profits.
5. Details of the proposed plan of operation.
6. Calculation of participation formulas.

Sullivan (1956, p. 371) reports that each royalty owner must be personally contacted and briefed on the aspects of the unitization program. In many cases
the public is not acquainted with the technicalities of oil production and must be educated concerning the advantages of unitization.

Where there are large numbers of interested parties, cooperation of the royalty owners is difficult to achieve. Keyes (1944, p. 305) lists the following as causes of this disagreement: (1) lack of understanding of the problems involved, (2) unfamiliarity with the benefits to be obtained, and (3) various items of self interest. Logan (1930, p. 180) believes that complete pooling of interests is likely to come in but few cases, as there are always a certain number who cannot be convinced or, for various reasons are not willing to consolidate their interests.

If a unit becomes effective without a royalty owners consent, he can forbid the use of his land for purposes of execution of the program; although by so doing, he is not entitled to receive royalty on the excess production (Sullivan, 1956, p. 399). Sullivan (1956, p. 399) goes on to say that most voluntary unit agreements become effective when sixty to seventy-five per cent of the royalty interest signify their approval.

State Authorities

Sullivan (1956, p. 370) remarks that the state is frequently a party to the agreement where the laws require approval of the conservation agency before unit
operation can begin. In most states, hearings are held prior to unitization, such as in North Dakota where the North Dakota State Industrial Commission considers applications for unitization. At these hearings, the potential unit operator presents his testimony as to why he believes the pool should be operated as a unit. After consideration by the State Geological Survey or other conservation authority, the plan is either rejected or approved.

Pirson (1957, p. 166) states that unitization regulations are variable in each oil producing state. In Texas the laws governing unit operation are very specific in their requirements. Some of the more important clauses according to Pirson (1957, p. 166) are:

1. a unit may not be formed to reduce operating cost and prevent competition; it must be shown that an increase in ultimate recovery will result,
2. it must be shown that the increased cost of operation under unitization will be less than the value of the additional oil recovered,
3. all interested parties must be given an equal opportunity to participate in the project and be on a voluntary basis, and
4. permission for unit operation is granted only after a public hearing before the state regulatory body, the Texas Railroad Commission. In Oklahoma and Arkansas, unitization may begin only if a certain percentage of
the working interest approves; sixty-three per cent in Oklahoma and seventy-five per cent in Arkansas (Pirson, 1957, p. 166). Louisiana permits voluntary oil and gas unitization but the state may compel participation in such projects in absence of agreement between parties. Colorado, New Mexico, Montana, and Wyoming permit unitization for conservation purposes through selective production, while water or gas injection is not always permitted (Pirson, 1957, p. 166). Ten other states have unitization statutes whereas California, Missouri, Utah, and Virginia have no conservation laws whatsoever.

Both before, during, and after unitization there must be complete frankness, trust, and confidence among all concerned.

**Recommended Contracts**

To be successful, a unit plan should enable active cooperation among royalty owners and operators by having contracts which are thoroughly understood by both parties.

Experience has shown according to Sullivan (1956, p. 370) that there should be two separate contracts in a unitization plan, the unit operator agreement and the royalty unitization agreement. The former specifies the details of the operator's duties and is signed only by them whereas in the latter, both lessees
and royalty owners agree to unit operations of the pool. The result is that each contract is shorter and less complicated making it more acceptable, especially to the royalty owners (Sullivan, 1956, p. 370).

Keplinger and Wanenmacher (1953, p. 203) report that most contracts are so worded that each operator markets his share of the petroleum products thereby avoiding the unit being considered as a separate corporation by the Treasury Department. If considered a corporation, the project would be subject to additional taxation.

According to Avery and Miller (1934, p. 1490) the rights and obligations of the various parties in a unit plan should be clearly shown in the initial contract accompanied by a statement of its extent and the conditions of its termination.

**Participation Formulas**

The core of a unitization program is the participation formula (Pirson, 1957, p. 164). Williams and Meyers (1957, p. 179) define it as a formula employed in the allocation of costs and proceeds of production under a unit operation agreement. According to Keyes (1944, p. 305) the best formula is the one which is simplest.

