CLASS NOTES

When advising us of a change of address, please confirm your position or title and company affiliation.

1882-1930

FRANK E. LEWIS, 41, of 101 W. 66th, Cincinnati, Ohio, writes that he uses the Mines Men Directory a great deal. He adds: "Don't think any other School has anything like it."

HENRY W. KING, 50, 1440 Hill Dr., Los Angeles 41, Calif., recently broke his arm and is recuperating in a skating rink. Mrs. King writes that "it will be some time before he is able to walk or be about.

W. C. CHASE, x-95, advises that his new permanent address is 179 Gene Reed Rd., Birmingham 13, Ala.

ARTHUR R. BRANDT, '97, has moved from Denver to Georgetown, Colo.

EDWARD D. WILCOXSON, '12, has moved from Rio Vista, Calif., to 1535 Wadsworth Lane, Los Altos, Calif.

MEARLE G. HEITZMAN, '17, has moved from Detroit to Grand Rapids, Mich. He is assistant in the general manager's office, Bethlehem Steel Co., 500 California St., San Francisco, Calif.

R. S. COULTER, '39, whose home address is 2459 Maricopa Dr., Burlingame, Calif., is assistant in the general manager's office, Bethlehem Steel Co., 500 California St., San Francisco, Calif.

JOSE ZAMBRANO, '21, is engineer for Mines de Potosí with headquarters at Buenos Aires, Buenos Aires, Argentina.

R. B. LOWE, '32, vice president of engineering and construction for Union Carbide Plastics Co., gives his new business address as 2 West Union Carbide Ct., 270 Park Ave. (R-4494), New York 17, N.Y.

ADOLPH W. BECK, Jr., '28, general superintendent of oil and gas operators, Tennessee Coal, Iron & R. R. Division, U. S. Steel Corp., has moved from Birmingham, Ala., to 1608 Shades Crest Circle, Birmingham 5, Ala.

COL. MERLE G. DANIELLETZ, '23, U. S. Army retired, is living at 1307 Old Fort Dr., Easton, Calif.

BAILEY E. PRICK, '22, whose home address is 160 E. Brand St., Columbus, Ohio, has been promoted by National Electric Co. to general sales manager of advertising and sales division.

PAUL A. GRANT, '25, may be addressed at 3441 Wellington Rd., Ft. Worth 15, Texas.

R. HARRINGTON, x-24, 223 Cedar St., Newport, N. Y., is director of secondary education, Albuquerque Public Schools.

G. WOOD SMITH, '24, is vice president for construction, Sverdrup & Parcel Engineering Co., 911 Olive St., St. Louis 3, Mo. His home address is 3535, Kirkwood, Mo.

JOHN L. HUTTON, '25, has changed his mailing address from Cleveland, Ohio to P. 0. Box 3, 25 Millswyn Rd., Ft. Worth 3, Texas.

HOWARD F. LESLIE, '32, whose business address is 1461 Diolinda Rd., Studio City, Calif., is taking it easy at 100 NW 22nd St., Washington, D.C.

JOHN L. HUTTON, '25, has changed his mailing address from Cleveland, Ohio to P. 0. Box 3, Denver 5, Colo.

ARTHUR R. BRANDT, '07, has moved from Danville, Va., to 1603 Shades Glen Circle, Birmingham 5, Ala.

W. C. CHASE, x-95, advises that his new permanent address is 179 Gene Reed Rd., Birmingham 13, Ala.

ROBERT W. PRICE, '35, has moved from Tucson, Ariz., to Salt Lake City, Utah, where his street address is 18 South 24th St., A-2.

GEORGE T. GOULD, '03, owner of the Gould Engineering Co., has a new business address: 888 Broadway Bldg., Tulsa, Okla.

LOWELL O. GREEN, '32, has moved from 411 Verrillam to 14 E, Woodlawn, Danville, Ill.

HOWARD A. WOLF, '22, has retired and is taking it easy at 1307 Old Fort Dr., Easton, Calif.

HOWARD F. LESLIE, '32, whose mailing address is 1601 Diolinda Rd., Santa Fe, N. M., is highway engineer for the state of New Mexico.

ROBERT W. PRICE, '35., has moved from Texarkana, Ark., to Salt Lake City, Utah, where he is vice president of Montana Engineering Co. His home address is 1350 Evergreen Lane.

(Continued on page 6)

SECONDARY RECOVERY--EVEN MORE PROMISING WITH DOWELL'S NEW IDEAS!

Many of the tools, techniques and products recently developed by Dowell for improving stimulation treatments are being used effectively in secondary recovery operations. For example, Rockjet* -- a new service using implosion capsules to lower injection pressures; Abrasijet* -- a service used to clean the formation face and condition the zone for better fluid acceptance; Engle* -- a low-pour-point surfactant used to lower water injection pressure; Slip Water* -- a friction-reducing agent used to cut pumping pressures by more than half during stimulation treatments; and a special agent used to remove calcium sulfate so that injection pressures can be cut by more than half during stimulation treatments. These are only a few of Dowell's new services and products. More new ideas are on the way. If you're involved in secondary recovery work, it will pay you to dial Dowell, Tulsa, Okla.

"DOWELL SERVICES FOR THE OIL INDUSTRY"

DIVISION OF THE DOW CHEMICAL COMPANY

price tower
BARTLESVILLE • OKLAHOMA

THE MINES MAGAZINE • NOVEMBER, 1960
Companies Form Joint Venture To Produce Vanadium Pentoxide

A plan to produce vanadium pentoxide has been announced jointly by Minerals Engineering Co. of Grand Junction, Colo., and Susquehanna-Western, Inc., a subsidiary of The Susquehanna Corp., Chicago.

The two companies have formed a joint venture operation to produce vanadium pentoxide, an important steel alloying material, in a newly acquired plant near Salt Lake City, Utah.

An entirely new process, first of its kind in the United States, will be employed to chemically extract vanadium from vanadium-bearing slag, a heretofore wasted by-product of western phosphorous operations.

As a heat and corrosion resistant metal, vanadium finds its principal use as an alloy in the manufacture of steel. New opportunities for the extensive use of vanadium have been opened by successful experimental extractions of pure vanadium tubing for use in the nuclear and process industries, and as a result of qualities which make it a suitable anti-smog agent.

The Columbia-Grenada taconite project at Atlantic City is proceeding on schedule, according to an item in the Oct. 3 Wyoming Mining Assn. Newsletter.

Other Wyoming projects moving ahead are (1) the Stauffer Chemical Co. which has begun construction work on a trona mine and plant north of Green River; (2) a reservoir being constructed by Utah Power & Light for cooling water for the power plant to be built near Kemmerer; (3) the Foods Machinery & Chemical Corp.'s $5 million pilot plant for coking low-grade coal, now just about completed with test runs being made on the equipment.

Ohio Oil Assesses Ownership Of Kinney-Coastal Properties

The Ohio Oil Co., recently announced that it has assumed ownership of all Kinney-Coastal Oil Co. properties for $4,209,000 cash plus an oil and gas production payment of $7,200,000. The latter payment is expected to cover a period of about seven years.

Glenn F. Bish, Ohio Oil vice president of domestic production, said that Kinney-Coastal net production amounted to about 2,500 barrels of oil daily, mostly from Greenfield Field in Big Horn Basin of Wyoming where it holds a half interest. Ohio Oil, owning the other half, has operated the Kinney-Coastal properties in the field for the past 30 years. The Greenfield Field represents approximately 80 per cent of the acquisition.

Kinney-Coastal also has a one-fourth interest in production from Dorman and Rapp leases in Nebraska, as well as other holdings, consisting of royalties and leases in Kansas, Nebraska, Oklahoma, Texas, Mississippi and Colorado.

Kinney-Coastal has some natural gas production.

Mr. Bish said the purchase is a part of the Ohio Oil program to build up its domestic reserve holdings. Kinney-Coastal is the third company in which Ohio Oil has acquired major interests this year. The previous two were McClure Oil Company of Michigan, and Oregon Basin Oil and Gas Company in Wyoming.

Bureau Releases Film On California Resources

An all-new version of "California and Its Natural Resources," one of the most popular films in the Bureau of Mines motion-picture library, is now available on free short-term loan for group showings throughout the United States, the Department of the Interior has announced.

The film was completed recently under the sponsorship of the Richfield Oil Corp., Los Angeles, which paid all production costs and provided prints for circulation to schools, universities, scientific, civic, and industrial groups, and similar organizations. It can be obtained on request directly from the Bureau of Mines at Pittsburgh, Pa., or from deposits in 40 States.

The Bureau of Mines said the new version of "California" emphasizes the contribution of mineral and energy resources to the Golden State's notable industrial and economic progress, much of which has occurred since the film was last revised. Sequences picturing mining operations, irrigation projects, petroleum production, modern farming, and forestry practices show how Californians are developing and conserving their natural resources to provide an ample foundation for present and future growth.

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CLASS NOTES

(Continued from page 3)

MILTON A. LAGERGREEN, '51, project engineer for Kennecott Copper Corp., lives at 1203 South 26th St., Salt Lake City, Utah.

JOHN B. TRAYLOR, '50, gives his new mailing address as 1423 Glenmore, Denver 10, Colo.

JAMES K. WERNER, '51, has moved from 2100 S. V bullet, Phoenix, Ariz., to 1212 South 24th St., Salt Lake City, Utah.

RICHARD JOHN SCANLON, '51, reports a new P. O. Box number, 1219, in Fort Worth, Tex.

CHARLES M. YARK, '39, senior staff engineer for Continental Oil Co., has moved from 110 Allison to 160 Dudley St., Denver 20, Colo.

ROScoe C. MCCuTCHEN, '43, assistant division engineer, Phillips Petroleum Co., has a new street address in Oklahoma city, 2037 South Santa Fe.

HENRY N. STARBOOKS, '32, whose mailing address is Box 204, Douglas, Wyo., is now living in McCall, Laymore, Hunter Co.

WILFORD L. HARTZ, '29, whose mailing address is P. O. Box 1574, Lynch Station, Ariz., is now employed as district manager at Kennecott Copper Corp.'s Chino Mines Div., Hudley, N. Mex.

CHARLES W. COLES, '43, engineer for Chromwell Constructors, lives at 33 Cove Rd., the Yorke, France.

LYNN D. ERVIN, '43, has built a new home at 155 Tymberstone Lane, Houston 29, Tex.

CHARLES S. LINDBERG, '43, is a "just alum" whose address has been found; 909 North Butler, Farmington, N. M.

1941-45

R. E. PIERSSEN, '45, has moved from Chicago to 4180 W. 14th Pl., Tinley Park, Ill.

ROBERT E. MOYAR, '41, has asked to have his mailing address changed from Karachi, Pakistan, to Box 219, Roswell, N. Mex., and an employee of Standard Vacuum Oil Co., wrote on Sept. 26, 1959, that he would be leaving soon for the U.S.A. and vacation.

GEORGE W. KING, '42, receives mail at 227 Baypoint, Humble, Texas.

RICHARD B. SIMPSON, '42, of 1014 Post, Arvada, Colo., is training engineer for Tieton, Inc. He was formerly a sales engineer for Morse Bros. Machinery Co.

JAMES E. GEARY, '44, is still living in San Luis Obispo, Calif., but his new address is 241 Aver off Center St., Los Angeles, Calif.

KENNETH E. GIBBS, '44, plant engineer for El Paso Natural Gas Co., has moved 16 blocks on Maple St. to 1618.

LEROY B. CRANE, '44, lives in San Luis Obispo, Calif., but his new address is 241 Aver off Center St., Los Angeles, Calif.

FRANK J. ADLER, '44, geologist for Phillips Petroleum Co., has moved from Durango, Colo., to 2403 Bruns Court, Denver 10, Colo.

B. R. HUDSON, '43, a hydro-geologist for the United Nations Bureau of Technical Assistance Operations, may be addressed at 720 Green St., Yellow Springs, Ohio. A recent note from the United Nations advises us that "his address is the most current one on our records."

Hudson's article, "Cathedral in the High Andes," was published in the January 1940 issue of The Mines Magazine.

1946-50

JOHN P. Cogan, '47, area petroleum engineer for Shell Oil Co., has a new street address in Midland, Texas.

WILLIAM W. DAVIS, '47, who was general manager of Weh Chang Corp., has moved from Weh Chang Corp.'s office in the Woolworth Bldg., New York 7, to 283 Madison Ave., New York 16.

RICHARD J. AULKIRK, '47, may be reached at P. O. Box 257, Westwater, La., as "foremost exploration engineer, Shell Oil Co."

LAWRENCE W. MYERS, '47, is division engineer, Production Dept., Continental Oil Co. His mailing address is Box 100, Carey, Wyo.

M. T. RADER, '48, has been transferred by Unocal Petroleum Corp., from Caracas to Aruba, 172, Schorco, Z'*.

LOUIS HIRSH, '48, has moved to 424 Oakley Rd., Columbia, Ill. He is assistant district engineer for North American Aviation.

P. G. MILLER, '49, who was in the Atlantic Gas Transporation Division of Westinghouse Corp. in Kansas City, Mo., has moved to 946 Madison Ave., Casper, Wyo.

MORRIS W. MORE, '49, has a new street address in Feminington, Calif., 118 Adams St.

DANIEL OAKLAND, '49, has moved to a new address in Philadelphia, Calif., 118 Adams St.

BOMER G. PHELPS, '50, is living at 406 Delaware Rd., Fredericksburg, Md., where he is assistant administrative assistant with Aeronautical General Corp.

J. D. McIVER, '50, managed to reach his family, including three sons and one daughter, when they moved to Kaisman, Okla., this fall. Mr. McIVER writes that he managed to leave home address 5109 Iris, Arvada, Colo., 57 Cedar Rd., Severn Park, Md.

JOHN D. McIVER, '50, managed to visit the Oil City, Pennsylvania, Penn., and its industrial efficiency. It is a story of Standard Oil of Ohio's new Superior ASU greases, for example. These revolutionary lubricants assure normal performance at fantasia temperatures—from 70°F. below zero to 490°F. above. Their development has made possible major advances in America's Space Age defense program, and its industrial efficiency.

The story behind the development of Superior ASU greases is as fascinating as the products themselves. For it is a story of Standard Oil research teamwork. Physical chemists, organic chemists, chemical engineers, mechanical engineers and technicians worked together for five years to break down a major barrier in the lubricant field. At Standard Oil, scientists and engineers of many types have the opportunity to work on a wide variety of challenging projects. That is one reason why so many young men have chosen to build satisfying careers with Standard Oil.

MANY SCIENTIFIC SKILLS are needed to meet the research challenges of the petroleum industry. Shown above are (1. to r.): Kemp Hunting, mechanical engineer; Arthur Hilson, physical chemist; Thornton Traiez, organic chemist; Wilbur Hayne, chemical engineer. They are members of the research team that developed Standard Oil's revolutionary new Superior ASU greases. These amazing lubricants are the first to deliver normal performance at both extremely high and low temperatures.

Four heads are better than one

Standard Oil is a major petroleum advance the work of man—or one kind of knowledge. It is the result of a group of scientists whose efforts encompasses the entire petrolem industry. Shown above are (1. to r.): Kemp Hunting, mechanical engineer; Arthur Hilson, physical chemist; Thornton Traiez, organic chemist; Wilbur Hayne, chemical engineer. They are members of the research team that developed Standard Oil's revolutionary new Superior ASU greases. These amazing lubricants are the first to deliver normal performance at both extremely high and low temperatures.
CLASS NOTES
(Continued from page 6)

Colo. He was formerly sales engineer with Johnson Testers, Inc. in Casper, Wyo.

E. C. SPALDING, 36, a staff geologist for Texas-Zinc Minerals Corp., is being transferred back to the parent company, New Jersey Zinc, on a new assignment. He will continue to reside in Grand Junction, Colo., which he writes is "kinda nice in its way."

1951

CHARLES R. CLARK has been transferred by Pure Oil Co. to Zuni Parkage, Colo. to 3557 Sherman, Denver 7, Colo.

JEAN F. HARTMAN, 1714 South Johnston, Bartsville, Okla., is staff geologist, International Drier, Phillips Petroleum Co.

PAUL A. JOHNSON, formerly of Anderton, Okla., is living in 4658 Thistlewood Dr., Honolulu, Ill.

ROBERT W. MACCANNON's new mailing address is Box 1121, Cedar City, Utah. Mr. MacCannon's article, "CFI Sodium (Why?) Mine's Safety Program," was published in the September 1960 issue of THE MINES Magazine.

CHARLES C. STEWART, Jr., 328 Monroe, Crooks Picnic, Farm, Ark., is assistant vice president and manager of the Petroleum Department, National Bank of Detroit.

E. P. VAN ARSDAL, 1520 St. Louis, New Orleans 12, La., has left the employ of Shell Oil Co. and has joined Continental Oil Co.

1952

MILLARD E. BENSON, field foreman for Texas Inc., has moved from Bona Park, Calif., to 845 Olive St., Pami Robin, Calif.

RUSSELL CHECCHI's new address is 2216 Bluebona St., Regina, Saskatchewan, Canada. He was living in Karachi, Pakistan.

ARTHUR J. GRAVES may be addressed at 4000 West Needham, Chicago, Ill.

ROGER A. HITCHCOCK, 1517 W. 43rd St., Kansas City, Mo., is superintendent of National Rigidizers, Inc., Topeka, Kansas, and is assistant superintendent, Vans Drive Plan, Kansas Ammonium & Chemical Co. His mailing address is Box 147, Topeka, Kans.

JOHN E. DELORE, 4415 McCormick Dr., Box J-290, Dallas, Texas, is a first lieutenant, U. S. Army, 5th Aviation Company, Ft. Carson, Colo.

CALVIN A. DERNISON, Jr., formerly of Port Arthur, Texas, is living at 1425 Oakwood Drive, Dallas, Texas.

NORMAN F. VOTE is living at 555 N. 25th St., Grand Junction, Colo., where he is geological engineer with AEC.

D. P. WINSLOW has moved from Jepson, Mo., to 4218 Tulane, Long Beach 8, Calif.

1953

GEORGE W. ANDERSON is now metallurgical engineer in the Denver office of American Insulating & Refractory Co. His home address is 7118 Racoon, Denver 21, Colo. Mr. Anderson was formerly of Port Arthur, Texas, and is now vice president of Black Hawk Steel Co., a division of Texas-Colorado Minerals Corp.

Wallace E. Rainier, Jr., 960 S. W., Vienna, Va. His present position is as sales engineer with Grader Stationary Engines, Milwaukee, Wis.

PAUL A. JOHNSON, formerly with American Smelting & Refining Co., is now a drilling engineer for Texas-Zinc Minerals Corp., in Caracas, Venezuela.

DANIEL GILBERT, formerly with Texaco Inc., has joined Continental Oil Co.

ABDUL Q. MAJEED is chief petroleum engineer, Ministry of Mines and Industries, Kabul, Afghanistan.

1955

R. E. C. SPALDING, 36, a staff geologist for Texas-Zinc Minerals Corp., is being transferred back to the parent company, New Jersey Zinc, on a new assignment. He will continue to reside in Grand Junction, Colo., which he writes is "kinda nice in its way."

