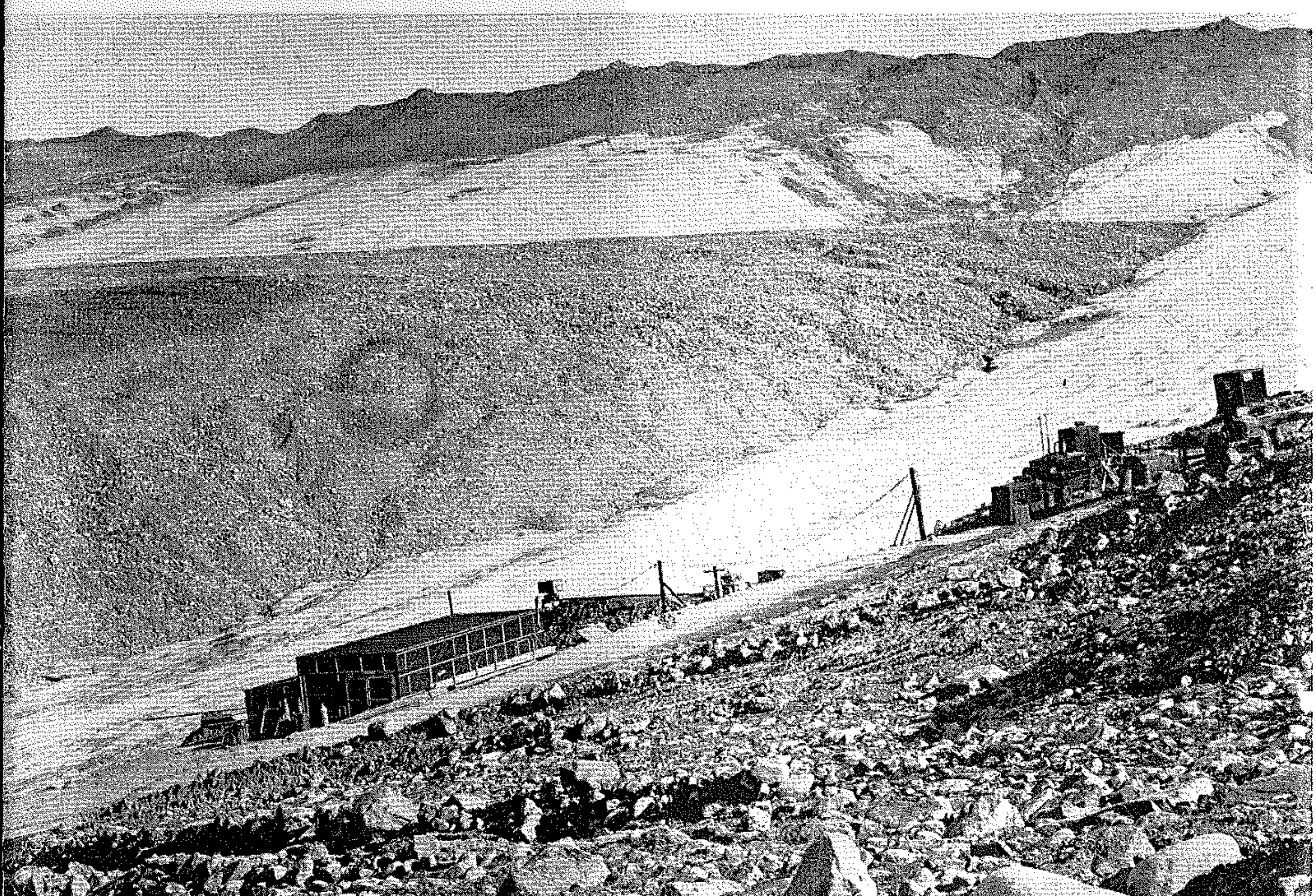
THE MINES MAGAZINE

MARCH 1960

- Permafrost Tunnel
- Powder Metallurgy Research
- Controlled Particle Movement
- Process Development and Operating Costs
- Academic and Physical Fitness Education



CLASS NOTES

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

1882-1930

C. C. MALMSTROM, '00, has asked to have his mailing address changed from Sacramento, Calif., to 684 Jones Rd., Yuba City, Calif.

J. MARVIN KLEFF, '06, has moved from Leadville, Colo., to 2670 Yates St., Denver 12, Colo.

Mr. and Mrs. THOMAS S. HARRISON, '08, observed their 50th wedding anniversary Feb. 21 at an open house in their home, 254 Tigertail Rd., Los Angeles, Calif.

ALLAN H. GRAHAM, '15, has moved from Falmouth Heights, Mass., to River View Rd., Gates Miles, Ohio.

GEORGE M. KINTZ, '20, district health and safety supervisor, U. S. Bureau of Mines, Dallas, Texas, visited the Alumni office. He is interested in obtaining a graduating senior in petroleum engineering to work as his assistant. While in Golden, he discussed the matter with Dean William Burger, who now handles placement activities. After leaving Denver, Kintz will visit Mexico, Puerto Rico, and Canada on an extended inspection trip devoted largely to recent developments in safety practices in both production and refining of petroleum.

JUAN ENRIQUE SERRANO, '20, is vice president of Nitrato de Chile, Sociedad Argentina, with mailing address Callao 2024, Buenos Aires, Argentina.

ETHELBERT DOWDEN, '20, has left Lima, Peru, for Casilla 390, Antofagasta, Chile.

JAMES A. CLARK, '21, has retired as president and director of Esso Standard (Libya) Inc. His mailing address is still 555 Park Ave., New York 21, N. Y.

WALTER MAYER, '22, senior engineer for Cook County Highway Department, recently returned from a South American cruise. His home address is 7820 Linder Ave., Morton Grove, Ill.

H. P. WALMSLEY, x-'23, has changed his mailing address from St. Louis, Mo., to 308 Waddington Rd., Birmingham, Mich.

GLEN L. RITTER, '24, is vice president of American Bitumids & Asphalt Co. with mailing address P. O. Box 3495, San Francisco 20, Calif.

CHARLES E. STOTT, '25, general manager of Tsumeb Corp., Ltd., Tsumeb, Southwest Africa, writes that his company is involved in an addition to and expansion of metallurgical plants and is bringing in a new mine some distance from Tsumeb. Two new plants are planned, one designed to recover Germanium by a roast, leach and distillation process, while the other will be a copper smelter.

FRED A. MATTEI, '30, has moved from Littleton, Colo., to 6410 W. 3rd Ave., Lakewood 26, Colo.

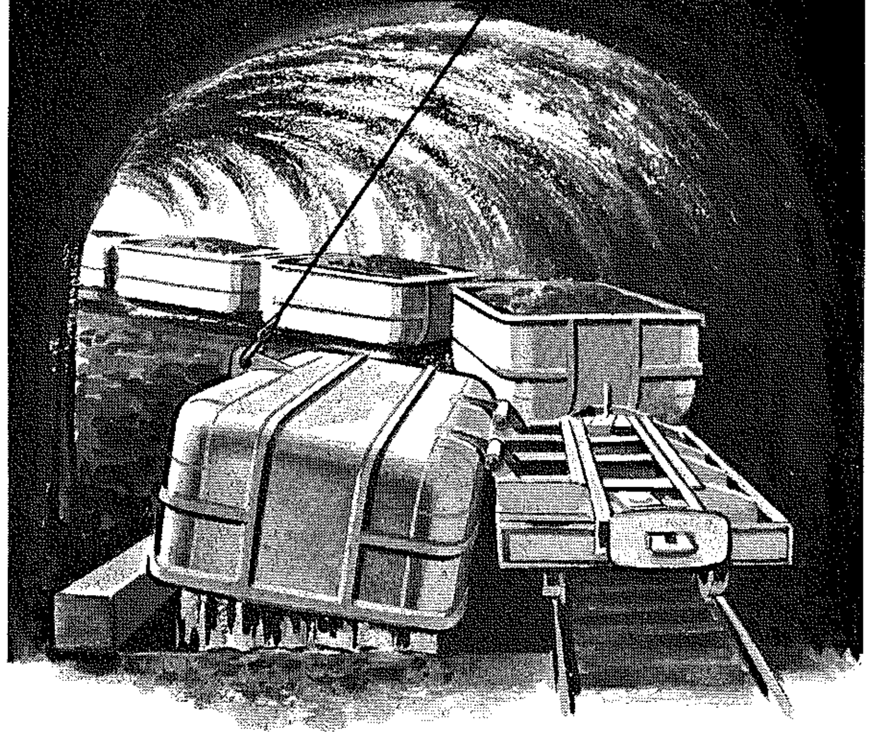
1931-'40

ARTHUR B. BENNETT, '32, is vice president and general manager of Chrysler Subsidiary Corp. with mailing address USAFTA APO 336, New York, N. Y.

LT. COL. WALTER H. ZWICK, '32, is living at 3540 N.E. Couch St., Portland, Ore.

(Continued on page 37)

KERMAC SOLVES AMBROSIO LAKE SLIMES WITH TELLURIDE TYPE CARS



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Following successful introduction of the first lot of those heavy duty Card cars, Kermac Nuclear has placed additional orders which will provide them a complement of 82 cars of this type. No haulage troubles have been encountered with these cars, and resulting haulage costs are satisfyingly low.

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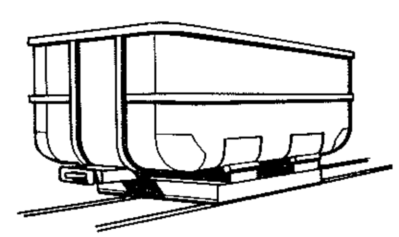

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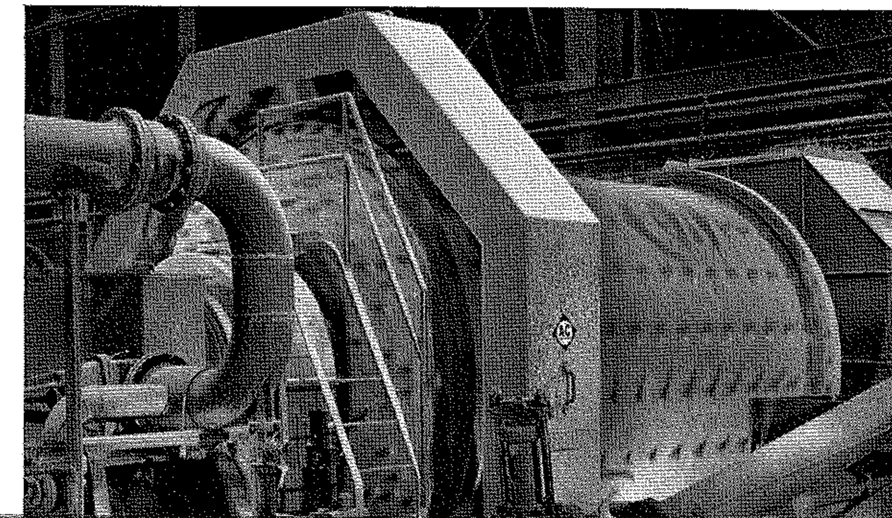
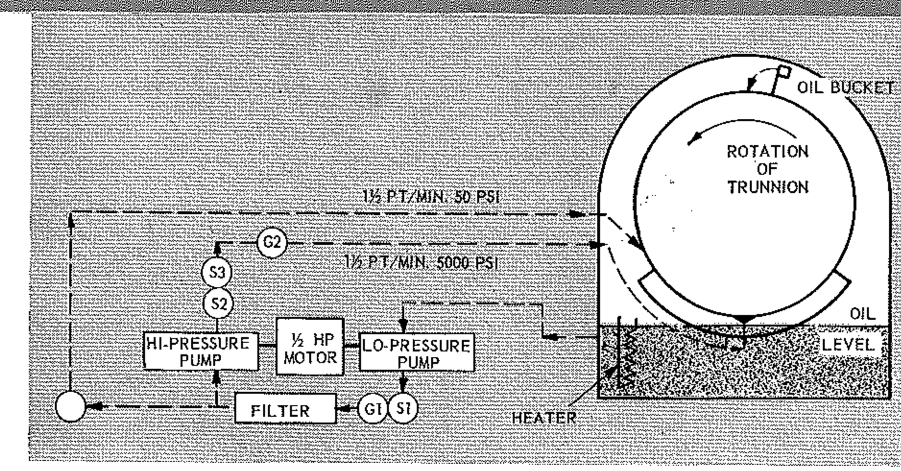
metal mining modernization





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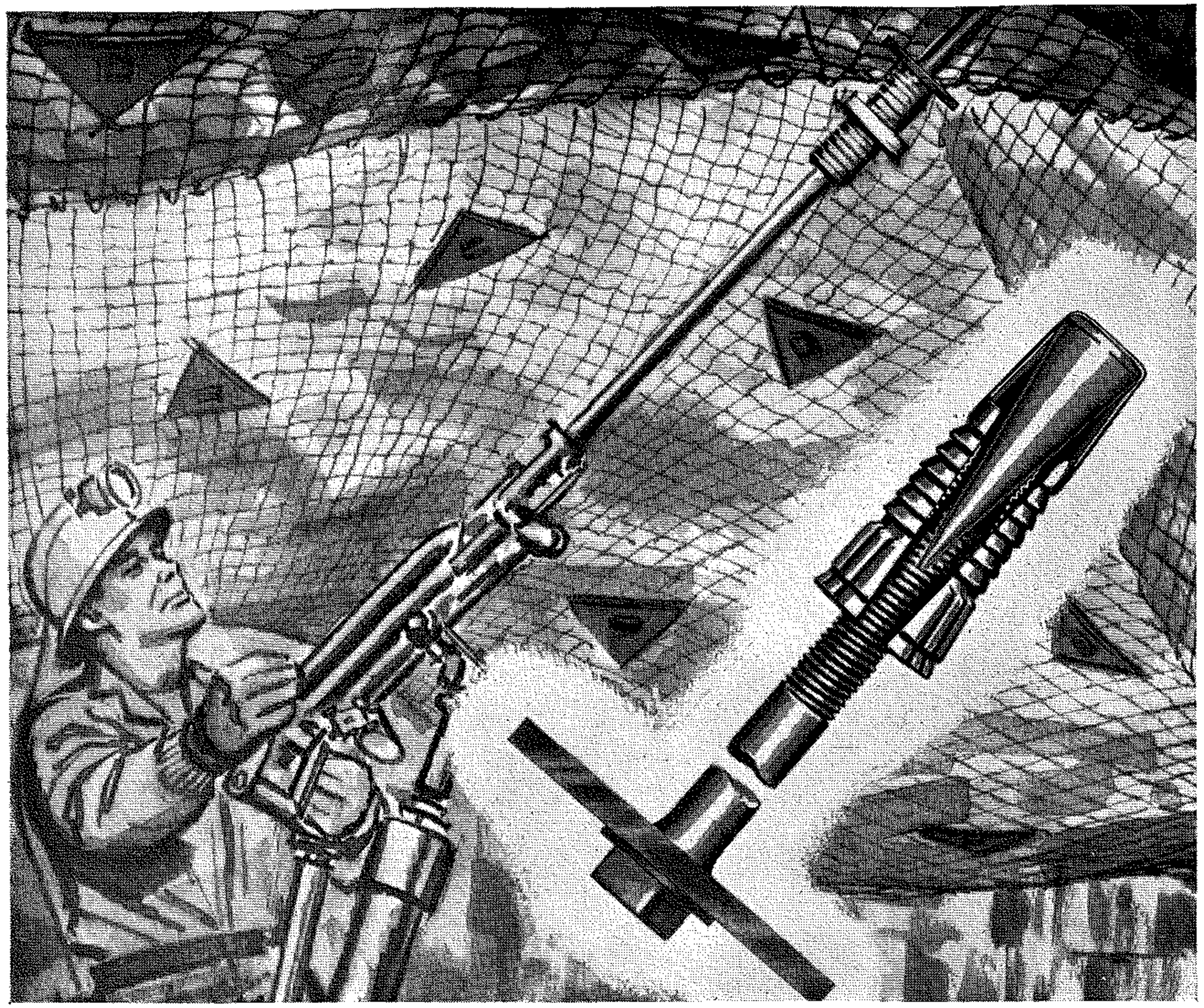

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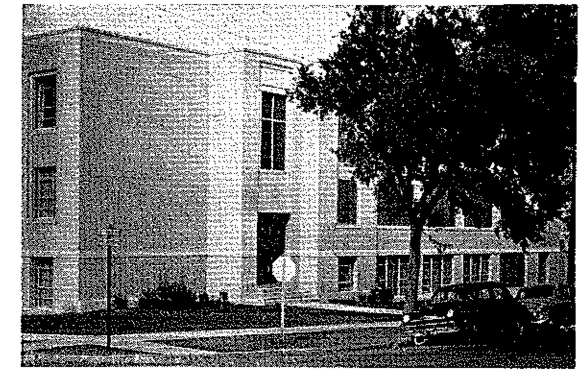

The Mines Magazine

Volume L | March, 1960 | Number 3

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* * *

CONTENTS—

DEPARTMENTS—

FRONT COVER—

Surface view of operations, Permafrost Tunnel, located along the south side of a valley in frozen glacial till one mile north of Camp Tuto, Greenland, under direction and control of U. S. Army Snow Ice and Permafrost Research Establishment. (See article on page 12.)