Two basic principles should be followed in the formation of a participation formula: (1) production should be allocated according to the contribution of
each leaseholder, and (2) consideration of the degree of depletion that has set in when unitization is begun. As a means of adhering to these two principles, Pirson (1957, p. 164) lists the following factors as those which usually enter into determination of the participation formula:

1. Productive acreage.
2. Effective pay (acre-feet).
3. Recoverable oil in place exclusive of that due to migration.
4. Producible reserves inclusive of oil which may have migrated; this is difficult to evaluate and is therefore largely a matter of opinion.
5. Value of future reserves including that which may be obtained by artificial stimulation of the reservoir.
7. Allowable production at present (a measure of current income).
8. Cumulative production.
9. Number of wells (a measure of the original investment of each operator).
10. Bottom-hole pressure (a measure of the state of depletion of a tract).
11. Productivity index (another measure of current income).
12. Ownership of oil in place. This is in terms of
net acre-feet which equals feet of pay times oil saturation. This is considered a poor factor in determination of the participation formula because it disregards oil recoverable due to migration.

13. Acre-feet times porosity.
15. Present day value of reserves.
16. Adjusted acre-feet. This must be considered because most reservoirs yield oil, gas, and condensate in varying ratios with a different market price being paid for each. According to Pirson (1957, p. 164) in some units, gas-in-place has been given one-fifth the value of oil-in-place.

Of the sixteen factors listed, migration, reserves, and present worth are largely interpretative thereby making it difficult to arrive at an acceptable equity (Pirson, 1957, p. 165).

Surface Acres

The simplest formula is that based on surface acreage and was the one most widely used in the past (Myers, 1957, p. 77). This formula is unfair since only where the productive formation is uniform in thickness, permeability, and quality of oil will each owner be receiving his rightful portion of revenue. Allocation
on a surface acres basis according to Keyes (1944, p. 305) is fair only when there is one producing unit of equal thickness over the entire producing tract. This type formula has been used where little is known about the character and extent of the reservoir and where production is from one zone. According to Miller (1953, p. 184) after more information is accumulated on the field, the surface acres formula may be converted to a volumetric or acre-foot basis. Where there is more than one zone of production varying in thickness, an entirely different and more complicated formula must be used.

Basing participation on surface acres leads to the danger of including non-productive acreage within the unit (Myers, 1957, p. 78). According to Logan (1930, p. 179), under surface acres, there is no distinction between properties closer to or farther from the present wells. Apportionment is merely based on the ratio of estimated ultimate production of the leases owned by each party to the estimated ultimate recovery of all leases in the tract. Logan (1930, p. 179) relates that on such a basis, the more productive leases will eventually receive greater profits per acre.

"Split" Formula

A recent development in participation formulas is the "split" formula. According to Pirson (1957, p.166),
it was originally used in semi-depleted fields but recently has been used in new oil fields. It takes into account that each owners share of oil production is not the same during the period of primary production as it is during secondary recovery operations. The "split" formula provides a certain formula be followed until such time as the estimated primary reserves are produced. After that, a different formula is in effect for the remaining life of the field (Pirson, 1957, p. 166). In other words, one formula is used to compute the primary reserves and another to compute secondary reserves.

According to Myers (1957, p. 79) the participation formula in most agreements today is worded as follows:

"The participation of each member tract in the unit area shall be based 75% on the proportion expressed in per cent, that the gross acre-feet of Canyon Reef above the water table underlying said tract bears to the gross acre-feet of Canyon Reef above the water table under the unit as a whole; and 25% in the proportion expressed in per cent that the number of producing wells producing from the Canyon Reef on said tract bears to the total number of producing wells producing from the Canyon Reef in the unit area."

Miscellaneous Formulas

Although the "split" formula is becoming the most popular throughout the industry, there are innumerable
others employed where conditions are such that neither the most simple or complex formula would be desirable.

A common formula determines participation on the basis of fifty per cent oil-in-place and fifty per cent on current production. In areas where oil may migrate over long distances, more weight is given to oil-in-place (reserves) than to current production (Pirson, 1957, p. 166).

