Mineral Industries

School of Mineral Industries

VOLUME 20

NUMBER 7

The Pennsylvania State College

STATE COLLEGE, PA., APRIL, 1951

Graduate Research In Petroleum Production

By R. F. Nielsen*

The School of Mineral Industries has for many years offered opportunities for graduate study leading to advanced degrees in its various curricula. Graduate study in the Division of Petroleum and Natural Gas Engineering, as in the other divisions, involves an appropriate balance of formal courses, seminars, research, and independent study. Formal courses include advanced studies within the division, as well as appropriate courses in mathematics and physics, engineering, and earth sciences. The writing of a dissertation based on a part of the candidate's research is required for the degrees of Master of Science and Doctor of Philosophy.

The research projects now being carried on by graduate students in petroleum and natural gas engineering will be reviewed briefly. Some of these projects are supplied by funds from private industry.

Gas plays a very important part in the production of oil by both primary and secondary methods of recovery. To understand the part played by gas it is necessary to have information on the interactions between gas and oil alone without the complications involved in the movement of the fluids through the pores of the producing sand. Such phase equilibrium studies involve, among other things, the determination of the amount of gas dissolved in the oil at various pressures and temperatures and the effect of such dissolved gas on the physical properties of the oil, as, for example, viscosity and density.

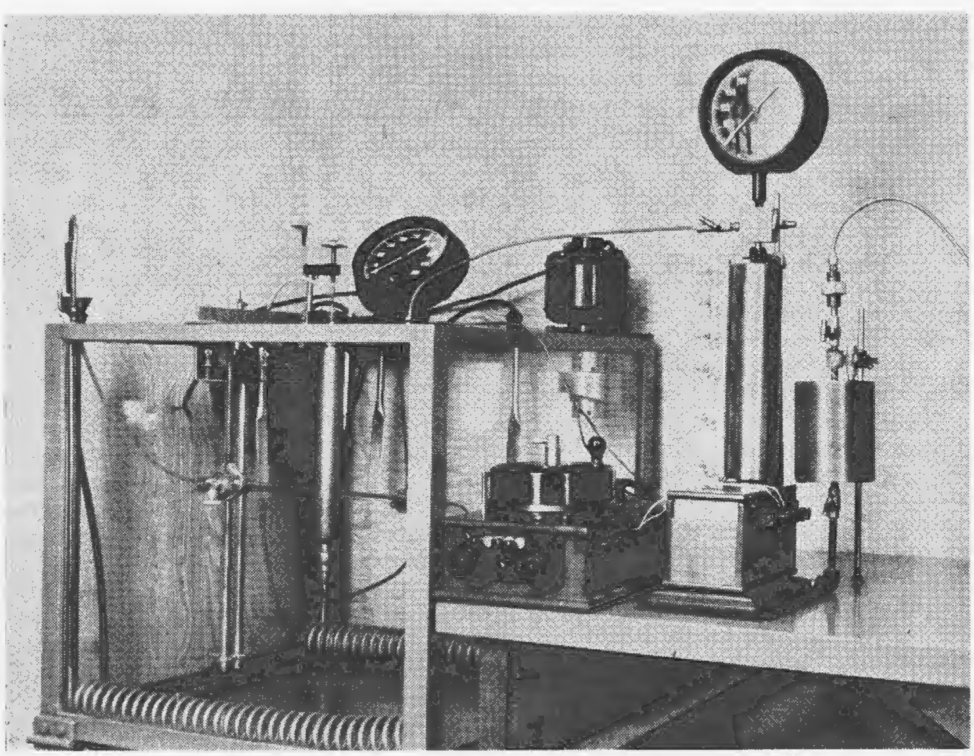

Figure 1 — Apparatus for measuring gas solubility.

Because of the complex chemical make-up of petroleum, special calculation techniques have been designed for such mixtures. The results of physical measurements are usually correlated in the form of tables or graphs of numerical quantities or "constants" to be used in such calculations. Since it would be impossible to measure the properties of the infinite variety of possible mixtures, these "constants" serve to give the contributions of the individual components toward the properties. The properties and behavior may then be calculated for a specific case in which the composition is known. Since these "constants" actually vary with conditions, measurements are continually being made in laboratories to determine the "corrections" to be made for various compositions, types of oil, and other conditions.

SOLUBILITY OF NATURAL GAS IN OIL

The solubility of natural gas in Bradford crude is under investigation by Clark Sherwood, using apparatus shown in Figure 1. The gas is compressed by means of mercury in a steel U-tube. A cylinder of compressed nitrogen serves as a source of pressure in the right arm of the U-tube. The gas whose solubility is to be tested is placed in the left arm. As the mercury rises in this arm, it closes electric circuits, causing lights to go on, at definite points. Previous calibrations determine the gas volumes at these points. The compressed gas enters the equilibrium cell, containing oil, in the constant temperature bath, and by constant agitation of this cell, the gas dissolves in the oil to equilibrium conditions. Pressures are read from gauges shown in the illustration. These gauges are checked against "dead weight" gauge testers.

The increase in oil volume due to the dissolved gas is measured with a "level finder" attached to a micrometer screw with a vernier. This "level finder" is hollow and has a small thermocouple at the lower end. The couple is heated by a warm air stream, and a deflection is obtained on a galvanometer when the couple touches the oil surface. The apparatus is designed so that the oil with its dissolved

(Continued on Page Four)

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Mineral Industries

Published monthly by the School of Mineral Industries from October to May inclusive

The Pennsylvania State College

Mineral Industries Extension Services
D. C. JONES, Director

Pennsylvania's School of Mineral Industries and Experiment Station

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Entered as second-class matter at State College, Pa., November 1, 1938, under the Act of August 24, 1912.