JOHN A. DORR'S new address is 1791 W. 56th St., Arlington, Miss.

JOHN W. BWIRN and family have moved from 1770 Fuls Court Lane in 12190 Drift Oak St., Salt Lake City 17, Utah.

JAMES R. HAME has left Glenview, Ill. to 2153 Brentwood Way, Sacramento 22, Calif.

CHARLES K. BEACH has left 2229 North Holly, Lincoln, Neb.

MARLON L. LANG has returned to the United States from Managua, Nicaragua. His address is 1259 McConnell St., Farmington, Iowa.

AUBREY M. MAJEED is chief petroleum engineer, Ministry of Mines and Industries, Kabul, Afghanistan.

1955

R. E. C. SPALDING, 36, a staff geologist for Texas-Zinc Minerals Corp., is being transferred back to the parent company, New Jersey Zinc, on a new assignment. He will continue to reside in Grand Junction, Colo., which he writes is "kinda nice in its way."

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DEEPER AND DEEPER
with CF&I Seamless Casing and Tubing

The deeper wells and advanced equipment required for today's oil recovery demand the finest in casing and tubing — CF&I Seamless Casing and Tubing. The CF&I mill at Pueblo uses equipment rated among the most up-to-date in the industry. Production techniques feature unusually exact quality controls.

From its central location, CF&I Seamless Casing and Tubing can be distributed rapidly to the major oil fields. All CF&I Seamless Casing and Tubing is made to API specifications, in sizes 2¾" to 9¾" O.D. For full details, contact your local CF&I Sales Office or our General Sales Office, Denver, Colorado.
**Drilling-Blasting Symposium Held Oct. 16-19 at Mines**

Technological advances and innovations in production drilling for the metallic and nonmetallic industries were the topics of discussion Oct. 16-19 at the 15th Annual Drilling and Blasting Symposium held at the Colorado School of Mines, Golden, Colo., Oct. 16-19. The annual meeting is sponsored on a revolving basis by the Colorado School of Mines, the University of Minnesota, and the University of Alabama.

This year's meeting marked the first time that the symposium has been held at Mines. Chairman for the conference was Prof. E. P. Pfleider, chief of the division of land engineering at Mines, who also served as general chairman and as vice-president in charge of production for Standard Oil Co. of California in San Francisco.

Drilling-Blasting Symposium

**Presented at SPE Meeting**

New methods of recovering oil by injection of alcohol and by injection of steam into underground oil reservoirs were among the topics covered by engineers attending the 15th Annual Fall Meeting of the Society of Petroleum Engineers held at the University of AIME in Denver, Colo., Oct. 2-5.

In all, some 26 technical papers on drilling and recovery of petroleum were presented, the 3,500 persons attending the meeting from throughout the world heard such subjects as oil recovery processes, drilling, reservoir fluid-flow mechanisms, and production operations.

Two papers written by students and faculty members of the Colorado School of Mines, arranged at the Rock Mechanics technical session, Mines papers presented are "Drilling and Reservoir Engineering," by P. C. Badgley of the Colorado School of Mines; "Water Injection," by W. M. Parker of Mines.


H. K. van Paeles, researcher, research engineer for the Ohio Oil Co., and guest speaker at the Colorado School of Mines, arranged the 9th annual Mines session and served as presiding chairman—along with T. O. Mottons of Texaco, Inc.

Paul M. Kipp will be the 1961 president of the society, talking in Feb.

Kipp is a special year's writer on production problems on the staff of the vice-president in charge of production for Standard Oil Co. of California in San Francisco.

Kipp will replace 1960 President W. E. Gline, production manager units for Continental Oil Co.

David B. Elding, a 1954 graduate of Mines and production research director for the Los Angeles Petroleum Co., Tota, will become president-elect in 1961 of the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME). In 1962, he will assume vice-presidency. (See p. 59, Sept. 1960 issue of THE MINES Magazine.)

Elding was nominated for this position by the Society of Petroleum Engineers as one of the three resulting candidates of AIME. He is a member of the technical advisory panel and has served as a member of the AIME Board (1960) as well as president of AIME (1953-1954). AIME is composed of 16,000 mining-engineering students throughout the world.

**Rocks Mountain Oil & Gas Convention in Denver**

The 15th Annual Rocky Mountain Oil and Gas Convention was held Oct. 15-22 in Denver, Colo. Some 2,000 reports and papers were made on oil and gas industry topics heard at convention sessions on hydrocarbon exploration and development, the future of oil and gas, and other topics.

Dr. Arthur A. Smith, vice president, and chief engineer of the Range Oil Co., vice-chairman of the Finance Committee.

Kenny King, president and chairman of the executive committee.

Kenny King, president and chairman of the executive committee.

Michel T. Cooper, president of the International Salt Co., and special lecturer in the mining industry, will be keynote speaker.

Dick Krip, president of the Colorado School of Mines, arranged the 9th annual Mines session and served as presiding chairman—along with T. O. Mottons of Texaco, Inc.


Dr. Arthur A. Smith, vice president, and chief engineer of the Range Oil Co., vice-chairman of the Finance Committee.

Kenny King, president and chairman of the executive committee.

Michel T. Cooper, president of the International Salt Co., and special lecturer in the mining industry, will be keynote speaker.
Taking the pulse of a petrified river

From the Colorado plateau—once the floor of a vast inland sea—comes the ponderous metal uranium. Using sensitive instruments, Union Carbide geologists find its faint gamma rays along the beds of ancient petrified rivers.

Every ton that is mined ultimately yields just about half an ounce of uranium 235...precious food for atomic reactors. At Oak Ridge, Tennessee—the great atomic energy center operated by Union Carbide for the U.S. Atomic Energy Commission—the fuel becomes the kind of energy that will drive a submarine...light a city... or help doctors pinpoint the location of diseased tissue.

Finding, refining, and researching the materials used in atomic energy are all part of the work done by the people of Union Carbide to enrich your daily life. With pioneering curiosity, they are seeking new things not only in atomic energy, but also in the fields of carbons, chemicals, gasses, metals, and plastics.
MINERAL INDUSTRIES

(Continued from page 4)

$80 Million Beryllium Industry Foreseen

Bruce Odium, president of Beryl-
ium Resources, Inc., said recently
that beryllium minerals exist "in suf-
ficient quantity to allow the industry
to expand to a major industry."

Beryllium, Odium said, "is taking
on the infamous character of 'glamour' that was attached to ura-
nium and titanium a few years ago.

Beryllium is a high-strength, resis-
tant, strong metal used in satellites, mis-
siles, heat sinks, nuclear reactors and
for other uses.

Odium pointed out that the struc-
tural uses for beryllium can be un-
limited, because of the metal's strength-to-weight ratio. In its stiffness,
he said, "it is almost unbeatable. Its
weight is negligible."

He pointed out that if a DC-7 were
made of beryllium, it would weigh
about half what it weighs to-day.

Odium said that "one can speculate
and dream of a metal empire in beryl-
lium which might seem as real, as
large and as universal as the present
day aluminum empire." But he
pointed out that beryllium occurs in the
earth only about as often as arsenic
and is about one-seventh as abundant
as tin.

He said that in relation to nuclear
power plants, for example, "it is esti-
mated that if England's gas-cooled
reactor at Windscale performs as ex-
pected, it will create a demand in the
United Kingdom for between 40 and
100 tons of beryllium annually. This
is the equivalent of between 1,000 and
2,000 tons of beryl—the equivalent
of nearly 20 per cent of all the
beryllium ore consumed in the U. S.
"Today's $40-million industry will
to-day.

Odium pointed out that "contin-
uous growth of the beryllium indus-
try is clearly indicated—growth to
date has doubled every other year.
Today's $40-million industry will
surely be tomorrow's $80-million in-
dustry."

He predicted that because of beryl-
lium's composition and its position in
the periodic table, it is likely to be
replaced by a newer alloy.

Contribution of Nickel
To Alloys Highlighted

The many unique contributions of
nickel to alloy steels and stainless
steels by keynoted International Nickel
Co.'s participation at the National Metal
Exposition and Congress in Phila-

The nickel-exhibit featured nickel's role in these
alloys.

The part nickel plays in carburiz-
ing steels was highlighted by the an-
notation of two new nickel-alkali-
denium steels, one an economical
light duty type, and the other an extra
heavy duty grade with improved
processing characteristics. Both new
steels combine the outstanding proces-
sing qualities and reliable service per-
formance which are characteristic of the
older members of the nickel-molybdenum family.

Aerial Mapping of Libya
Completed by Fairchild

One of the most difficult and dan-
gerous aerial mapping assignments has
just been completed in Libya by Fair-
child Aerial Surveys, Inc., a wholly-
owned subsidiary of Fairchild Camera
and Instrument Corp.

The survey, covering 260,000 square
kilometers of Southern Libya's sur-
face, featureless, wasteland (equal to
six New Yorks or one Texas) was
completed in spite of blistering tem-
peratures, violent dust storms and
completely unreliable base maps.

Flying a specially modified Lock-
heed Lodestar at altitude ranging
from 23,000' to 25,000', the Fair-
child averaged about 3,000 square
miles of photography a day. Aerial
pictures were taken with two Fair-
child mapping cameras, specially
mounted and triggered simultaneously
to provide "dihedral" coverage of an
angle of 136°.

The photographs were then trans-
formed to equivalent vertical
photography by correction at the base
laboratory. With this wide-angle
dihedral coverage coming in over
an area that could be subdivided into
small units, it was necessary to pro-
vide a high degree of overlap be-
tween the photographs.

The project was undertaken on a
non-exclusive basis for five United
States and foreign oil companies en-
gaged in active exploration in this re-
 mote area. As the first reliable infor-
mation of Libya's interior, it will
serve many purposes. Of vital inter-
est in the exploration field is the value
of the aerial photograph for geologi-
cal study.

From interpretation of the air
photography, oil exploration experts
will be able to evaluate the terrain and
select prospective areas. Equally im-
portant is the value of the photogra-
phy in graphic presentation of physical
detail of the virtually unexplored ter-
rain. With this information, access
routes, camp locations and physical
advantages can be analyzed along the
best possible lines for the immediate
development of this Southern Libya hinter-
land.

Magnetometer Survey
In Northeast Alaska

An air/ground magnetometer survey of
a 21,000 square mile area in north-
eastern Alaska this summer was com-
pleted by Fairchild Aerial Surveys.

The survey, performed for five U.
S. oil companies, was designed to give
a quick overall picture of the import-
ant and significant geological features
of this relatively unexplored area.

(Continued on page 19)
Providing all important source of critical war material.
Dry Hole Money... The Fair Contribution*

By JOHN H. FOLKS

There are certain features concerning dry hole contributions under serious consideration today which should result in more uniform thinking. If accepted, these would serve to curb the greed which exists in all of us, so that more advantageous contributions might be granted and resolved with the end result that more deals will be consummated.

This is being made in the belief that "shabby trading" is an activity rapidly vanishing. There appears everywhere a clearly defined trend that the vast majority of management wants to bear the true burden in acreage evaluation.

Under consideration for use in arriving at fair contributions are six "yardsticks." The usage of these and the inequities involved in three traditional commitments are discussed here.

1. Circle Method

This is frequently referred to as the Proximity System. It consists of a series of circles, the first being of sufficient size to embrace one drillsite; three additional ones exist, each covering an area two drillsites greater in diameter than the former; the contribution to be borne by any drillsite is derived by the area that drillsite includes by that circle which includes the greater portion of the tract.

This method takes no cognizance of structure, faults or any other technical data; neither is any credit given for any acreage lying outside of the largest circle. The amount of money to be borne by any tract is determined by its geographical distance from the proposed location (Fig. 1).

In applying this method, 50 percent of the dry hole cost is charged to the owner of the well simply because of the well's ownership. It should be pointed out that this is somewhat arbitrary, since the area covered by the inner circle includes only one drillsite, the assessment should be the national pool dry hole risk ratio, which approximates only 30 percent. The risk of drilling a dry offset to the first well is, of course, the reason for assessing a larger proportionate part of the drilling cost to the owner of the tract on which the first well is located.

The owners of the eight drill sites (quarter quarter sections in this instance) which are embraced by the second circle, bear 25 percent of the total dry hole cost. Each drillsite, therefore, bears $3000 dry hole money.

The owners of all drill sites within the third circle bear 35 percent of the cost, a total of $14,400. Within the circle there are 12 tracts which participate equally in the cost so that each tract bears $1200.

Ten percent ($900) is borne by the owner within the fourth circle. This circle contains 16 participating tracts and each therefore, bears $600.

As is generally the case, this system compels the drilling party to pay or bear that proportionate part of the drill site risk not attributable to any tract which, either because of being unlocated or bearing loss, refuses to support, does not bear its burden.

2. Square System

This again is a proximity method and in principle is the same as the circle method. This system consists of a series of four square rectangles (Fig. 2). The first will embrace only one drillsite, the second one will be drill sites greater in width than the former. This "yardstick" is more easily employed than the circle method since no tract is traversed by more than one rectangle.

The owner of the drill site bears 50 percent of the cost plus, of course, that part attributable to any tract which does not bear its part. Half of the eight tracts within the second rectangle bears 3 percent of the cost. Those within the third rectangle each bear 1 percent and those within the fourth rectangle 25 percent.

A mechanical tool can easily be made and employed for using the square system as a basis of comparison. On any tracts or series of tracts, material light colored lines so that on the sketch map the concentrated technical information would prevent, by the converse, some application of either will normally result in a contribution being made which, because of the total absence of technical information, could not otherwise be granted.

3. Adjacent Quarter Section System

A method which some contend to be the most logical and at the same time, most equitable is the small fields as exist in Kansas, Eastern Oklahoma, Illinois, Indiana, and Kentucky, is the "adjacent quarter section system."

This method requires the owners of the entire quarter section on which the well is located to bear 50 percent of the cost. Each of the eight quarter sections pay twice as the outside of the square is unimportant. Those outside the well's ownership and universe small fields, the question of how and what little acreage the contained party has elsewhere is unimportant. Those objections which prevail both in the circle and square methods quite generally prevent a literal application of either. While strict application often result in worthless acreage bearing a share of the cost, the usage of available technical information would prevent, by the converse, some application of either will normally result in a contribution being made which, because of the total absence of technical information, could not otherwise be granted.

Burdens of sharing dry holes are considered important and, along with other factors, are used in determining dry hole contributions. This system does not consider structure, faults or other technical aspects.
Burdens of Sharing $100,000 Dry Hole Cost:

<table>
<thead>
<tr>
<th>Party</th>
<th>Percentage</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Able</td>
<td>45%</td>
<td>$45,000</td>
</tr>
<tr>
<td>Baker</td>
<td>16%</td>
<td>$16,000</td>
</tr>
<tr>
<td>Charley</td>
<td>16%</td>
<td>$16,000</td>
</tr>
<tr>
<td>Love</td>
<td>13%</td>
<td>$13,000</td>
</tr>
<tr>
<td>Dog</td>
<td>13%</td>
<td>$13,000</td>
</tr>
</tbody>
</table>

Figure 4. Proportionate ownership method is converse in theory from the circle and square systems, as proximity is entirely disregarded. The contributing party is the sole judge of who insists upon using this "yardstick" will frequently invite the selecting party to pay in proportion as they own in the section. The possibility that the well may be completed gas well at cost. Each of the other owners in the offsetting sections pays 1/32 of 1/2 for each quarter section of ownership. 6. Per Acre Basis

This, by and large, seems to be one of the most widely used of all the "yardsticks." An operator arbitrarily agrees to pay a specified sum for each acre that is evaluated. Since only one well will be drilled in each offsetting section, there is no advantage to being on the inside 80-acre tract, such as Able, since this is an inside 80-acre tract, such as Able, can be applied, coupled with the knowledge that it is far less likely to complete a well of sufficient depth to test the Ar-C 'bundle, unless production, 6000 ft., granite or impervious substances are encountered at a lesser depth, and in support therefor receives proportionate part of the cost of the well. The owner of the well being abandoned as a dry hole. Good concludes its profit picture including the drilling company pays 1/3 for ownership of the NE SE of Section 8 and incurs an expenditure of $60,000. At a depth of 2000 ft. an existing gas well at cost.

Burdens of Sharing $24,000 Dry Hole Cost:

<table>
<thead>
<tr>
<th>Party</th>
<th>Percentage</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Able</td>
<td>44.25%</td>
<td>$10,620</td>
</tr>
<tr>
<td>Baker</td>
<td>44.25%</td>
<td>$10,620</td>
</tr>
<tr>
<td>Dog</td>
<td>13.5%</td>
<td>$3,240</td>
</tr>
</tbody>
</table>

Figure 5. Per acre basis for figuring dry hole contributions is perhaps the most widely used method, as no operator arbitrarily agrees to pay a specified sum for each acre that is evaluated.
was that Able share in approximately 16 percent of the drilling cost below the Permian. Yet, be­cause the cost is such that a proper appreciation of true in­
terest in the drive the $6600 which was determined by the

event of such an event, the tech­
nique to be employed in each in­
test must be thoroughly consid­
ered. In areas of gentle relief and
thick formations, such as those
thin Mississippiian day which contain
possible productive zones, the
formula makes the point here.

1. In event Good encounters gran­
ite at a depth lesser than the
objective, he is forced to abandon
the per foot sum will result in Able
having more nearly in proportion
than in the case of the heretofore
in the case of the钻 hole sum.

2. Should Good complete the
Mississippian or Permian, and
Baker desire to pay for the deeper
drillings in an economic manner,
the per foot of drilling establishes
a satisfactory sum to both parties
which can be consum­
mated with a minimum of negoti­
ation.

3. Should Good drill to the
agreed upon stop depth of 6000 ft.
without having reached the
Ar­
cinite, the per foot formula makes
for ease in extending the depth
although the cost of drilling is a
price is normal at this point in
order.

4. Should Good complete a pro­
derer of gas in the Permian or Mis­
issippian and the contribution let­
ter contains a “back in” provision in­
to such gas well at cost of drilling
and to completing in the productive
formation,” the “Two-Section Offset
Principle” allocates the total cost
of the well to a total of 16,000 acres
or outside in the section is not ma­
ted by virtue of their overpay­
ment from nearby production, or to
wait for imminent expiration of
leases owned by others are all ade­
quate reasons to forego participa­
tion. One gets something for noth­
ing to the extent that one does not
pay his true share in the drillings.

Those who do not desire to pay
their full participating share may
find paying 50 percent or some­
ting greater in the form of dry­
hole money an approach that will
facilitate consummation of the
project. Occasionally an inequity
of the type caused by an owner in
the drilling failing to participate
can be adjusted by effecting an
exchange of properties. The drill­
ing party may assign to the non-participating owner the
proportion of acres adjacent to the
drillings and then the non­

Naturally all owners within a
drillings section may not desire to
participate in drilling a wildcard.

The lack of adequate acreage in the
area, the desire is waafs for develop­
ment from nearby production, or to
wait for imminent expiration of
leases owned by others are all ade­
quate reasons to forego participa­
tion. One gets something for noth­
ing to the extent that one does not
pay his true share in the drillings.