According to Pirson (1957, p. 166) the following formula is used at Levelland field, West Texas: 0.375 on acreage, 0.50 on current production, and 0.125 on the number of wells.

Economic Effects

Miller (1953, p. 191) says one of the most important considerations of operators and royalty owners is the effect the formula has on current income. When unit operation is undertaken, the income of each operator must be adjusted to the new level of production. Many formulas, especially those used in fields unitized for secondary recovery, are designed to lessen the effects of a lowering or raising of current income (Miller, 1953, p. 191). The "split" formula does this by maintaining income at approximately its current level during the transition period from primary to secondary recovery operations (Miller, 1953, p. 193).
Recent Developments

Recent advances in reservoir engineering have enabled participation formulas to be equally fair to royalty owners and operators. Subsurface conditions and reservoir content are now more accurately interpreted thereby providing a more reasonable basis for participation (Keyes, 1944, p. 305). Where a particular formula may be slightly to the disadvantage of the company with large expenses in unitization, the rewards are usually great enough to enable it to sacrifice the loss (Myers, 1957, p. 77).

Many long and laborious hours of work must be put into participation formulas before both sides agree to acceptance. Just how enthusiastically it is received by the working interest and royalty owners is probably the real test of whether or not the formula is practical and workable.

Operating the Unit

Unit Operator

The unit operator according to Williams and Meyers (1957, p. 268) is the person, association, partnership, corporation or other business group designated under a unit agreement to conduct operations on unitized land.

Appointment

The unit operator is usually selected at an early
stage in the formation of the unit and most often is
the company having the largest holdings in the tract,
although the owner of a lesser interest may be se-
lected because of his experience in the proposed oper-
atations (Keplinger and Wanenmacher, 1953, p. 200).

Having a unit operator tends to eliminate disa-
greements between operators concerning methods of oper-
ation. One operator may be cautious, while another
may be inclined to take chances; one operator may like
to work with heavy equipment and deep holes, whereas
another may be satisfied with lighter equipment and
shallower holes; and one operator may be scientific
or more curious than another who has a more practical
attitude toward unit operation (Levorsen, 1954, p. 648).

Obligations

Keplinger and Wanenmacher (1953, p. 203) cite the
following as some of the duties of the unit operator:

1. Conduct operations in a workmanlike manner.

2. Handle the bookkeeping of the unit. This in-
cludes paying for the drilling equipment and
its upkeep as well as keeping an accurate set
of books of the operation. The books are
customarily audited once a year by a disinter-
ested party or at any time the other operators
may request it. In addition, every month,
each party is given a statement showing all
receipts and expenses during the preceding month with all invoices or bills being made available on demand.

3. The unit operator must mail to each non-operator, a statement showing the following:
   a) Monthly fluid production (oil, gas and water).
   b) Results of individual wells (each well must be tested at least once a month).
   c) Fluid produced to date.
   d) Number of producing wells.

If the area has been unitized for secondary recovery operations the following should also be included in the monthly statement:
   e) Amount of fluid injected into the reservoir during the month.
   f) Input well-head pressures.
   g) Fluid injected to date.
   h) Number of input wells.

4. Furnish each party with records of drilling results and progress reports concerning the results of secondary recovery operations.

5. Keep the operating committee informed at all times on the proposed drilling operations, design of equipment required and detailed estimates of costs. The unit operator should have frequent
meetings with the operating committee to discuss these items.

6. Comply with the orders, rules and regulations made by state or governmental authorities.

7. Carry sufficient insurance and comply with the Workmen’s Compensation laws.

According to Keplinger and Wanenmacher (1953, p. 203), after the operator has been selected, it becomes his responsibility to see that the unit is operated in accordance with the best economic and conservational practices and in keeping with the unit contract.