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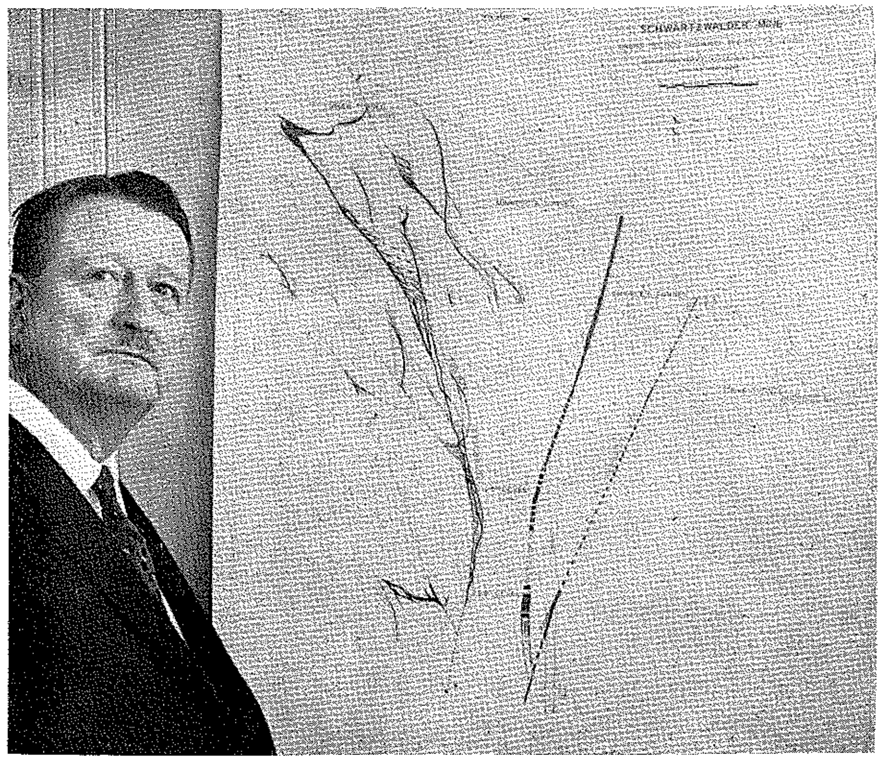
NEWS of the MINERAL INDUSTRIES



▼Charles O. Parker, '23, president of Denver-Golden Corp., recently announced the signing of a new five-year contract with Cotter Corp. covering treatment of uranium ore from the Schwartzwalder Mine outside of Golden, Colo.

Denver-Golden, Cotter Sign Ore Treatment Contract

A five-year uranium ore treatment contract has been signed by Denver-Golden Corp. of Denver and the Cotter Corp. of Santa Fe, N. M. Under terms of the contract, Denver-Golden—mine operator and 27 per cent owner of the Schwartzwalder Mine near Golden, Colo.—will ship a minimum of 15,000 tons of .70 per cent U_3O_8 ore each year to the Cotter Corp.'s Front Range Uranium Mill at Canon City, Colo. These monthly shipments of 1250 tons add up to a total of 75,000 tons over the 60-month life of the contract.

A report to Denver-Golden stockholders stated that the new Cotter contract will mean a $5 per ton increase in prices to be realized by the company. Net cash proceeds to the corporation through the contract will be a minimum average of $165,000 per year for the next five years.

Annual Income Assured

"The assured annual income, guaranteed by the Cotter contract, will enable longer range planning than has been feasible heretofore," said C. O. Parker, president of Denver-Golden Corp. "Broader possibilities for acquisition of substantial income producing properties are now presented by a clearly forecastable cash position."

Denver-Golden Corp. began operations in June 1955 as Denver Golden Oil & Uranium Corp. The name was shortened in 1959. Besides uranium mining, the firm is active in U. S. mineral exploration, including base and precious metals.

Cotter Expands Mill

A uranium purchase contract recently signed by Cotter Corp. and the Atomic Energy Commission will result in expansion of Cotter's pilot plant from a capacity of about 50 tons a day to 200 tons a day. Construction began the last week of October 1959 and will be completed not later than April 15.

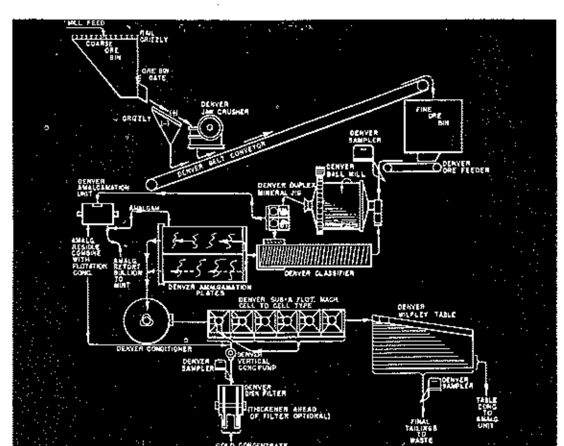
"Anticipated cost of the expansion," said David P. Marcott, executive vice president and general manager, "is larger than the cost of the pilot plant, which is presently treating over 100 tons per day and cost less than $900,000. The disparity between the cost of construction phases is due to the inclusion of a sizeable tonnage of bentonitic ore which will require special handling and treatment."

Over 90 Per Cent Recovery

Mr. Marcott said that pilot plant operation has been an unqualified success although there were times when it seemed destined to be an utter failure. He said that recoveries since start-up, including several months

(Continued on page 17)

DENVER MILL DESIGN



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TECHNICAL SOCIETIES and ASSOCIATIONS

Denver Section Schedules Mines Dinner, April 21

Denver Section, CSM Alumni Association, will hold its annual Colorado Mining Convention dinner on Thursday, April 21, at 6 p.m. at the Denver Press Club, 1330 Glenarm Pl.

National Western Mining Conference April 21-23

Denver's luxurious new Hilton Hotel will be the scene April 21-23 of one of the nation's most important mining conventions — the National Western Mining Conference. The convention will offer an opportunity to several thousand Western mining people to air the many problems of the industry and to attend three luncheons, the elaborate and formal Gold and Silver Banquet, and the world-famous Sowbelly Dinner.

Colorado School of Mines faculty members who are preparing papers for the convention are Dr. Michael Klugman, "Exploration"; Hildreth Frost, "Setting Up and Equipping a Metallurgical Laboratory"; Harold Bloom, "Geo-Chemistry and What the Russians Are Doing"; John Jones, "Mining Education"; Dr. Oscar H. Lentz, "Economics of Mining."

Highlights of the technical sessions are:

Uranium: Not only is the convention committee planning on an overall coverage of uranium in all of its technical phases, but also is bringing to the convention men who are in a position to help the industry in providing additional markets for the product of our mines. Technical papers include: "New Methods of Driving an Upraiser" by J. Borcherdt of Anaconda; "Large Diameter Rotary Drilling of Vertical Shafts" by S. C. Berube and William I. Wohlfeld; "Gamma-Only Assaying for Disequilibrium Corrections" by Philip H. Dodd and James H. Scott; "Alteration at Ambrosia Lake" by S. Ralph Austin; "The Completion of the Circular Concrete Shaft at the Rio de Oro Uranium Mines" by Ray Schultze; "Trends in Uranium Processing" by A. E. Ruehle; "Standard Uranium Corp.'s Developments in San Juan County" by Russell L. Wood; "Waste Deposit Practices at Uranium Processing Mills" by Marling J. Ankeny, director of U. S. Bureau of Mines.

Atomic Energy: Henry C. Anderson of the Atomic Power Equipment Department of General Electric will participate, as will Patrick J. Selak, manager of the Nuclear Engineering Development Department, Kaiser Engineers of Oakland, Calif. Jackson E. O'Connel will speak on "Cooperation Between Industry and the Atomic Energy Commission." Dr. L. M. Currie, vice president of Babcock & Wilcox, will travel from New York to give one of the major addresses. Dr. Paul F. Genachte, director of the Atomic Energy Division, Chase Manhattan Bank, will address miners on "Economic Trends in the Development of Atomic Energy."

Radio Isotopes: Several papers will be presented on the subject of radio isotopes and their importance to domestic life. They include "Sodium Chlorate and Uranium Refining" by Robert Rice, "The Powderhorn Carbonatite" by Dr. Robert M. Grogan, and "Advances in the Potash Industry" as seen by the American Potash & Chemical Corp.

Gold: L. L. Huelsdonk of Best Mines Co., Inc., Downieville, Calif., is preparing a special paper for the convention, as is one of the top officials of the International Monetary Fund. Oscar L. Altman of Washington, D. C., will address one of the important luncheons at the new Hilton. A paper on "Principal Gold Deposits of the U. S." will be presented by Dr. A. H. Koschmann.

Silver: A complete review of the principal silver deposits of the U. S. will be given by E. T. McKnight, and H. B. Johnson, manager, Sunshine Mine, Kellogg, Idaho, will speak on the subject of silver.

Lead and Zinc: Miles Romney, chairman of the Emergency Committee, Dr. Schrade F. Radtke, research director of the American Institute and the Lead Industries Association of New York, and Ed Snyder, Combined Metals Reduction Co., will provide the fire for this Section.

Beryllium: D. H. Hershberger of Brush Beryllium Co. will again come from Cleveland to address the conference. Charles Hawley will discuss the Lake George Beryl Deposits, as

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will Don Peaker of the Boomer Mine. James D. Williams of the Mt. Wheeler Mines, Inc., of Salt Lake City, will explain beryl developments in Nevada. A field instrument for quantitative determination of beryllium will be displayed and demonstrated.

Special Sections: Speakers will include Fritz McGonigle of Howe Sound on "Manganese," T. E. Tietz of Lockheed Aircraft on "Tungsten Requirements"; T. W. Merrill, director of product research for Vanadium Corp. of America, on "Vanadium," and Ward W. Minkler of Titanium Metals Corp. of America will discuss "Titanium."

Oil Shale: Dr. Charles H. Prien, head of the Chemical Division of Denver Research Institute, is planning this section of the convention.

Industrial Minerals: Two men—Tom Evans and W. C. Peters—have arranged an all-inclusive program from phosphate developments in the Rocky Mountain Region to industrial minerals. Bernard J. O'Neill of Stanford Research Institute will come to Denver to appear on this important section. Papers presented will include those on cement raw materials, beneficiation of coal, coking use, asbestos and ceramic mineral materials and a host of others.

Miscellaneous: Public Lands Section promises to be the best in years. Workmen's Compensation will be reviewed by Frank Van Portfliet. J. Roy Price, assistant director for Resources and Production, Office of Civil and Defense Mobilization, will discuss the problems of the mining industry with the Executive Branches of our government. The Tax Section is being arranged by Frank Cavanaugh. George O. Argall, Jr., editor of *Mining World* and a 1935 graduate of Mines, will again present his awards at the Gold and Silver Banquet.

Faculty Students Represented At AIME Meet; Dr. Vanderwilt Gives Welcoming Address

Eight members of the Colorado School of Mines faculty and six students (five of whom represented the Mines AIME Student Chapter) attended AIME's annual meeting Feb. 14-18 in New York City.

Faculty members attending were: Dr. John W Vanderwilt, who gave the welcoming address at the opening AIME luncheon; Dean Truman H. Kuhn, chairman of the Society of Mining Engineers' Education Committee and secretary of AIME's Council on Education; Prof. Niles E. Grosvenor, who presented a paper, "A Method for Determining the True Tensile Strength of Rock"; Professors Lute J. Parkinson, H. Gordon Poole and Robert H. Carpenter, who acted as chairmen of committees or of technical sessions; Prof. Charles M. Shull, Jr., of the chemistry department, and Mr. Harold Bloom, special lecturer in the geology department.

Students attending were: Mel Erskine, Bob Green, Don Longnecker, Bill McClain, John Selters, and Johan Sikkar, who received a prize for submitting the best metallurgy paper in the AIME Student Writing Contest.

A shortage of mineral engineering graduates was forecast by Dr. Vanderwilt who told delegates it is industry's responsibility to promote engineering enrollments.

"Enrollment figures show that available new graduates will be about the same in 1960, decreasing a small amount in 1961, decreasing substantially in 1962 and in 1963," Dr. Vanderwilt said. "Thus, a shortage in the supply of new mineral engineering graduates is indicated particularly in 1962 and 1963. After 1963, the shortage will continue as long as engineering freshman enrollment remains low each succeeding year.

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"Therefore, it becomes important to consider what can be done to encourage more young men to enter mineral engineering. This is primarily the responsibility of industry."

Dr. Vanderwilt said industry promotion programs solved earlier, similar threats in electrical, chemical and aviation engineering fields.

"The ultimate distribution of engineering manpower," Dr. Vanderwilt asserted, "will favor those industries which are most successful in making known what their respective fields have to offer in salaries, job advancement opportunities and satisfying life careers.

"The mineral industries, which indeed offer a wide variety of career opportunities, have a good story to tell in the competition for additional mineral engineering manpower resources. They must tell it more often and more emphatically in the future if they are to meet the needs that lie ahead."

In support of his belief that demand for engineers exceeds supply, Dr. Vanderwilt pointed to the record of placement for the Colorado School of Mines graduates during 1959 and 1960. In a group of 40 graduating geological engineers, several had more than one job offer, while on the other extreme, two were without job offers until the close of the school year, when they did accept positions. In the class of 32 graduating metallurgical engineers, one man had eight job offers and two men had none until late in the school year. All of the graduates who did not either enter the military service or continue into graduate work, were placed.

"Thus far this year," Dr. Vanderwilt said, "inquiries from interviews and prospective employers support the feeling that the outlook this year for our graduates will be as good, if not better, than the past year. From the information that I have been able to obtain, our experience has been little different than that of other colleges of mineral engineering."

Nuclear Physicist Appointed To Battelle Board of Trustees

Dr. John A. Wheeler, noted nuclear physicist and a professor at Princeton University, has accepted an appointment to the Board of Trustees of Battelle Memorial Institute, Dr. B. D. Thomas, president of the Columbus, Ohio, research center, announced recently.

A member of the Princeton faculty since 1938, Dr. Wheeler has often served as a consultant to government defense agencies. During World War II, his research on nuclear fission took him from Princeton to the University of Chicago, and finally the Hanford Project. He headed up the group of scientists in Project Matterhorn at the James Forrestal Research Center which produced the theoretical work essential to the development of the hydrogen bomb.

Dr. Wheeler's studies have covered such areas as the mechanism of nuclear fission, electromagnetic action at a distance, theory of radiation, structure and transformations of atomic nuclei and elementary particles. His work in mathematics resulted in recognition of the "geon."

Oil and Gas Corrosion Problems Scheduled

Corrosion in the oil and gas production industry is the subject of five technical papers to be given in a special symposium March 15 during the 16th Annual Conference, National Association of Corrosion Engineers. Seven other papers of direct interest to corrosion engineers in oil and gas production will be presented in other symposia. The conference will be held March 14-18, in Dallas, concurrently with the 1960 Corrosion Show.