APRIL, 1951

Trends and Objectives

By Dean Edward Steidle

THE MAGMA

(Seventh in a series of editorials on *Wanted: Mineral Industries Colleges* — a phase of higher education in the mineral arts and sciences)

Human progress has a visible material phase, easily discernible, that is expressed in the standard of living. This material phase, however, is only the outward expression of a spiritual or mental phase that acts as a driving force in making humanity improve both its outlook and its mode of living.

The instrument of progress is the human brain. Under the urge of spiritual drive, the brain acts as a focal point to utilize the forces of nature and put them to work for the benefit of mankind. Besides intelligence, which is an innate quality, the tools of the human brain are knowledge, experience, training, initiative, and skill. Given sufficient intelligence, the human brain can make an amazing amount of progress, provided it is supplied with an adequate spiritual and moral urge and a good technical background. It is the role of education to supply such a background.

The material phase of human progress proceeds on a series of parallel fronts, all of them interdependent to some extent (Fig. 1). The rise of the standard of living, dependent as it is upon the manufacture and mass distribution of goods, is based essentially upon the development and utilization of the material resources of a country or land area. This development involves the extraction of mineral and organic products from Mother Earth, their transportation to manufacturing centers, their transformation into finished goods and their distribution to the people. All of these operations proceed continually and simultaneously on a parallel broad front, but each operation involves a series of stages, and each of these stages is conducted by human beings in whom qualities of intelligence, skill, and industry must be found in order to facilitate efficient consummation.

But the same kinds of intelligence and skill are not necessarily required for each of the different operations. In manufacturing and distributing, two requirements are very important: (1) an intimate knowledge of machinery, its best uses, its potentialities; and (2) an understanding of human relations, personnel problems, and public relations.

In the stage of building and constructing the physical plants, and providing means of transportation and distribution, the problems are different. In this stage the human equation is less of a problem than the conquest of hostile environments, the overcoming of natural obstructions.

In the basic stage of development of primary wealth in agriculture and mineral industries, man comes in closest and most direct contact with Nature. Nevertheless, the approaches to the problems in these two fields are different. In agriculture, each farmer traditionally has dealt with a single plot, and the net result has been the accumulation of many thousands of individual efforts, each man working in his own way without much consideration of the result as a whole. However, in mineral industries, at least in the more modern aspect, the approach is different. In exploiting mineral resources, type, degree, intensity, and speed of operation have been dictated by national or international requirements. There are relatively few mines and oil fields, and they are scattered throughout the globe. Their operation usually entails a struggle against natural difficulties, and once exhausted, the supply is irreplaceable.

In order to be able to deal with the problems unique to their field, men training for mineral industries must have several basic qualities. They must have the ability to understand natural problems as a whole, the ability to interpret the functionings of the different fields in terms of national economy, the ability to solve problems which change from day to day, and a deep sense of obligation to exploit natural resources wisely and conserve them well. All this requires well-developed tech-

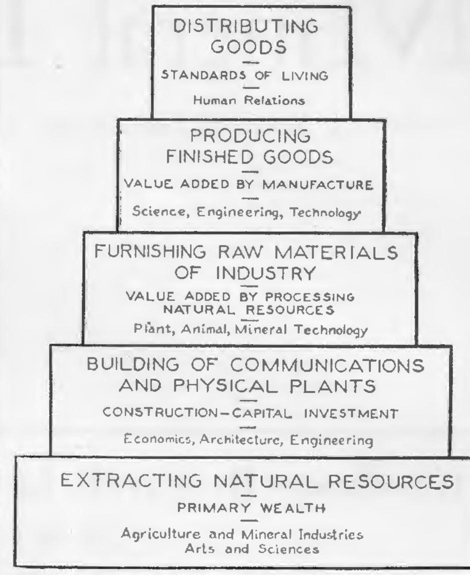


Figure 1 — Human progress and the five stages of applied science.

nical skills, and know-how of mechanical operations, as well as a strong general scientific and cultural background.

How can mineral industries education best meet such difficult requirements? This function might well be compared with the natural process of the formation of a crystal. The high temperature solution, magma, from which igneous rocks originate, forms minerals by the process of crystallization. The quality of the finished mineral, its durability, its potential usefulness, will depend upon the chemical composition of the magma. By the same token the potentially highest level of mineral industries graduates depends upon the basic qualities of intelligence of the entering freshmen, a fact which should be remembered by those who are in charge of secondary education.

However, the high intelligence of a freshman class does not necessarily predicate the final achievement of the highest level of graduates. Nor does the correct concentration of a chemical solution insure the formation of a perfect crystal. There must be proper control of reactions taking place during crystallization. Temperature, pressure, and proper balance between physicochemical fields must all be controlled for a definite period of time. Otherwise, a totally unexpected mineral may result; the crystal might be highly unstable, ready to invert and shatter as soon as pressure and temperature conditions change.

Similarly, well-rounded curricula must be provided and rigid standards maintained over an adequate period of time in order to produce a high-caliber graduate, a man well qualified to meet any exigency he might encounter. Otherwise, a mere automaton, a technician capable of only

(Continued on Page Six)

Oil Recovery Method Announced Recently Substantiates Earlier Researches Here

The recent disclosure (*Producers Monthly,* January 1951, page 6, and the *Oil and Gas Journal,* January 25, 1951, pages 171-172) of the discovery of a new and efficient method (the Orco process) of recovery of oil from the reservoir rock in place recalls some early and financially unsupported investigations made between 1940 and 1943 in the School of Mineral Industries of The Pennsylvania State College.

Reviewing briefly the Orco process, it is stated that "an hitherto unknown reaction of carbon dioxide gas with hydrocarbons" is put to use in recovering oil from the earth. This involves "some chemical conversion of oil in formation which promotes its movement through permeable media." It is inferred that work started on the project in 1947 and that the process "employs carbon dioxide in water solution which is injected to the oil-bearing formation in input wells" and that "the process does not utilize carbon dioxide for the purpose of repressuring the reservoir." However, "the *temperature and pressure relations* under which carbon dioxide gives these favorable results are those common to most water-flood secondary recovery projects."