**Operating Committee**

The operating committee, relate Keplinger and Wanenmacher (1953, p. 203), is the agent for the parties in the unit and is composed of one member from each company in the unit agreement. The unit operator carries out the orders of this committee. This committee meets at regular intervals and handles various business affairs of the unit and with recommendations from the unit operator, carries out its operating policies. The committee usually has engineering, land, and accounting committees within it for advice on specific aspects of unit operation. It is the final authority and has the power to replace the unit operator. In any decisions by this committee, a simple majority of its members is final (Keplinger and Wanenmacher, 1953, p. 203).
Operating Procedure

Once the properties have been appraised and all operators have agreed to participation, the unitization program can proceed along several lines. One alternative according to Uren (1950, p. 185) is that if the owners wish to retain technical ownership of their individual properties, it may be arranged that each tract shall be operated by a trustee. Expenses and profits would be divided among the members according to the initial valuation of their properties. Uren (1950, p. 185) mentions the following as another plan. The individual operators could exchange title to their holdings for stock in a new company. The new company would act as a holding company to operate the entire unit. Under this plan the maximum advantages of unitization are achieved (Uren, 1950, p. 185). If control of production is a matter of importance to an individual operator, it might be provided that each operator may claim his share of oil instead of a monetary profit from its sale.

Dissolution of the Unit

Provision should always be made in a unit agreement for its termination when it has served the purpose for which it was originally formed. The following is a common termination contract according to Myers (1957, p. 396 - 397).
"Subject to the other provisions hereof, this agreement shall be in force and effect so long as unitized substances are produced or are capable of being produced from the participating area in paying quantities or operations for the discovery, development, or production of unitized substances are conducted thereon with no cessation of more than ninety (90) consecutive days. A determination by operators, voting in accordance with the voting provisions of the actual unit agreement, that unitized substances can no longer be produced from the participating area in paying quantities shall be effective to terminate this agreement, provided that the unit operator shall file for record in . . . . . . County, . . . . . . . . . . a certificate to the effect that such a determination has been made and the termination of this agreement thus accomplished shall be effective as of the date of such filing for record.

Upon the termination of this agreement all rights in and to the several tracts there comprising the participation area shall revert to the owners and lessors thereof, and unit operator, with the approval of other operators shall provide for the salvaging, liquidation, and other distribution of assets and properties used in the operation of the participating area in a manner consistent with the operators' respective interests therein. The owners or lessees of any such tract desiring to take over and continue to operate a well located thereon may do so by paying unit operator for the benefit of all operations, the fair salvage value of the equipment used in the operation of such well and by agreeing to plug the well at his expense at such time as it is abandoned."
V. IMPORTANCE AND BENEFITS

Unitization offers economic, engineering, and conservational benefits the importance of which are common knowledge within the petroleum industry. State and federal governments will also agree with this whereas some royalty owners are not always fully convinced.

Economic

Avery and Miller (1934, p. 1462) state that the principle justification for unit operation is economic; since, exploration costs are cut, production expenses are lessened, reservoir energy is conserved, oil and gas are kept in the ground till needed and the life of the field is extended. The following economic benefits of unitization are not presented in their order of importance but merely in random manner.

Competitive Drilling Avoided

It is definitely more costly to develop oil producing properties under the competitive system than under a unitization program (Uren, 1950, p. 178). Especially in new fields, competition for early production leads to simultaneous drilling of many wells throughout the structure (Uren, 1956, p. 38). This is evident today in many areas of California, where derrick legs are actually within the base of one another. Some of these fields will never repay their
cost of development. If they had been unitized, fewer wells would have been drilled and a savings in capital would have resulted.

Most oil companies keep secret their information concerning the geology of the leases in a given area. Under unitization, all operators in the pool would be given free use of available data and would work together to secure maximum oil recovery (Uren, 1950, p. 178).

Duplication Avoided

This economic benefit is closely related to the previous one in that if you avoid competition, duplication is also reduced. The number of drilling rigs, camps, pump stations, storage facilities, and pipelines could be cut considerably (Brock and Landis, 1952, p. 206).