Titles and Authors of papers in the Oil and Gas Production symposium

(Continued on page 45)

Technical Men Wanted

Those interested in any of the positions listed should direct inquiries to W. B. Hutchinson, Employment and Training Manager, The Pure Oil Co., 35 East Wacker Drive, Chicago 1, Illinois.

MATHEMATICAL STATISTICIAN—Masters or Ph.D. Degree, major in mathematics or mathematical statistics. Experience in applied mathematics and computer applications desirable. To perform operations research work and to analyze experimental data arising from economic studies and laboratory research.

MATHEMATICIAN—Knowledge of linear programming and model construction methods. Computer programming experience desirable but not essential. To work with central analysis and planning group of major integrated oil company. Assignments will embrace mathematical analysis and solution of problems in exploration, production and refining of crude oil, and distribution of petroleum products.

MATHEMATICIAN—Ph.D. in Mathematics. To provide mathematical consultation and assistance in the solution of business, operating and research problems. Utilizing medium and large scale computers. Prefer some practical business experience in this field.

AUDITOR—Degree with major in accounting or its equivalent in formal education in accounting and business experience. To assist in the execution of audit assignments in all phases of the company's operations. Breadth of assignment will depend on experience. Will consider applicant with no experience or up to three years in an accounting or auditing capacity with an industrial organization or public accounting firm.

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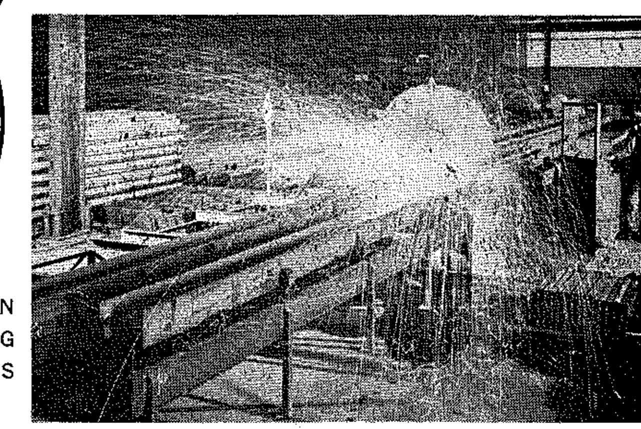

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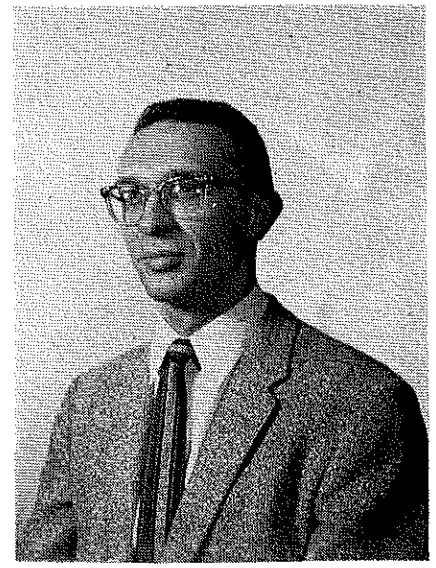
Permafrost Tunnel

By
JOHN F. ABEL, JR., '56

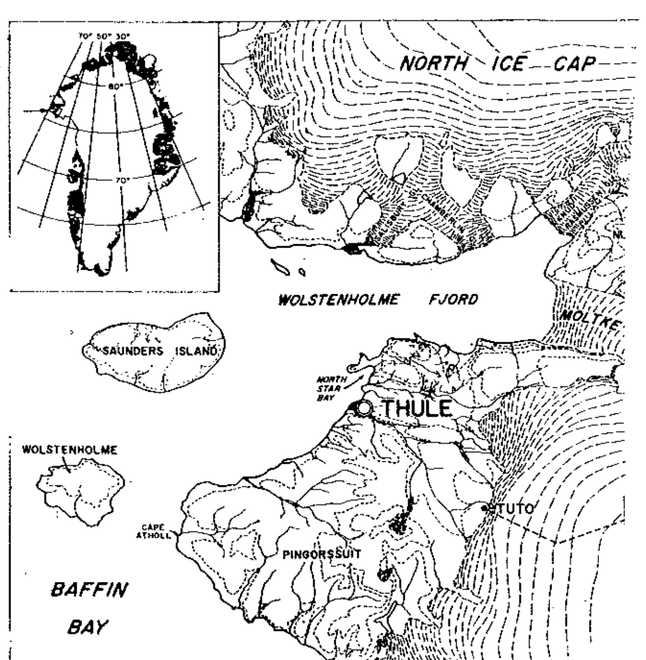


JOHN F. ABEL, JR.

Permafrost mining techniques described in this report were developed during the 1959 Greenland summer season. The operation was conducted as part of the U. S. Army, Corps of Engineers, Greenland Research and Development, Cold Regions Research Program under the direction and control of the U. S. Army Snow Ice and Permafrost Research Establishment (USA SIPRE).

This report was prepared by John F. Abel, Jr., mining engineer, Applied Research Branch, USA SIPRE, under the supervision of W. K. Boyd, Chief, Applied Research Branch, USA SIPRE.

Purposes of the USA SIPRE permafrost tunneling investigation have been to: (1) determine the feasibility of excavating sub-surface openings in frozen glacial till, (2) develop efficient methods of excavating this material, and (3) to determine the characteristics of the glacial till at depth.



▼Figure 1. Geographical location of Camp Tuto, Greenland.

THE AUTHOR

John F. Abel, Jr., who received his P.E. degree in 1956 and his M.Sc. degree in 1959 from the Colorado School of Mines, has been with the U. S. Army Corps of Engineers, Snow, Ice and Permafrost Research Establishment for over two years. He has spent four summers in Greenland—the last two as project leader for the ice tunnels and the permafrost tunnel. His master's thesis at Mines was based upon his research in Greenland.

Mr. Abel writes that Mines men have gained a reputation as hard workers—each of the Greenland project crews having accomplished more than the planned amount of work. (See article in October 1959 issue for a listing of Mines men employed on the Greenland project.)

The experimental tunnel was driven into the side of a glacial till hillside approximately one mile north of Camp Tuto, Greenland. Camp Tuto is a Corps of Engineers camp operated by the U. S. Army Polar Research and Development Center (USA PRDC) in support of the CE Cold Regions Research Program. The location of Camp Tuto, 16 mi. inland from Thule Air Force Base, is shown in *Figure 1*.

A site for the tunnel was selected in 1958 along the south side of a valley in frozen glacial till one mile north of Camp Tuto. It was possible, by driving into the hillside, to obtain 100 ft. of cover for the sub-surface opening without sinking a shaft or driving an inclined tunnel, both of which would have presented more difficult mining problems.

It was decided that a tunnel approximately 300 ft. long having a cross section 10 ft. wide by 9 ft. high would be attempted in 1959 using conventional hard-rock mining equipment and methods. The plan was to drive the tunnel using the standard drill-blast-muck cycle of operations and to experiment in the process with drilling equipment, blasting patterns, explosive types, roof support methods, and ventilation refrigeration equipment.

Field Operations

The permafrost tunnel project operated on a two shift basis six days a week. Each shift was 11 hours in length, with travel time to and from the tunnel and the lunch period reducing the working period to 10 hours per day. The shifts were each made up of two civilians and five enlisted military personnel.

▼Figure 2. Tunnel surface facilities, showing haulage track, mucking machine, battery locomotive, mine car, and disposal dump.

The civilians served as shift boss and miner on each crew. They were furnished to the project by Denver Research Institute (DRI) through a contract with USA SIPRE. J. F. Sulzbach, '56, and D. K. Walker, '57 were the shift bosses, and the miners were two students at the Colorado School of Mines, R. W. Jennings, Jr., and W. E. Brown.

The enlisted military personnel were furnished to the project by the supporting military unit, the U. S. Army Engineer Research and Development Detachment (USA ERDD). They served as timbering and mining assistants and as generator and compressor operators.

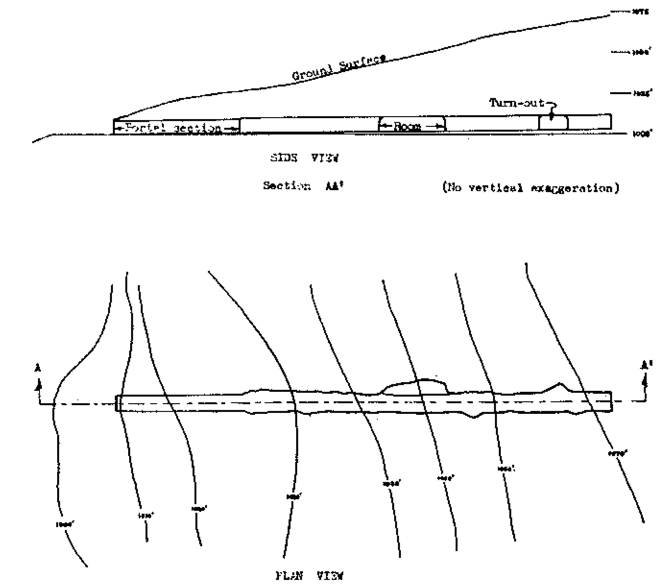
In addition to the shift personnel, the USA SIPRE project leader supervised the project operations and research efforts.

Before mining could be started, it was necessary to construct an access road to the tunnel area, construct a level bench on the hillside for the surface equipment, erect a shop building, move the mining equipment to the tunnel site, and prepare the equipment for operation. *Figure 2* shows the surface installations erected.

The preliminary phase of the operation was started May 30 and sufficiently completed to allow mining operations to start on June 8, 1959. The erection of shop building was completed June 15, 1959.

A basic hard rock mining method was used during all mining operations including portal, tunnel, and room excavation. The different unit operations involved in the method included drilling out the blast holes, loading the blast holes, blasting the drill round, ventilating the tunnel to remove the fumes from blasting, mucking (loading) out the broken material, extending the rail to the face, and placing protective arches where required.

The mining operations carried on by the tunneling project were separated into two phases by the type of material. The first phase, construction of the portal, presented the most difficult mining problem because of the presence of the thawed and unconsolidated active zone which required support to prevent caving. The second phase of the mining operation was the straight-



▼Figure 3. Permafrost Tunnel, plan and side views.

forward mining of the major portion of the tunnel once the portal had been completed, and driven into competent permanently frozen ground. No roof support was required during the second phase. After completion of the tunnel driving, an experimental room was excavated along the tunnel axis. The room dimensions were 20 ft. wide by 25 ft. long. Protective steel arches were erected in this area of the main tunnel when the roof of the room began to sound "drummy" (hollow), when sounded with a bar.

The total volume of material excavated from the permafrost tunnel was 1,080 cubic yards, 334 cubic yards of which were excavated during the portal construction, 666 cubic yards during the tunnel excavation, and 80 cubic yards during the experimental room excavation. *Figure 3* is a plan and side view of the permafrost tunnel excavations completed in 1959.

Portal Construction

The construction of the portal, which is shown in *Figure 4*, was complicated by the presence of the un-

▼Figure 4. Tunnel portal construction, showing steel arches and timber lagging around tunnel.

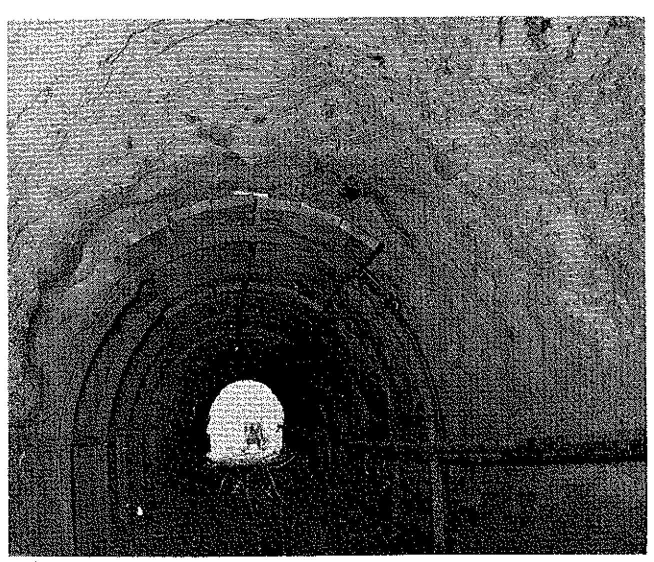
frozen active layer, about 2 ft. in thickness on the hillside. This active layer had little, if any, inherent strength. When the tunnel was advanced into the hillside, the active zone was unable to support itself over the tunnel width and caved into the tunnel as the supporting frozen material was removed.

In order to develop a vertical face, into which a tunnel round could be drilled, it was first necessary to drive a slot into the hillside. This slot was excavated by blasting a series of successively deeper slices from the face of the slot. Seven slices were blasted during the slot excavation before the face was sufficiently high, 11 ft., so a full height tunnel round could be drilled in the face.

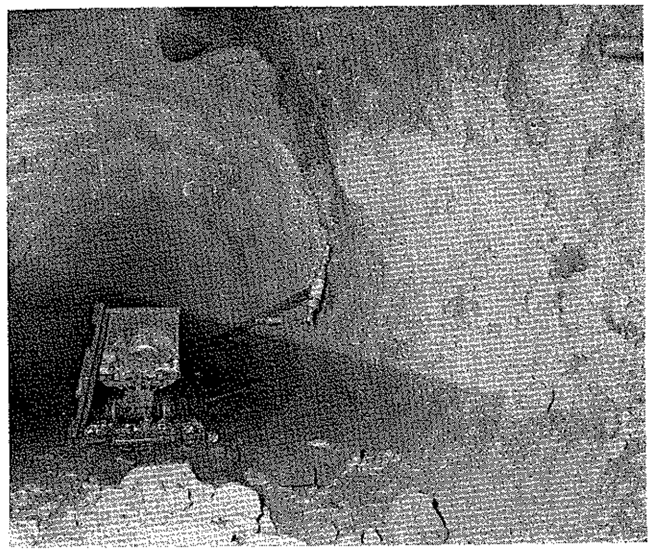
The first three tunnel rounds, blasted in the face of the slot, broke to the surface of the hillside, failing to break out the permafrost as an underground tunnel round. Care had to be exercised to protect the men from rock falling into the slot during drilling, loading, and mucking. The men were protected by overhead timber lagging (covering), carried in contact with the face. It was necessary to remove this protective lagging during blasting, since there was no way to hold it down during a blast. Once the tunnel went below the surface it was possible to wedge the timber lagging against the back of the tunnel to hold it in position during blasting.

The face height was approximately 15 ft. when the first successful underground tunneling round was blasted. Since the tunnel height was only 9 ft., the brow at the tunnel portal was then 6 ft., made up of 4 ft. of load bearing frozen galcial till and 2 ft. of the unconsolidated active layer. The first tunnel round was excavated on June 20, 1959.

It was necessary to place steel arches with protective lagging completely around the tunnel in the portal area. This protective portal structure was needed to prevent loose material from over the portal and loosened material which melted out of the tunnel roof from falling into the tunnel and endangering workers. The use of protective arches was necessary for the first 78 ft. of the tunnel. The lagging of the entire set was required for the initial 54 ft. of the tunnel and only top lagging was required for the remaining 24 ft. of the portal section. *Figure 5* shows the last group of portal arches with the protective top lagging. Beyond the last protective arch the roof was sufficiently strong to stand safely without support. This was possible because the temperature of the permafrost was low enough to avoid melting in the roof as the result of the natural ventilation (circulation).



▼ Figure 5. Tunnel portal construction, showing protective top lagging.



▼ Figure 6. Unsupported tunnel section.

The portal construction was completed on July 1, when the last protective arch was erected. During the portal construction period, 44 shifts were employed in the driving of 78 ft. of tunnel and 60 ft. of access slot. Fourteen protective arches were erected. Average advance during the portal construction period was 2 ft. per shift.

Tunnel Excavation

Once the portal construction was completed, the tunnel was driven by conventional hard-rock mining methods, without the roof support or protection required in the portal portion of the tunnel. Between July 1 and August 10, 1959, 222 ft. of 10 ft. wide by 9 ft. high tunnel was driven. The average tunnel advance per shift during the tunnel excavation period was 3-¼ ft. per shift. *Figure 6* shows the unsupported permafrost tunnel.