**Gas Well Contributions**

Certain features which should
result in more uniform thinking
with regard to the industry con­
tribution to gas wells which are
drilling. The per foot of drilling
only are under consideration.

It accepted these should serve to
promote cooperation by all par­
ties concerned so that more advan­
tageous contributions may be
granted and received with the end
result that more wells will be
drilled in search of gas.

In province of 600-acre opening
for gas many members of the indus­
try per cent on the drillings section
and Charley was forced to shut-in
which were taking production from
it. Charley in the future will, of
naturally, arrest such unfortunate
repercussions. This is one of the
diagonal method for the sake of

2. Equity in rental obligations.

In those cases in which Charley re­
ers to bearable proportions.

In areas of sparse pioneer con­
control in which drilling is more or less
random and in which the dry-hole cost
exceeds $100,000, the per section formula creates a burden of
such magnitude as to become im­
practical. In such cases the burden
must be borne by owners within a
larger geographical area. Employ­
ing the “Two-Section Offset Prin­
ciple” distributes the cost over a
tremendous section area and serves
to reduce the burden for all.

By application of this principle
the owners of the drillings section bear one-third of the dry-hole cost of
the well. This is achieved by the

gas as an offset to a producing well
statistically approaches thirty-three
per cent. The fact that gas wells
are drilled at lower intervals than oil
makes the pool development risk to
be higher gas for drilling than for oil.

**SHARING $300,000 DRY HOLE COST**

<table>
<thead>
<tr>
<th>Owners of those 6 sections</th>
<th>pay $/cost</th>
<th>$50,000.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each section bears</td>
<td>$3,125.00</td>
<td></td>
</tr>
<tr>
<td>Owners of those 8 sections</td>
<td>$45,000.00</td>
<td></td>
</tr>
<tr>
<td>Each section bears</td>
<td>$6,750.00</td>
<td></td>
</tr>
<tr>
<td>Owners pay</td>
<td>$18,750.00</td>
<td></td>
</tr>
<tr>
<td>Owners</td>
<td>$30,000.00</td>
<td></td>
</tr>
</tbody>
</table>

- **ABLE bears $112,500.00**
- **Baker pays $45,000.00**
- **CHARLEY $14,062.50**
- **DOG pays $7,031.25**
Unusual Design
Results In Low Cost
Large Volume Water
Supply for Flood at
Sholem Alechem

By W. C. PEARSON, '39, and
W. A. VAN HOOK, '35

Introduction
Engineering planning of the Sholem Alechem Fault Block "A" Waterflood indicated a water supply of over 160 million barrels would be necessary. Total water to be handled by surface injection would range from 150 to 350 million barrels depending on the degree of recovery required to achieve flooded condition of the reservoir. The initial requirement of 45,000 BWPD combined with a water compatibility problem presented unusual features in the water supply system designed, the subject of this paper.

The Fault Block "A" Sims Sand Unit of the Sholem Alechem Field is in Stephens County, Okla., 70 miles south of Oklahoma City. It is the largest of eight faults that create fault blocks in the Sholem Alechem Field and comprises 245 wells on a 10-acre spacing pattern. The average depth of the Sims Sand is 4900 feet. The effective pay in ranges from 60 to 200 feet in thickness. Two major areas are being flooded concurrently in the Sims Sand, the upper called the First Sims and the lower member called the Second Sims. Each of these zones has a gas cap in both domes; however, the Second Sims gas cap in the west dome is not of significant size. This waterflood is on a peripheral pattern, except for an area of poor sand development on the southwest flank which is being handled with a modified line drive.

A third advance in planning of the waterflood was the discovery of large gas caps on the east dome. The Second Sims gas caps are shown on the map as a means of evaluating this possibility. To achieve the volumes required to serve each plant, high-capacity lift equipment would be necessary. Therefore, the casing program for the well to handle a lineshaft turbine pump. Twenty inch surface casing was set at 350 with a 13% inch production string set at 1970 feet; total depth to 2400 feet.

An unusual precaution taken in drilling these wells was restriction of the production from 1000 feet to 1800 feet and 2000 feet to 2400 feet. Such restriction was considered advisable to avoid plugging the perforating. Wellington water was tested in some of these wells. Early testing of the initial injection water well indicated that the volume required was available with a 100% production from approximately 700 feet. No stimulation was considered necessary in these wells. The design of the lift equipment is to serve each plant high-capacity lift equipment with minimum anticipated problems.
rubber bearings are used on the impeller shafts. All bearings are water lubricated, thus requiring filling the column pipe from the surface before starting up. A high pressure discharge line with a special steel top-column flange sits on the wellhead with a gearhead completing the wellhead assembly.

This equipment is driven by a 12 cylinder 3000 hp displacement oilfield engine rated at 400 HP at 1000 RPM. Engine cooling is accomplished through heat exchangers using Pontotoc supply water as the heat removal medium. The engine is coupled to the gearhead through a 40 inch flexible coupling. The gearhead serves as a right angle drive and also as a speed increaser with a ratio of 5:1. Pump speed varies from 1200 to 1500 RPM in normal operation.

Lift Equipment

While waiting on fabrication and delivery of deep well turbine pumps, an electric-powered submersible turbine pump was employed to evaluate the capacity of the first three supply wells. Well No. 246, serving the Plant 1 area, was put in service with this equipment in November, 1956 and was operated for a period of nine months. During this period, over 3 million barrels of water were produced from this well. Wells Nos. 247 and 248 serving Plants 2 and 3 were operated in this manner seven and five months respectively, producing 2.4 and 1.0 million barrels of water. Operation of this equipment was evaluated carefully as a possible alternative to the line-shaft type equipment. Overall lifting cost with electric-powered submersible pumps was $0.00365/barrel.

In August, 1956, the first line-shaft turbine pump was delivered and installed in the well serving Plant 1. This equipment consisted of a 10 inch 41-stage deep well turbine pump with a column of 8% inch tubing by rubber bearings held in steel bearing spider. This equipment is a mounted in the center of each coupling between the ends of the 10 foot joints. Both metal and a 10 foot joints. Both metal and
static level by only 20 feet. The average productivity of the three supply wells during the interim production interval had declined from 46 barrels per day per foot of drawdown to 41 barrels per day per foot.

Injection Equipment and System

From the discharge head on the supply well at each of the four plants water goes to two vertical 480 barrel 30 psi working pressure surge tanks. A by-pass of 15 to 30 psi is maintained on these tanks through controlling the evaporation of gas evolving from the Pontotoc water. This pressure serves to reduce the collar within the tanks and keeps a positive gas blanket on the water, eliminating corrosion and assuring a positive charging head to the injection pumps.

The injection pumps are horizontal, single acting, triple plunger pumps powered by 6 cylinder, 970 cubic inch displacement engines equipped with heavy duty oil field radiators, 220 volt electric starters, wipers, automatic oil level controllers and exhaust condensers for cooling water makeup. This combination appears to be a well matched package and performance has been quite satisfactory.

Tests of the injection pumps indicate 96 to 97 per cent efficiency. Operating pressure was 1,000 psi initially and the triple pumps are now operating at 1,200 psi. Changes are being made in a portion of the system to raise injection pressure as high as 2,000 psi, the maximum anticipated when ultimate fill-up of the reservoir is realized. This will be accomplished by the installation of one quintuple plunger pump at Plant 2 with a capacity of 15,000 barrels per day at 2,000 psi. Originally no automatic control devices were installed in the water plants and differences between supply well production and injection pump withdrawal were adjusted manually through observing fluid level changes in the surge tanks from internal float-operating ground level gauging devices. More recently gas-operated pressure-sensing throttle controllers have been employed to maintain a constant fluid level in the surge tanks at one point regardless of variations in withdrawal rates. These devices are giving satisfactory service and all plants are to be so equipped in the near future.

Other protection devices are employed to afford insurance against high discharge pressure on the discharge pump, low water level in the surge tanks, low engine oil pressure, high cooling water temperature on the supply well engine and injection pump engines and low pump oil pressure on the injection pumps. A vibration detection switch is mounted on the well tank head to shut off the supply pump in the event unusual vibration is detected in the lift equipment. "Tattle-tale" switches indicate the function causing the shutdown so as to identify the source of trouble. The photograph in Figure VII shows a general layout of pump and engine assembly with the surge tanks in the background.

The injection system in the first three plants consists of 6 inch trunklines and 2½ inch laterals from header stations throughout the field (Figure VII), terminating at each injection well where injection into each zone is controlled (Figure VIII). All these lines are cement-lined combined pipe with all connections and fittings of 2,000 psig working pressure. Test nipples were installed at representative points in the system for study of corrosion and sealant tendencies. Careful observation of these nipples and other equipment exposed to the injection water indicates negligible corrosion and recent additions have been completed with bare pipe having no internal protection.

The high working pressure of the field system was based on a forecast necessity of increasing injection pressure as the flood front progressed inward from the outside injection wells. Injection pressures have increased as anticipated and some portions of the injection systems are operating at pressures up to 1,800 psi. Further modifications and changes have been made during the use of injection pressures as necessary to maintain the fluid movement in the reservoir.

The preliminary findings of negligible corrosion tendency, and of injection well plugging being minimized by employing a totally enclosed air-free system, has been substantiated through actual experience. Thus, considerable savings have resulted through use of a simplified water treatment system consisting of surge tanks only with no filtering, precipitation, or neutralization being required. No evidence of injection well plugging due to precipitation has been noted.

Injection of Water in Gas Caps

As discussed in the previous papers on this project, water injection in the gas caps became necessary as a control measure. The large volume of water required for this purpose exceeded the capacity of the three water supply wells. Utilizing produced water for gas cap injection was considered as a solution to this problem.

Performance of the Pontotoc water supply reservoir indicated the presence of a sufficiently large aquifer to provide ample productivity for the overall water injection requirements without the necessity of returning produced water into the Pontotoc Sand. However, since the residual oil saturation in the gas caps was very low (5 per cent of pore space), it was believed that water produced from the Sims Sand might be successfully injected in the gas cap without plugging difficulties. This would avoid the continued expense of injecting produced water into the Pontotoc Sand and relitiging it for gas cap injection.

On a trial basis, injection for produced water into the Sims Sand was started near the south edge of the large gas cap close to the pinch-out of the sand. The location was well remote from the oil column in this sand member which minimized the possibility of damage to the oil bearing part of the formation. The trial was successful and currently all produced water is being injected into two gas cap wells in this area without difficulty. Produced water for injection is handled in a separate system from the regular water supply to preclude any mixing of produced water with the water being injected into the oil saturated sands.

Summary

Operation of the water supply system in SAFBAU shows deep well turbines are economical for a high-rate large-volume shallow water supply in waterflooding. Maintaining compatibility of the injected water with the flood reservoir formation water by handling all injection water through a complete water treatment system successfully eliminates treating and filtering expense. Through preliminary planning of the original construction of supply facilities and application of early experience to later completion and additions in the supply-injection systems will result in significant savings to the operators and extending the life of this waterflood.

McELROY RANCH COMPANY

OIL OPERATORS

CATTLE GROWERS

405 Fort Worth National Bank Bldg.
Fort Worth 2, Texas

700 Wilco Bldg.
Midland, Texas

312 Denver U.S. National Center
Denver, Colorado

Edward J. Brook, '33

Lloyd W. Medlin, '41

THE MINES MAGAZINE • NOVEMBER, 1960
Oil Recovery

By Thermal Methods

By S. E. SZASZ

I. Introduction

Conventional methods of oil recovery, based on flow and on fluid-fluid displacement, leave behind as "unrecoverable" on the average, about two-thirds of the oil originally in place. This exceedingly low recovery is due mainly to two causes: retention of the oil by capillary forces, and inefficiency of the mechanism which drives the oil to the producing wells in a reservoir which is far from homogeneous and uniform.

The use of heat, in addition to mechanical energy, is intended to mitigate the above effects: capillary forces are eliminated when some of the oil is vaporized, and heat transport by conduction overcomes, at least in part, permeability inhomogeneities in the reservoir.

Over 20 thermal recovery projects have been planned, started or completed in this country; but only a few have been adequately described and analyzed in the literature. Our present knowledge is based on these, and also on laboratory experiments and on theoretical considerations; but we have to learn much more before we have a complete, quantitative knowledge of the thermal recovery process.

This article is intended to review our present knowledge based on theoretical and laboratory research, as well as on field tests, and to furnish some guidelines to the petroleum engineer planning a thermal recovery project.

II. Description of the Heat Wave Process

In the basic case which we will consider first, air is injected into wells initially heated to the ignition point, and oil, water and gaseous products emerge from the producing wells. A wave-like zone of elevated temperature moves through the formation, in the same direction as the flowing gas; and at any instant, the temperature starts to rise: light components of the oil are vaporized and carried forward in the gas stream, but they recondense when they again hit a region of lower temperature, thus creating a bank of vaporizable light product which recondenses further downstream, but which also includes non-vaporizable "cracking gas" which appears in the produced gas and imparts to it a heating value of perhaps 50 Btu/std. cu. ft. Finally, in the combustion zone, the residual fuel burns with the oxygen in the injected air, generating water vapor, CO2 and some CO. If the temperature in this zone is high enough, its advance is given by the following two conditions: no combustible fuel is left behind, and no free oxygen can pass forward through it. Thus, if we know the rate of oxygen (air) injection and the amount of residual fuel, we can calculate the rate of advance of the combustion front.

An idealized graph of temperature and saturation distribution in the formation is given in Figure 1. The real, physical picture is much more complicated than the above simplified description. In Zones 2 and 4, heat also moves by conduction in the matrix due to the temperature gradient; the latent heat of vaporization and condensation, and endothermic and exothermic effects associated with cracking and with phase changes in the matrix influence the temperature level; and some heat is lost by vertical conduction to the over- and under-burden. This makes a complete theoretical treatment of the system almost impossible.

Research into the heat wave process has progressed mainly along the following three lines of approach:

1. Neglecting, in a first approximation, the influence of moving fluids other than the air (gas) stream, and thermal effects of phase and chemical changes except the combustion reaction, the movement of the heat wave appears as the solution of a partial differential equation, with proper boundary conditions, including terms for heat exchange between stationary matrix and flowing gas, for heat conduction both in the direction of gas flow and toward the over- and under-burden, and for heat generation in the proper amount and in the proper place. Papers based on this approach, with certain simplifying assumptions, were published by Ramsey 1 and by Bailey and Larkin 2.

2. The real, physical picture is much more complicated than the above simplified description. In Zones 2 and 4, heat also moves by conduction in the matrix due to the temperature gradient; the latent heat of vaporization and condensation, and endothermic and exothermic effects associated with cracking and with phase changes in the matrix influence the temperature level; and some heat is lost by vertical conduction to the over- and under-burden. This makes a complete theoretical treatment of the system almost impossible.

3. Running through the heat wave process has progressed mainly along the following three lines of approach:

...
cieniely good approximation, the reaction rate, which decreases sharply with decreasing temperature, might be so low that the overall residence time of the injected air in the high-temperature region is less than the residence time of the air in Zones 5 and 6. This has actually been observed in field tests. Note that on its way through Zone 4, the injected air may come into contact with some movable oil, so that the movable oil is not the only fuel used by the process. Further, some enrichment of the combustion zone, serving as equalizer, and oil and gas in the reservoir may be lost near the combination of good vertical connection and high flame temperatures favors not only the combination of good vertical connection and high flame temperatures favors not only the combination of good vertical connection and high flame temperatures.
some of the produced gas, according to a schedule of experimental and theoretical studies of this "reverse spontaneous ignition also occurred in the field test of previous production and because no oil is left in the producing wells: if not, modify the previous estimates accordingly.

It is realized that there are several questions which cannot be answered reliably from our present knowledge, for instance, we do not know for how long, or over what maximum distance of travel, the heat wave can be kept "alive," i.e., above ignition temperature despite ever-increasing heat losses, a consideration which could impose a lower limit on the acceptable well spacing. However, as our research data and field experience accumulate, it is hoped that the petroleum engineer will be in a position to more readily predict the performance of a thermal recovery project.

It is apparent that there are several questions which cannot be answered reliably from our present knowledge, for instance, we do not know for how long, or over what maximum distance of travel, the heat wave can be kept "alive," i.e., above ignition temperature despite ever-increasing heat losses, a consideration which could impose a lower limit on the acceptable well spacing. However, as our research data and field experience accumulate, it is hoped that the petroleum engineer will be in a position to more readily predict the performance of a thermal recovery project.

From the preceding considerations, it is apparent that the characteristics of any thermal recovery process give rise to a suggestion by Megyesi 19. In reservoirs containing extremely viscous crude, e.g., the Athabasca tar sands, any backflood-up of oil in Zone 5 would immediately destroy the mobility to gas. Mention is made of establishing air permeability and then ignite the producing, not the injection, fluid when the front then moves convectively to the air stream, and oil flow occurs only between the combustion front and the producing front, i.e., the area below the maximum temperature and greatly decreased oil viscosity. Reed at al 20. Warren et al 21 and Berry and Parrish have made experimental and theoretical studies of this "reverse burning" process and have shown its characteristics. The main problem seems to be that, because the reaction between crude and oxygen proceeds at some very low rate even at ordinary temperature, the viability of the injection well will heat up spontaneously and a forward heat wave will be started; note that spontaneous ignition also occurred in the field test described by Gates and Ramsey 22.

V. Conclusions

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designated by Roman numerals I to VI and the large subfault blocks by the suffix A, B, and C. Although the faulting may have begun during Late Miocene time, most of it probably occurred during the Lower Pleocene time. The strike of the faults is approximately north and south. The majority of the largest faults may have begun during late Upper Miocene time, as indicated by Roman numerals I to VI and the large subfault blocks which had to the west as shown in cross section in Figure 2. The vertical displacement of the major faults varies from a maximum of 350 ft. at the top of the Terminal Zone on the "Wilmore" Fault to less than 100 ft. on the Allied Fault. The subsurface structure is not reflected on the surface owing to the existence of an unconformity at a depth of about 2000 ft. Consequently, subsurface studies have guided the exploration of the field.

The upper 900 to 1000 ft of formation is Quaternary and Pleistocene in age and below this lies the Plio Pleocene formation of the Upper Terminal Zone, with thickness varying from 1000 to 1200 ft. The Plio-Pleistocene beds are unconformably overlain by the Repetto formation, which varies in thickness from 900 to 1500 ft and contains sands and gravel of the Pliocene and upper portion of the Miocene age. The underlying Pliocene formation of Miocene age contain the lower portions of the Ranger Zone, designated by electrical logs as HX, J, T, K, X, Z, and A. The HX sand is further divided into upper, middle and lower HX. The average thickness of the HX sands ranges from 350 to 460 barrels per acre-foot. Upper Terminal Fault Block VB has a higher average oil viscosity than the Upper Terminal pools to the west and was considered to have the lowest ultimate primary reserve.

Water Injection System

The water injection system consists of salt water source wells, facilities for treatment of the salt water, pipe lines, and water distribution plants with the capacity to inject water under pressure to the subsurface formations. Source Wells—Injection water is salt water obtained from beneath the northeastern portion of Terminal Island to an unknown distance beneath the Pacific Ocean. These beds act as a natural filter in addition to further strata which have been provided with only an "injection" which is an enhanced diameter section of the drilled hole through the 1400-2000 ft. drilled interval. This is accomplished by scraping the drilled hole from the normal hole diameter of 10% in. or 12% in. to 22 inches. The annulus between the casing and the hole is then filled through ports in the casing with a high strength fluid from the top of the cement outside of the casing to the surface. The "cushion" provided has been very effective in minimizing casing damage.