It is impossible to ascertain from the scanty details contained in press releases on the Orco process if it is in any way parallel to the early work at Penn State, but it is stated that "in the past there have been unsuccessful efforts made by others to employ carbon dioxide in the recovery of oil."

The chronology of the early work at Penn State is as follows:

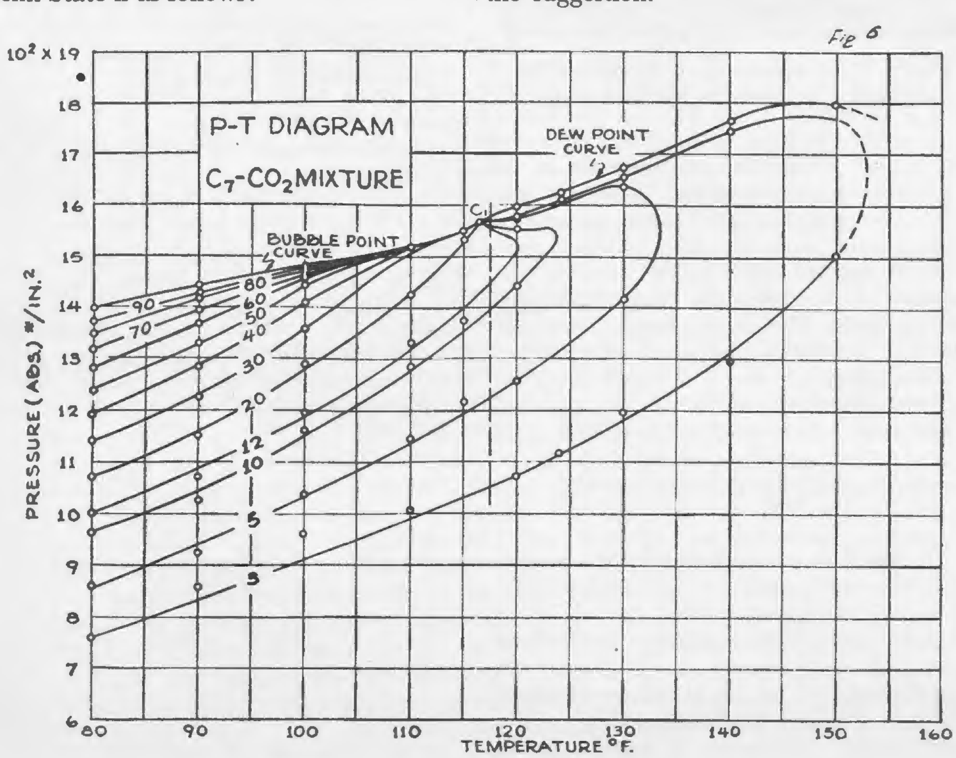
On June 26, 1941, a paper written by Dr. Sylvain J. Pirson, then head of the Petroleum and Natural Gas Department, and entitled *Tertiary Recovery of Oil* was read before the AIME Central Appalachian Section Meeting at White Sulphur Springs, West Virginia.

In discussing the various possible approaches to recover a "third crop of oil" the paper made the following statement:

"Of more interest are the possible processes classified under 'Vapor Solvent Extraction Methods.' It is well known that most gases under very high pressures, above their critical temperature, assume properties very similar to those which they have when liquefied. In particular, their solvent power is greatly increased. If a second liquid, normally soluble in the liquefied gas, is brought in contact with the gas when under pressure, this liquid will have a tendency to vaporize; this is known as the phenomenon of 'Retrograde Vaporization'. "

Various gases were investigated theoretically as possibilities for stripping residual oils from reservoir rock: ethane, propane, and carbon dioxide. Ethane and propane were rejected as too expensive and requiring too high a pressure and reservoir temperature to achieve the desired result. Carbon dioxide, on the other hand, because of its availability, low critical temperature (89.5F), and pressure (1072 psia) was strongly advocated.

In conclusion, Pirson made it clear that the suggestions were altogether futuristic and that no laboratory or field tests had been made to ascertain the possibilities of the suggestion.



The interest in carbon dioxide injection for the recovery of oil remained in theoretical circles, and no response was received from industry. However, the theory appeared so promising that when a graduate student, Mr. Carlos Lara, Jr., from Venezuela, was searching for a thesis subject, he was assigned some exploratory experimental work on phase relationship between hydrocarbons and carbon dioxide. At that time, Gulf bottom hole sample testing equipment had just been received from which the mercury pump and pressure gauges could be adapted to the study of phase relationships in a glass capillary. Lara's thesis issued from Penn State in October 1943, was entitled *Phase Diagram for Normal Heptane-Carbon Dioxide System.*

The essential results of the study are represented in the accompanying figure which gives the phase relationship for a carbon dioxide-normal heptane mixture in the volumetric ratio of 24 cc. of CO_2 at normal temperature pressure for 0.0127 cc. of liquid n-C_7H_{16}. The research time allocated to Master of Science theses did not permit the investigation of systems of other compositions. This was, however, the first time a normally liquid hydrocarbon was shown to give rise to a pronounced retrograde vaporization phenomenon, although J. P. Kuenen had investigated the ethane-carbon dioxide system at the close of the past century.

It was evident that Lara's work had opened an avenue of research hitherto unexplored for the recovery of oil. Already enough was known about the behavior of such systems to permit generalization by analogy and to expect similar phenomena, differing only in degree, to occur with crude oils. The inferences were simple and sweeping, and they totally validated the predictions made in the earlier AIME paper. All that was needed was to inject a sufficient amount of carbon dioxide in a depleted oil reservoir in order to vaporize the remaining oil in place and recover it to the last drop.