During the tunnel excavation, experimentation with drilling equipment, drill-round patterns, and explosives was conducted. The results of this experimentation will be presented later in this report.

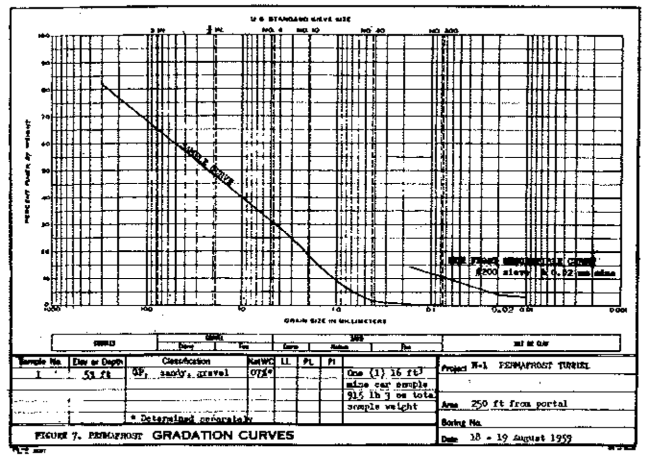
Room Excavation

Following the completion of the planned 300 ft. of tunnel excavation, an experimental room was excavated. Eighty cubic yards of material were removed enlarging the tunnel to a width of 20 ft. between the 165 and 200 ft. tunnel points. The excavation of this room was utilized for slab round experimentation.

After the experimental room had been constructed, protective arches and roof support were placed through the main tunnel part of the room as a safety measure in case of future roof failure in the wide span area. This safety measure was dictated by the hollow sound of the roof in portions of the experimental room.

Description of Permafrost

In order to evaluate the information obtained from the permafrost tunnel research program, a description of the permafrost material is presented.



▼ Figure 7. Permafrost gradation curves.

A particle size gradation curve for a mine car size sample, 16 ft.³ of the glacial till is shown in *Figure 7*. This till would be classified as a poorly graded gravel (GP) under the unified soil classification system of the Corps of Engineers. The till would be considered free draining and non-frost susceptible if thawed, in that no volume change would take place upon freezing and thawing. Normally no ice segregation or lensing would be likely to occur in this gravel. Observable free ice was found as a surface film on the bottom of two boulders and in ten thin tabular inclusions. None of these was greater in thickness than ¼ in.

The car size sample was taken 250 ft. inside the tunnel. It can be considered to be representative since there were no visible differences in composition throughout the entire tunnel, once the active zone layer at the portal was passed. The particle size gradation was determined by drying, desegregating, and sieving the entire sample.

Moisture samples taken of the material indicate a moisture content of approximately 7 per cent by weight.

The major portion, approximately 95 per cent by weight, of the rock material encountered in the permafrost tunnel was a granite gneiss. Random fragments composed wholly of the minerals, hematite, epidote, or olivene were encountered. A few specimens of a competent silicified pink sandstone were also found.

Temperature data pertaining to the tunnel are presented below:

Location (Ft. from Portal)	Temperature
300 ft. (1 ft. in wall)	—10.8°C
250 ft. (at wall)	— 9.5°C
200 ft. (at wall)	— 6.0°C
100 ft. (15 ft. in wall)	— 9.6°C

The indications of these data are a decreasing temperature with increasing overburden and an artifically elevated wall temperature in the tunnel caused by the natural circulation and the forced ventilation with the warm ambient outside air. The temperatures recorded in the permafrost tunnel were in the same range of temperatures as recorded in the ice tunnel about 2 miles away on the ice cap; —5.0°C to —10.5°C.

Blasting Investigation

Two types of tunnel blasting rounds were used to excavate the permafrost tunnel, a burn cut and a V-cut round. These were selected because of their ease of drilling with the airleg drills employed. All blast holes in all rounds were drilled with 1-⅝ in. diameter bits.

Twenty-six burn cut rounds were blasted during the excavation of 118 ft. of the tunnel. This included two 8-ft. rounds, five 6-ft. rounds, and eighteen 4-ft. rounds. The drilling required for the burn cut rounds averaged 31.1 ft. of hole per foot of advance, or 9.9 ft. of hole per cubic yard of inplace permafrost removed. The drilling time for the tunnel using the burn cut was 0.9 man hours per foot of advance.

Forty V-cut rounds were blasted during the excavation of 176 ft. of tunnel. This included two 8-ft. rounds, four 6-ft. rounds, and thirty-four 4-ft. rounds. The drilling required for the V-cut rounds averaged 34.2 ft. of hole per foot of tunnel advance, or 10.1 ft. of hole per cubic yard of inplace permafrost removed. The drilling time for the tunnel using the V-cut round was 1.1 man hours per foot of advance.

Accurate records of powder consumption were kept for all blasting. However, the basic philosophy behind the use of powder was that "Powder is the cheapest man on the job." Whenever it was possible to save time through the use of additional explosives, it was used. Additional explosives, will to a limited degree, reduce the number of blast holes required. This in turn reduces the man hours required to drill out the round and complete a drill-blast-muck cycle.

The cost of explosives consumed during the tunnel excavation was approximately $1,300, or $1.20 per yard of permafrost blasted, or $4.00 per foot of tunnel advance. Blasting cap costs were $1,170, or $1.08 per yard, or $3.60 per foot of tunnel advance.

The experimental blasting record is presented by *Table 2*. It can be readily seen that the initial blasting experiments were attempts to find a workable drill round. The object of each set of experiments was to develop a drill pattern for each of the explosive types employed. Four types of explosives were used during the blasting experimentation. They were the Hercules Powder Co. explosives described in *Table 1*.

Table 1. Explosives Used

Percent Strength	Name	Detonation Velocity	Stick Count (1¼x8 in. Cartridges)
30%	Gelatin Extra	8,500 ft/sec	90
60%	Gelatin Extra	8,500 ft/sec	98
50%	Nitroglycerin Dynamite	17,400 ft/sec	108
65%	Gelamite 1-X	11,500 ft/sec	112

The determination of a satisfactory round was based on whether or not secondary blasting was required. If any secondary blasting was required, the round was considered unsatisfactory. Secondary blasting was required if the round failed to break out the material drilled or if fragments were dislodged too large to be loaded by the 4-½ cubic foot capacity mine car loader used.

While no quantitative data are available about fragmentation sizes, observations indicate that much finer fragmentation was obtained with the high-detonation-velocity explosives. Whenever blasting fragments larger in size than 2 cubic ft. were encountered in the muck pile, secondary blasting was required. Since reblasting is very time consuming, it cannot be tolerated in an efficient mining operation. The low-detonation-velocity explosives tended to push the material without breaking it into fragments. In one case a large boulder was penetrated by three blast holes but the boulder was not broken by the subsequent blast with 30 per cent powder. The finer portions of the permafrost apparently absorbed the force of the explosions and the boulder was dislodged without being broken. The high-detonation-velocity explosives apparently broke the boulders before the softer portions of the permafrost could absorb the shock of the blast. The superior fragmentation obtained with the higher-detonation-velocity explosives is shown by the consistency of the satisfactorily fragmented drill rounds obtained with them. This can be seen in *Table 2*.

Table 2. Experimental Blasting Record

Frag —fragmentation
S —Satisfactory (no secondary blasting required)
U —Unsatisfactory (secondary blasting required)

		V-Cut				Burn Cut			
Date	Explosive	Depth Round Ft	No. Holes	Frag. S-U	Powder Factor lb/yd	Depth Round Ft	No. Holes	Frag. S-U	Powder Factor lb/yd
June									
13	30%					8	18	U	1.6
15	30%					4	25	U	1.9
19	30%					4	25	U	2.0
19	30%					4	24	U	2.2
20	30%					4	28	U	1.6
22	60%	6	30	U	3.5				
24	30%	4	31	U	3.0				
26	30%	6	29	U	2.3				
28	30%	4	39	U	3.4				
29	30%	4	30	U	3.3				
29	30%	4	42	S	3.8				
30	30%	4	31	U	3.5				
30	30%	4	33	U	4.8				
July									
1	30%	4	47	S	4.4				
2	30%	8	35	U	4.5				
3	30%	4	32	U	4.2				
3	30%	4	34	U	4.5				
4	30%	4	33	U	4.3				
6	30%	4	36	S	4.7				
7	30%	4	36	S	4.7				
8	30%					4	44	S	7.5
9	30%	4	36	U	5.0				
10	30%	4	36	U	4.7				
11	30%					6	46	S	5.6
12	60%					6	37	U	4.4
13	60%	6	36	U	5.3				
14	60%					6	37	U	5.2
15	60%					6	40	U	5.4
15	60%	6	35	S	5.5				
16	60%	8	36	S	4.2				
16	60%					6	38	U	5.8
17	60%	4	36	U	4.8				
18	60%	4	36	S	4.9				
19	60%	4	36	S	4.9				
20	1-X					4	45	S	7.0
20	60%	4	36	S	6.9				
21	60%	4	36	S	6.9				
22	1-X					4	34	S	6.2
22	60%	4	36	S	6.5				
22	60%	4	36	S	6.5				
23	50%	4	36	S	4.9				
24	60%	4	36	S	6.4				
26	50%					4	31	S	3.9
27	50%	4	36	S	6.4				
27	50%					4	31	S	4.4
28	50%	4	36	S	6.4				
28	50%					4	35	S	6.0
29	50%	4	36	S	6.6				
29	50%					4	34	S	5.8
30	50%	4	36	S	6.7				
31	50%	4	36	S	5.7				
Aug.									
1	1-X	4	36	S	6.2				
3	1-X					4	34	S	6.2
3	1-X	4	36	S	6.2				
4	1-X					4	38	S	5.7
4	1-X	4	36	S	6.2				
5	1-X	4	36	S	6.2				
5	1-X					4	34	S	7.4
6	1-X					4	35	S	6.3
6	1-X	4	36	S	6.4				
7	1-X					4	35	S	6.7
8	1-X					4	37	S	7.3
9	1-X					4	38	S	7.2
10	1-X	4	36	S	6.2				
11	1-X					8	38	S	7.9

Several satisfactory drill rounds were developed. The loading information for these rounds is presented in *Table 3*. The drill rounds which used the lower velocity, 30 and 60 per cent explosives would not be recommended because of the poorer fragmentation obtained with these explosives. The drill rounds which required more than 36 holes would not be recommended because of the increased drilling required by these rounds.

The drill round which gave the best results, used a 5-hole burn cut (4 loaded, 1 not loaded), a total of 35

Table 3. Satisfactory Drill Rounds

		V-Cut		Burn Cut	
Explosive Type	Depth Round (ft)	Number Holes	Powder Factor (lb/yd)	Number Holes	Powder Factor (lb/yd)
30%	4	42	3.8	44	7.5
30%	6			46	5.6
60%	4	36	6.5		
60%	6	36	5.5		
60%	8	36	4.5		
50%	4	36	6.5	34	*6.0
1-X (65%)	4	36	6.5	35	7.0
1-X (65%)	8			38	7.9

*-recommended drill round

holes, and 50 per cent nitroglycerine dynamite. The drill pattern for this round is shown in *Figure 8b*. This pattern can be used to blast rounds from 4 to 8 ft. deep.

Drilling Investigation

Blast hole drilling with airleg mounted percussion drills and diamond drills was carried on as part of the Permafrost Tunnel project.

During the planning of the permafrost tunnel it was not known if useable blast holes could be produced with percussion rock drills; therefore the diamond drills were purchased so that another method of drilling blast holes would be available.

The percussion drills proved satisfactory in operation and the diamond drill equipment was not tested until after the completion of the tunnel excavation when the penetration rate obtained with the diamond equipment proved too slow to compete with the percussion drills.

Drilling rate records were maintained during the tunnel driving. The drilling equipment used consisted of two Chicago Pneumatic Co. airleg rock drills, Model CPISL 459W, 4 and 8-ft. Gardner Denver drill steel,

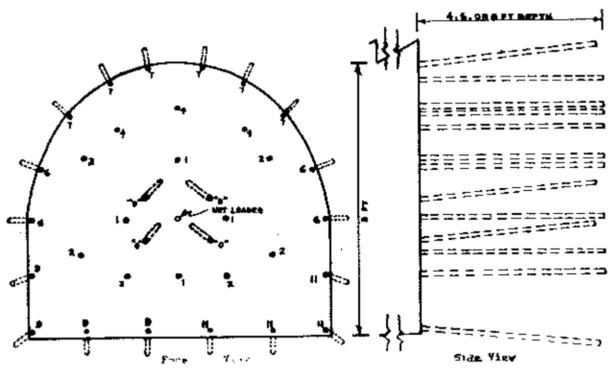


Figure 8a. Recommended 'V'-cut drill pattern.

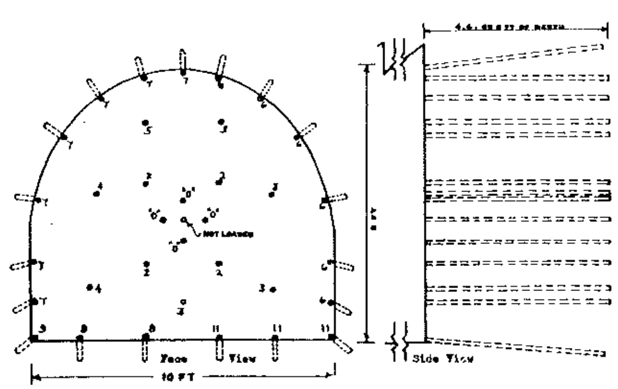


Figure 8b. Recommended burn cut drill pattern.

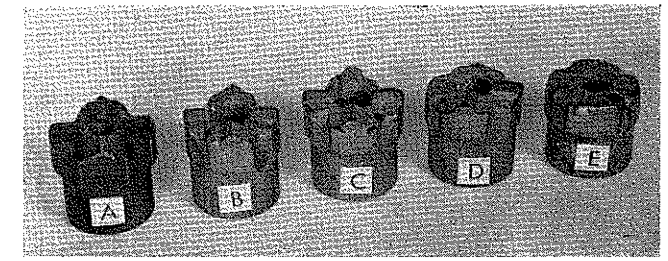


Figure 9. Percussion drill bits, showing typical wear pattern. A—new 1⅝ in. diameter, tungsten-carbide one-use drill bit. B—through —E, stages of wear to destruction.

and Western Rock Bit Mfg. Co., 1-⅝ in. tungsten carbide throwaway bits, all of which had been purchased on low bid. The drilling time required to drill the reported 9,911 ft. of 1-⅝ in. drill hole was 9,815 minutes, for an average drilling rate of 1.01 ft. per minute. This overall drilling rate included the time required to prepare the drill platform for drilling, to drill out the round, and to tear down and remove the drill platform from the tunnel. This figure does not represent the penetration rate of the drills, steel and bits.

The penetration rate of the drilling equipment was determined after the tunnel had been finished by drilling a series of timed holes. A total of 159 ft. of hole was drilled at an average rate of 2.38 ft. per minute. A penetration rate test of an Atlas Copco AB rock drill, Model BBD 41WK, was made at the same time. This test was run to compare the two drills, which have percussion rates of approximately 2,000 blows per minute for the CPISL 459W and 3,000 blows per minute for the BBD 41WK. The BBD 41WK drilled 142.5 ft. of blast hole at the rate of 1.33 ft. per minute. This test indicated that a more rapid percussion rate does not speed the drilling rate in permafrost.

Several of the percussion drill bits used are shown in *Figure 9*. The typical percussion bit wear pattern resulted in destruction of the tungsten carbide inserted bit through loss of the inserts. The inserts were lost because of the wearing away of that portion of the bit body holding the inserts. This wear of the bit body is apparently caused by the deep penetration of the bit, with each blow, into the finer portions of the till. The deep penetration apparently dislodged large fragments of the fine materials which were forced back through the water channels on the bits and ground-up by the rotation of the bit. The result was abrasive rubbing of the softer steel body portion of the bit in an augering action. The high proportion of quartz in the till contributed to the rate of wear of the bit body.