Experience gained during the operation of the first injection wells led to more satisfactory completion techniques in the remaining wells. It was observed that running and stringing the tubing in constant diameter casing was slow and the packers extreme. It was also believed that the swelling action prior to receiving chemical treatment. A variety of chemical inhibitors have been used to reduce corrosion of the annulus, distribution systems and in the injection wells. The following table presents a summary of reservoir rock and fluid properties of the Upper Terminal Fault Block VB sands:

### RESERVOIR DATA

<table>
<thead>
<tr>
<th>Property</th>
<th>HX Sands</th>
<th>A Sands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand Volume, Acre-Feet</td>
<td>18,600</td>
<td>16,800</td>
</tr>
<tr>
<td>Average Permeability, md</td>
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<td>30</td>
</tr>
<tr>
<td>Interstitial Water, Percent</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Average Oil Gravity, &quot;API&quot;</td>
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<td>28</td>
</tr>
<tr>
<td>Average Gas Specific Gravity</td>
<td>0.56</td>
<td>0.48</td>
</tr>
<tr>
<td>Datum-Watered Average Porosity</td>
<td>64</td>
<td>67</td>
</tr>
<tr>
<td>Initial Reservoir Pressure</td>
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<td>1200</td>
</tr>
<tr>
<td>Original Solution Gas-Oil Ratio</td>
<td>96%</td>
<td>96%</td>
</tr>
<tr>
<td>PIP-CI Index</td>
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<td>100</td>
</tr>
<tr>
<td>Bubble Point Formation Volume</td>
<td>0.65</td>
<td>0.65</td>
</tr>
<tr>
<td>Factor</td>
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<td>1.05</td>
</tr>
<tr>
<td>Average Temperature °F</td>
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<td>140</td>
</tr>
<tr>
<td>Viscosity of Reservoir Oil at Tm</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>of Fluid, Centistokes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Primary reserve estimates for the Upper Terminal pools of the Wilmington Oil Field have ranged from 350 to 450 barrels per acre-foot. Upper Terminal Fault Block VB has a higher average oil viscosity than the Upper Terminal pools to the west and was considered to have the lowest ultimate primary reserve.
induced by the packers when pulling them might cause premature casing failure if done too often. A prudent completion method was discarded in favor of a water string that would provide water for other injection projects in operation in Fault Block VB and in other fault blocks. The cost of the original 21,000 B/D plant was approximately $180,000. The cost of the 121,000 B/D plant was $970,000.

**Figure 3.** Upper Terminal Zone, Fault Block VB, Wilmington Field.

**Production and Injection History**

**History of Production**—The first production from Upper Terminal VB was from a crestal well completed in December 1944. This well was shut in because of an excessively high gas-oil ratio and full development of the zone was not resumed until late 1947 when several downstructure locations were drilled. Orderly development continued until March 1950 when the K, Z, W and A sands were found productive in the towndlot area to the north. This touched off a competitive drilling campaign that resulted in the completion of 70 new wells and brought the pool total to 126 wells by January 1952.

Heavy withdrawals caused rapid water encroachment on the north flank and the early abandonment of towndlot wells. As a result, by early 1952 it was possible for the Harbor Department to commence gas-oil ratio control and to prepare plans for gas and water injection in the Upper Terminal VB pool since essentially all commercial oil production was on Long Beach Harbor Department tidelands property. The production history for the 6-year period 1951 through August 1958 is shown in Figure 5.

The large drop in producing wells in early 1952 reflects the curtailment of high gas-oil ratio producers. The subsequent decline in producing wells during 1952 and 1953 was a result of shutting in watered out K and Z sands producers north of the towndlot boundary, and the conversion of a few Harbor Department wells to gas injection. In December 1958 a further curtailment of high gas-oil ratio wells took place. Most of this group of wells have since been put back on production as low gas-oil ratio producers as a result of the flood.

**History of Injection**—The Long Beach Harbor Department did not have the converted high gas-oil ratio producers. In December 1958 a further curtailment of high gas-oil ratio wells took place. Most of this group of wells have since been put back on production as low gas-oil ratio producers as a result of the flood.

**Injection Plants—** Three plants supply the water to the Upper Terminal Zone injection wells. These plants utilize both triplex and quintuplex plunger pumps driven by gas powered reciprocating engines. Plant sizes vary from 12,000 B/D to 123,000 B/D at pressures up to 3000 psi. In addition to supplying water to the Upper Terminal VB injection system, these plants also provide water for other injection projects in operation in Fault Block VB and in other fault blocks. The cost of the original 21,000 B/D plant was approximately $180,000. The cost of the 121,000 B/D plant was $970,000.

**Injection Well Costs**—Injection well costs have varied from $85,000 per well to $139,000. Included in the $139,000 figure is a $14,000 coring program.

**Injection Well Operations**—Injection well operations have been based on information obtained from individual well injection rates during subsequent operations have been based on the periodic running of spinner and temperature surveys.

**Distribution of Injection Water**—Injection water has been injected into the Upper Terminal Zone injection wells by the foregoing methods.

March 1957 to start injection into the full HX interval. In June 1958 injection was started into the J, Y, K, Z, W, and A sands on the south flank of the structure and subsequently in May 1959 the Y, W, and A sands were included on the north flank. This was followed in September 1959 by the J, K, Z, W and A sands which put the full Upper Terminal Zone of VB on flood. Currently, there are six water injection wells operating in the zone. The wells operate with surface injection pressures ranging from 800 to 1600 psi. Individual injection well rates range from 8000 barrels per day to 15,000 barrels per day.

In July 1958 gas injection was started on the crest of the structure in the Upper Terminal Zone of Fault Block VB, and except for a short period in 1953 and early 1954 when the HX sand received gas, all Upper Terminal gas injection was confined to the six lower sands. The gas injection program was suspended in February 1960. The flooded water injection by this time had been to exceed the high gas-oil ratio area to control and several wells which were previously curtailed were found to be low gas-oil ratio producers. During 1960 additional floods near the crest of the structure have exhibited low gas-oil ratio performance and as a result have remained on production.

**Waterflooding Performance**

Injection Water Control—Distribution of injection water to meet the requirements of individual sands has been based on volumetric calculations utilizing original sand volumes, original productive limits, and formation saturation characteristics of each sand. This should ensure repartitioning of all sands. In addition, surface injection water distribution has been designed to flood the lowermost sands progressively ahead of the upper sands.

General practice in injection well completion throughout the tidelands properties has been to open the first injection well to all the productive sands in each zone. The exceptions to this are the two pilot injection wells which have been selectively perforated to complement the first wells for selectivity of injection. Adjustments for control of the selectivity in the completion program and centralization of individual well injection rates during subsequent operations have been based on the periodic running of spinner and temperature surveys.

**Injection History**—Production and injection history water in multi-sand injection has been improved by selective plugging of excessive flow to the well and occasionally operating in the zone. Where additional control has been necessary, single and multiple packers have been used. As mentioned previously, the cement bond in the blank intervals between the main sand bodies is tested to insure an effective separation of the sands. Considerable success has been realized in obtaining the desired distribution of injection water by the foregoing methods.

**Injection Volume**—Injection volume for the desired injection volumes for each sand was considered a necessary starting procedure. It has always been considered that these pre-determined rates would require adjustment based on observation. In order to observe and control the injection of injection water to individual sands, single sand producing wells have been placed in this manner between each other as a result of the structure. A continuous
check on productivity, water-oil ratio and gas-oil ratio is made in these wells. Periodically, pressures are taken in the wells in order to develop trends that will aid in analyzing the balance between withdrawals and injection rates in each sand.

The histories of all producing wells are up-dated monthly and reviewed for anomalous performance in respect to water-oil ratio, gas-oil ratio and total stimulation. In cases where the production from a producing edge well has reached the economic limit of production, and is subject to being shut in, a review is made on the desirability of continuing the well on production for the purpose of using the well as a means of controlling the flood front. Further consideration is given to the possibility of converting the well to an injection well.

**Performance**—During the first two years of injection, the improved performance of the HX pilot pool was included in the waterflood program, an initial injection rate of approximately 0.5 barrels per day per acre-foot was used. As a result, the effect of flooding these sands has been much sharper and was obtained much sooner than in HX, in that first line wells to the aquifer were showing stimulation within the economic limit of production.

Injection rates were substantially increased in May 1955 and preparations were started for opening the full interval of the HX sand to injection. During this period, injection rates were substantially increased in May 1955 and preparations were started for opening the full interval of the HX sand to injection.
Miscible Displacement

By J. B. Mattei

Introduction

During the past few years there has been a great deal of attention given by the oil industry to various new recovery processes, all of which have the same objective—to get more oil out of the ground than has been possible in the past by primary means and by conventional water or gas injection techniques.

One class of these new recovery processes is termed "miscible displacement." The idea is that oil is displaced by a fluid which is completely miscible with the oil, and that fluid can then dissolve the oil. The oil can dissolve if it is not pushed out of the way. One class of these new recovery processes results in simultaneous recovery of oil and gas. This type of process is accomplished by creating in the reservoir a pattern and conformance efficiency. This condition is achieved by injecting at relatively high pressures gas which is essentially free from solution effects, effects which increase the efficiency of displacement of oil as the viscosity of the oil phase approaches that of the oil phase.

High-Pressure Gas Process

The high-pressure gas injection process will be discussed first. This process which was first tried in the field, and it is one which is easily understood. This process was developed by Atlantic Refining Co. The Atlantic process involves injection at a pressure of 3,000 psi or more into a reservoir containing oil having a fairly high concentration of intermediate components. The injected gas is enriched with vaporization of these intermediate components from the residual oil in the vicinity of the injection well so that it becomes miscible with the reservoir oil. This type of gas drive is quite different from the conventional gas injection process. Normal dry gas injection results in a pressure range from as low as 30 per cent to as high as 80 per cent. This wide range of pressure causes difficulty in making variations of such factors as sand permeability, oil viscosity, and structural dip.

The high-pressure gas process involves the injection at relatively high pressures of a lean (dry) natural gas, mainly methane. Methane is not miscible with oil less concentrated in intermediate components. However, under favorable circumstances, a miscible lean gas, this one with an initial small volume, may be formed in the reservoir by methane injection. This is viewed as creating miscibility in the reservoir.

What happens with a small "batch" of injected gas when the injection operation is started? This gas eventually comes into intimate contact with the reservoir oil. These are two immiscible phases that will come to equilibrium with each other. The gas will be enriched due to the presence of intermediate components. In turn, the crude will be stripped of these intermediate components. The enriched gas has a greater mobility and its injection rate increases. The enriched gas will move on to contact the crude oil at high pressure (3,500 psi) because of: (1) evaporation at relatively high pressures; (2) dissolving of gas into the undersaturated oil; (3) stripping of valuable intermediate components; (4) "simultaneous enriched gas and water." (5) simultaneous enriched gas and water. Each of these processes has received a great deal of attention in the laboratory by many oil companies, and all are currently being tested in the field. In all of these processes except the slug process, miscibility has to be developed in the reservoir. In the slug process, the slug itself is miscible with the reservoir oil. For the other processes to work, the sharp interface between the displaced and displacing fluids must be eliminated. This is accomplished by creating in the reservoir a mixing zone between the injected and produced fluids, in which the fluid properties grade from those of the displaced to the displacing medium. Under these conditions, capillary and interfacial tension forces are not believed to be present.

The elimination of these capillary forces makes 100 per cent recovery from contacted areas possible. However, the adverse mobility ratio present in the various miscible displacement processes remains a major problem. The movement of the miscible fluid is controlled by fingering and channeling and tends to cause poor pattern and conformance efficiency. This condition is responsible for the currently widespread belief that the favorable mobility of simultaneously enriched gas and water injection will make that process more applicable than any other. Although the other types of miscible displacement will continue to be useful in certain cases.

One of the four miscible displacement recovery processes will be discussed separately, first by explaining the theory by which these processes are believed to operate and then by given examples of their application in the field. In this discussion, several terms will be used which would be well to define at this time. "missile"—the reservoir oil composition lies in the unsuitable composition area, the "recovery" area, the outer limits reached by the displacing fluid at depletion divided by the total volume of the reservoir. "Displacement effect"—the area in the pattern volume divided by which the displacing fluid actually moves divided by the total pore space in the pattern volume.

Displacement Efficiency—The amount of oil displacement is the portion of the pattern volume divided by the oil originally present in the common gas process. To get the high-pressure gas process is applicable only with reservoir fluids relatively rich in intermediate components.

University Block 31 Field Project

The Block 31 (University Lands) Field is located about 30 miles south of Odessa in Crane County, Texas. It was discovered in 1940. The producing formation is the Devonian which is encountered at an anticlinal structure at a depth of 7,900 feet. The reservoir rock is a calcareous dolomite limestone. The field has been developed and is operated on 90-acre spacing with 73 wells.

The lack of an effective water drive and the need for maintenance of reservoir pressure were recognized early in the development of the field, as the reservoir pressure declined rapidly. During the first 2% of years of production barrels of oil were produced, with a decline in pressure of 500 psi from initial reservoir pressure. Gas injection was commenced in 1949.

The original intent was to inject field-produced gas into the oil. As the result of the structure to provide partial pressure maintenance in the reservoir, maintain productivity, and increase recovery. However, research demonstrated that much greater additional recovery could be obtained by high-pressure gas injection. The gas injection program was expanded in 1952 to full pressure maintenance. This gas injection program became known as the "high-pressure gas process." Laboratory research by Atlantic Refining Co. showed that ultimate recovery of oil in the Block 31 Field could be increased by injecting natural gas at high pressures (3,000 psi) because of: (1) evaporation of oil into the injected gas phase, thus increasing the oil recovery. (2) The gas solubility and the simultaneous enrichment of gas. (3) The simultaneous increase in the viscosity of the gas phase and decrease in the viscosity of the oil phase because of the mutual solubility. Effect of this enrichment increases the efficiency of displacement of oil as the viscosity of the gas phase approaches that of the oil phase.

After the Texas Railroad Commission approved Atlantic's application to undertake full pressure maintenance in the Block 31 Field, an initial MBR (rate) of 10,000 barrels per day was assigned. Increases in this rate were granted as the injection experiment was extended, and the final production was set at 15,000 barrels of oil per day. In September, 1953, the rate was increased to 15,000 barrels per day; and currently, the rate is assigned an allowable of 16,400 barrels per day.

THE MINES MAGAZINE • NOVEMBER, 1960
Gas is being injected on 80-acre spacing with three large nine-spots in the center of the field. The mobility ratio is about 10. Approximately 100 million cubic feet of gas have been injected and the pressure has increased to 1,000 psi, setting its eleventh year, still has experienced no major gas channeling or breakthrough.

The only problem that Atlantic encountered in the Block 31 project is difficulty in building up the pressure in the large central pattern of the field. This problem is evidenced by the presence of oil and gas at the limit of the active pattern of the field, and is gradually being solved by injection of LPG in the center of the field, and is usually being solved by pressure studies and workovers.

Gradually being solved by pressure studies and workovers is the problem of the LPG "wedged" between the gas and oil phase during the injection process. Here, a band or slug of LPG is completely miscible with the reservoir oil. Unfavorable water injection. The objective is to maintain the reservoir pressure above 1,000 psi with the gas following it. This means there is no interface. It should be noted that a minimum reservoir pressure needs to be exceeded before miscible displacement will take place.

In the slug process, the oil will be miscible with the gas, and there will be no two-phase region. This is in contrast to an immiscible gas drive process. In the latter case an immiscible gas drive process, the gas gets the intermediates from a level close to the oil. Thus Atlantic decided to inject a sufficient slug of gas to attain the miscible slug process. Laboratorial work by the laboratory indicates the project is proceeding largely according to plan. Atlantic also points out that the project is functioning as is designed, concerning miscible-type displacement which could not be predicted by normal engineering calculations or through laboratory experiments.

Although many difficulties have been experienced with the miscible slug method, it still remains the most promising of processes in the miscible category. Nearly half of the 44 miscible displacement projects currently active in the United States are using the technique of injecting LPG followed by dry gas. The main reason favoring this miscible process is economic. Humble Oil & Refining Co. has indicated that the amount needed will vary greatly from reservoir to reservoir. In many instances the gas must be stored and perhaps moved to the reservoir.

The Slaughter Field is one of the biggest fields in West Texas. Twenty-five tank trucks of propane were purchased to obtain seasonally low prices. In November 1957, the Texas Railroad Commission approved Atlantic's plans. These plans included the propane injection process and injectant about 250,000 barrels of propane to be proposed by about 3.4 million cubic feet of gas over the next 2 to 3 years. Then the plan called for injection of about 6,000 barrels of water daily at the end of the project.

This project would force oil toward surrounding leases where the pressure would be much lower. Thus Atlantic decided to inject a mule field front only until it swept about 40 per cent of their lease. After that, it might be considered a dry lease. At that point, the pressure would be allowed to decline to a level comparable to neighboring leases, and the field would be carried to conclusion under declining pressure.

The Atlantic estimate of oil originally in place under primary depletion is 15 per cent of the original. It was estimated that an additional 5 per cent of the original oil could be recovered by continued primary production and by injection of gas. Atlantic estimated total recovery from their lease to be about 62 per cent of the original. This was 10 per cent more than primary. As compared with waterflood, the miscible process will net only about 25 per cent of the original oil, but it would be higher if the operation dealt with an entire reservoir and did not face the problem of pushing oil into a dry zone.

In May 1958, Atlantic commenced injection of propane and by early July had injected the 550,000,000 cubic feet of gas into the reservoir. The rate of injection was quite enough to meet the needs of the oil and gas as has been evidenced and concluded that the reservoir were well suited for the miscible displacement. This will cause the displacement process to break down into the much less efficient immiscible gas drive. A field operation could be designed (if possible) such that a sufficient slug material is injected to tolerate the mixing without destroying the reservoir below the reservoir needed for immiscible displacement.

Slaughter Field Project

The Slaughter Field is one of the biggest fields in West Texas with an area of about 35,893 acres and is developed on 25-acre spacing with approximately 2,000 wells. The top-per well average is 74 barrels per day produced.
An enriched gas-water injection project was initiated by Humble Oil and Refining Co. in the Seeligson Zone 21-A sand in June 1960. This reservoir is a small sand formation covering about 760 acres at a depth of about 6,800 feet.

At the start of the project, there was one injection well and four production wells, all of which were initially injected in order to form a miscible bank. This design was followed by a simultaneous injection of a displacing fluid composed of 50 per cent water and 50 per cent enriched gas. The enriched gas portion will be made up of 50 per cent ethane and 50 per cent dry gas. It is planned to drill another producing well to this reservoir and to connect one of the injection wells to this reservoir in the near future.