Economic Employment of Personnel

According to Uren (1950, p. 180) every oil company in a field must have a field superintendent, foreman, office staff, gauger, storekeeper, and many others whose time may not be fully occupied because the property the company holds is small. However, each of these men must be employed because of the difference in character of their work. Unitization would reduce both technical and administrative personnel and the time of each worker would be more fully occupied.
Marketing Advantages

Uren (1950, p. 181) relates that most small producers have insufficient capital to enable them to store their oil before selling it; therefore he must sell his product at current market prices. A group of operators organized into a unit can afford to build storage facilities to take advantage of market fluctuations. During times of low prices they can save their oil and in addition can buy and store the oil of others for future selling.

The greatest marketing advantage offered by unitization is that supply and demand can be regulated thus preventing any extreme variations in oil prices (Uren, 1950, p. 181). Large amounts of oil placed on the market at one time cause oil prices to drop and if this occurs simultaneously in several fields, the after-effects are sometimes long-enduring. The rate of production must not exceed market demand (Fanning, 1950, p. 87).

Engineering

Control of Water Incursion

Water encroachment on an oil field is impossible to control effectively without a cooperative agreement among operators in the field. Levorsen (1954, p. 452) states that encroachment upon a productive oil field
will ruin the reservoir by closing off portions of the reservoir rock which still contain oil. According to Uren (1950, p. 177) success of water control is possible only through unitization of the entire productive area.

Control of Reservoir Energy

Fanning (1950, p. 82) relates that maximum recovery from a petroleum reservoir requires the field be operated so as to utilize the natural energy associated with the oil. One operator cannot practice reservoir pressure control without the cooperation of his neighbors. Uren (1950, p. 176) reports that less than twenty-five per cent of the original oil content of the reservoir rocks is recovered in competitively operated fields. Only where acreage is operated cooperatively can pressure associated with the oil be controlled to obtain maximum recovery from the reservoir. When reservoir pressure is exhausted, oil production is also exhausted no matter what other circumstances may prevail. As Kaveler (1956, p. 32) relates, the machine represented by the rocks runs out of energy to expel the oil.

Scientific Well Spacing

Small oil properties tend to create unsystematic well spacing. Well locations are determined by pro-
perty lines and not by how it will affect the life of the pool (Uren, 1950, p. 177). Under unitization, boundary lines are discarded and the wells are spaced so as to promote maximum drainage with the least number of wells.

Brock and Landis (1952, p. 206) relate that had the Seminole Pool in Oklahoma been unitized instead of wells being haphazardly drilled, the saving in development costs would have been $17,000,000 plus a $14,500,000 saving in operating costs.

Pirson (1957, p. 164) considers the reduction of unnecessary wells as one of the primary incentives of unitization.

**Coordination of Drilling Programs**

It is important that all wells in a field be drilled at the appropriate time with respect to others in the same general area or on the same structure (Uren, 1950, p. 177). Delays in drilling specific locations can mean losses in ultimate recovery and can cause injury to the reservoir by depleting the gas cap.

Unitization of large tracts permits a predetermined plan to be followed while the field is being developed, instead of each operator trying to outdo the other for early production. When the drilling program is planned cooperatively by all concerned, a vast storehouse of knowledge, experience, and oil operation know-how
becomes available to all operators (Brock and Landis, 1952, p. 206).

Conservation

According to Fanning (1950, p. 83) the day the petroleum industry realized that an oil and gas reservoir is a physical unit marked the real beginning of conservation. Conservation is so closely related to unit operation that it would be impossible to write a unitization contract without at least a fundamental understanding of how conservation is affected by unitization (Benoit, 1944, p. 299).

Avery and Miller (1934, p. 1490) state that the importance of petroleum, made evident by two World Wars, has led to the development of many conservation measures by both federal and state governments. In most unit operations it is necessary that the program be in strict accordance with the conservation laws of the state and federal authorities (Benoit, 1944, p. 297). According to Uren (1950, p. 160), a landowner who drills a well into an oil reservoir and allows gas to escape wastefully can be restrained by injunction. Courts have upheld this principle saying that anyone who wastes natural resources or damages a common reservoir can be prosecuted. As a result of these and other conservation statutes, the petroleum industry is in a much better position today to operate fields on a
unitized basis (Benoit, 1944, p. 299). According to Williams and Meyers (1957, p. 266) the best results in conservation can be attained only by unitization since only in this way can reservoir pressures be conserved for maximum extraction of oil deposits.
VI. OBJECTIONS TO UNITIZATION

Logan (1930, p. 141) believes some people are leery of unitization merely because the word sounds unpleasant. The writer finds this hard to comprehend although the suffix "ization" does tend to have a disagreeable connotation. "To some people it suggests merger and monopoly rather than economy and efficiency" (Logan, 1930, p. 141).