Drilling records were kept for nine drill bits, which were drilled to destruction, i. e., the inserts were lost or destroyed. The data for these bits are presented in *Table 4*. The average bit life for these bits was 212 ft. per bit. The resulting bit cost per foot of hole was 2.7¢.

Table 4. Test Bit Data

Bit Number	Feet Drilled
1	230
2	212
3	100
4	108
5	294
6	288
7	460
8	114
9	98
AVERAGE BIT FOOTAGE—212 ft	

A total of 15 drill bits was destroyed, and 70 additional bits were used and worn, but not destroyed, in the course of drilling 11, 146 ft. of blast hole. If it is assumed that half the life was left in the 70 worn bits, the effective consumption of bits was 50. This would give an estimated bit footage of 223 ft., which checks closely the measured footage for the nine test bits.

The drill steel consumption during the excavation of the permafrost tunnel amounted to 35 pieces of drill steel, five each of the 8-ft. drill steels and 30 each of the 4-ft. steels. Of the drill steel used, 15 pieces were broken and 20 pieces were rendered useless by plugging of the water hole with permafrost. The steel cost averaged 3.2¢ per ft. of hole.

The average drill round employed 36 blast holes. The estimated drill bit and steel cost per foot of tunnel advance was $2.12.

Conclusions and Recommendations

The excavation of frozen glacial till is feasible by conventional hardrock mining methods, slightly modified to allow for the below freezing temperature.

Commercial percussion drilling of blast holes is recommended in conjunction with a non-freezing anti-freeze-water drill fluid. Diamond drilling with cooled diesel fuel is recommended for drilling of clean walled holes in the frozen glacial till.

High detonation velocity explosives are recommended for blasting in order to achieve proper fragmentation.

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NEWS—INDUSTRIES

(Continued from page 6)

where the recoveries ran less than 85 per cent, are now in excess of 90 per cent with through-put averaging better than 100 tons per working day and average grade in excess of six-tenths of one per cent contained U_3O_8.

All experimental work was done by the Colorado School of Mines Research Foundation, while Western-Knapp Engineering Co. of San Francisco—which had done such an excellent job in constructing the pilot plant—was awarded the contract for the design, engineering and construction of the mill addition.

Cotter Corp. is authorized to buy ore from seven producers and will purchase ore from other producers when requested to do so by the AEC.

California Mineral Production Down 4.5 Per Cent in 1959

According to preliminary estimates submitted by individual producers to the Bureau of Mines, the total value of California mineral production dropped 4.5 per cent from the 1958 figure, to the lowest level since 1954. The $67 million decline was attrib-

(Continued on page 26)

Powder Metallurgy Research*

By
DR. CHOH-YI ANG, '43 & '47

DR. CHOH-YI ANG

Introduction

In modern powder metallurgy we do not have the situation of the art or practice antedating pure research. In fact, in the last 20 or 30 years, basic research in physics of metals and in solid state physics has advanced far ahead of the art of powder metallurgy. It is true that during the past decade, some strides have been made in the attempt to apply principles and techniques developed from studying the physics of metals to the investigation of basic phenomena associated with various powder metallurgical processes. However, there has been little sound applied research, and the gap between pure research and practical engineering in this branch of metallurgy has not been closed. The lack of evidence of sound applied research in powder metallurgy is probably due to lack of understanding of the researchers and the process engineers in each other's field of activities.

When powder metallurgy is mistaken for a science, or for a tool to do basic research, the researcher will be in trouble. Only with luck, and under limited conditions, can the researcher find his powder metallurgical experiments approximating the theories in results. If one attempts to establish new principles or theorems on the basis of his powder metallurgical experimentation, he will soon discover that his findings are worthless for general application, and may even be misleading for limited application. The situation is worse when the applied researcher has had little or no training in practical powder metallurgy and does not realize that any one of the multitude of variables in materials and processes, if not properly controlled, will render very difficult the correct interpretation of his experimental results.

The practical powder metallurgists or process engineers, on the other hand, should realize that the principles governing the phenomena which occur in all stages of powder metal processing are to be found in the study of the physics and chemistry of solids, liquids and gases, and their interrelationships under various conditions. The professional powder metallurgists should train themselves to understand the language and findings of basic research.

It was not too long ago when the physicists "discovered" the importance of the constitutional diagrams of alloy systems, and the ferrous and nonferrous metallurgists began deriving benefits from the basic studies on the atomic structures of metals and the mechanisms of atom movements. The present status of powder metallurgy is not very much different from that of smelting and refining of metals or steelmaking a few decades age. Perhaps another reason for the lack of rapid progress in closing the gap between basic research and practical powder metallurgy is the fact that this branch of metals technology is still limited in scope (even with the stimuli provided by the newly born nuclear metallurgy and space technology), and has not produced enough highly trained technicians.

There are many facets in powder metallurgy; but, to serve as examples for discussion, one may select some important topics such as powder characteristics, pressing, sintering and infiltration. By bringing out the basic principles governing some of the phenomena involved, discussing some of the loopholes in the reported experimental procedures and suggesting certain avenues of approach for applied research, it is hoped that the closing of the gap between basic research and practical powder metallurgy will be accelerated.

THE AUTHOR

Born July 11, 1920, Dr. Ang attended the University of Santo Tomas, Manila, Philippines, from 1938 to 1941 before coming to the Colorado School of Mines. He graduated from Mines in 1943 with a degree of Engineer of Mines, and again in 1947 with the degrees of Metallurgical Engineer and M.S. in mining engineering. He came to the United States for the third time in 1950, and received his Ph.D. in metallurgy from the University of Illinois in 1954.

During the 40's, besides serving in the U. S. Marine Corps as a language specialist, he was associated with various mines, mills and smelters in the United States, the Philippines and China. He gained experience in the minerals technology of such metals as lead, zinc, gold, tungsten, antimony and tin. He also worked for the U. S. Steel Corp. in Chicago for a short time.

As a research assistant at the University of Illinois, he studied the anelasticity of metals under Prof. Charles A. Wert. During this period, he authored or co-authored several technical papers dealing with the internal friction and diffusion phenomena in alloys of iron, gold, nickel, tantalum and columbium. He is a member of AIME, ASM, Society of Nondestructive Testing, Institute of Metals (London), American Astronautical Society, and the honorary engineering and scientific societies Tau Beta Pi and Sigma Xi.

Dr. Ang is presently the director of the Corporate Materials Laboratories of the P. R. Mallory & Co. Inc., Indianapolis, Ind. Associated with Mallory since February, 1954, his experience in the field of materials technology includes the research and development of refactory and reactive metals and alloys, age-hardenable copper and silver alloys, electrical contact materials, high strength powdered metals and steels, radiation shields and reactor fuels, capacitor and resistor materials, heat resistant and semiconducting intermetallics, and a wide variety of material processing techniques.

* A portion of this paper was presented at the Notre Dame conference on Sintering and Related Phenomena in June, 1959. Acknowledgment is due P. R. Mallory & Co., Inc. for permission to publish this paper in the Mines Magazine.

Powder Characteristics

While it is generally recognized that the sinterability or sintering activity, A, is a function of the particle size in the following manner:

$$A \backsim 1/d^2,$$

where d is the diameter of the particle, basic research can hardly be conducted using commercial powders because of the lack of uniformity in size, shape and size distribution of the powder particles. Furthermore, an accurate method of size measurement has not yet been developed. The influence of particle size, shape and distribution on the bulk density, pressing characteristics, and sintering behavior has been proven to be of paramount importance. Nowadays, one sees more and more powder specifications use the term "average particle size" (usually in microns) instead of or in addition to screen analysis. Unfortunately, it will be quite some time before the powder manufacturers can control particle size and size distribution scientifically and accurately.

The present day powder metallurgists must, therefore, turn to the theoretical findings from the study of micromeritics for guidance. For example, on the basis of geometric considerations, one knows that in a system with uniformly sized spheres, porosity may vary between 25.75 per cent to 47.64 per cent, depending on the manner of packing which produces pores of such shapes as rhombohedral, orthorhombic, cubic, etc. It can also be shown mathematically that the decrease in porosity is not very marked with the addition of fine particles, unless they are small enough to fill the smallest interstices.

Since the degree of packing directly affects the bulk or apparent density of powder, which in turn influences pressing and sintering characteristics, it is therefore obvious that the size distribution (in the subsieve range) of powder is an important factor in powder metallurgy. Depending on the type and composition of powder and on the mode of sintering (liquid phase or solid state), one may find that normal or near-normal size distribution is desirable in one instance, whereas, a hyperbolic distribution is beneficial in another. It should be pointed out that the yardstick one uses to describe the size distribution of a powder is dependent upon the accuracy of his method of size measurement and particle counting. If an accurate method of size measurement were available, it would not be surprising for one to find that all mechanically comminuted powders show a frequency distribution approaching that of subdivision of matter in nature—a combination of a skew-probability curve and a hyperbolic curve that goes through a maximum and drops as particle size further decreases (See *Figure 1*).

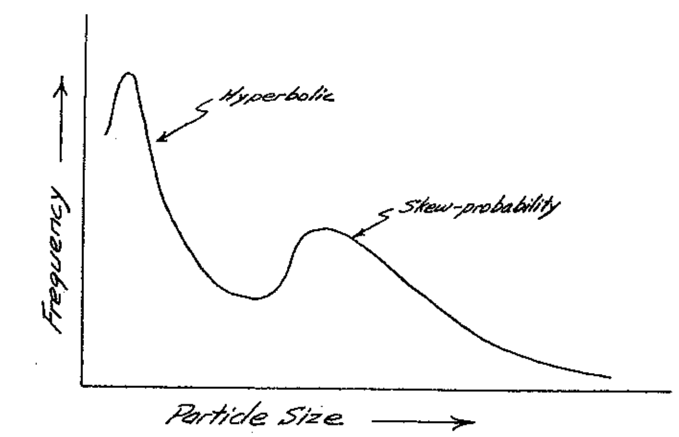

Figure 1. Postulated Size Distribution of the Subdivision of Particles

The shape of the powder particles is another important factor to both the practical powder metallurgists and the researchers. For good green strength and high sinterability, one finds spongy or irregularly shaped particles are desirable. For good compactibility, particles which are nearly spherical in shape are better. In slip casting of metal powders, one may again find that spherical particles give optimum results. To the researchers who are concerned with the mechanisms of sintering, the interlocking effect of irregularly shaped particles may upset the theories formulated from experimental results dealing with spherical particles or with wires.

Other powder characteristics such as adsorbed gas films, dissolved interstitials, amount of cold work and associated lattice strains, degree of alloying or prealloying, stoichiometry, etc., all play important parts in powder metallurgy. Many practical powder metallurgists know this but seldom find useful guidance from basic researches. Yet, when the influential factors are physical and chemical in nature, they are most suited for fundamental research, because the principles established should be applicable to all materials and processes.

Pressing

In the past decade much work has been done on the mechanisms for sintering but with only passing comments on the possible effects of pressing. There have been a few attempts at studying the sintering behavior of powder particles under pressure (warm or hot pressing), but this is one aspect of powder metallurgy where basic research must be strictly fundamental in character and applied research will have only limited significance.

To the practical powder metallurgists, the pressing operation is one single important step in the process, without which there will not be any finished parts. Raw materials can be changed or reworked; further densification can be achieved usually by using higher temperatures plus longer times, or by repeated repressing and resintering; but, if compacts with good green strength and free from pressure laminations cannot be made to specified dimensions and configurations, there is then no process of fabricating the product by conventional powder metallurgy.

The behavior of powder particles under pressure and the stress distribution in a compact during compaction and ejection are worthwhile fundamental investigations for the stress analysts. From the observation of a similarity between the behavior of powder in a die and that of a rope around a pulley, Ballhausen (1) derived a die friction equation which relates the variables, ratio of top and bottom pressure (P_t/P_b), height to diameter ratio (H/D), coefficient of friction between powder and die wall (u) and the angle between the pressure vectors (a), as follows:

$$P_t/P_b = e^{4(H/D)u \tan a}$$

After conducting various pressing experiments using materials such as copper and iron powders, steel balls, rubber, etc., Ballhausen further reduced his equation to an empirical form,

$$P_t/P_b = CH/D$$

in which C is a constant, between 1.4 and 2, which must be determined experimentally for the powder and die material used. Actually the theoretical findings even without the aid of experimental evidence will give considerable help to the practical powder metallurgists in the raw material preparation and tooling.

To conduct research experiments in this area, it is preferable to employ techniques and materials which are controllable, although they may seemingly bear no direct relationship to powder metallurgy. For example, it may be possible to use the three-dimensional photoelasticity techniques with instruments such as the photoelastic dynamometer to uncover the behavior of particles and the variation of stress distribution in a compact during pressing and ejection. Any sound principles that can be established from basic studies should help reduce to minimum the engineer's effort in cut-and-try powder preparation and in tool redesigning.

Another aspect of powder compacting is the use of lubricants to reduce friction and of binders to increase green strength. This practice of doping the powder to improve compatibility is almost as old as the development of automatic presses. Yet, as the requirement for high density powder metals with optimum physical properties becomes more and more apparent, one begins to wonder what effects the various additives may have on the sintering or infiltration operation, which will eventually show up in the properties of the finished products. Here is an area where basic and applied research may be conducted under controlled conditions, with no apologies needed for the lack of control of variables associated with powder metallurgical processes.

Sintering

It is now fairly well established that diffusion (volume, surface or grain boundary) is the most influential method of material transport in the densification process. It is also true that there are still many conflicting evidences and many experimental results which do not quite confirm the theories. For example, a certain investigator may find the activation energy for sintering copper differs from that in copper self diffusion by 20 per cent, or his rate of densification follows a time to the 1/3.5 power curve instead of time to the 1/3 power as his theory indicates. But, one must remember that whatever powder metallurgical experiments conducted in the attempt to support a theory, the investigator is dealing with many uncontrollable variables, any of which will influence the rate of densification to a certain degree. Some of the more influential variables or factors are (1) powder characteristics before and after compaction which will determine the amount, size, shape and distribution of pores that are to be changed or eliminated by sintering, (2) degree of cold work (amount of dislocations and stored strain energy) from pressing which may affect the diffusion coefficient or even the activation energy for the densification process, (3) surface properties of powder particles which may either promote or retard diffusion, and (4) other factors such as the condition of the compact (presence of pressure laminations, effect of smeared peripheral surfaces, etc.), lubricant or binder used, sintering atmosphere and its variation, and actual length of time at the sintering temperature.

If the practical powder metallurgist is convinced that diffusion is the major mechanism in densification, he may derive much useful information from studying the Arrhenius expression,

$$r = r_o e^{-E/RT}$$

where, r is the rate of the process; r_o, the rate coefficient; E, the activation energy in calories per mol; R, the gas constant; T, the absolute temperature in °K, and e, the base of natural logarithm.

One variable in the above equation, the temperature T, may appear to be the easiest to change, but to a process engineer, it involves many practical and economic limitations. While higher sintering temperature obviously accelerates densification, the matter of shape distortions and availability and maintenance of high temperature production furnaces must be taken into consideration.

The term r_o is not really a constant; in fact, it has the unit of length squared per unit time (same as r). The value for this term is usually determined experimentally, but it can also be derived for certain diffusion systems and can be shown to be dependent on lattice configuration, atomic vibration frequency and the entropy of activation for the system. Any means to increase the value of r_o, such as by variation of stoichiometry of an intermetallic compound, will hasten the diffusion process.

The activation energy, E, represents a wall blocking the path of a moving atom or vacancy. A low value for E means faster diffusion and easier densification. However, to change the value of E in a given system without changing the chemical composition is something only fundamental research can help the practical powder metallurgists. Perhaps the introduction of a large amount of vacancies and dislocations could change the activation energy required for the process. By manipulating the processing cycle, it might be possible to

vary the predominant mode of diffusion (e. g., from volume to grain boundary or to surface diffusion), resulting in a change in activation energy. If an alloy system permits, it might also be possible to increase the rate of densification by the repeated occurrence during sintering of any one of such phenomena as (1) phase transformation, (2) order-disorder change, (3) solution and precipitation, (4) crossing of a Curie point, and (5) the upsetting of equilibrium conditions.