FORMER DIVISION CHIEF IS AUTHOR OF PETROLEUM TEXT

Dr. S. J. Pirson, formerly Professor of Geophysics, now Special Research Associate with Stanolind Oil and Gas Company, Tulsa, Oklahoma, has written an important petroleum text entitled *Elements of Oil Reservoir Engineering* which was published recently by McGraw-Hill Book Co., Inc. Dr. Pirson's authoritative and timely treatise deals with the principles which govern the behavior of geological petroleum reservoirs when placed under production, not only during their primary phase but also during the application of external sources of energy as practiced in secondary recovery operations.

GRADUATE RESEARCH

(Continued from Page One)

gas may be transferred under pressure to a rolling ball type viscosimeter for viscosity measurements.

PRIOR GAS INJECTION

Among the field practices requiring information on the solubility of gas in crude and its effect on the volume and other properties of the oil is the injection of gas ahead of a water flood. This practice is referred to as "prior gas injection". Certain laboratory studies have shown a greater percentage recovery of the oil in place when gas is injected ahead of a water flood than in the case of a water flood alone.

Jean Freeland is studying the effect of prior gas injection, using long cores of consolidated sand and other porous media. Some of his experiments involve a laboratory scale simulation of the field process; that is, the cores are saturated with oil and brine, and a part of the oil is produced as in primary or "flush" production. The remaining oil then corresponds to the amount present when secondary recovery methods, such as water flooding, must be initiated. At this point the core may be subjected to a water flood or to gas injection followed by a water flood.

Jean's problem is to find the reasons or mechanism by which any gains may be realized by prior gas injection and also to find the conditions under which such injection is most favorable. The billions of barrels of oil left in the ground after the usual primary and secondary recovery methods have been utilized present a challenge, and the use of gas and water together is one of the many approaches in an attempt to reduce this loss of a natural resource.

THE ROLE OF VISCOSITY IN WATER FLOODING

One of the effects of dissolving natural gas in oil is a lowering of the viscosity; that is, an increase in the ability of the oil to flow. Since this contributes to the rate of production, the phase equilibrium project mentioned above includes measurements of the viscosity of the oil with its dissolved gas. In "prior gas injection" the oil viscosity is obviously affected. The viscosity of the oil not only determines its flow rate, but may determine the amount of oil left in the ground after abandonment, due to uneconomic production. In secondary recovery operations by a water drive the injected water may break through to the producing wells before all the recoverable oil has been produced. This means pumping a great deal of water to obtain the last portion of oil. The viscosity of the oil plays a large part in determining the amount of residual oil at water break-through. The general problem of the role of viscosity in water flooding, with or without prior gas injection, is being studied by Carl Sherman. The problem is complicated by the fact that the effect of viscosity varies greatly with the type of oil sand.

VACUUM AND OIL PRODUCTION

There has been much controversy over possible gains obtained by applying vacuum to producing wells. A project for the study of the effect of vacuum on oil production from sands has been assigned to Patrick Huber.

The laboratory investigations on this problem fall into three categories in accordance with three possible mechanisms by which vacuum might aid production of oil. One of these is the release of additional gas from the oil, due to the vacuum. This release of gas amounts to an extension of the so-called "dissolved gas drive" beyond the point where such a drive would normally stop without vacuum. A second mechanism involves the increase in pressure drop toward the producing wells. The third possible mechanism may be the aiding of a water drive. For instance, if there is a water drive on the oil, the removal of gas by vacuum might make more pore space of the sand available for the flow of oil and water, thereby increasing the rate of oil production.

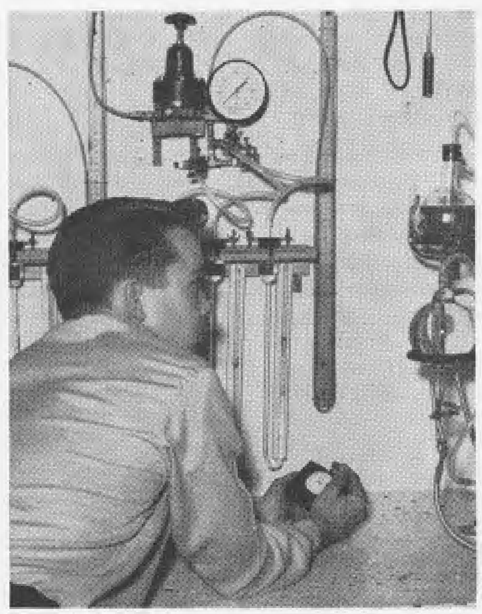


Figure 2 — Apparatus to determine the wettability of sands by oil and water.

Pat has set up sand-packed tubes loaded with oil, water, and gas to simulate field conditions, and has studied the effect of vacuum on the oil production from these tubes. The experiments have been so designed that each of the above mechanisms could be studied separately; that is, the experimental procedure in each case is planned so that if there is any effect from the vacuum, the mechanism giving the effect will be known. The results of these investigations should be very helpful in determining efficient field operating conditions and in helping toward a better understanding of basic principles of fluid displacement.

DISPLACEMENT STUDIES

Research which tends to increase our understanding of the mechanism of oil production is often referred to as "displacement studies". When oil is removed from the porous rock structure in which it is found, something must take its place in the pores. Thus, the oil may be displaced by a gas or by another liquid, such as water.

Displacement studies are usually macroscopic; that is, one observes the overall behavior of a piece of porous material. Any measurements made then represent an average or an integration for all the pores and capillaries in this sample. For certain kinds of information, however, it is desirable to use the microscopic attack, or observe what happens in the individual capillaries.

Francis Coley is making such observations, using a chemical microscope fitted with a special stage and other equipment. To obtain a system which can be observed, fine glass capillaries filled with powdered sand or microscopic glass beads are used. Some observations are also made on glass capillaries drawn out in such a way as to leave re-entrant angles in which liquids may be retained, due to surface tension. The displacement of oil by water or gas in these systems can be observed through the microscope which is fitted with a motion picture camera, thus permitting Frank to record any phenomena of interest on "technicolor" film. Magnifications up to 450 diameters are possible.