Since this project has just gotten underway, no results can be presented. It is believed, however, that the mixing of the water and enriched gas will lead to very low interfacial tensions. Also, if water is added to the injection fluid, an effect that occurs under the slug method of injection can be avoided. Humble also believes that enriched gas drive will result in lower recovery costs and also to recover 75 per cent of the original oil in place, compared with an estimated 25 per cent by primary means.

There is another additional miscible process injection involving gas. This process involves the use of LPG (liquid petroleum gas). This process has been studied and the goals of the project have been established in evaluating this process, but it has not been tried in the field. Plus gas is a relatively inexpensive additional component to the gas used in various miscible displacement processes but the miscibility relationships are more important. A large amount of gas is required, and it is a problem of economic evaluation whether fine gas should be substituted for hydrogen.

**Conclusions**

Given below is a list of some of the reservoir factors which make the miscible displacement process attractive. If the following factors are considered to be present, the technique should be considered:  
1. High dip, elongated oil column, and little or no gas cap.  
2. Uniform sand development with good permeability.  
3. Low recovery under the primary producing process.  
4. Good geologic control.  
5. A convenient supply of enriching material.  
6. Reasonably high injection pressure (about 1,000 psi or more).  

Another factor to be considered, the most important of all, is the economic factor. Some of the items which must be considered are:  
1. The cost of the injected material.  
2. The length of time the enriching materials will be tied up in the reservoir, and (3) the amount and value of the injected material that is recovered.

As indicated earlier, there is a considerable spread in cost on a per-barrel basis between injecting water and injecting flue gas. However, it is necessary to consider the economics of miscible drive processes, when compared to conventional waterflooding, in order to tell whether the miscible drive process may recover a greater amount of crude oil from the reservoir.  

The length of time that the enriching materials are tied up in the reservoir is dependent to a great extent upon the oil production rate to be expected. In many cases, controls with short injection times must be chosen for miscellaneous displacement projects. In other fields, however, this analysis must be required in order to make these projects economically attractive.  

A practical way to decrease the mobility of the injected fluid and the oil in place. The mobility of the injected gas (because of its relatively low viscosity) is increased by the mixing of the water and enriched gas. This, in turn, will increase oil recovery greatly in many instances. But field projects involving these processes will require the utmost in planning to become consistently effective.

**References on Field Miscible Displacement Projects**

- "Shell to Try LPG in Big Wasson Field," The Oil and Gas Journal, Vol. 58, No. 19, May 9, 1960, p. 100.
- "In the Panhandle Field," Petroleum Technology, May 1959, p. 25.
- "Early LPG Flood Runs into Trouble," The Oil and Gas Journal, December 7, 1959, p. 55.
The purpose of this study is to evaluate as thoroughly as possible the effect of layers of different permeability on recovery that takes into account all the combined effect of all these procedures given in this report. The layer has to be calculated individually for natural water drive, the performances of a line-drive or bank, the computations required are correspondingly greater. Nevertheless, the maximum computation time required on a high-speed digital computer has made this search in petroleum engineering a radical operation, and is a member of the AIME and API.

THE AUTHORS

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Alan J. Leighton is a petroleum research engineer for the U. S. Bureau of Mines in San Francisco. He received a B.S. degree in petroleum engineering at the University of California in 1956. After one year of graduate study at the University, he joined the Bureau of Mines and is a member of the AIME and API.

The method for calculating oil recovery from a reservoir rock of uniform thickness whose permeability-saturation relationship to oil and water is represented by only one set of curves is divided into linear segments the quantity of water and oil entering each cell equals the volume of oil and water leaving each cell, owing to the volume of oil and water-oil ratio of the effluxing liquid. The combined effect of all these changes influences the recovery of oil and water. A method for calculating oil recovery that takes into account all the changes in oil and water permeability and other variables, such as pressure, time, length, and others is presented in the report. Because of the number of computations involved, the method was programmed and run on the high-speed digital computer. Although the computer has made this an easy task, much thought and effort have been exerted to keep the number of procedures to a minimum in order that the computer cassette will not be a detriment to the use of the method. Moreover, the authors have made every effort to minimize the complexity of the method as much as to encourage general acceptance of the method by reservoir engineers.

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Multiple Layer Reservoir

Many reservoirs, especially in California, have pay thickness greater than the well spacing and in geological time were laid down in what is conveniently termed "layers of different permeabilities." These layers have led to the "layer principle" to aid in approximating the performance of reservoirs. This approach is more scientific than a guess at a permeability that will represent the average performance of all layers.

Where the effective permeability-saturation relations of these layers are multiples of 2 (same rock properties but different permeabilities to air), the time scales would be divided by the reciprocal of 2 or by 2^-1. Thus, where 10 is the time it would become 5.0, and the remaining time change would be proportional. These proportions can be generalized by the use of dimensionless ratios.

When the model is generalized, the ordinate and abscissa values remain the same and the new values are obtained as follows:

\[ \frac{Q_{(\text{mod})}}{Q_{(\text{ref})}} = \frac{h_{(\text{mod})}}{h_{(\text{ref})}} \times \frac{K_{(\text{mod})}}{K_{(\text{ref})}} \times \frac{P_{(\text{mod})}}{P_{(\text{ref})}} \]

Where the effective permeability-saturation relations are multiples of 2, the time scales would be divided by the reciprocal of 2 or by 2^-1, that is, where 10 is the time it would become 5.0, and the remaining time change would be proportional. These proportions can be generalized by the use of dimensionless ratios.

When the model is generalized, the ordinate and abscissa values remain the same and the new values are obtained as follows:

\[ \frac{Q_{(\text{mod})}}{Q_{(\text{ref})}} = \frac{h_{(\text{mod})}}{h_{(\text{ref})}} \times \frac{K_{(\text{mod})}}{K_{(\text{ref})}} \times \frac{P_{(\text{mod})}}{P_{(\text{ref})}} \]

The oil rate in Fig. 1 and water-oil ratio in Fig. 1 are due to the sudden drop in oil production, because the breakthrough of water has occurred for one of the layers. The oil rate at this time in the life of the field is low and therefore sensitive to the contributions from the layers.

Several specific examples have been worked to show the effect on the recovery of oil from hypothetical reservoirs having layers of reservoir sand whose permeability-saturation relations are multiples of 2.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Permeability of layers of 10- and 20-layer reservoirs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer No</td>
<td>10-layer reservoir</td>
</tr>
<tr>
<td>1</td>
<td>1,310</td>
</tr>
<tr>
<td>2</td>
<td>1,290</td>
</tr>
<tr>
<td>3</td>
<td>1,270</td>
</tr>
<tr>
<td>4</td>
<td>1,250</td>
</tr>
<tr>
<td>5</td>
<td>1,230</td>
</tr>
<tr>
<td>6</td>
<td>1,210</td>
</tr>
<tr>
<td>7</td>
<td>1,190</td>
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<td>8</td>
<td>1,170</td>
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<td>9</td>
<td>1,150</td>
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<td>10</td>
<td>1,130</td>
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<td>11</td>
<td>1,110</td>
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<tr>
<td>12</td>
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<td>13</td>
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<td>14</td>
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<td>15</td>
<td>1,030</td>
</tr>
<tr>
<td>16</td>
<td>1,010</td>
</tr>
<tr>
<td>17</td>
<td>0.990</td>
</tr>
<tr>
<td>18</td>
<td>0.970</td>
</tr>
<tr>
<td>19</td>
<td>0.950</td>
</tr>
<tr>
<td>20</td>
<td>0.930</td>
</tr>
</tbody>
</table>

The oil rate and other data shown in Fig. 5 follow the trend required by reservoir engineering concepts. The oil rate increases until the "bank of oil" passes through the outlet face. Then the oil rate drops rapidly because the recovery of 2-centipoise oil occurs rapidly.

The water-oil ratio curve is flat until the breakthrough of the bank of oil.

Recovery After "Fill-Up"

Many reservoirs having no natural water drive are potential projects for waterflooding after part of the oil has been recovered by the expansion of dissolved gas. To aid in economic evaluation, recoveries of potential waterflooding with this history, the space occupied in Fig. 1 is considered to be filled first with injected water. Then the potential recovery of oil by waterflooding is calculated. The data in Fig. 5 pertain to such a reservoir evaluation. The only difference between the starting conditions in Fig. 5 and 1 is the water saturation used for "fill-up." In Fig. 5 a starting 40 per cent was used instead of 20 per cent as in Fig. 1. In other words, 20 per cent of the reservoir was considered to have been produced, first by expansion of dissolved gas and then by filling with injected water.

The oil rate and other data shown in Fig. 5 follow the trend required by reservoir engineering concepts. The oil rate increases until the "bank of oil" passes through the outlet face. Then the oil rate drops rapidly because the recovery of 2-centipoise oil occurs rapidly.

The water-oil ratio curve is flat until the breakthrough of the bank of oil.
water-oil ratio is 50, but a well yielding only 1 pound of oil a day with less than a 50 water-oil ratio may not be economic. Accordingly, a thick "pay" has a longer economic life. However, for sand layers of the same thickness, the curves of water-oil ratio as a function of percentage of recovery are good comparative indices. Such curves are shown in Figure 6. The curves show the expected trend. The highest recovery of oil for the same water-oil ratio is from the single layer containing a viscous oil having a viscosity of 2 centipoises. The recovery from the 10-layer group having an initial combined conductivity equal to that of the single layer is higher than that of the single layer for the same water-oil ratio than the 10-layer reservoir containing the 2-centipoise oil. This expectation is normal; that is, the higher the viscosity the lower the recovery.

Commentary

At the start of each flood the saturation of the pores to oil and water in each cell was made the same for convenience. With a few changes in the computer program each cell can begin with a different saturation and even have a different set of permeability curves. This could represent the conditions in the reservoir. For convenience each cell also had the same size and shape. With a few changes in the computer program each cell can have a different size and shape. This has been done for a five-spot pattern.

Conclusions

A method is presented to calculate performances of (1) waterfloods with augmented natural water drives and (2) waterfloods of reservoirs after fill-up of the pore space voided by the oil that was produced during the process of the draining of the reservoir. The method is applicable where the geometry of these floods can be represented by the linear flow of oil and water. A procedure also given to evaluate the performance of waterfloods when the conductivities of multiple layers in the reservoir differ from each other. In the calculations, changing oil saturation and changing Buckley-Leverett relationships with saturations at any time and in every part of reservoir layers are those used in evaluating the flood performance.

Effect of the effective permeability-saturation relationships of the layers with the same or different by a constant, this computer calculations for one layer can be used as a model to obtain the rates, recoveries, water-oil ratio, and changed time for other layers, even though the length and pressures are constant. Rates and recoveries of the individual layers were totaled to obtain the performance of multiple-layer reservoirs.

The authors minimized the mathematical and physical concepts required to make the calculations so as to save computer time and encourage repetition of the method. Nevertheless, the authors believe that the performance of waterfloods has been thoroughly evaluated.

The trend of the result of all calculations fulfills the physical and mathematical concepts of reservoir engineering.

Bibliography

piated by the unpredictable lifetimes of the earlier stages of primary production. Uncounted floods, severe rains, pipe failures, water-completes, salt-water disposal, damaged casing, casing and liners, fast-tie and intercepted, improperly plugged wells, old oil holes, junk left in wells—all these are important factors; all are subject to the influence of the unpredictable natural and human conditions.

Automation in water flooding is thus contrasted with the operation of an automobile plant or a refinery, where the production is confined to a relatively small area, where the nature of raw materials is known, and where the changes in the production line and the processes can be accurately predicted.

Evidence of the degree of automation is found when the required number of barrels is extracted. In the new area developed, one lease foreman and sub-foreman supervise the new area developed, one lease crew (mechanic and helper) and equipment checking is performed. In addition to this, the chemical proportioning unit (Fig. 3), which performs this function, is a recent Phillips addition to automation at the North Burbank Unit.

At peak production, the system is handled by a field mechanic bi-monthly by a field mechanic, (mechanic and helper) and equipment checking is performed. In addition to this, the chemical proportioning unit (Fig. 3), which performs this function, is a recent Phillips addition to automation at the North Burbank Unit.

The chemical-proportioning unit (Fig. 3), which performs this function, is a recent Phillips addition to automation at the North Burbank Unit. At 15-min. intervals, the output of the BS&W monitor reel, which is pulling the oil from the heater-treater, is used to reset reavers in a stepping switch located in a panel rack inside the pump's damper. The current from this switch is then relayed to a South Coast pressure transmitter (Fig. 3), located near the heater-treater. Here the current is converted into gas pressure, which is piped to diaphragm valves located near gas-operated chemical pumps on the incoming trunk lead lines at both sides of the tank battery.

It follows that chemical is added only when and as required to maintain the BS&W of the oil being sold at the desired percentage. Experience has shown that the BS&W proportioning unit is one that may be connected to take oil from a single tank battery.

For purposes of discussion, the automatic tank batteries may be subdivided into seven smaller systems:

1. Almost all equipment failure safely; i.e., its failure will not cause damage to other equipment; will not shut down the production of oil; and will not cause waste or pollution. Emergency storage of both oil and water is provided until equipment malfunctions can be corrected and normal operations restored.

2. Equipment failure and major equipment changes are signaled immediately to the operator and identification is provided to locate quickly the area of trouble.

3. Protection is provided automatically against white faction accidents caused by either draining stagnant water lines and pumps or by filling them with warm, clean oil during idle periods.

4. Technical and maintenance work is performed by an experienced mechanic and helper daily and monthly.

5. At peak production, the forgoing group may be responsible for the handling of 10,000 bbl. of oil per day and 110,000 bbl. of water per day, and for the clarification and injection of 190,000 bbl. of water per day. Most of all the unscheduled maintenance is handled by a centralized maintenance group, serving all area areas.

6. Water flooding can be broken down into systems and sub-systems. The various systems may work independently of one another, or they may share equipment.

7. Water injection.

8. Oil treating (including chemical-proportioning unit).

9. Lease automatic custody transfer.

The significance of "controlling" the BS&W content of the oil by as to offset any "automatic" 0.2 per cent BS&W deduction by the sales unit is that the oil may be eventually cleaned—especially by the producer.

The results of this automatic system are rather amazing and may well eliminate the oil treaters. The unit is so new that we have it installed at only one automatic battery. This gives us an opportunity to compare it with two otherwise identical batteries installed at the same time. By controlling the BS&W percentage and injection the compound only under the concrete treatment, the amount of BS&W in the oil is reduced to a ratio of 2.0 bbl. of oil per gallon of chemical. By manually setting the treating ratio using conventional bottle tests at the other two batteries, the treating ratio averages about 100 bbl. of oil per gallon of chemical. The payoff of this 20 bbl. additional installation cost is obvious.

Lease Automatic Custody Transfer

To date, the North Burbank Unit has sold 15,000,000 bbl. of oil through eight LACT systems.

Much has been said and written about the Phillips LACT system. It will be reviewed very briefly since it makes up a vital part of automation in water flooding.

The Phillips system uses the basic water-injection system, from the heater-treater enters a 500-bbl. surge tank and the monitor pump starts as soon as the refill level is reached. The monitor pump then runs continuously. Its function is to regulate oil through the monitor cell and assure proper content of the BS&W to the heater-treater until merchantable oil is again seen by the monitor. The pump continues to run for 10 minutes after sale has resumed. This...
the integrator so that the actual
units that will share common
these visits—as, for example, once
per month. Obviously, consid­
vides all the basic data required
age is converted to a pulse rate by
and
senses the change in the crude-oil
application of this equipment,
was designed by Phillips

Gas Venting and Sales

The sale of low-pressure gas from the tank batteries is the most
possible because of the availability of a gasoline plant. To make de-
brines into the plant’s gravity instrument
The device is a simple manomcroner
system. The mercury column con-
tinually reflects exactly the level
of oil in the surge tank. The vent-
system pressure is con-
trolled by a conventional back-
pressure regulating valve located
on the tank walk. A dry-gas bubble
system insures that the gas-pres-
sure-transmission lines, especialL’ a
sure head for pump station suction,
permits maximum settling time for
line.

Water Clarification

The need for emergency storage
permits the operator to signal

Water Injection

Static suction and discharge pressures from the pump station are clipped through hlined lines to the
hodogone and are continuously recorded on weekly charts. An inspection of the system reveals
mains and the suction line to the
surge tank serve as an oil-

Clean water is drained from the
drain valves when the supply
drainage time. Although this may not

Emphasis on safety

The safety relief valve that would not

But when the bbl.

Relief and Oil Slimming

The usage of bbl.

Water injection

The usage of bbl.

The new venting system required a
safety relief valve that would not

But when the bbl.

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The usage of bbl.

Water injection

The usage of bbl.
cycles. It will indicate any tendency for unbalanced loading and the need for more frequent backwashing.

The pump and engines at the pump station represent the only equipment which are not set on portable concrete blocks. Portable concrete is used for setting all individual pumping units and all tank-battery vessels and equipment.

Rubber suction and discharge hoses are utilized to minimize corrosion and to assist in control of pressure surges. A simple automatic oil level controller is connected to the main level of all engine lubricators.

Portable concrete blocks are used wherever required. They are made of outside-type plywood and lined with insulation. They are light and easily removable in much the same manner as a drawer.

No buildings are required, except for the pumper's doghouse.

Unsuitable sediment or waste pits are required in the operation of the tank battery. Accumulations of sediments in the backwash tanks and the equipment being removed by a vacuum tank truck, after cleaning, have been handled by a special high-temperature washing system.

Conclusion

The major effort must now be directed to the identification of pressure maintenance and secondary recovery processes for treating crude oil. Continued optimism and close cooperation of the pipeline companies and the producers are needed to realize the progress that is indicated by present trends of operations.

References


CLASS NOTES

(Continued from page 14)

O'KEFEE, M. L., McGOLDRICK is in the research and technical service division of Shell Oil Co., with mailing address P. O. Box 323, New Iberia, La.

ROBERT C. MORELLI, an engineer with Peter Kiewit Sons Co., has moved from Bridgeport, Conn., to 177 S. Michigan Ave., Chicago, Ill.

ALBERT E. MILLER is living in Ames, Iowa, where he is graduated student, Department of Chemistry, Iowa State University.

JOSEPH W. REESE, editor to have his mail sent to his home address, 356 W. 114th St., New York, N.Y., is notified of his OCS Navy address.

MERL E. REDHAW, new address is 1210 Catina Rd., Whittier, Calif.

RALPH N. ROCKWELL has moved his residence, Cozad, to 220 Ford Ave., Golden, Colo. However, he will continue to be the Army at Ft. Leonard Wood, Mo.

DAVID M. ROGACH's address is 175 N. Grove Ave., Oak Park, Ill.

GEORGE M. VENABLE, Jr., has left Golden, Colo. for Elkhorn, Ga.

GARY E. WARNER, formerly of Garrett, N.C., is now a new address: Route 1, Walters, Okla.

AUGUSTINE J. SLANOICH is junior engineer for Elmoce, Tolleson, Ariz. Tempe and B Ridgecrest, Kansas City, Mo. His mailing address is 135 W. Grant, Tulsa, Okla.

ROBERT A. SULTZBACH may be addressed at 2412 E. 50th St., Chicago, Ill.

BERNARD J. TURPIN recently joined the Alamo Association. His address is in A Avenue on the Eastern Border of Mines, Golden, Colo.