Several observations made by basic researchers regarding diffusion should be noted by the practical powder metallurgists who are engaged in product or process development, or in conducting applied research programs. These observations concerning two-component diffusion phenomena are (1) the diffusion coefficient of a given element is usually smaller the higher the melting point of the solvent, (2) the diffusivity is inversely proportional to the solid solubility of the components, (3) the direction of rapid diffusion is toward the element which has the greater interatomic distance, and (4) the activation energy for the diffusion of the solute is always less than that for self-diffusion in the solvent, especially when the two elements are very much dissimilar.

Some years ago, in his study on self-diffusion in solid sodium, Nachtrieb (2) discovered a very interesting relationship between the activation energies for self-diffusion in cubic metals (e. g., Au, Ag, Cu, Co, Fe and Na) and their latent heats of fusion. This relationship may be written as

$$E = 16.5 L_m$$

which was established from experimental data and the application of the Clausius-Clapeyron equation. According to Nachtrieb, this relationship may also be derived from the consideration of the amount of relaxed lattice vacancies created or introduced at the instant of melting. Fundamental research of this type in the area of chemistry and physics of metals is also the fundamental research for powder metallurgy.

Infiltration

In conventional powder metallurgy, infiltration is also an important step in the process of making high density products which possess special properties. Many Fe-Cu structural powder alloys, certain carbide tool tips, and a variety of electrical contact materials are produced by this process. Furthermore, not only many phenomena or principles involved in infiltration are associated with or applicable to liquid-phase sintering (also in some degree to solid state sintering), the process itself is intimately related to sintering, pressing and powder preparation.

This subject of infiltration offers a lucrative field for fundamental research. There have been some fine basic researches done in the past years, but not enough applied research to fill the gap between research and practical technology. Today's process engineers are still using cut-and-try methods to solve production problems, and the product development powder metallurgists have yet to have the opportunity to apply research findings to their field of endeavor. With respect to applied research on infiltration, it is again very important for the investigators to realize that no laws or principles can be established from the results of experiments using commercial powders.

To serve as an example of what research areas related to the problems of infiltration that will yield useful results to the practical powder metallurgists, and what possible research findings that the latter can apply to

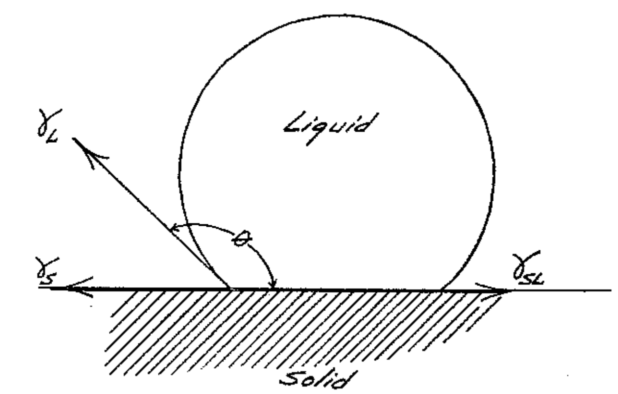

Figure 2. Relationship between the Surface Energies of A Liquid and A Solid

their daily problems, one may examine the relationship between the contact angle, (⊖) and the surface tension or energy of the solid, liquid and solid-liquid interface, as shown by *Figure 2* and the following equation.

$$\cos \Theta = \frac{\gamma S - \gamma SL}{\gamma L}$$

On the basis of the simple relationship described by the above equation, it is obvious that the wettability will be favored by a decrease in contact angle. It is certainly not unreasonable to speculate on the possibilities of decreasing ⊖ by using additives, changing the physical characteristics of the capillaries, or applying special powder treatments to change the values of one or two or all three terms on the right side of the equation.

Concluding Remarks

Probably the best way to speed up the closing of the gap between research and practical powder metallurgy is to recognize the fact that powder metallurgy is but a technique of metals or materials fabrication and to proceed from there. Fundamental research in powder metallurgy means fundamental research in the chemistry and physics of solids, liquids and gases, and their interrelationships under various conditions. Applied powder metallurgical research should be conducted by technicians who are familiar with basic research techniques as well as experienced in production processes. When research in powder metallurgy is done in this manner, it follows logically that the process engineers must prepare themselves for the task of translating research findings into practical uses.

While only four topics in the realm of conventional powder metallurgy have been discussed to support the theme of this paper, one can easily make similar inferences in the examination of such technique variations as hot pressing, slip casting, powder extrusion, powder rolling and explosive compacting, or such closely related fields as cermets, ferrites, porous powder metallurgy and fiber metallurgy.

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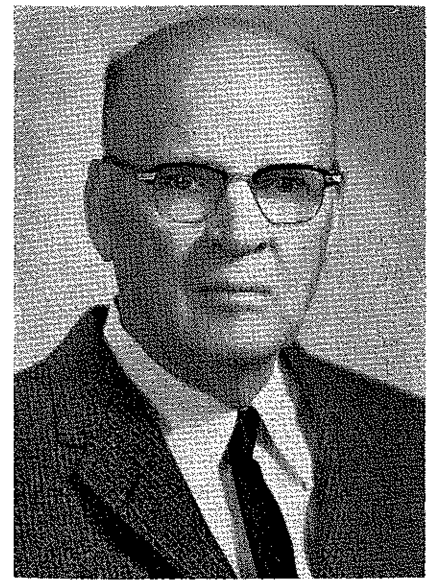
Controlled Particle Movement In Counter-Current Flow Heating

By
HARRY K. SAVAGE



HARRY K. SAVAGE

Research indicates that the current method of heating broken solids with hot gas by counter-current flow can be made more effective. To design and operate equipment for the purpose will require a knowledge of how broken solids flow. Closely associated with flow is the feature of agitating in some degree a mass of broken solids, using no other force than gravity.

Little work has been done on the flow of broken solids until in recent years (1), (2). The following data are offered as a contribution to a better understanding of the subject.

Experimental work with crushed gravel was done with a container, so built, that a desired cross-section of rock flow could be observed. The floor design of the container was an adaptation from mining by block caving which is illustrated by *Figure 1.* With such a floor design, two types of flow were developed when flow into the container was substantially equal to out flow:

1—Mass flow in which the individual particles fell with but little deviation from the vertical.

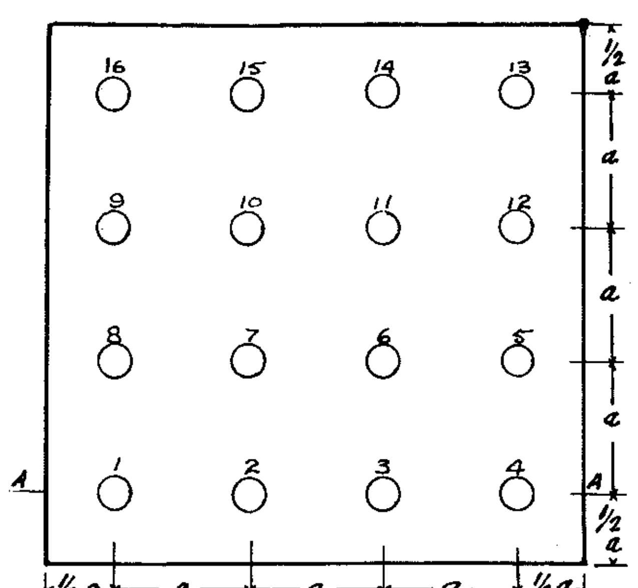


Figure 1.

THE AUTHOR

Although he is a native of Colorado, Harry K. Savage received his technical education at Stanford University where in 1907 he received his A.B. degree in civil engineering. From 1920 to 1931 he was a field engineer for D. D. Potter & Associates of Denver.

Early in his career he became interested in the technical problems of oil shale. He discovered that the utilization of oil shale will be a close combination of mining and chemical engineering. Later he concluded that efficient retorting by counter-current flow requires a knowledge of how broken solids behave in motion. Since there was little literature on the subject, it became necessary for him to undertake research on the flow of broken solids.

2—Cone flow in which the particles fell at different rates and directions, mostly non-vertical.

Mass flow was obtained by opening simultaneously all the outlets shown by *Figure 1.* This flow is illustrated by *Figure 2* which is a cross section, A-A of *Figure 1.* Above B-B of *Figure 2,* flow did not indicate any stress except in the vicinity of the sidewalls where friction caused a variation in velocity. This created shear and potential tension in that vicinity. Below B-B, mass flow was gradually superseded by cone flow with increased shear and tension as the outlets were approached.

Mass flow, because of its stability and lack of independent particle movement, is not conducive to rapid heating by counter-current methods. Technical literature on the subject, (3), states that only a portion of the voids in broken solids are available as gas carriers because many of them are blocked by overlying pieces of solid material and by interlocking. It has been estimated that only about one-fourth, (4), of the surface area of the individual particles comes in contact with the gas stream. Also, volumes of gas tend to set up convection currents, (5), which result in channeling and slow up further the heating process. Given enough time, heating will finally be accomplished by indirect means.

Caking, which sometimes occurs, can be minimized by agitating the particles at frequent intervals or by removing caking mediums, which are products of distillation, by the use of a sufficient amount of scavenging gases. Mass flow in the main is inimical to either of these methods.

On the other hand, cone flow produces varying conditions of velocity and direction. These induce individual particle movement and produce stress. This tends to break up static features in a bed of broken solids. This type of flow can be induced in a container of broken solids by outlet flow through a single orifice. Its location in regard to the sidewalls will determine the pattern of flow. An orifice in the center of the bottom will produce a balanced inverted cone as shown by *Figure 3.* If in any other position, flow may be influenced by the sidewalls. If so, the flow pattern will be that of an imbalanced cone as illustrated by *Figures 4* and *5.*

Height of the container in relation to its width is another important factor. If the height is about two and one-half times the width, flow at that point and above, if the container is higher, will be similar to mass flow shown above B-B by *Figure 2.* Below the critical height there will be a combination of mass and cone flow with the latter increasing in proportion until mass flow ceases and cone flow takes over completely. As mass flow diminishes shear and tension increase. The cone-flow pattern will be that of an inverted cone flowing through an upright cone-like figure of static material. The line of contact between the two cones of broken rock will be at an angle of 70° from the horizontal, (*Figure 3*). Different materials have different flow angles; catalyst pellets 71°, (6); a good grade of oil shale, 72°, (7).

When flow was through outlet #1, (*Figure 1*), the pattern was that of an imbalanced cone, (*Figure 4*). The pattern was quite different from that of a balanced cone, (*Figure 3*), one side of the imperfect cone was heavier than the other with the lighter side being between the center of the cone and the side wall. When flow began through outlet #1, the initial flow in the upper part of the cone was toward the side wall rather than toward the outlet. Soon most of the material changed direction toward the outlet, but part of it as shown by markers 2, 3 and 4, continued toward the side wall until near the bottom of the container. It then changed direction rather abruptly to flow to the outlet. The peculiarities of this type of flow indicates greater shear and tension than that of *Figure 3.*

When outlet #1 was closed and outlet #2 opened a different type of imbalanced cone flowed as illustrated by *Figure 5.* It was more nearly in balance than the cone illustrated by *Figure 4.*

Draw through outlets 1, 4, 13 and 16 will produce imbalanced cones with similar patterns. Draw through outlets 2, 3, 5, 8, 9, 12, 14 and 15 will produce imbalanced cones with patterns similar to *Figure 5.* Draw through outlets 6, 7, 10, 11 may produce balanced cones similar to *Figure 3.* If all the cones were drawn

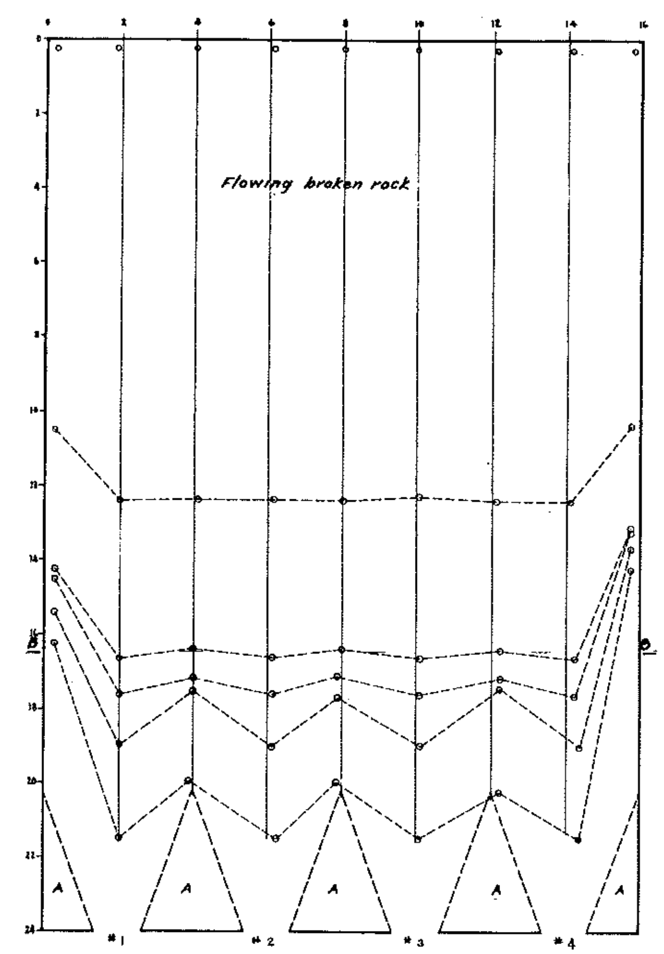


Figure 2.