Stagnating Effect

A common argument against unit operation is that it tends to create stagnation in the industry by eliminating competition (Logan, 1930, p. 189). This is logical since if a number of operators were competing for the oil in a pool, they would be developing new engineering methods and uncovering additional geological information with which to aid them in exploratory work.

Restraint of Trade

Some critics have said unitization is a combination in restraint of trade and therefore illegal. According to Sullivan (1956, p. 365) trade is restrained where cooperative agreements have the effect of fixing prices and excluding other operators from the market. Nearly all states have laws restricting trade, however many state conservation commissions encourage unitization in the interest of conservation realizing reduced waste
overshadows the trade aspect (Logan, 1930, p. 201).

Monopolistic

It has been said that unitization has monopolistic tendencies (Logan, 1930, p. 172). This is groundless in that it is no more monopolistic than the case where one operator has exclusive control of a large area. This appears to be the weakest of the arguments against unitization.

Distribution of Royalty

Ever since the days of Doherty, the basis by which royalty is distributed has been a drawback to unit operation. The basis of such criticism is, that the exact amount of oil in the reservoir cannot be determined, hence distribution is sometimes unfair. Logan (1930, p. 143) agrees that royalty distribution is not exact, but at least it has shown improvement over the old rule of capture whereby some landowners would receive up to thirty times as much oil as they were entitled to.
VII. BEAVER LODGE-TIOGA UNIT OPERATION

History

Early in 1957, operators in the Beaver Lodge and Tioga oil fields headed by the major leaseholder, Amerada Petroleum Corporation, were negotiating and studying the possibilities of integrating the two fields (Grand Forks Herald, May 5, 1957, p. 20). These two fields cover 37,421 acres and their producing wells, 281 in Tioga and 193 in Beaver Lodge, represent nearly half of North Dakota's producing holes (Grand Forks Herald, March 5, 1958, p. 1). Plate 1, in the back of this thesis, illustrates the geographic relationships of the two fields and their relation to other fields in the northern portion of the Nessan anticline.

Engineering and Geologic Studies

The normal procedure for forming a unit was followed at the time and as a first step, the operators formed a committee to study its feasibility in these tracts. Each of the twenty-one producing companies in the two fields had their engineers and geologists working on the problems expected to be encountered in such a huge project. A detailed study was made of the main reservoir to determine the number of acre-feet of productive limestone. According to Bartram (1954, p. 40) the Beaver Lodge-Tioga fields produce from a continuous
permeable horizon in the Madison limestone group. Beaver Lodge-Madison has 1,460,882 acre-feet and Tioga-Madison 1,313,144 acre-feet of productive Madison limestone (Williston Basin Oil Review, March, 1958, p.3).


Hearings

After all preliminary work among the operators had been concluded, Amerada Petroleum Corporation (hereafter referred to as Amerada), in hearings before the North Dakota State Industrial Commission during February and March, 1958, presented evidence for unitization of the
Beaver Lodge-Tioga fields. In her capacity as potential unit operator, Amerada had numerous specialists testify in behalf of unitization at these hearings in Bismarck, North Dakota. According to the Williston Basin Oil Review (March, 1958, p. 21) some of those testifying were: Henry Keplinger, consulting petroleum geologist from Tulsa; William Pearce, Bismarck attorney; James W. Snyder, Assistant Chief Geologist with Amerada; C.V. Millikan, Amerada's Chief Petroleum Engineer; and H.A. Nedom, petroleum engineer from Tulsa, also with Amerada. These men gave testimony concerning the geological and engineering characteristics of the two fields; illustrating by use of charts and drawings how unitization would decrease the unnecessary drilling of wells and increase the ultimate recovery of the fields.