CAPILLARY PRESSURE

In the displacement of oil by water or gas certain retentive forces must be overcome. One measure of the degree of retention is the "capillary pressure", which has been investigated by Paul Kinney. Figure 2 shows a bank of cells which Paul has been employing to make capillary pressure measurements as a means of determining the wettability of sands by oil and water. For instance, he has demonstrated that Bradford oil sand is preferentially wet by oil and Venango sand is preferentially wet by water. Such information is important in determining the procedure for other physical measurements on the sand. It is also important in our constant search for materials and methods of lessening the retentive forces and thereby increasing the amount of recoverable oil. Very recently capillary pressure measurements have been

(Continued on Next Page)

Experiment Station Publications

Copies of these publications may be obtained by writing to the Mineral Industries Experiment Station, The Pennsylvania State College, State College, Pennsylvania. When copies are indicated as not available, contact should be made with the journal in which they were published, or with a library where files of the journal are available.

T. P. 163. "Efficiency of Packed Fractionating Columns. Effect of Vacuum Operation." R. T. Struck and C. R. Kinney. *Industrial and Engineering Chemistry,* Vol. 42, No. 1 (January 1950). The effect of diminished pressure on the efficiency of packed fractionating columns has been investigated in a 0.75-inch glass column packed with Raschig rings, Fenske stainless steel helices, Cannon pertruded packing, and McMahon wire gauze saddles. Column efficiency was found to vary little with pressure, being slightly higher at 50 and 100 mm. of mercury absolute pressure than at 10, 20, or 730 mm. of mercury. In addition to efficiency tests on the four packings, vapor-liquid equilibrium data and correlations of hold-up and pressure drop are reported. (Free)

T. P. 164. "Ozonization of Humic Acids Prepared from Oxidized Bituminous Coal." M. D. Ahmed and C. R. Kinney. *Journal of the American Chemical Society,* 72, 559 (1950). On the assumption that the nuclei of the humic acid-like oxidation products of bituminous coal contain amorphous carbon, the humic acids have been subjected to ozonization. For comparison, carbon black, graphite oxide and the brown, water-soluble acids obtained from carbon black by hot nitric acid oxidation were ozonized under the same conditions. Both carbonic and oxalic acids appear to be the primary products in the ozonization of the humic acids and account for about 65% of the carbon. Practically all of the remaining carbon was converted to almost colorless, water-soluble, ozone-resistant acids. Although carbon black and graphite oxide did not react with ozone appreciably, the brown water-soluble acids prepared by oxidizing carbon black with nitric acid did react like the humic acids, giving carbonic, oxalic, and ozone-resistant acids. (Free)

T. P. 165. "Some Aspects of the Mineral Position of Eight Principal Industrial Nations." E. Willard Miller. *Economic Geography,* Vol. 26, No. 2 (April 1950). Modern mineral exploitation began and has developed most rapidly in the eight industrialized countries—United States, Great Britain, Russia, Belgium, France, Germany, Italy, and Japan. These nations consume 85 per cent of the world's mineral output and produce approximately 80 per cent of the manufactured goods of the world. This report examines the trends of mineral production in these eight industrialized nations. A series of charts has been prepared showing the percentage of world's total production for each of the eight nations covering the period 1925 to 1945, inclusive, of seven basic minerals—coal, petroleum, iron, copper, lead, zinc, and aluminum. (Free)

T. P. 166. "Pyrolysis of Humic Acids Prepared from Oxidized Bituminous Coal." M. D. Ahmed and C. R. Kinney. *Journal of the American Chemical Society,* 72, 556 (1950). Pyrolysis of the humic acid-like substances obtained from bituminous coal by oxidation has been studied particularly in connection with the constitution of these acids and, indirectly, the constitution of the coal from which they were made. No aromatic substances or tar were obtained; the volatile substances identified were water, carbon dioxide and monoxide, ammonia, hydrogen, methane, nitrogen, and oxides of nitrogen. No diminution in the gas volume was observed with fuming sulfuric acid, indicating an absence of unsaturated hydrocarbons, as well as aromatics. Likewise, no hydrogen sulfide, sulfur dioxide, nitric oxide, or oxygen was detected. (Free)

T. P. 167. "Solid and Gaseous Fuels." H. T. Darby *Analytical Chemistry,* Vol. 22, No. 2 (February 1950). This review of the analysis of solid and gaseous fuels is a continuation of the review by Gauger and Darby (T. P. 146) and includes a bibliography of 110 references found from August 1948 through September 1949. The arrangement follows closely that of the original review. (Free)

T. P. 168. "Experimental Study of the Effect of Air Pollution on the Persistence of Fog." H. Neuberger and M. Gutnick. *Proceedings of the First National Air Pollution Symposium* (March 1950). This paper reports the results of experiments on the problem of the relationship between air pollution and fog persistence. The present study was carried out at The Pennsylvania State College (lat. 40° 48′N.; long. 77° 52″W.; el. 368 m.). Artificial fogs were employed because it is impossible to control the nuclei content of the free atmosphere and because natural fogs in this area are rather infrequent. (Free)

T. P. 169. "Observations on the Thermal Expansion of Crystalline and Glassy Substances." F. A. Hummel. *Journal of the American Ceramic Society,* Vol. 33, No. 3 (March 1950). The temperature interval of the reversible thermal expansion of inorganic substances may be small as in dental porcelain, or large, as in open hearth refractory brick. In spite of the major influence of this property on the practical service life of industrial products, very few broad principles have been advanced regarding the effect of crystal structure on the reversible thermal expansion of pure compounds. In general, close-packed crystalline structures of the sodium chloride or spinel type, which have simple geometrical arrangements, seem to have high expansions. (Free)

GRADUATE RESEARCH

(Continued from Previous Page)

employed to calculate the relative permeabilities or conductivities of a sand for oil and water. Paul is a Navy reservist and was recalled to active duty recently.