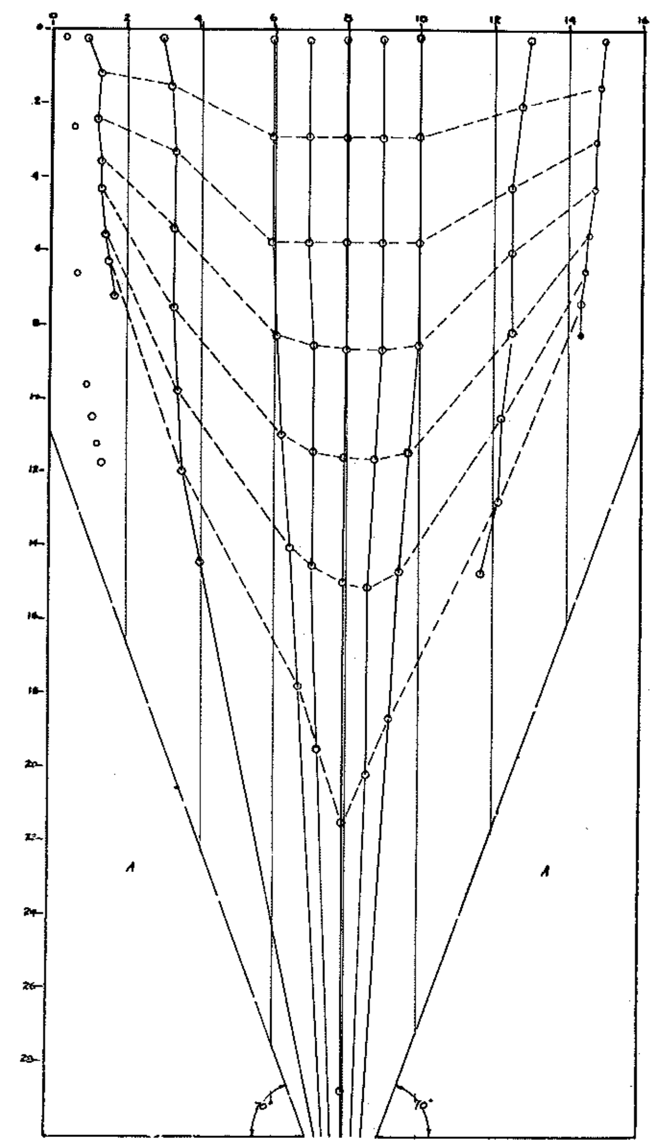
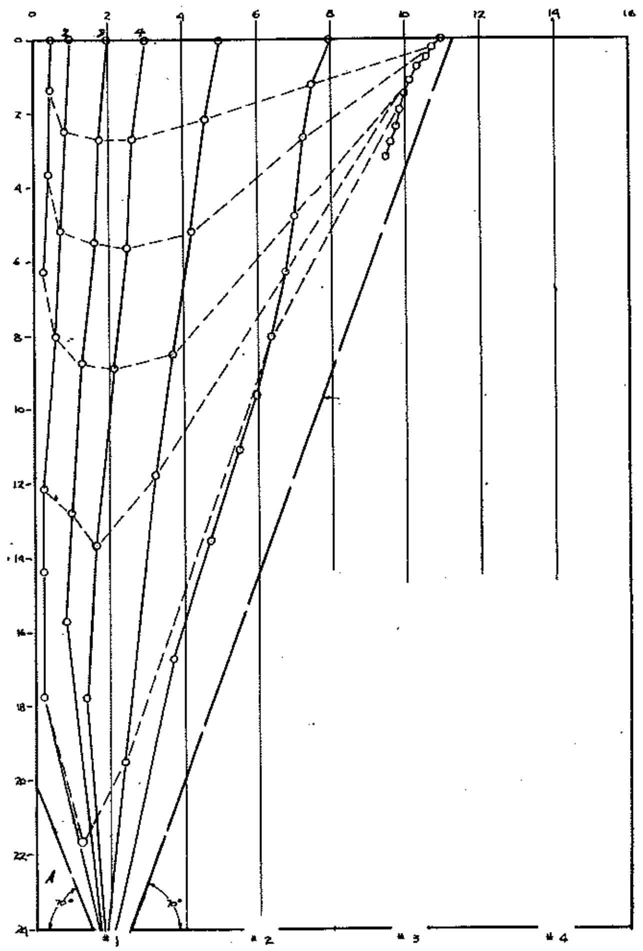
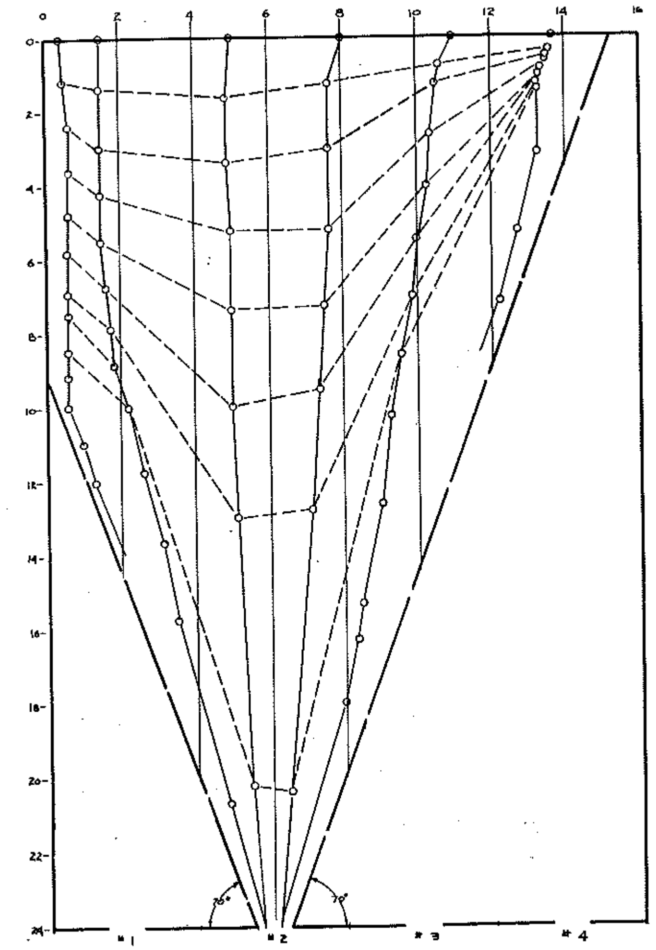


Figure 3.



▼ Figure 4.



▼ Figure 5.

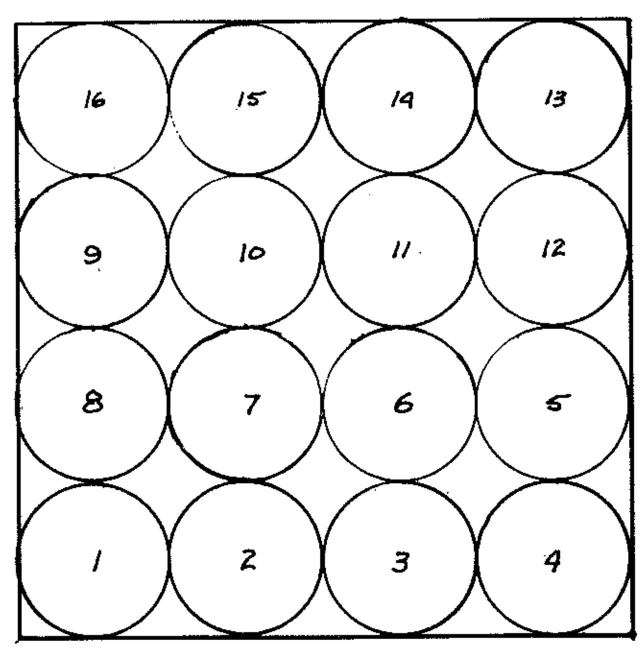
simultaneously the flow downward would be uniform except in the vicinity of the side walls where friction would cause a differential in velocity. At a distance above the floor, depending upon the distance between outlets and the specific gravity of the material, the flow would become true cones which would be tangent to each other as illustrated by *Figure 6*. Probably there would be a transitional area above the cones, equal to their height, in which mass flow gradually changed to cone flow. (*See Figure 2.*)

If the cones were drawn sequentially, beginning with outlet #1, there would be overlapping as illustrated by *Figure 7*. If draw through outlet #2 followed draw through outlet #1, a portion of #2 cone would be composed of part of what had been #1 cone. With a change in cone, most of the particles changed velocity, which depended on their positions in the cone. If a particle was in the center of its cone it would move at maximum speed. If in the change it found a position near the perimeter of the new cone its velocity would be greatly decreased.

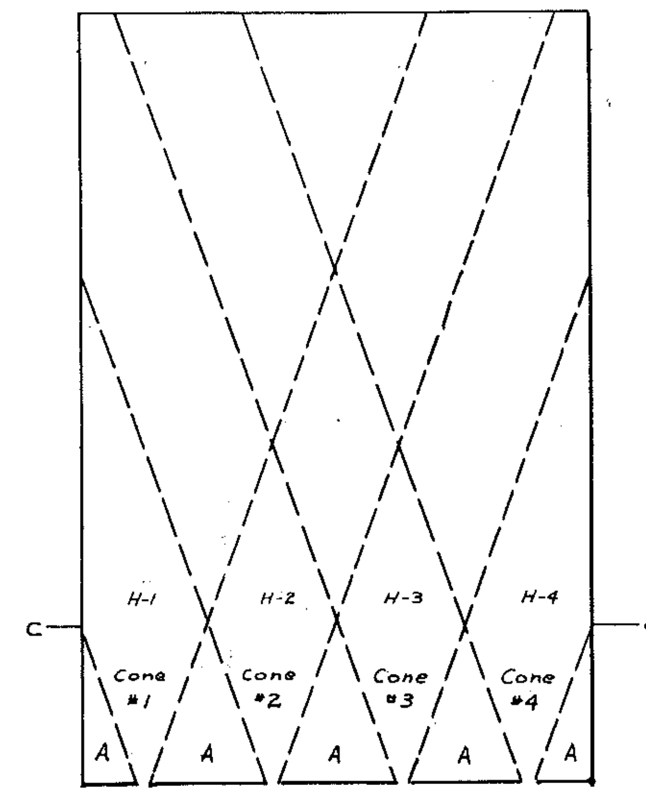
With a change in cone all the particles changed direction. This resulted in a zigzag downward course as shown by *Figure 8*.

Figure 8 does not show by any means all the changes that took place in sequential flow. It merely shows the course of certain individual pieces used as markers. At each change of outlet new markers took the same initial position that the former markers had occupied but their initial flow from datum was different, which resulted in additional patterns of flow as illustrated by *Figure 9*. Marker 4a at datum flowed to position 4a-1 when outlet #1 was opened for unit time. Marker 4b replaced 4a at datum. When outlet #2 was opened for unit time 4a proceeded from 4a-1 to 4a-2; 4b to position 4b-1 and so on as the different outlets were opened. The pattern of 4c, if shown, would be similar to 4b but not identical.

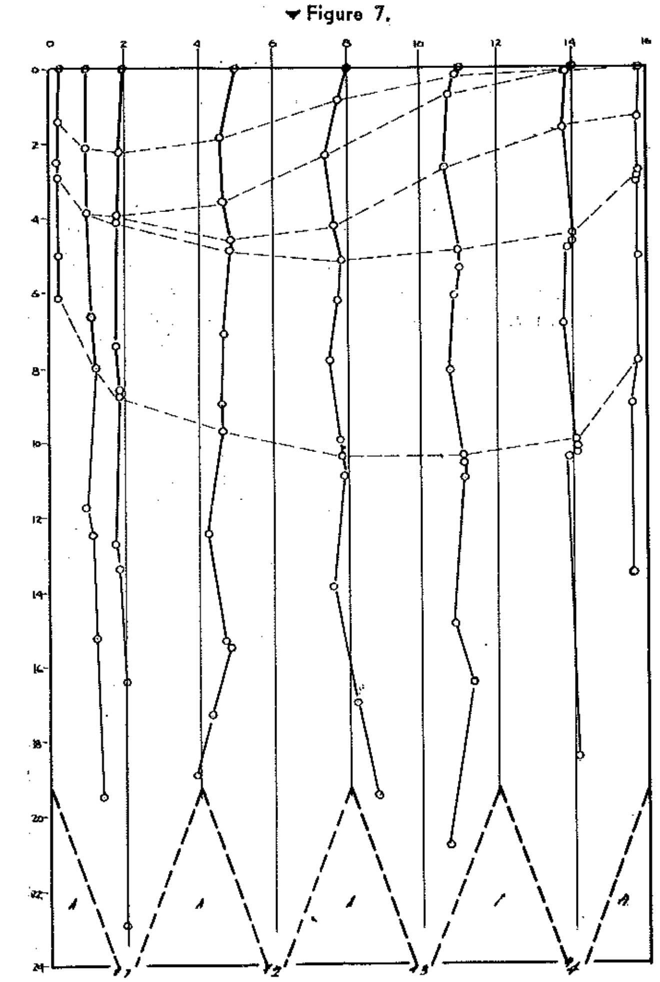
The time-quantity factor of sequential flow is im-



▼ Figure 6.

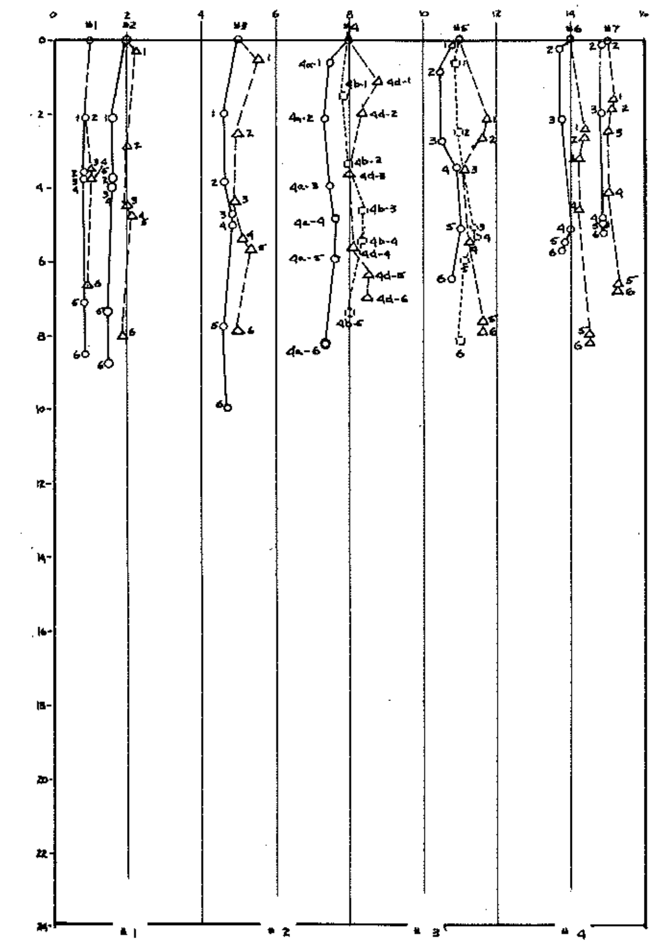


▼ Figure 7.



▼ Figure 8.

portant to secure the most desirable results. The increment must be small. This causes the particles to move downward for composite periods of draw at a fairly uniform rate as illustrated by *Figure 8*. The diagram indicates that a slightly slower time-quantity rate would have produced more uniform results.



▼ Figure 9.

Above tangency, the cones if drawn one by one, would overlap each other's draw as illustrated by *Figure 7*. The amount of overlap would increase with height until at some point the overlapping would be complete. With increased height, each draw through an outlet would cover a greater part of the cross-section of the container until there could be constant agitation.

Below the point of complete overlap there are sections of *Figure 7* labeled H where particle movement takes place only when a particular outlet is drawn. This imbalance of particle movement can be compensated to a considerable degree by short periods of simultaneous flow through all the outlets. Sequential draw of all 16 outlets, interrupted at intervals by short periods of simultaneous flow could be a workable combination.

A different pattern could be developed by dividing the floor into four units of four outlets each. This would simplify collection of the material for disposal after it was processed.

To accomplish all of the desired effects in heating by counter-current flow, forces must be generated within the apparatus itself. This can be done by utilizing the characteristics of a flowing inverted cone.

- 1-a Constant decrease in the diameter of an inverted cone requires the individual particles to constantly change direction, except for a core of small diameter in the center.
- 1-b Increase in velocity from the perimeter toward the center and over-all increase in velocity

from the top of the container to the outlet produce stress.

2- Sequential draw brings about transfer of particles from one cone to another, resulting in change in direction and usually a change in velocity. Both of these occurring quite abruptly at times.

3- Sidewall friction caused either by the walls of the container or by perimeter of the cone itself.

4- Imbalanced cones in which a portion of a cone on one side of its axis is normal but the other side is subnormal.

Cone flow with a small amount of mass flow interspersed is more effective than either mass or cone flow alone.

The foregoing data apply only where flow into the container and outflow are substantially the same and when the particles are approximately of the same size. Those used in the experimental work were broken gravel ranging from one-quarter inch to five-eights inch in their greatest dimension.

Only part of the data apply to a mixture of large and small pieces.

The pattern of flow will be influenced by particle size, specific gravity, design of the apparatus through which the particles flow and the way in which the apparatus is operated.

LEGEND

Outside heavy full line is confines of the container.

Dashed heavy line is boundary between flowing and non-flowing broken rock.

Small circles connected by medium lines are markers used to note rate and direction of flow.

Medium broken lines designate equal time of flow.

Light vertical lines are reference lines.

No. 1, No. 2, No. 3, No. 4 are numbers of outlets in the bottom of the container.

Areas designated by A are static.

Comments by the Author

Experiments were performed intermittently beginning in 1945 and still continued at intervals, in a small rock laboratory at my home in Downey, Calif.

Several different models were used, depending upon the problems being investigated.

The principal model was 30 inches high, 16 inches wide and 5 inches thick. All models had plate glass fronts with the inner side of the glass placed at the center of the outlet or outlets.

Figure 1 has no absolute dimensions. It illustrates a type of floor design by which mass flow or cone flow could be induced. The letter *a* of the illustration could be almost any figure depending on particles size and results desired.

The ordinate and abcissa of *Figures 3, 4,* and *5* were for the purpose of plotting the course of the markers and to show the relationship between height and width. *Figure 3,* as an illustration, shows a constant change in the cross-section of the pattern of flow which is a function of height and width. If the height remained at 30 and the width became greater or less than 16 the pattern of flow would vary from that of *Figure 3.*

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NEWS—INDUSTRIES

(Continued from page 17)

uted directly to the lower volume and value of the 1959 crude petroleum yield.

The total value of the nonmetallic mineral production rose 8 per cent, to nearly $30 million above the previous year. Only four commodities in this group (bromine compounds, calcium chloride, sulfur ore and magnesite) were reported in lesser quantity and value than in 1958, as most non-metallic minerals reflected the comparatively high level of activity experienced by the construction and chemical industries in 1959.