LETTERS TO THE EDITOR

G. F. PERGER, BGE, 928, with the new address is 115 Chambers Ave., New York, N.Y., and that old address is Harrison, N.J., he is in law school where he is specializing in the law of merchant and the law of oil and gas.

Getting myself to Colonel Perger, he comments: "Your articles in The Mines have been interesting. My feelings toward the oilfield are always the same; then engineering, then mining, then what he knew about the GEM correlation, rather than the other way around."*

DONALD M. MORRISON, '57, Boulder, Colo. writes: "I have just completed a study using the MINES Magazine, and wish to express my appreciation of the information that was presented at AIEE Conference, Sept. 17-19, 1959. I have been very interested in the work being done on the Greenland Project. A certain amount of work has been done in the Arctic, but the real work is just beginning. I find this work very interesting and enjoyable experience.

"For the future I am still open to product advertise your consideration. By January 1 it will be complete to permit Calt form development.

(Editor's Note: Thanks Don for your letter and particularly the list of authors of the other Mines who are in metal- lurgical research or the use of raw materials.)

CLASS NOTES

ROBERT A. SULTZBACH may be addressed at 2412 E. 50th St., Chicago, Ill.


**

The AUTHOR

The Engineering Aspects of Pressure Maintenance and Secondary Recovery Operations

By SHOFNER SMITH

Introduction

Engineering consists of the economic application of the physical properties of matter to the service of man. This definition reveals that the engineering aspects of an operation encompass consideration of both the physical and economic aspects of the operation.

The primary production, or pressure depletion, oil recovery process is inherently inefficient in that only 10 to 30 percent of the oil can be recovered from most oil producing reservoirs by utilization of the natural energy available in the reservoir. The characteristic inefficiency of the primary oil production process in most reservoirs is the basic justification for supplementing natural energy available for production of oil by injection of extraneous fluids. Such injection can be either "pressure maintenance" or "secondary recovery" operation.

No attempt will be made in this paper to set forth criteria and conditions requisite to successful application of pressure maintenance and secondary recovery operations to oil producing reservoirs. It should be evident that factors which determine whether a reservoir is susceptible to pressure maintenance or secondary recovery operation, and if so, which of the various forms of operation is most profitable, in complex and physical economic and analytical decisions. Analysis of this nature must be made on an individual project basis after detailed and thorough analysis by qualified personnel.

The purpose of this paper is to make readily available that background information, relating to the physical and economic aspects of oil recovery processes, which will aid in the promotion and adoption of technologically superior oil producing techniques which are economically sound and result in the effective preservation of oil and gas, an irreplaceable resource.

Pressure Maintenance and Secondary Recovery

Pressure maintenance and secondary recovery are fluid injection operations conducted for the purpose of increasing the economic recovery of oil from underground reservoirs. The distinction between pressure maintenance and secondary recovery...
Depletion

Figure 2 is a schematic representation of reservoir fluid distribution following depletion of reservoir pressure to an abandonment level. A significant aquifer of oil remaining in the reservoir, and the gas bubbles have enlarged and interconnected to form continuous gas saturation flow paths through the formation. Remaining gas tends to move through the formation with greater ease. The primary pressure depletion process just described is commonly referred to as "solution gas drive." It is the natural functioning of the physical properties of reservoir oil, when reservoir pressure declines, which permits the preferential flow of gas through the oil-bearing formation and renders the primary pressure depletion process inherently inefficient.

Figure 4 is a plot of reservoir pressure versus oil recovery expressed as per cent of oil originally in place. This figure shows that production from a typical solution gas drive reservoir causes a continuous decline in reservoir pressure, until substantially all pressure has been dissipated, with an attendant representative oil recovery equal to only 20 per cent of the oil initially in place. Although only one-fifth of the oil has been recovered, production continues because there is no longer energy available for moving oil into the well bore.

Figure 5 is a plot of oil producing rate in the absence of producing rate restrictions, for a solution gas drive reservoir as compared to time. Producing rates increase rapidly while wells are being drilled and completed. Maximum oil producing rates are generally achieved in the first one or two years of a reservoir's producing life. Subsequently, the producing rate declines until revenue from sale of produced oil equals the cost of operation of the wells. At this point secondary recovery operations must be commenced, or the wells will be plugged and abandoned.

The principal natural source of energy for production of oil from most reservoirs is the energy associated with gas in solution with oil at initial reservoir pressure. Such reservoirs are referred to as "solution gas drive reservoirs." It is in reservoirs of this type that pressure maintenance or secondary recovery operation will bring about the greatest increase in ultimate oil recovery. In some reservoirs natural energy is utilized to maintain pressure in the oil-bearing portion of the reservoir, and the gas bubbles have enlarged and interconnected to form continuous gas saturation flow paths through the formation. Gas is released from solution with reservoir oil when the reservoir pressure is reduced to a level below the bubble point pressure. Continued oil production results in the further release of gas from solution with oil and a corresponding enlargement or increase in number and size of gas bubbles in the formation. Such reservoirs are referred to as "solution gas drive."
free gas space that may have been created by prior production from the reservoir.

Figure 7 is a schematic representation of the fluid distribution in the reservoir following depletion by secondary recovery waterflood operation. A considerable quantity of oil has been trapped in the formation behind the advancing water front. Ultimate oil recovery as a result of primary pressure depletion and secondary recovery waterflood operations will generally not exceed 40 per cent of the oil in place in the reservoir.

Figure 8 is a pressure versus recovery plot which shows pressure distribution in the reservoir during secondary recovery waterflood operations as at a comparatively low level but somewhat above reservoir abandonment pressure by primary pressure depletion methods.

Figure 9 is a plot of producing rate versus time which shows the relationship between primary recovery producing rates and secondary recovery waterflood producing rates. Producing rate during waterflood operation generally follows the production rate history of the reservoir during primary recovery operation. On occasions the maximum oil producing rate during waterflood operations will exceed the maximum rate achieved during the primary recovery life of the field. Primary pressure depletion followed by secondary recovery waterflood has the disadvantage of extending the operating life of the reservoir over a large number of years, with correspondingly lower total operating cost during the reservoir producing life.

Pressure Maintenance—Conventional Gas Injection

Pressure maintenance by conventional gas injection has been utilized to increase ultimate oil recovery from reservoirs. Conventional gas injection refers to the injection of port or all of the gas produced with the oil, or in addition, injection of make-up gas, at reservoir pressure above those required to achieve miscibility of injected gas and reservoir oil. Conventional gas injection is declining in usage because of increased income available to operators from sale of gas as it is produced, and the ability of other forms of pressure maintenance to produce more oil at less cost.

Figure 10 is a schematic representation of the fluid distribution within a reservoir following depletion by conventional gas injection. The portion of the pore space occupied by gas is greater after conventional gas injection than after primary depletion. Figure 11 is a reservoir pressure versus recovery plot showing pressure history typical of pressure maintenance gas-injection operation, as well as pressure history for primary depletion and secondary recovery waterflood. The return of gas to the reservoir decreases the rate of decline of reservoir pressure and results in the recovery of substantially more oil than could be recovered without supplementing natural reservoir energy. Recovery of oil by conventional gas injection, although greater than by primary pressure depletion, generally will not exceed 30 to 35 per cent of the oil originally in place in the reservoir.

New Recovery Processes

The oil industry is acutely aware of the necessity, from both the economic and conservation points of view, of developing oil recovery processes that will produce a substantial portion of the 40 to 60 per cent of original oil in place in a reservoir which remains unproduced following the most successful application of heretofore conventional forms of pressure maintenance and secondary recovery operations. The research effort within the oil producing industry has brought about development of several new oil recovery processes, some of which are now in practice in a limited number of fields. These processes will recover substantially all of the oil initially in place in the reservoir, within the area swept by injected fluids.

The high pressure gas injection, enriched gas injection, hydrocarbon solvent slug injection, and amphi-

Figure 13 is a reservoir pressure versus recovery plot following the most successful application of heretofore conventional forms of pressure maintenance and secondary recovery operations. This curve illustrates one of the principal economic advantages of water-injection pressure maintenance operation in that it shows greater oil recovery in a lesser period of time. This means more revenue and less operating cost.

Although conventional gas injection generally results in a lesser ultimate oil recovery than water-injection pressure maintenance, it will continue to be economically attractive in reservoirs where: first, connate water saturation (i.e., water in place with oil in the reservoir) is sufficiently high to preclude, or render doubtful, the successful application of water injection operations; second, bottom water (i.e., water segregated from and underlying the oil accumulation in the same porous and permeable rocks of the reservoir) would render water injection ineffective as a means of increasing oil recovery; third, steeply dipping and highly permeable reservoirs permit the force of gravity, as aided by up-dip conventional gas injection, to produce more oil than could be recovered by down-dip water injection; and fourth, lack of a market for produced gas renders the recovery of gas to the reservoir for storage, future production, and sale, economically attractive.

Pressure Maintenance—Water Injection

Pressure maintenance by water injection has been utilized to increase ultimate oil recovery from reservoirs. Conventional water injection refers to the injection of water-injection pressure maintenance, as well as pressure history of the forms of operation previously mentioned. Oil recovery by this method of operation will generally exceed 50 per cent of the oil in place in the reservoir. Fluid distribution in the reservoir following this type operation is similar to that following secondary recovery waterflood operation, the only difference being that a lesser quantity of oil remains unrecovered in the reservoir.
Our Stake In Percentage Depletion

By GEORGE E. TARBOX, '52

In this, a presidential election year, we seem be set on all sides with theory political issues. Many of these issues are raised by politicians from both parties as vehicles upon which they can ride to election—or re-election. And of course there are many innuendoes and half-truths that surround a political campaign which often distort or conceal the objective facts about an issue.

One of those issues is the so-called "tax loophole" of the percentage depletion allowance for the extractive industries, with that of petroleum in particular. Note that the election is over and the dust is beginning to settle, let's look at the objective facts about percentage depletion. They are the same facts that have always existed (and, in fact, this article is being written before the election), but somehow this same information never seems to filter through the mass of political innuendoes to the average voter. Indeed, many of the programs employed by the affected companies do not realize the importance of the depletion allowance.

Like most readers of this magazine, I am an engineer in the mineral industries, and as we know, domestic and foreign petroleum exploration and production are in a very vulnerable position because of the depressed state of the industry; this also applies to certain phases of the mining industry. As we know, the statement that is keeping us going is percentage depletion, and it has become such a political football that we are in increasing danger of being taken behind the stage where the general public has a distorted view of it, and it is time for you and me to do something about it.

The statements in the following article, however, are not the facts. If we want to survive in doing these things, we must do everything possible to inform the general public and the oil companies have a responsibility to learn the facts and preach them—unless we want to play guessing games about whether our company will further reduce its operations (and lose with it) in the years ahead.

"But what can I do? you ask. Shall we let the public relations boys in the head office defend us against those attacks on depletion? No! It's not enough to do the job. If we want to survive in do-

Post editorial cartoon showing the oil companies as a big hog wallowing in the "27 1/2% depletion tax allowance?" On Jack Steinle (The Independent newspaper) stating that depletion was "one of the biggest windfalls and tax-avoidance gimmicks of all"? Or Senator Proxmire of Wisconsin proclaiming on the senate floor that it is the "number one example of unfairness, inequity, and ineffectiveness in our tax sys-

THE AUTHOR

George F. Tarbox, a 1952 graduate of Colorado School of Mines in geophysical engineering, has been employed by Pan American Petroleum Corp. since that time. During the Korean War, Mr. Tarbox served as an engineering officer and pilot of fixed wing aircraft and helicopters in Alaska and Hawaii for the Army Engineers. He is still active in the Engineers as inspector-observer to reserve units.

Mr. Tarbox has worked in geophysical exploration in Oklahoma, Kansas, Mississippi and Texas, and is now located in Pan American's Lubbock, Texas office as district geophysicist. As community programs chairman for 18 counties for Texas Mid-Continent Oil & Gas Assn., he is well aware of the importance of the depletion allowance to the petroleum industry. The statements in the following article, however, are his own and do not necessarily reflect the policies of Pan American Petroleum Corp.

Other publications by Mr. Tarbox include "Radio Surveying Applied to Geophysics" (MINES Magazine, May 1952), "The Helicopter—New Tool of the Petroleum Industry" (The Petroleum Engineer, June 1956), "Recent Developments in Western Minerals Exploration" (MINES Magazine, January 1957), "Bibliography of Graduate Theses on Geophysics in U.S. and Canadian Institutions" (MINES Quarterly, January 1958), and several others.

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swallow the catch-phrases and believe them. It is not necessary for us to be defensive about the issue at all, and certainly the critics would not gain support if the public could see the facts for themselves. Let us examine the pertinent questions involved:

(1) What is percentage depletion and how is it legally and soundly founded? Or is it to be called a tax loophole?
(2) Is the depletion percentage too low or too high? What if it were stopped? Or were the rates reduced?
(3) Does depletion affect me, a salaried engineer? And what can I do about it?

To answer the first question completely would involve volumes of legal discussion and explanation. But we can look at a few of the basic points. For more complete reading, there appears at the end of this article a short list of material on depletion and what may be called a reference section.

In the first place, the supporters of the critics do not seem to realise the difference between selling a barrel of oil (or a ton of coal) and selling a pair of shoes. But if the shoe factory sold a small portion of the factory along with the shoes, its capacity to profit from the shoes would not be the same. The basic problem, then, is that of being able to reinvest that capital into a new shoe factory. Not only that, but the shoe manufacturer need not build nine or ten factories before he has one that will produce.

Consider this problem long ago as did the Constitution of the United States, in the Sixteenth Amendment of the Constitution, congress was enabled to tax income from capital. But it was not capital itself. But a troublesome question arose for the extractive industries in that it was (and is) extremely difficult to estimate what percentage of a barrel of oil or ton of ore is returning as capital and what percentage is taxes. The lawmakers was a soil method of doing this, there would be no uproar over depletions.

Cost Depletion.
The initial method proposed to compensate for the fact that a portion of the product was a sale of a capital asset and (tax-exempt) was cost depletion. This method, in general, allows you to deduct your original investment, or cost, in that particular oil well or other property. Thus, the concept of depletion, when it is used in all phases of business, is hard to apply to the extractive industries for these reasons and the concept of depletion allowances necessarily (and justly) substituted. Depletion, in its various forms, was an attempt to give some type of return of production of capital values as depletions, are allowed to industries with more fixed and tangible risks.

Discovery Value Depletion.
The Revenue Act of 1918 instituted a broadening of cost definitions to include other development costs and further stated that if the fair market value of the discovery was disproportionately low to the cost, then the depletion tax allowance would be on the fair market value at the time of discovery or within 30 days thereafter. This was termed "discovery value depletion" and was used in various forms until the passage of the 1926 Revenue Act. What the legis-

mittee and a Select Senate Committee known as the Commissions on these. These investigations pointed out and attacked several weaknesses in the discovery value method, such as the difficulties involved with placing a value on a mineral discovery before it has been recovered. The gross value of each year's yield should be multiplied by a percentage (the percentage depletion values known only too well, this is impossible to establish with accuracy and would necessarily be constant as amended or new veins or pay sections or new production techniques (such as secondary recovery) are developed.

Percentage Depletion.
The concept of percentage depletion, then, was the result of your legislative effort to find an equitable method of allowing for loss of capital assets and taxing only that portion of the sale of the oil (or ore) that can be called income. We in the extractive industries should not feel defensive about this, for it merely attempts to put us on an equal footing with manufacturers who utilise depletion for the same purpose.

Basically, the percentage depletion deduction allows that, for oil and gas, 271/2 per cent of the gross income may be deducted but is limited to an amount not to exceed 50 per cent of the net income from the property. Thus on inefficient production, "stripder" wells and with high operating costs, 50 per cent of the net income can be much less than 271/2 per cent of the gross income.

Before we can answer our first question: percentage depletion is both legally and ethically sound and just. It might even be argued that not to allow it is in violation of our Constitution. The period 1925 to 1957 suggests itself, because before 1925 we operated under discovery value depletion. During this 23-year period, oil companies have averaged 10 per cent invested capital (with the aid of percentage depletion); this is compared with 11.7 per cent for manufacturing companies and 11.3 per cent for trade corporations. In addition, oil was seventeenth in earnings among 55 industries surveyed between 1925 and 1935. It would not appear then, that the oil companies are making away "excess profits." (The term can be described) as a result of the depletion deduction. Further, the actual depletion averages only about 15 per cent of the gross income. Limitation to 50 per cent of net income; this is never brought out by the critics, possibly because they are afraid that if they did, the oil industry and its molasses and shale and gravel receive a 5 per cent deduction.

Our second question thus no other discussion than the one remaining for us, namely, the percentage deduction, it is noted, varies from 271/2 per cent for oil and gas wells to 23 per cent for sulphur, uranium and (if from U.S. deposits) bauxite, mica, lead, nickel, zinc and many other ores. Limestone, fieldlamps, granites, but-

Incidentally, the allowance applied to gross income while the limitation applies to 50 per cent of net income? Senator Reed, a member of the Senate Finance Committee during the 1926 debate, answers this point:

"We are trying, by the finance committee amendment, to get away from those unfortunates and to adopt a rule of thumb which will do approximate justice to both the government and the taxpayers."

"We find, then, that probably the best way to do it is to provide that an arbitrary percentage on the gross value of each year's yield be chalked off for depletion. We figure it on gross income instead of net income, because the net income from all wells varies greatly. When the first flush production comes, the operating cost of the well is very low per barrel, but as the well starts to go along, we have to produce a small quantity of oil, the cost increases. Up in my state we have many wells working which average less than a quarter of a barrel per day. Obviously, the operating costs of those wells is pretty high, and in many cases production goes down to the point where there practically no net income, and yet the oil keeps flowing. There is a reduction of 60 per cent going on, and we based the depletion on net income we would not always reflect it."

Returning to our second question, then, is the 271/2 per cent allowed to oil and gas too high? Look at the earnings reports of oil companies and the answer is clear. Of course the last couple of years have been poor ones as far as earnings are concerned, so in order to be more objective a longer period should be used.

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Effect of Cut in Depletion.
What, then, if the depletion deduction were not allowed? Or cut to a lesser percentage? Again let us examine examples of net income. If we use the current discovery rate of life, if we last depletion, a 50 per cent price increase of crude oil would be needed to compensate for the depletion. The price of oil would have to increase some 5 cents per gallon.

In Texas alone, 4.5 billions of gallons of petroleum fuel are used each year. Using this figure, loss of depletion would cost Texas motorists $255 million annually. The nation as a whole would lose $2 billion a year, or $50 million per day. Again using Texas as an example, we have seen that depletion, loss of depreciation would also mean:

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*Figure 3. Crude reserves proven per foot drilled has been dropping steadily.*
have a widespread effect.

ment admits, however, that income taxes from oil companies would drop some $65 million and that the federal government. It becomes obvious, then, that if depletion were stopped, the "closing" of such a "tax loophole" would mean a loss of $44 million in tax revenue to state and local governments and $48 million yearly to the federal government.