RELATIVE PERMEABILITY STUDIES

The relative permeabilities of a sand to oil and water, or to gas and oil in the presence of water, are values that should be known to predict the production behavior of a reservoir. A large part of the research in production laboratories for the past few years has been devoted to the development of methods for measuring these quantities. Alan Meldrum, using the so-called "Penn State Method", is studying the factors that affect such measurements so that the values obtained may be the nearest possible approach to what these values are in the reservoir during production.

APPLICATION OF LABORATORY DATA

If the research work in petroleum production is to have any value, the quantitative information obtained from laboratory studies must eventually be applied to the behavior of an oil field. Such application generally involves mathematical devices, not only because of field dimensions but also because of field geometry, as well as the irregularities found in nature.

For instance, certain laboratory data are usually obtained by flowing fluids in one direction in a sample of uniform cross-section. These data may have to be applied to a system in which the flow is from a set of injection wells to a set of producing wells, with the flow lines converging on these wells. Furthermore, the properties of any formation varies from point to point, in particular from top to bottom of the pay sand.

Drew Stahl has just completed a series of calculations showing how laboratory data can be applied to the prediction of production behavior during a gas or air drive. A system in which the permeability varies from top to bottom in a preassigned manner was treated mathematically, using as a measure of the degree of heterogeneity a distribution coefficient known as the "Lorenz factor".

The research work in petroleum production constitutes an integrated program: that is, each project benefits by and is partially dependent on the results of the other projects. Since petroleum engineering is an applied science, there is competition with the research laboratories of major oil companies. The research men must, therefore, be in constant touch, through the literature and through visits, with what is going on in production research, so that our work, limited for economic reasons, will contribute to but not duplicate the work of other laboratories.

THE MAGMA

(Continued from Page Two)

mechanical operations requiring no initiative, might result.

A comparison of the conditions governing the growth of a crystal from solution (the magma) and the development of a professional man from student material (the freshman) is given below:

CRYSTAL GROWTH

1. Proper concentration and physicochemical fields and phases (PH., etc.).
2. Proper intensity of crystallization (temperature and pressure).
3. Proper balance between various physicochemical processes going on in the solution and symmetrically directed flow of nutrient solution toward crystal faces.
4. Adequate length of time for crystallization.

STUDENT DEVELOPMENT

1. Adequate curricula and courses.
2. Rigid standards.
3. Teamwork between different divisions and curricula; cooperation between subjects; observance of prerequisites.
4. Sufficient length of education (4-year basic curriculum and at least one year of graduate work under traditional standards.)

In order to obtain from a magma large and perfect crystals, without flaws, such as quartz, usable for exacting, technological purposes, it is necessary to have a slow period of crystallization. Too rapid crystallization either will produce many small and imperfect crystals, or large crystals which might be full of bubbles, flaws, inclusions, and impurities.

Similarly, the university training should be unhurried in order to obtain men of polished intellect and good judgment. Too rapid schooling produces men with little preparation, fit only for routine jobs, or men full of ill-digested knowledge who are incapable of applying their knowledge well.

KAPPA CHAPTER OF SIGMA GAMMA EPSILON

national mineral industries honorary society, as the members assembled at the Nittany Lion Inn, December 12, for the banquet following their annual winter initiation which was held in the M. I. Art Gallery. At the banquet Dean Steidle welcomed the new initiates, after which William (Bill) Jeffrey, popular Penn State soccer coach, was introduced as the speaker of the evening. Coach Jeffrey's Scottish wit and interesting account of his South American trip as coach of the U. S. soccer team which competed for the international soccer championship provided a most enjoyable evening. Included in the photograph, with asterisks indicating initiates, are the following:

1st row: R. F. Higgs, I. Van der Hoven (Vice-Pres.), F. L. Turk, J. C. Kraft (Sec.-Treas.), J. A. Wasson; *2nd row*: Coach Jeffrey, W. F. Mullen, W. R. Sittig (Pres.), Dr. T. F. Bates (Adviser), Dean Steidle; *3rd row*: J. D. Harrison,* R. E. Huber,* H. E. Harris, M. Martinez,* M. D. Burkhart, J. G. Goodwin; *4th row*: R. B. Wassall,* F. R. Johnson,* D. Budenstein,* C. T. Houseman,* E. C. Fiedorek,* W. C. Stewart, G. P. Vose.*

MAUTHE TO RECEIVE McFARLAND AWARD

The 1951 recipient of the McFarland Award, to be presented by the Penn State Chapter of the American Society for Metals at a dinner meeting on May 4, will be J. Lester Mauthe, one of the School's most illustrious alumni.

A native of Turkey City, Clarion County (Pa.), "Pete" Mauthe grew up in DuBois where he attended both elementary and secondary schools. He enrolled in metallurgy at Penn State in 1909 and received his B. S. degree in 1913; the technical degree of Metallurgical Engineer was granted in 1948. During his undergraduate days, Pete always maintained better than average grades, and took an active part in school activities, especially in his chosen field of metallurgy.

He was probably best-known in his student days as an outstanding football player. Generally conceded to be one of the great place kickers and punters of all time, he played fullback during his four years in college, was captain of the team in 1912, and enjoyed the rare distinction of never playing in a game which was lost The team was undefeated in 1909, lost two games in 1910 while Pete was sidelined with a broken leg, was undefeated in 1911, and was both undefeated and untied in 1912. During this last season he scored 119 points, which included eight field goals and 29 out of a possible 34 extra points.