Method of Secondary Recovery

In subsequent hearings before the commission, Amerada disclosed that its goal in this unit operation would be to inject millions of gallons of salt water into the Madison producing zone through wells situated around the periphery of the structure, thereby floating the oil upstructure to the producing wells for extraction (Nedom, public address, March 7, 1958). This process is called water-flooding and is accomplished by drilling special wells around the edges of the field, these to be used as injection wells (Grand Forks Herald,
May 5, 1957, p. 20). The Grand Forks Herald (March 6, 1958, p. 1) states that forty such injection wells will have been drilled by the time the program is in full operation. The chief element in water flooding, in order to secure greater ultimate recovery, is the strategic location of the input wells (Sullivan, 1956, p. 376). The pressure thus exerted by the injected water, together with a controlled rate of production, will allow the oil-water contact to encroach up-dip at a definite rate. As Myers (1957, p. 26) says, the oil will tend to be swept forward by degrees, producing wells converted into injection wells as the oil-water contact reaches them and their production ceases.

The Grand Forks Herald (March 6, 1958, p. 1) relates it will cost seven to eight million dollars to put this waterflooding program into effect with eighty per cent of this being paid by Amerada, since it holds the majority of leases in the area. Amerada officials believe this cost is justified in order to insure a greater recovery over a longer period of time. Water injection facilities will be aided by the natural water drive present in the area. According to Keplinger (1954, p. 18) the energy presently producing oil at Tioga is water encroachment along with solution-gas drive.

Fanning (1950, p. 131) reports that water drive fields can be expected to yield up to ninety per cent of the
recoverable oil if conditions are favorable and up to sixty per cent if conditions are unfavorable. As shown below in figures 1 and 2, the increase in petroleum production from Beaver Lodge and Tioga fields is expected to exceed 125 million barrels.

Figure 1
According to the Williston Basin Oil Review (March, 1958, p. 23) this additional recovery will amount to approximately one billion dollars worth of oil and gas products which are expected to come out of the two pools from the time water flooding begins until the reservoirs are depleted. The Grand Forks Herald (February 12, 1958, p. 1) estimates it will bring an additional 500 million dollars to the state including the additional revenue derived through the law stating that oil cannot
be taxed unless it is recovered. According to C. V. Millikan, Amerada's chief engineer, water flooding would be in full operation within eighteen months after sufficient royalty owners agreed to the program (Grand Forks Herald, March 6, 1958, p. 1).

Water flooding oil production appears to be in a minority throughout the United States. Smith (1957, p. 48) relates it accounts for approximately three per cent of the total oil produced in this country. The most famous and largest water flooding project is the East Texas field.

**Present Status**

On March 13, 1958, the State Industrial Commission granted Amerada permission to proceed with the unitization project (Grand Forks Herald, March 14, 1958, p. 1). In granting permission, the commission orders said, "a pressure maintenance program is in the public interest and is necessary to prevent the waste of oil and gas" (Grand Forks Herald, March 14, 1958, p. 1). In the Grand Forks Herald (May 5, 1957, p. 20) Dr. Wilson M. Laird, State Geologist of North Dakota said, "Technically speaking, this method is the best way to operate the fields."

**Royalty Owners Approval**

Amerada must now seek the approval and signatures
of the 1500 owners of royalty rights on the 515 tracts in the two fields (Nedom, public address, March 7, 1958). These royalty owners are situated all over the United States and Canada with some as far away as Norway. John Hammond, Amerada production superintendent, said in the Grand Forks Herald (March 6, 1958, p. 1) that the target date for signing up eighty-five per cent of the royalty owners is April 1, 1959. At least this percentage must give their approval since less than this would make efficient operation of the unit difficult. If Amerada should be unsuccessful in getting the required percentage, she has the alternative of unitizing only part of the area. However, the reservoir will not be depleted as efficiently as it would be if the entire reservoir were included. From latest reports, the project is receiving good backing from the royalty owners (Grand Forks Herald, April 6, 1958, p. 18). Eighty-four per cent of the mineral interest have approved in Beaver Lodge whereas seventy-four per cent have consented in Tioga (Grand Forks Herald, May 4, 1958, p. 13).