This would mean approximately $60 million less in farmer and rancher income from leasing. Loss of depletion would mean approximately 6000 less wells drilled in Texas alone, resulting in a 200 million barrel decrease in reserves. Aside from the above effects due to this decreased activity, this would mean a loss of $4 million in tax revenues to state and local governments and $60 million yearly to the federal government.

It becomes obvious, then, that if depletion were stopped, the "closing" of such a "tax loophole" would in the face of reduced activity, this would mean a $19 million loss to Texas in production taxes. The Texas Employment Commission states that there were 10,000 fewer workers in the state, Texas may be in financial difficulties.

But in that same year, 3287 fewer wells were drilled in Texas than in 1957. Crude production was off 134 million barrels (39 per cent) which caused a $19 million loss to Texas in production taxes. The Texas Employment Commission states that there were 10,000 fewer workers in the state's petroleum industry in 1958 than in 1957. From 1958 to 1960 it is an even sadder story, and from present oil income taxes paid by the public. That $198 million represents two-thirds of the Farm-Assistance Foundation School Fund, and many others.

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When we see or hear such mummosed as "tax loophole," let us speak up and ask for facts... and, further, give facts to the press in letters, or in communications to our elected representatives, and to everyone who will listen objectively. If we are not interested, then we, and the extractive industries, will lose by default.

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7. "The Case for Percentage Depletion for Oil and Gas," available from the Texas Mid-Continent Oil & Gas Association, 2920 Southland Center, Dallas, Texas.
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Classifiers
Ball and Rod Mills
Flotation Machines
Ore Feeders
Conditioners and Agitators
Morse Bros. Machinery
2900 Brighton Blvd., Denver 1, Colorado

Laboratory Equipment
Thickeners
For All Your Mining and Milling Requirements

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rabbits. Average rainfall is less than fifteen inches, and land of sagebrush, tumbleweed, bear grass and jack

indicate that there are more ways than one of getting substantial investments. The story of one oil well in far beneath the surface. Today oil rather than cattle of cattle to a square-mile section of land. Generations oil out of the ground today.

that have raised oil-field production. These methods and, perhaps of equal interest, the scientific techniques

of the company's district superintendent was to "seal up as much equipment as possible and permanently plug and abandon the well." The division geologist and the petroleum engineering department concurred. Although Howe No. 1 had produced nearly 44,000 barrels of oil in 10 years, its life was apparently at an end.

Howe No. 1 Plugged and Abandoned

It had taken almost a month to drill the well, but plugging took only two days. Gravel and cement were

neared into the bottom of the hole. A charge of nitroglycerin was lowered to a depth of 1,000 feet, and the explosion took place. In so far as one could tell, the top three-quarters of the hole could be sealed. The well was then cased with another 20,000 feet of cement. In Henryville a line was also plugged, and the well was leased by the

posessed of five-eighths of his royalty interest for 26 mares, a banker in Ionia, Mo., in exchange for 26 mares.

West Texas area where rock formations are hard and of lower than average, although it was normal for this

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Texas Railroad Commission, which regulates all wells on test produced at the rate of 1,178 barrels a day. The

Humble company, and a request to abandon was granted by the state authorities. The recommendation to recover a far greater proportion of the oil in a reservoir.

the reservoir fluids. Application of the process requires determination of its flow pattern through the oil-bearing rock

the reservoir. Many of these techniques have been incorporated into production practice in recent years. As technology advances, new methods of oil recovery are being explored, such as waterflooding, enhanced oil recovery, and the use of chemicals to increase oil recovery. Waterflooding involves the injection of water into the reservoir to displace the remaining oil. Enhanced oil recovery techniques, such as chemical flooding, involve the injection of chemicals to increase oil recovery. These methods are particularly useful in reservoirs where the oil is viscous or viscous sandstone.

The average primary recovery from oil fields in the United States has been on the order of 20 per cent, and scientists are continually exploring new methods with which they expect to recover a far greater proportion of the oil in a reservoir. These methods should greatly increase the reserves of oil available for future use.

The heirs of Mr. J. F. Howe continue to receive

royalty payments on an investment made 48 years ago. The drilling of this well has proved to be a remarkable investment, as the oil that was recovered was sold at about $260 per barrel.

Figure 16 is a schematic representation of the in situ combustion process. Air is injected into in situ well and combustion is initiated either spontaneously or by introduction of outside heat into the injection well bore. The burning of the injected oxygen front moves radially outward from the injection well toward the producing wells. Several distinct zones develop in the vicinity of the injection well, including a deoxygenated zone, an oxidation zone, and a water production zone. In the deoxygenated zone, the oil is subjected to the available heat; a zone containing coke, which is the residue left after oil is subjected to the available heat; a zone containing cracked gases, resulting from the burning of residual oil in the reservoir, and a zone containing cracked gases, resulting from the burning of residual oil in the reservoir. The burning of the oxygen front leads to the formation of carbon dioxide, which is released from the reservoir.

In situ combustion results in the removal of all oil from the reservoir and is an efficient method of oil recovery. It is particularly useful in reservoirs with a low permeability and a high viscosity. In situ combustion is an environmentally friendly method of oil recovery, as it does not involve the use of chemicals or other pollutants. It is also an efficient method of oil recovery, as it can recover a large proportion of the oil in place.
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PLANT NEWS

New Torch Cuts Through Metal 30 Inches Thick

Crucible Will Market All Around Tool Steel

Crucible Steel Co. of America, world's largest producer of tool and high speed steels, has announced the availability of a low temperature air-hardening die steel which will be marketed under the trade name CRUCIBLE. In addition to its free-machining qualities, this all around tool steel (AISI grade A-6) combines many of the advantages of air-hardening grades with the low hardening temperature of oil-hardening grades.

Link-Belt Co. Appoints Three General Managers

Link-Belt Co., has announced general managers for three of its plants. T. Webster Matchett, former manager of the Caldwell plant, has been appointed general manager of the Pershing Road plant in Chicago. He is succeeded at the Caldwell plant by George Ramsey, general manager of the North Central Division in Minneapolis. Ramden is succeeded in Minneapolis by Gerald A. Stone, district manager of the Dallas office and factory branch store. The appointments were effective Sept. 15.

The announcement was made by Robert C. Becherer, president of Link-Belt Co., manufacturer of materials handling and mechanical power transmission equipment.

CFRI Gets Right to Prospect in Apache Indian Land, Ariz.

Colorado Fuel and Iron Corp. has announced the successful conclusion of a permit and option negotiation with the White Mountain Apache Tribe granting the Co. an exclusive prospecting permit and option to lease Apache Indian land in Arizona. The permit covers 16 square miles in the northwestern section of the Fort Apache Indian Reservation and gives CFRI the right to prospect for all minerals except oil and gas. The permit is for two years, with the right to extend it for an additional two years if desired.

The presence of iron ore deposits has been known for many years. CFRI plans to continue the prospecting work presently being done by the U. S. Bureau of Mines and the U. S. Geological Survey, which have indicated reserves of about 10 million tons of iron ore, according to R. R. Williams, Jr., 29 manager of mines for the company. The company also plans to investigate deposits of asbestos, manganese, and coal in the area.

Conveyor Systems, Inc., Buys A. B. Farquhar Division

Purchase of A. B. Farquhar Division by Conveyor Systems, Inc., Martins Groove, Ill. on April 1 makes conveyor Systems the second largest manufacturer of standard and custom conveyor equipment for industry. The A. B. Farquhar Division manufactures a complete line of standard conveyors for bulk and package handling and its new parent company, Conveyor Systems, Inc., is a specialist in custom conveyor engineering and construction, including conveyor systems, slat conveyors and other types of materials handling equipment.

According to Marvin H. Coleman, president of Conveyor Systems, Inc., the sales efforts of these two companies will be integrated to provide service as complete as any now existing in the materials handling field.

The announcement was made in York, Penn., where the acquisition was formally completed about Aug. 15 and manufacturing operations began about Aug. 25 in the newly-expanded plant of Conveyor Systems, Inc.

Michigan Chemical Doubles Capacity of Bromine Plant

Michigan Chemical Corp.'s new bromine plant expansion at El Dorado, Ark., is now completed and in operation. This doubles the capacity of the facility which is a joint venture with Murphy Corp. of El Dorado.

This additional capacity will more than double Michigan Chemical's bromide-producing plants at Saint Louis and Monroe, Mich.8.3. Michigan provides the chemical industry with three dependable sources of high-quality bromine for bromination of organic compounds, fuels, fungicides, nitrates, refrigerants, refined fuels, and pharmaceuticals. Analysis of bromine offers a new chemical process and fine chemicals industry.

A-C Appointments

The appointment of Will Mitchell, Jr., as vice director of Research Division, Allis-Chalmers Manufacturing Co., has been announced by R. S. Stevenson, president. Mitchell previously was associate director of the company's Research Division. He succeeds the late Dr. H. K. Ihig, director of research and vice president of the company, who died Aug. 11.

Allis-Chalmers Centrifugal Pump and Light Weight Foundry, Inc., announced the following appointments:

Joseph J. Jacobs, chief engineer:

C. L. Bubb, senior staff engineer:

W. W. Wellment, senior development engineer.
CATALOGS and TRADE PUBLICATIONS

A two-page Application Data Sheet, EH 5033, by Scientific and Process Instrument Division of Beckman Instruments, Inc., describes the new Beckman Electrolytic Hygrometer Cell which makes it possible to measure the moisture content in hydrogen streams.

A six-page welding, brazing and soldering alloy and flux Catalog & Instruction Manual, by All-State Welding Alloys Co., is designed for design, maintenance and production welding engineers and foremen, trade school instructors and purchasing agents.

A new (1045) WELDING ALLOY CATALOG, a 16-page catalog just released by Caterpillar Tractor Co., Peoria, Ill., contains 24 pages of articles describing the new universal setup and capabilities of their new line of welding alloys.

A four-page pamphlet by American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N. Y. presenting some of the Cyanamid chemical and suggested uses and featuring the "Do's and Don'ts to Prevent Accidents in the Use of Explosives." This bulletin discusses the principles of operation, and how to select and specify Polydyne units. Also discussed: the benefits of mechanical adjustable speed drives, and how to select and specify Polydyne units.

A four-page brochure by Golden Metal Couplings, Inc., 2133 S. Kedzie Ave., Chicago 23, 111. A completely new self-contained double diaphragm coupling with high pressure capabilities is offered, with easy-to-read mounting instructions.

A four-page bulletin by Filtration Engineer Division, American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N. Y. describes the new Disc Filter, These filters offer high capacity, trouble-free agitation, minimum floor area, and sizes to 250 sq. ft.

A 16-page catalog by General Electric Co., Schenectady 5, N. Y. describes the new Polydyne Drives. Bulletin discusses the principles of operation, and how to select and specify Polydyne units. Also discussed: the benefits of mechanical adjustable speed drives, and how to select and specify Polydyne units.

A 16-page catalog by American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N. Y., lists the complete line of American Cyanamid explosives and emphasizes the fact that The Mines Magazine is the only publishing medium advertising explosives under mining regulations.

WELDING ALLOY CATALOG. A new welding alloy, brazing and soldering alloy and flux Catalog & Instruction Manual, by All-State Welding Alloys Co., is designed for design, maintenance and production welding engineers and foremen, trade school instructors and purchasing agents.

EXPLOSIVES & REAGENT NEWS. A 16-page catalog by American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N. Y., lists the complete line of American Cyanamid explosives and emphasizes the fact that The Mines Magazine is the only publishing medium advertising explosives under mining regulations.

DIHEDRAL SPINDLE COUPLINGS. By American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N. Y., lists the complete line of American Cyanamid explosives and emphasizes the fact that The Mines Magazine is the only publishing medium advertising explosives under mining regulations.


A small amount of the purpose of mutual helpfulness need not have waited until the last moment to turn in a ballot. The Mines Magazine has been listed for the past two months in Standard Rate and Data Catalog. In talking with your company or other prospective clients, emphasize the fact that The Mines Magazine is the only publishing medium advertising explosives under mining regulations.
Roy B. Munroe

General Membership Will Vote On Proposal to Amend Certificate of Incorporation

To effect these proposals, the Association shall have the power: 1) To publish a magazine dedicated to the growth of the dynamic mineral industry and to the continued advancement of professional relations among the graduates of the Colorado School of Mines.  
2) To acquire by gift, lease, sale, assignment, or purchase personal or mixed as assets, right, property, or non-real property.
3) To issue, acquire, hold, mortgage, pledge, hypothecate, sell, exchange or transfer any securities of any nature and exercise all the rights, powers, and privileges of ownership in the...
VINCENT N. BURNHART

Mr. Burnhart, who graduated from Mines in 1932 with a degree in mining engineering, was associated until 1942 with American Metals Climates. Between 1942 and 1946 he commanded a battalion in the Corps of Engineers, serving in China, India and Burma. Joining the Longyear Co. in 1946, Mr. Burnhart was senior metallurgist, Army Reactors, U.S.A.E.C., at Germantown, Md.

Prior to leaving the company, Mr. Burnhart prepared a paper, "A Comparison of Stainless Steel and Zirconium for Use in Pressurized Water Reactors," which has been offered for publication in THE MINES Magazine.

Baroch, '54, Accepts Position with Battelle

Charles J. Baroch, a 1954 metallurgical engineering graduate of the Colorado School of Mines, has accepted a position as senior engineer in Frank Stephens' ('42) Extractive Metallurgy Division at Battelle Memorial Institute. His address is 770 Harley Dr., Columbus, Ohio. Before joining Battelle, Mr. Baroch was general manager of the Contract Drilling Division in 1947. He was named general manager in April of 1957 and became vice president in January 1958.

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94 Mines Men Attend Luncheon at AMC Meeting


The purpose of the Carll Award is to recognize "leadership in the advancement of contributions in or contributions to petroleum engineering," it was established in 1957 and has previously been awarded to Herbert Comstock Ott, Gen. E. O. Thompson and Eugene A. Stephenhorn.

Schilthuis joined Humble in 1930 after graduating with a petroleum engineering degree from Colorado School of Mines. During his 30-year tenure with the company, he has served in various capacities in the Production Research Division, Administrative Department, Petroleum Engineering Division, Gas Division, and Production Department. In 1955 he was elected a director, and in 1957, vice-president, and was named president of the company in 1959.

Schilthuis has previously been honored for his engineering achievements when he received the Alfred Noble Prize in 1938 from the founder engineer societies for an outstanding technical paper written by a member of less than 30 years old.

Conventions Scheduled


Mr. and Mrs. Mills E. Bunger, '29, Celebrating Their Golden Wedding Anniversary

Mr. and Mrs. Mills E. Bunger of 3850 Harlan St. Wheatridge, Colo., celebrated their 50th wedding anniversary with a dinner at the Holland House in Golden. They were married in Denver Sept. 29, 1910.

Mills graduated from the Colorado School of Mines, class of '29. Mrs. Bunger, formerly Mary Ethel Dale, graduated from Greeley class of '30.

They have a son, David Elwood, of Klamath Falls, Ore., and two daughters, Mrs. Barbara Fagerberg of Powell, Wyo., and Mrs. Dorothy Lingle of Sturgeon Bay, Wis., and six grandchildren.

Mills retired from the Foreign Service of the State Department and is now a consultant on water problems.

Metzger, '34, Joins Houston Chemical Corp. As District Sales Manager

Russell E. Metzger, E. M. '34, has left the employ of the Texas Co., where he was general manager of tubular sales and has joined Houston Chemical Co. as district sales manager with office and residence in Houston. His address is the American Petroleum Institute Building, floor 16, 3722 Drummond Dr., Houston 25, Texas, tele­phone MA 3-2753.

Now constructing a plant in Beaumont, Tex., for the manufacture of tetra ethyl and tetra methyl lead, Houston Chemical is the third largest manufacturer of TEL and TME in the country.

Mr. and Mrs. Grubeth and two children—Jill, 5, and Cindy, 3—are nicely settled in Houston, Texas at 9331 Warwana Rd.

After graduating from Mines, Mr. Grubeth was employed as a junior geologist by Superior Oil Co., its Grand Junction, Colo. Three years later he decided to become a student engineer and was named its Master's degree in business administration, which he received from Harvard University in June 1960.

RALPH A. SCHILTHUIS

Mr. and Mrs. Grubeth received the 1960 John Franklin Grubeth Award at SPE Meeting

Ralph J. Schilthuis, executive vice-president and member of the board of the Humble Division of Houston Oil & Refining Co., received the 1960 John Franklin Grubeth Award of the Society of Petroleum Engineers of AIME.

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John S. Phillips, a 1949 geological engineering graduate of the Colorado School of Mines, received his Ph.D. in geology this spring from Harvard University. Since July he has been employed in mineral exploration by W. R. Marvin and Associates, a Chicago company. He is the company’s treasurer, office manager, and one of the company’s assistant engineers.

Phillips graduated from the Colorado School of Mines in September 1949 with a B.S. degree in geological engineering. He has been working in the mining industry ever since, most recently with the W. R. Marvin and Associates group, where he has been involved in the exploration of mineral deposits.

Phillips is the son of Mr. and Mrs. George S. Phillips, who reside in Durango, Colorado. He is married to Miss Susan Arnold, who is currently teaching school in the Colorado area.

This information was obtained from a recent issue of the Colorado School of Mines Alumni Magazine.

The Denver Section of the Colorado School of Mines Alumni Association has announced the election of its new officers for the upcoming year. They are:

President: Paul Shanklin, ‘49
Vice President: John Bolles, ‘50
Secretary-Treasurer: C. E. Ramsey, ‘58

The Section is active in organizing alumni events and activities, and encourages all former students to stay in touch and support the school.

The Culver City Section of the Colorado School of Mines Alumni Association has named Mr. John S. Phillips as its new president. Mr. Phillips is a graduate of the Colorado School of Mines and has been active in the mining industry for several years.

The Culver City Section meets regularly, and encourages all former students to attend and stay informed about the latest developments at the school.

The Los Angeles Section of the Colorado School of Mines Alumni Association has announced the election of its new officers for the upcoming year. They are:

President: Jack Earl, ‘52
Vice President: John Boles, ‘50
Secretary-Treasurer: C. E. Ramsey, ‘58

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By PROF. CLARK F. BARR, '25

Petroleum engineering education at the Colorado School of Mines dates from the fall of 1916 when a course entitled "Mining Engineering" was offered. Mr. C. W. Barbour, "95, of practical experience, was engaged to head the new department. Several courses in production, transportation, and refining were introduced in addition to the petroleum courses already being given by the Chemistry and Geology Departments.

Professor Kirby was succeeded by Prof. R. C. Beckstrom who came to the school from Oklahoma University in 1925. He organized a strong refining operation and gave a few courses in oil refining, which were published in 1926, Mr. P. H. Shannon of the Continental Oil Co. took over the work on the production phases of oil technology and expanded that portion of the subject. Ten lecture hours of strictly petroleum refining subjects and nine hours of strictly production subjects were being offered by the department by 1926.

Professor Beckstrom left the department in the spring of 1928 and Professor Shannon became head of the department. Professor Shannon left the school in the fall of 1928 and was succeeded by Mr. Byron B. Bostwick as head of the department. Professor Bostwick resigned in 1937 and Prof. Clark F. Barr was appointed head of the Petroleum Engineering Department which gave the department the name of petroleum engineering and expanded that portion of the subject. Ten lecture hours of strictly petroleum refining subjects and nine hours of strictly production subjects were being offered by the department by 1926.