Although summer vacation work had been done in the blast furnace department of the Carnegie Steel Co. at Duquesne (Pa.), Mauthe chose to coach the Gettysburg College football team upon graduation in 1913. Later the same year he joined the National Tube Co. in McKeesport (Pa.), and in 1915 he was made assistant superintendent of blast furnaces at that plant. In 1917 he moved to the Midvale

(Continued on Page Eight)

J. LESTER MAUTHE

Mineral Economics

by J. J. Schanz*

The national significance of Pennsylvania's mineral production is immediately apparent when one realizes that year after year the State contributes close to 11 per cent of the value of the nation's mineral production. This value is exceeded only by Texas with 23 per cent of the national total. Though Pennsylvania has been relegated to second position since 1935, previous to that year it was always the leading state and the cumulative value of Pennsylvania's all-time mineral production is well above that of any other state. In only one year has Pennsylvania ever fallen below second position, and that was in 1938 when California moved slightly ahead of Pennsylvania. Even today California is not far behind Pennsylvania, as it provides 9 per cent of the United States total. The doubling of California's population since 1930 has given adequate proof that new population will bring new industry and the minerals that build this new industry are those that are required by it. The only other state having a mineral production of over one billion dollars per year is West Virginia. Texas, Pennsylvania, California, and West Virginia together produce half of the U. S. mineral values.

The part Pennsylvania plays in the mineral industries is not entirely represented by the value of its mineral production as this only includes the extractive phases of mineral production. If the great mineral refining and processing industries are brought into consideration, Pennsylvania has no equal. Though Pennsylvania is primarily a fuel producer, as are also Texas, California, and West Virginia, its mineral production is also noteworthy for the great variety of minerals that are produced. In addition to bituminous and anthracite coal, which are 80 per cent of the total value, Pennsylvania also produces important quantities of cement, raw clay, cobalt, iron ore, lime, natural gas, petroleum, sand, gravel, slate, and stone.

Primary wealth is defined as those commodities and materials which are grown in the earth or extracted from it. The implication of the word "primary" is that it is original wealth and all other wealth or dollars are built upon this original value. The income of the state or of the nation is therefore like an inverted pyramid with the base representing the output of mines and farms. Upon this base additional dollar values are built by providing services or adding labor to the primary materials. The top of the pyramid will then be the cumulative total income derived from all materials, services, and labor of the state or nation.

It is interesting to note in the case of Pennsylvania that there is a rather unusual ratio between the two major classes of primary wealth. The income derived from mineral production is almost twice as much as that derived from the selling of farm products. For the nation as a whole the ratio between farm income and mine income is almost exactly the opposite, with national farm income about twice as large as the value of mineral production. There is only one other state that has a higher ratio in favor of mineral wealth, and that is West Virginia where the ratio is 8 to 1. This unusual comparison of primary wealth sources in West Virginia is explained by the fact that it ranks very near the bottom in agricultural production. Pennsylvania, on the other hand, is about twelfth.

A common misconception that our national mineral resources and our mineral industries are centered in the western states is quite readily dispelled by the information presented above. Pennsylvania's past, present, and future is intimately concerned with mineral development, and as such it is a keystone of the nation's mineral economy.

Great Britain, the first of the industry-based-on-domestic-coal nations, has found itself in an unenviable position. A once great exporter, Great Britain now has difficulty supplying her own needs. Despite the pinch at home, it has been necessary for Britain to export coal to stabilize her economy. As a result of these opposing demands, Great Britain was forced recently to import four million tons of coal for re-exportation to other countries in order to fulfill export obligations. The most trying aspect of the difficulty was that it could be solved only at a loss of $10 a ton for the additional coal, an expense that Britain could ill afford.

The British situation is just one aspect of the coal deficit that faces all Europe. According to advance reports, in the first quarter of 1951 Europe will have a five million ton shortage of coal and will be lacking one million tons of coke.

On the brighter side of the picture, a British coal mine has discovered that a continuous coal mining machine can be operated successfully in their coal beds. Despite former claims that U. S. continuous mining machines were not adaptable to English operations, recent trials showed that not only could they be operated, at least in some locations, but that the savings realized would compensate for the increased percentage of finer sizes produced. Perhaps this will in time provide a means to overcome the net loss of 22,000 men the English coal industry suffered last year.[1]

That Pennsylvania mineral industry has reached a certain degree of maturity is indicated by the many operations that are approaching or have passed their first century of service. The well-known Pennsylvania Salt Manufacturing Company, whose first plant was located at East Tarentum, Pennsylvania (now Natrona) was organized one hundred years ago last September. Today Pennsalt is one of the leading basic chemical manufacturers of America.

Though Pennsylvania is no longer among the leading oil producers of the nation in respect to quantity, the birthplace of the United States oil industry shows its durability by possessing what is believed to be the oldest producing well in the country. McClintock No. 1 well was completed in August 1861 and has been in production ever since. The well is located two miles north of Oil City and is operated by the Brundred Oil Corporation. Production is from the second and third Venango Sands, and the well is 620 feet deep.

[1] Williams, A. Wyn, World Wide Coal, *Mechanization*, Nos. 1 and 2, Vol. 15, Jan. and Feb. 1951.

The oldest producing oil well in the United States, McClintock No. 1, near Oil City, Pa.

*Instructor in Mineral Economics

McFARLAND AWARD

(Continued from Page Six)

Steel Co. at Coatesville (Pa.) as superintendent of blast furnaces, and two years later joined the Illinois Steel Co. at Gary (Ind.), initially as assistant superintendent of the coke plant, and later as assistant superintendent of blast furnaces.

In 1920 he became superintendent of the National Tube Company's blast furnaces at Lorain, Ohio, and in 1930 was appointed assistant general superintendent. In 1935 he joined the Youngstown Sheet and Tube Company as assistant superintendent of the Campbell plant, became general superintendent of the Youngstown district operations in 1937, was made vice-president in charge of operations in 1943, and in 1946 was elected a director of the company.