**Participation Formula**

C.V. Millikan said the participation formula used would take into account: (1) the volume of the productive Madison limestone under each tract, (2) the productive acreage of each tract, and (3) the pro-
ductivity of each well (Grand Forks Herald, March 6, 1958, p. 1). As an example, an eighty acre tract in Beaver Lodge with an average productive thickness of eighty feet having a well now producing at least fifty-six barrels of oil per day would get .5264 per cent of the pools daily production. The figure of fifty-six barrels per day was chosen because that was the approximate allowable during the first half of 1957; in other words, wells capable of producing fifty-six barrels per day on June 1, 1957 were assigned that figure (Williston Basin Oil Review, March, 1958, p. 25). Accordingly, other wells were assigned a figure, something between zero and fifty-six, depending upon what they were capable of producing on the same date. According to Nedom (public address, March 7, 1958) over 25,000 separate calculations were required while figuring the revenue each landowner was to receive. These had to be thoroughly checked and rechecked.

As under any unitization project, revenues from the entire area will be pooled and apportioned out to those concerned, regardless of which wells within the unitized area produce the oil.

Future Status and Conclusions

Some people may ask, "Why did the operators in Beaver Lodge-Tioga decide to unitize now?" The time of unitization must be considered from an engineering point of
view. Engineers in these two fields estimated from studying production records and pressure reductions in each well, that pressure maintenance operations would be necessary to obtain ultimate production from the structure. The most economical method of maintaining pressure is to operate the area cooperatively. Amerada and the other twenty operators in Beaver Lodge-Tioga began work on unit operations nearly two years ago, but theoretically unitization work began from the time the first well was brought in during April, 1951. The writer believes the sooner unit operations are begun in the life of a field, the better. The sooner in its life a lion is trained, the easier and more rewarding the training will be. So it is with an oil reservoir; letting a field be operated too long without artificial adjustment results in waste and eventually, reservoir damage will become too far advanced for anything to be done to obtain maximum recovery.

Through the Beaver Lodge-Tioga unitization, the writer believes Amerada, along with its fellow operators, is bringing financial and conservational benefits to North Dakota. How much it will benefit and how successful the program will be, remains to be seen, but if its past success in other unitized fields is any indication then doubts anyone may now have can safely be abandoned.
The people of North Dakota should be grateful to the State Industrial Commission which has seen to it that the states' oil resources have not been wasted through poor production methods. This group has done a superlative job since it set its first monthly allowable in 1961 to the present unitization ruling.

In the final analysis, evaluation of North Dakota's first large scale unitization project will be possible only after sufficient time has elapsed to make an accurate study of the resulting additional production.
VIII. SUMMARY

The petroleum industry has learned through long experience that efficient operation is profitable operation (Levorsen, 1954, p. 467). Certainly unitization is a milestone in the progress of the industry and is good evidence of the cooperation which can be achieved between operators and royalty owners.

To the geologist belongs the task of initiating a unitization program, with subsequent supervision by the petroleum engineer to control production by economic well spacing and full utilization of reservoir energy. The tasks of the geologist and engineer are made easier through unit control of a single geologic structure (Avery and Miller, 1934, p. 1491).

According to Wilson (1938, p. 1086) placing a unit program into effect requires the discard of the spirit of individualism which has and always will characterize operators and royalty owners. A few operators are indifferent toward unitization while others find it complicated but the principle is logical and is working in over 1000 projects in the United States.

Where legal obstacles to unitization exist, state laws should be clarified to encourage and facilitate the initiation of unit plans. State conservation authorities should be conscious of the principle in order to promote real conservation of oil and gas.
resources (Pirson, 1957, p. 166).

As is evident from the amount written in this paper concerning each, the benefits far outnumber the drawbacks of unitization. This is obvious, since were it not overwhelmingly advantageous, unit operation would not be so prevalent as it is throughout the oil fields of the world.

In these days when so much emphasis is being placed on economy, it is important to take advantage of the savings which can be achieved through unitization. In science as well as in business, it pays to stop and figure things out in advance.
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