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Engineers is the case in some schools. The Petroleum Department at Mines has been unique in that such background knowledge may be used in the development and operation of oil fields.

CLARK F. BARB, who has been professor and head of the Department of Petroleum Engineering at the Colorado School of Mines since 1936, received P.E. and M.S. degrees (1925 and 1928) from Mines. He also attended Kansas State Agricultural College in 1915-16 and worked as a part-time student on a Ph.D. degree in 1925. He was in charge of the Mining Experiment Station and Mining Commission. During the past 10 years that followed, Professor Barb has been active as a professor of petroleum engineering at the Colorado School of Mines as a professor of petroleum engineering (1936 and for a few years at Pennsylvania State College) and as a petroleum engineering consultant for many government agencies and private corporations.

During World War II, Professor Barb acted as consultant to the Petroleum Administration for War in Pennsylvania from 1943 to 1945 as an engineering graduate of the University of Nebraska, class of 1925. Following graduation, he spent three years in Venezuela in oil exploration and development work and then entered The Johns Hopkins University from which he received a Ph.D. degree in geology in 1933. The years 1933-1941 were spent with the Tropical Oil Co. (Standard). The period 1941-49 was spent in Washington, D.C., as chief of the development unit, Petroleum Administration for War, and as director of secondary recovery of oil research for the Pennsylvania State College.

He is a native of the Netherlands and studied at the University of Delft, where he received his B.S. degree in 1948. He then studied at the Colorado School of Mines and received a Master's degree in engineering in 1955.

Following his graduation, Dr. van Poollen returned to the Netherlands to serve in the Dutch Army until 1951, at which time he joined the Standard Vacuum Petroleum Manufacturing, Sumatra, as a reservoir engineer. In 1954, he returned to the Colorado School of Mines to receive his D.Sc. degree in mining engineering in 1955.

Subsequently, he was employed with Haliburton Oil Well Cementing Co. in Duncan, Okla., as a reservoir engineering section leader. In 1958, he joined the Ohio Oil Co.

Starring in the fall of 1960, Dr. van Poollen became a special lecturer in reservoir engineering at the Colorado School of Mines on a part-time basis.

He has published several articles in technical journals in the areas of well simulation and drill stem testing. The course he teaches at the Colorado School of Mines is a part-time basis.

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By DR. JAMES H. GARY

During the past few years some rather dramatic changes have been made in the various curricula of the School of Mines and the Department of Petroleum Refining Engineering. There are the obvious reasons which have resulted in these developments and the effects they will have upon the qualifications of our graduates will be discussed after the faculty of the Department is introduced to you.

GEORGE W. LE MAIRE, Mines '26, joined the Mines faculty in April, 1946, as assistant professor. Professor LeMaire served as associate professor and was promoted to professor and acting head of the Department of Petroleum-Refining Engineering Department in 1959-60.

He was employed by the Standard Oil Co. (New Jersey) for two years in the Crude Oil Evaluation and Economics Section. This was followed by five years with Humble Oil Co., where he worked on the development of a process for the manufacture of alcohol from light hydrocarbons and served in the Technical Service Department. From 1953 to 1944 he designed and was engineer in charge of the treating processes of the Aruba Refinery in the Netherlands West Indies. From 1944 to 1946 Professor LeMaire was technical supervisor of the alkylation, isomerization and treating operations for the Chevron refinery of Frontier Refining Co.

Dr. Gary taught for four years at the University of Virginia where he held the rank of assistant professor of chemical engineering and research director in the Engineering Experiment Station. He was then an associate professor for three years and professor of chemical engineering for one year at the University of Alabama and was in charge of the Engineering Experiment Laboratory there before coming to Mines this summer.

After leaving industry, Dr. Gary taught for four years at the University of Virginia where he held the rank of assistant professor of chemical engineering and research director in the Engineering Experiment Station. He was then an associate professor for three years and professor of chemical engineering for one year at the University of Alabama and was in charge of the Engineering Experiment Laboratory there before coming to Mines this summer.

Dr. Gary has been employed as consultant to the Allen-Sherman-Hoff Co., International Paper Co., Cities Service Refining Co., Standard Oil Co. (Ohio), and the U.S. Bureau of Mines.

Professor LeMaire is the holder of patents in the field of fractional systems engineering.

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DR. LYMAN W. MORGAN came to Mines in 1953 as an associate professor. He received his Ph.D. degree in chemical engineering in 1958 at the Massachusetts Institute of Technology with a B.S. in chemical engineering. He went on to graduate work at the Georgia Institute of Technology and received both the M.S. and the Ph.D. degrees there.

Upon graduation from Georgia Tech, Dr. Morgan joined Phillips Petroleum Co. and became group leader of the Systems Analysis Group in Research and Development. While with Phillips, he did theoretical analyses of research, pilot plant, and full scale plant data and designed automatic optimizing control units for plant application.

Dr. Morgan is the holder of patents in the systems analysis field and has contributed to technical magazines. He specializes in process engineering and systems analysis and this year initiated a new course which introduces the engineering science of transport phenomena at the Junior level. He is also consultant to the Oil and Refining Co. in the field of process systems engineering.

JOHN C. THOMAS joined the Refining Engineering Department at Mines in January 1960 as a laboratory assistant in charge of designing and installing a process systems engineering laboratory suitable for both graduate and undergraduate use. He is a graduate in chemical engineering from Texas Agricultural and Mechanical College.

After graduation, he worked with Phillips Chemical Co. as a developmental research engineer and later transferred to the Phillips Petroleum Co. as an instrument development en-
JOHN C. THOMAS

engineer in their Research and Development Department. Mr. Thomas has several instruments and processes, and the development of on-stream and laboratory analytical instrumentation for Phillips.

He is a registered professional engineer in the state of Texas and is a consultant in the field of process systems engineering.

The curriculum of the Department of Petroleum Engineering approved by the ECPD (Engineers' Council for Professional Development) on the basis of chemical engineering. This means that while by the title of the degree we are preparing students for that phase of the chemical industry devoted to the refining of crude oil and the manufacture of products derived from it, the graduate from Mines in Petroleum Refining is competitive in basic and fundamental engineering training with chemical engineering graduates across the country.

This is a decided advantage to the student with respect to his application and association in the field and his professional achievement. It is also advantageous to the faculty in the teaching material, objectives and teaching philosophy can be strengthened by comparison with and utilization of the experience of chemical engineering departments in other colleges and universities.

In conjunction with departmental curriculum changes, the overall curricula of all options in the school has been revised considerably after more than two years of study by the Curriculum Committee of the Faculty. This was the result of a number of factors some of which include suggestions by accrediting groups, changes in engineering requirements in industry, progress in the development and application of electronics and computers in the areas of process control, statistics and analysis, and the opinion of the teaching staff.

At the lower class level these changes include the introduction of an organized orientation program for which academic credits are given which together with time provided for humanities electives provide for 19 hours in this area.

Physics has been built up to three semesters to strengthen training in this basic science and to permit time for the introduction of principles of modern physics.

Four semesters of chemistry are integrated to provide a sequence of chemical knowledge which includes principles in general chemistry, and emphasizes physical chemistry and thermodynamics.

At the upper level, changes which directly affect the option include the following:

Two semesters of a new course in mathematics were introduced in the Junior curricula called Engineering Mathematics. In these courses, the application of advanced mathematics to engineering and research situations is stressed including a further study of ordinary differentials, partial differential equations, introduction to the Fourier series and Laplace transform, vector analysis, complex variables, probability and statistics.

The math courses are taken concurrently with revised material in Unit Operations to permit the study of differential processes of momentum, heat and mass transport. The applied physics of the operations are taught in terms of their differential equations.

To strengthen the application of thermodynamic principles to process design, chemical and physical thermodynamics follow each other consecutively in the Junior curricula.

Emphasis in two semesters of organic chemistry is placed on the relations of chemical and physical properties to structure and reaction mechanisms involving bond type and structural elements.

Within the Petroleum Refining Engineering Department, the laboratory course in Chemical Engineering Unit Operations has been developed into a six weeks' Summer Field Course to follow the introductory material on transport phenomena and simple process equipment design given during the junior years. Topics of practical importance are taken up which are not included in the pure theoretical material of the regular Junior year. The propagation of experimental error is emphasized as a guide to the design of bench scale and pilot plant experimentation.

The prime need of the Senior year is to bring together into a coherent relationship the five general areas of chemical process engineering, namely properties and structure of matter, laws of conservation (e.g., energy balances), thermodynamics, physical and chemical kinetics, and process control. To accomplish this purpose it is necessary to develop the concepts of control and instrumentation in the chemical process plant at a level that has been the practice in the past.

A new course in Fluid Dynamics is offered during the first semester to provide the necessary emphasis in process control. It presents both theoretical and laboratory work in process measurement, dynamic and control. Emphasis is given to transient and sinusoidal testing, used to analyze the dynamics of both processes and instruments, lead to the design of a simple process control system by the end of the course.

The Engineering Mathematics course provides the necessary background in operational calculus.

A new course in Chemical Instrumentation is included in the same semester to complete the necessary introduction to process control. Consisting of both theory and laboratory experiments, the role of the chemical analysts in chemical process control are brought out.

Chemical Process Engineering is scheduled for the second semester to actually bring together the necessary areas of competence. This is done by making a rational approach to the control of chemical processing plants.

It is necessary to work out a mathematical model of the plant and this, in turn, requires all of the five areas. This three hour course is toward petro-chemical process engineering for its examples and uses the processing difficulties of colloidal and amorphous materials as practical problems. Methods of obtaining and interpreting data for the solution of problems supplemented by testing, analysis and experimentation are included. Process control, also important in itself for practical reasons, also serves as a framework on which to build a coherent course of instruction in chemical process engineering.

The faculty has the combination of practical experience, education, and teaching experience necessary to give the student a firm background in fundamentals and to show him how to apply the theoretical concepts to practical problems. In service, these men represent 35 years of plant experience and 26 years of teaching. Individual interests cover a wide variety of subjects which together form the basis for a well-rounded training in all phases of refining and petro-chemical engineering.

This faculty, together with the excellent facilities available, should result in progressive improvement in the quality of the graduates bearing the degree of Petroleum Refining Engineering.
several instrument and process analysts are preparing students for that engineer in the state of Texas and is the development of on-stream and parameters of chemical processes and entities pending as a result of his work. The prime need of the Senior year is to bring together into a coherent relationship the five general areas of chemical process engineering: namely properties and structure of matter, laws of conservation, energy balance, thermodynamics, physical, and chemical kinetics, and process control. To accomplish this purpose it is necessary to develop the concepts of control and instrumentation of the degree that has been the practice in the past.

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By such means the departmental faculty feels that individual interests and abilities of students can be aided and directed to areas that will be of maximum benefit to them and will better equip the graduate to become associated with job selection in any phase of chemical engineering. The faculty has the combination of practical experience, education, and teaching experience necessary to give the student a firm background in fundamentals and then to show him how to apply these theoretical concepts to practical problems. In service, these men represent 35 years of plant experience and 26 years of teaching. Individual interests cover a wide variety of subjects which to some extent are the basis for a well-rounded training in all phases of refining and petro-chemical engineering.

This faculty, together with the excellent facilities available, should result in progressive improvement in the quality of the graduates bearing the degree of Petroleum Refining Engineer.
Mines to Be in USIA Film Depicting Higher Education in the United States

The Colorado School of Mines has been selected as one of six colleges and universities to represent this nation's program of higher education in a large-budget movie film. The film, "Higher Education in the United States," is sponsored by the United States Information Agency, and was written by Gene Wyckoff, writer for the former TV series "Wide, Wide World."

The film, a half-hour sound and color production, is intended by USIA to answer a series of films produced by the University of Moscow, describing the education opportunities of the Russian university.

Six schools were selected from the more than 1800 colleges and universities in the country. The other five schools are Harvard, Pittsburgh, Caltech, Goucher and Wittenberg. Each will have a five minute segment in the film.

Film shooting crews from Baltimore, Md., will visit the campus before Christmas to shoot the Mines portion of the film.

Mines and CU Start Geology Teacher Exchange

The Colorado School of Mines and the University of Colorado have started a geology teacher exchange program this fall. The program is designed to supplement course offerings in geology at no additional cost to either institution.

This fall Dr. Robert Weimer, associate professor at Mines, is conducting a CU graduate seminar in "Principles in Stratigraphy" one afternoon a week.

Next spring the University of Colorado will send Dr. William C. Bradley, an assistant professor, to Golden for a seminar on "Glacial Geology."

Both institutions have planned compensatory adjustments in slight teaching load reductions for each professor when he is teaching at the other institution.

"This is a reciprocal agreement by which we both can profit," Dr. Warren O. Thompson, CU geology department head, declared. "Each school can offer its own special talents to fill in for the fields not covered at the other school."

Dr. L. W. LeRoy, Mines geology department head, agreed "wholeheartedly with the exchange. I think it certainly is going to be advantageous to both departments, and I hope we can continue to do something along this line in the future."

Both department heads stated the program was a good idea in which to utilize special talents cooperatively.

Both participating professors have advanced degrees from Stanford University. Weimer, who earned his bachelor's degree at the University of Wyoming and is beginning his fourth year at Mines, has a broad background in stratigraphy and geological structure in the Rocky Mountain region.

This summer Weimer presented a paper co-authored with Dr. John D. Haun of Mines at the International Geological Congress in Copenhagen, Denmark.

Bradley has done research in sedimentation and geomorphology and has had several papers published. He has an A.B. degree from the University of Wisconsin and belongs to Sigma Xi and Phi Kappa Phi societies. He is in his fifth year of teaching at CU.

The exchange program is part of the inter-institutional cooperative program arranged by the Association of State Institutions of Higher Education in Colorado.
SPORTS
Ore diggers Win 3, Lose 2 at Football

As of Oct. 23, the Miners have won three and lost two on the football field. Ore diggers victories were chalked up over Colorado College, 20-12, over Colorado College, 20-12, over Westminster, 20-13, and over Colorado College, 20-12. The Miners lose to Highlands University, 14-6 (Sept. 27) and to Colorado State College, 20-12 (Oct. 22).

The Ore diggers report that the win over Omaha was due to the Miners taking advantage of Indian miscues. Three Miners touchdowns came following two fumbles and one Indian pass interception. The final score: 26-20 in favor of Mines.

The Miners victory, 16-12, over Colorado College was a Rocky Mountain Conference football thriller. Mines used single wing power plays and took advantage of CC errors to score one touchdown. An intercepted pass and a wild center snap on an intended punt set up two of the Mines scores, and a safety in the final 27 seconds provided the icing.

Although the Miners were out-numbered 14-77 yards, alert defensive play and a few breaks gave them the game over the hard-fighting Westminster Parsons, 20-13. Led by the fine passing of Bruce Henry, the Ore diggers opened the scoring in the first quarter. In the second quarter Westminster scored back and Battles scored from the one-yard line, but the kick failed and the score was tied 6-6. Lattes in the same quarter, Mike McDougal dashed over for the second Miners score, but a 7-yard pass from Westminster Hill to Armstrong tied the score at half time 13-13. The final score came in the fourth quarter when the Ore diggers drove 50 yards for a touchdown, making the final score 20-13.

Two pass interceptions and a recovered fumble were used by the Colorado State College Bears to down Mines 20-12. Bob Schmidt picked off a Kay White pass and ran 80 yards for the Bears first touchdown in the second period. Two similar breaks produced two touchdowns and erased a 12-6 deficit in the fourth quarter. Leroy Wryefield scored two touchdowns on passes from White.

Mines defeated Idaho State 7-0 to win Homecoming victory on Oct. 29th.

MINERAL INDUSTRIES
(Continued from page 19)

Ohio Oil Contributions Total $400,000 in 1960

The Ohio Oil Co. will make contributions totaling more than $400,000 in aid to education and in support of community health, welfare and youth programs in 1960. The financial assistance is given chiefly through the Ohio Oil Company Foundation.

J. C. Downell, president, said that the current budget exceeds Ohio Oil's 1959 contributions by almost $75,000.

Grants this year furthering higher education account for over half of the total program, or $226,000. More than 240 colleges and universities in all parts of the nation will benefit from unrestricted grants and donations for expansion projects. Numerous schools from which Ohio Oil draws substantial numbers of employees are included.

Airborne Geophysical Data Released by Surinam

Geological and airborne geophysical data for most of Surinam is being released to mining companies by the government of Surinam. According to Dr. F. F. E. Enos, minister of Development of Surinam, the data is being published as rapidly as the reports and maps compilations are completed. Over 100 isometric map sheets are now available.

A photo-geological survey was completed last July, to guide airborne geophysical reconnaissance of approximately 105,000 sq. kms. of Surinam. The survey, flown by Aero Service Corp., Philadelphia, and Canadian Aero Service Ltd., Ottawa, was made with the Gulf airborne magnetometer and scintillation counter. Flight altitude was 150 meters, and the guided flight lines were spaced at 1 km. intervals. Doppler Radars guided the survey aircraft over the dense "sea of trees," covered by KLM's aerial photography of Surinam.

The airborne data are being compiled in maps at a scale of 1:40,000, at a 20 gamma contour interval. Geophysical interpretation will follow.

The remaining 160 magnetic map sheets were completed for the government of Surinam by Sept. 30, 1960, according to Aero Service Corp.

Changes in Minerals Eligible For Exploration Assistance

The Department of the Interior has announced a proposal to make additional types of asbestos and beryl- lium ores eligible for federal exploration assistance.

Under present regulations only beryl and the strategic type of asbestos are eligible. Two other changes in the regulations (30 CFR 301) are proposed also to clarify the language in section 301.5 concerning the filing of applications and in section 301.15, title to and disposition of property. Interested parties have 30 days in which to comment on these proposed changes before they become effective.

Frank E. Johnson, a 1922 Mines graduate and acting director of the Office of Minerals Exploration, said that this change will permit the federal government to extend exploration assistance to other ores not previously considered as eligible.

Since the inception of the federal exploration assistance program in 1951 under the Defense Minerals Exploration Administration, considerable interest has been shown in exploration for these two mineral commodities.

Sixty applications were received for asbestos exploration projects. Nineteen of these resulted in contracts having a total value of $616,000 with Government participation of $353,000. Five of these contracts were certified as discoveries or developments. Applications for beryl and beryl-mica exploration assistance numbered 105, of which 21 became contracts having a total value of $228,000 with Government participation of $203,000. Eight of these were certified as discoveries or developments.

Exploration assistance is available through the OME to qualified operators who wish to explore for any one or more of the 32 mineral commodities listed in the OME regulations.

Applications form and additional information about the program may be obtained from the following offices:

The Office of Minerals Exploration, Department of the Interior, Washington 25, D. C.

OME—Region I—South 157 Howard St., Spokane 4, Wash.
OME—Region II—420 Custom House, 355 Battery St., San Francisco 11, Calif.
OME—Region III—25th Building, Denver Federal Center, Denver 25, Colo.
OME—Region IV—Room 11, Post Office Bldg., Knoxville 2, Tenn.

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