In addition to his responsibilities in the metullurgical end, Mr. Mauthe is president and a director of the Youngstown Mines Corporation and the Buckeye Coal Company, a director of the Olga Coal Company and the Carbon Limestone Company, and is also a director and president or vice-president of various iron mining and other subsidiaries of the Youngstown Sheet and Tube Company.

His published works include *Mineralogy of Basic Open Hearth Slags* (co-author), which received the American Iron and Steel Institute medal in 1947, and *Sinter Quality — Effect on Blast Furnace Practices.*

He became a member of the Board of Trustees of Penn State on December 19, 1938, by appointment to fill the unexpired term of Hugh M. Clarke, and since that time has served continuously as a Board member, through alumni association elections since 1941. He has served on the Executive Committee of the Board since January 1946, and has also been chairman of the Standing Committee on Architecture since 1946.

Mr. Mauthe is a member of the Board of Governors of Youngstown College, and holds membership in the Youngstown Club, the Youngstown Country Club, the Castalia Trout Club, the Chicago Club, the American Iron and Steel Institute, the Association of Iron and Steel Engineers, and the Eastern States Blast Furnace and Coke Oven Association.

An account of the McFarland Award dinner meeting will be carried in the next issue of *Mineral Industries.*

EARTH SCIENCES

Dr. E. Willard Miller, chief of the Division of Geography, presented a paper at the Symposium on *Geographical Research in Northern Lands* at the meeting of American Geographers held in Chicago from March 19 to 21. Professor Miller spoke on *Agricultural Developments in the Fairbanks Region of Alaska.*

Dr. Frank M. Swartz, chief of the Division of Geology, discussed *Ground Water* at the luncheon of the Erie Rotary Club at Erie, Pennsylvania, on March 14.

Dr. Hans Neuberger, chief of the Division of Meteorology, spoke before the Rochester Academy of Science on March 15. His talk, entitled *There is More to Meteorology than Weather,* covered some of the less well-known phases of meteorological research.

EXTENSION SERVICES

Robert B. Hewes, Associate Professor in charge of Supervisory Extension Training, received the professional degree of Engineer of Mines at the midyear commencement on January 27.

James R. Coxey, Assistant Professor and Supervisor of Ceramics Extension since October 1945, has resigned from the faculty to accept the post of Chief of the Metals Section, Directorate of Industrial Resources, Office of the Deputy Chief of Staff, Materiel, Headquarters United States Air Force in Washington, D. C.

D. C. Jones, Director, and M. E. Altimus, Jr. and J. W. Hunt of the mining extension staff, attended the quarterly meeting of the Central Advisory Council, the Mining Electro-Mechanical Maintenance Association, at Pittsburgh on March 10. Professor Jones, president of the association since its organization in 1948, presided at the meeting which featured a report of visits to the six branches by members of the Organization Committee of which Altimus and Hunt are members. Plans were also made to expand the organization by organizing branches in the Brownsville (Pa.), Clarksville (W. Va.), and St. Clairsville (Ohio) areas.

D. C. Jones and O. F. Spencer, Supervisor of Petroleum and Natural Gas Extension, attended the tenth annual graduation exercises of the petroleum refining classes in Philadelphia on March 28. Professor Jones made a few remarks, and Professor Spencer presented the diplomas to the 29 graduates in this center. These classes and the closing exercises were sponsored by the Atlantic Refining Company.

MINERAL ENGINEERING

Mr. Charles Legg, first aid and mine rescue instructor of the Pennsylvania Department of Mines, Ebensburg, has just completed the training of 23 mining engineering students in first aid and mine rescue work. The instruction, similar to that given to mine workers throughout the State, is an essential part of the course Mng. 400, Mine Safety Engineering. Each student who successfully passed the rigid test will receive a First Aid and Mine Rescue Certificate from the Department of Mines.

Dr. H. B. Charmbury, chief of the Division of Mineral Preparation, has been appointed a member of the subcommittee on fine coal methods and a member of the subcommittee on nonfuel uses of coal in the Coal Division, A. I. M. E.

Recent appointments to the research staff of the Division of Petroleum and Natural Gas were as follows: Mr. Frank Bethel, B. E. M., Ohio State, 1948, previously employed by Superior Oil Co. of California, appointed as research associate; Mr. Floyd Preston, B.S., California Institute of Technology, 1944, B.S., University of Michigan, 1946, M.S., University of Michigan, 1948, previously employed by California Research Corp., appointed as research associate; Mr. Robert Killins, B. S., University of Oklahoma, 1951, appointed as a research assistant; and Mr. T. W. W. Hill, B.S., Missouri School of Mines, 1951, appointed as a graduate assistant. These appointees will do research work on secondary recovery of petroleum.

MINERAL TECHNOLOGY

Dr. W. A. Weyl, Head, Department of Mineral Technology, has completed a monograph prepared for the British Society of Glass Technology. The monograph, entitled *Coloured Glasses,* is now being published in Great Britain.

A chapter entitled *Fluorides in Ceramics* has been contributed by Dr. Weyl for Dr. J. H. Simons' book *Fluorine Chemistry,* published by the Academic Press.

A chapter on *Transitions in Glasses* has been contributed also by Dr. Weyl for the monograph *Phase Transformations in Solids,* sponsored by the National Research Council. The monograph, which was edited by Dr. R. Smoluchowski, Pittsburgh; J. E. Mayer, Chicago; and Dr. Weyl, is being published by John Wiley and Sons, Inc.

A paper entitled *The Strength and Ductility of Electro-deposited Metals III — Some Problems Relating to Specimen Preparation,* by Dr. H. J. Read and T. A. Prater of the Division of Metallurgy, appeared in the February issue of *Plating.*

On February 16, Dr. H. J. Read attended a meeting of the Editorial Board of the American Electroplaters' Society in Philadelphia. He is assistant editor of the publications of the Society.