Colorado Mineral Output Up One Per Cent in 1959

Colorado's $310.4 million value of mineral production in 1959 was a $3.9 million increase or 1 per cent over 1958, according to the Bureau of Mines, United States Department of the Interior. Fuels, metals, and nonmetals accounted for 56, 30, and 14 per cent, respectively, compared with 59, 27, and 14 in 1958.

The overall value of mineral fuels ($172 million) was 5 per cent less than in 1958, metals ($94 million) advanced 15 per cent, and nonmetals as a group remained unchanged (at $44.3 million) for both years.

Petroleum continued as the leading value commodity produced in the State, accounting for 44 per cent of the total.

Molybdenum again ranked first in value of output among the metals (second among all minerals in the State), followed by uranium, vanadium, and zinc. Cement maintained the value lead in the nonmetals group followed closely by sand and gravel.

Petroleum production declined for the second consecutive year and was 5 per cent below that of 1958. A drop in production at the Rangely field—amounting to more than the total decline throughout the State—was partially offset by production from new discoveries and other fields. Water-flooding operations were started in February 1959 in the Rangely Field Weber pool. Initial injection at the rate of 25,000 barrels a day will be increased to 60,000 barrels a day by March 1960 and ultimate injection rate will be 160,000 barrels a day.

Exploratory and development drilling was at a lower rate than in 1958. In 11 months 401 exploratory and 301 development wells had been completed, compared with 450 exploratory wells and 327 development wells completed in the same period in 1958.

N. Mex. Mineral Industry Produces $607 Million in '59

The mineral industry of New Mexico produced commodities valued at $607.3 million in 1959, an 8 per cent advance over 1958, according to the Bureau of Mines. Mineral fuels accounted for 71 per cent of the total value of production, nonmetals 15, and metals 14 per cent.

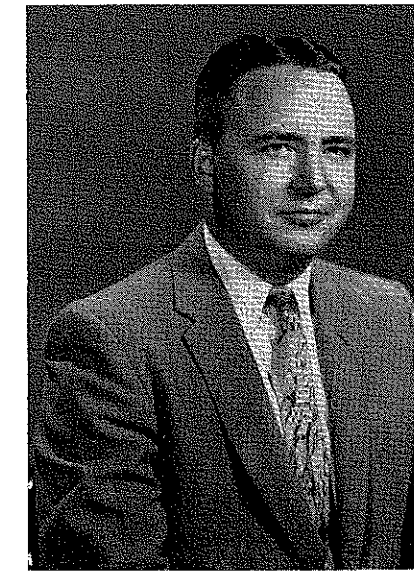
Petroleum, with a 7 per cent greater output than in 1958, was the most important mineral-industry product and for the first time in the history of the state, output exceeded 100 million barrels. The potash industry in the Carlsbad area recovered from its relatively unfavorable economic position in 1958, and the value of output rose 7 per cent in 1959.

The metals segment of the industry showed an overall 25 per cent gain in value of production largely because of a 69 per cent increase in the value of uranium production, despite a 16, 8, and 41 per cent drop in the value of copper, lead, and zinc, respectively.

Process Development And Operating Costs*

By

JOHN A. RIDDLE, '49



JOHN A. RIDDLE

THE AUTHOR

A native of southwestern Colorado, John A. Riddle graduated from Grand Junction High School in 1945 and then began his study of metallurgy at the Colorado School of Mines where he received his Met. E. degree in 1949.

After leaving Mines, he was employed by Oliver Iron Mining Co., Phelps Dodge Copper Refining Co., the Atomic Energy Commission, and spent some time prospecting for uranium before joining Union Carbide Nuclear Co. about five years ago.

Since 1956 he has been engaged in process engineering and project evaluation in Union Carbide Nuclear's New York office.

When evaluating a new project, several stages are considered in its progress from a prospect or a research project to an operating property. These are: first, a preliminary evaluation which should tell us if it is worth going to any work to develop more information; second, a more refined set of estimates after some work has been done; and third, a final complete evaluation on which a request for construction funds is based.

The stages are not usually separate and distinct, but blend one into another. As the project advances information and estimates naturally become more complete and should become more accurate. Estimates of ore reserves, capital costs and operating costs improve in accuracy from plus or minus 50 percent to plus or minus 10 percent.

Process Selection

Process selection is probably the most critical point, since it is here that the entire future of a project is determined, for better or for worse. Some of the information required before any intelligent selection may be attempted includes:

(1) Mineralogy—identification and occurrence of both ore and gangue minerals

(2) Mining characteristics—size, distribution, hardness, moisture content, ore reserves and expected range of production rates

(3) Geography—terrain, climate, labor market, transportation, availability of water, fuel, power and reagents

(4) Markets—price, volume, stability and product specifications

From this information a preliminary selection of the general treatment scheme can be made—such as concentration, hydrometallurgy, pyrometallurgy, or appropriate combinations of these.

If time permits and the project is large or unique enough to warrant it, pilot plant work should be done to get as much information as possible.

Even at this preliminary state, processing economics must be considered in choosing between alternatives. Use of the term "economics," rather than cost, is important, since it encompasses sales, operating costs, capital costs, and timing. Sales relates to market conditions, to the amount of the valuable constituent recovered from the ore, and to its quality. Operating costs are important, but low operating costs do not in themselves assure a profitable operation, since it is obvious that the way to achieve lowest operating costs is to shut down.

Capital costs must be written off over the life of the project, and process selection should be done with this in mind, especially if the operating life is expected to be relatively short. Finally, the timing of the cash flows is extremely important. A dollar spent or received today is worth a dollar, but if the transaction is delayed, the dollar must be discounted according to the rate it would earn if invested. At six percent interest, for example, a dollar that will be received a year from now is worth only $0.943 today. If it will not be received for five years, it is worth only $0.747 today. Using this concept, if a $1,000,000 expenditure is made today from which no return is expected for five years, the amount paid back must be more than $1,338,689 in order for the venture to be as attractive as a hypothetical six percent investment. Discounting cash flows according to their timing is the basis for such economic criteria as discounted cash flow rate of return and present worth (See Bates and Weaver, *Chemical Week*, June 15, 1957, pp. 116-127).

The production rate should, of course, be the maximum consistent with the ore body and the market. A method we have used frequently with fair success involves making a complete estimate for a medium-sized operation, then scaling both capital and operating costs to those which might be expected at several other

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rates. Using these figures and such criteria as payment time, return on investment or discounted cash flow, the optimum production rate can usually be approximated by a series of trial-and-error calculations. Market conditions and forecasts of general economic conditions also must be taken into account in determining the optimum rate.

Flowsheets and Equipment Lists

On the subject of the types of flowsheets and their use as a tool in process engineering, it should be noted that nothing else eliminates an impractical circuit as effectively as putting it on paper and finding that it cannot be balanced, or that it can be vastly simplified.

A variety of flowsheets are used in different stages of a project, but the most useful for preliminary evaluations is the type illustrated in *Figure 1*. Here is the treatment scheme, material balance and the makings of an equipment list all in one piece of paper. For comparison of various treatment schemes several flowsheets will be prepared, with equipment sizes and material balances as complete as possible. From these, preliminary capital cost estimates can be prepared, and also estimates on labor, reagent and utility costs. The flowsheet should usually be prepared with soft pencil on heavy tracing paper, so that necessary changes can be made and additional information added as it becomes available. A reproducible copy can be made from the master at each stage and retained to provide a record of the evolution of the final flowsheet.

Capital Cost Estimates

Cost estimates for an evaluation are a far cry from the complete detailed estimates made later when engineering is well advanced. Contingency allowances should be generous, for projects have a way of getting more complicated and expensive during the period between initial conception and plant start-up.

First stage capital costs are frequently obtained by analogy; that is, a plant three years ago was built for \$5,000,000, a new one of the same capacity should cost about \$6,000,000 today. A refinement of this technique is the use of the 0.6 power of the ratio of capacities to adjust from one size plant to another. The costs should also, of course, be adjusted to present-day levels by use of an appropriate cost index. For example, if we built a 300-tpd plant in 1956 for \$2,500,000 the approximate cost of a 500-tpd plant in 1959 would be:

$$(2.5 \times 10^6)\left(\frac{170}{150}\right)\left(\frac{500}{300}\right)^{0.6} = \$3{,}900{,}000,$$

where $\left(\frac{170}{150}\right)$ = Nelson Refinery Index $\left(\frac{\text{June 1959}}{\text{June 1956}}\right)$

Other cost indices such as the E.N.R. or the Marshall & Stevens Index could be used, of course. If the new plant is to be of milti-unit design, the capacity ratio might be taken directly as a cost multiplier, or perhaps to the 0.9 power instead of 0.6. These variations should be based upon analysis of previous experience, and upon the particular situation under consideration. It should be mentioned that this method can lead one far astray if an attempt is made to correlate different types of plants.

Second-round capital cost estimates are usually prepared with a flowsheet of the type shown in *figure 1* by adding prices to the equipment list, and by using experience factors to go from total equipment cost to total plant cost. For instance, the cost of a plant with no unusual auxiliaries such as power plant or employes' housing may be estimated as some factor times the cost of process equipment. Factors generally range from three to four, depending on location, type of process, etc. A very good discussion by Norman G. Bach on the application of this type of factor in capital cost estimates was published in *Chemical Engineering*, (Sept. 22, 1958, pp. 155-159) and many other references may be found in the literature.

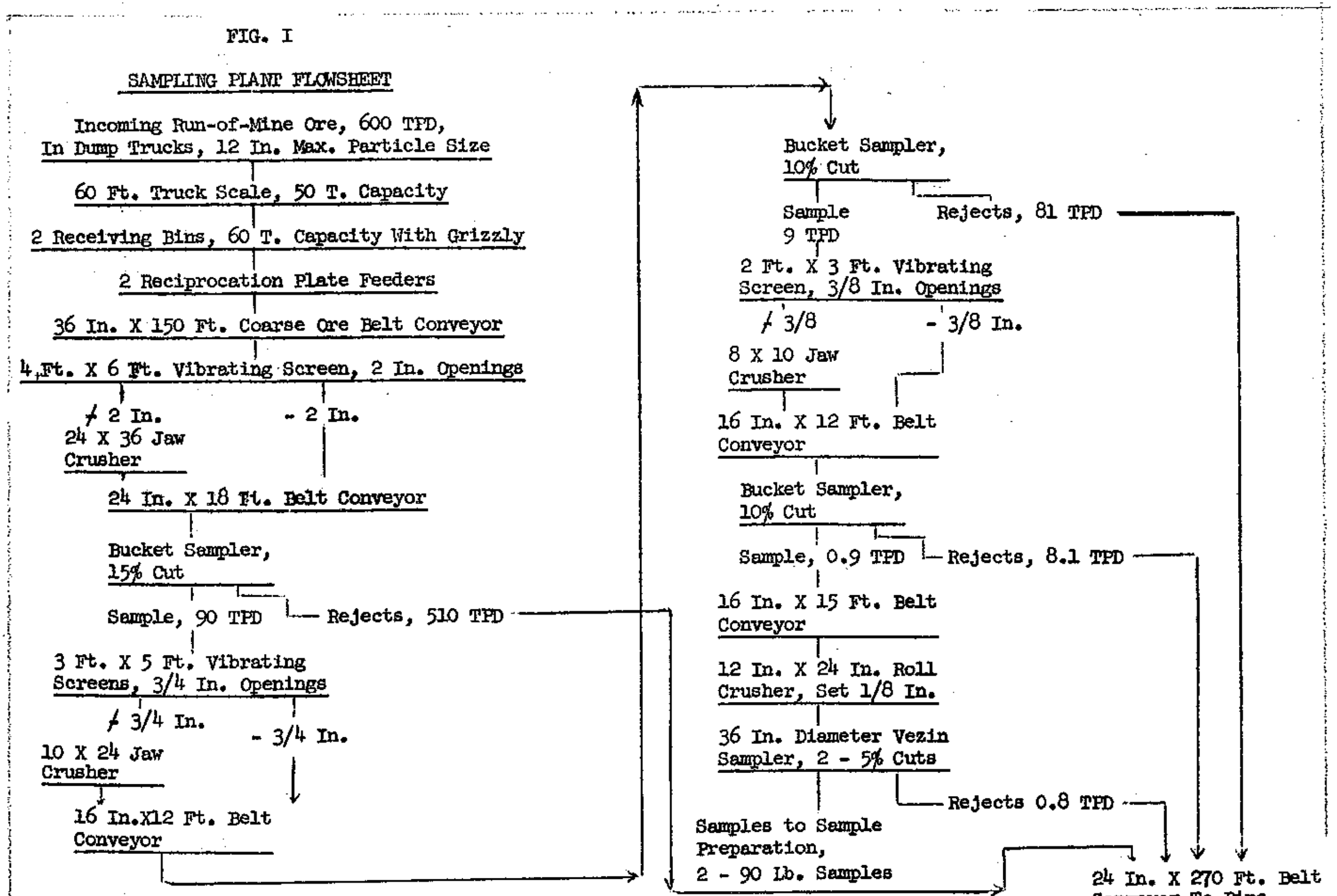


Figure 1.

As an example of the derivation of these estimating factors, the cost of an ore treatment plant built recently is shown in *Table I*. In this case, the process equipment cost 32 per cent of the total, so the factor would be three. *Table I* also illustrates the relative magnitude of some of the items of indirect cost.

Incidentally, the preliminary equipment list for this plant was prepared before detailed engineering began, and a cost estimate made at this stage totaled \$4,500,000. Although such close agreement is rare, it happens just often enough to be encouraging.

TABLE I
URANIUM PLANT COST

Item	Cost ($000)	Percent of total
Process Equipment	1,490	32
Material, equipment and buildings	379	8
Field labor	687	15
Subcontract, masonry, roofing, electrical	840	18
Freight	53	1
Sales tax	42	1
Total Direct Cost	3,491	75
Construction, tools, equipment supplies	225	
Temporary facilities	27	
Tests	2	
Field supervision	67	
Office supplies and communications		13
Job insurance	5	
Payroll taxes and insurance	90	
Subsistence	161	
Welfare	7	
Cleanup	10	
Total indirect cost	607	13
Engineering (50 percent salaries)	360	8
Purchasing (42 percent salaries)	53	1
Contractor's fee	142	3
Total cost	$4,653	100

Operating Cost Estimates

The first-stage evaluation of a project's operating cost is usually by analogy to previous experience. That is, if a given uranium ore can be treated by acid leach and resin-in-pulp ion exchange for \$10 per ton; a similar ore, which is known to consume an additional dollar's worth of acid, can probably be treated at the same tonnage rate for \$11.00 per ton. This type of comparison can be broken down to operating departments and extended to similar schemes for different ores, since much of the flowsheet will be the same; crush, grind, leach, wash, discard tailings, separate and prepare concentrate. For a given situation, plant throughput rate will have more effect on per-ton costs than almost any other factor.

A second stage processing cost evaluation is usually made in tabular form on the basis of direct and indirect operating costs. Direct operating costs are broken down in categories as to labor, reagents, operating supplies, maintenance supplies and utilities. In a typical break down each cost category is further broken down on a dollar per month and dollar per ton basis as to ore receiving and crushing, grinding, leaching, liquid-solid separation, product separation, and tailings disposal.

Indirect operating costs are broken down into ten major categories on a cost per month and cost per ton basis. Five categories—supervision and administration, maintenance, analytical and technical; water, air and steam; and purchasing, warehousing and accounting—are broken down as to labor and supply costs. Maintenance and water, air and steam costs also include charges for utilities. The remaining five expense categories are for payroll overhead, taxes and insurance, communications, product shipment and home office expense.

Estimates of this kind must be based on accurate cost information collected from other operations and on the best possible lab or pilot plant information as to reagent consumptions, process quantities, etc. Other forms which will be useful in developing the estimate, are hourly and salaried payroll lists, tables of reagent usages, heat balances and motor lists. It is frequently desirable to tabulate cost estimates in the form used for cost accounting in other operations, so that similar items may be conveniently cross-checked against actual experience.

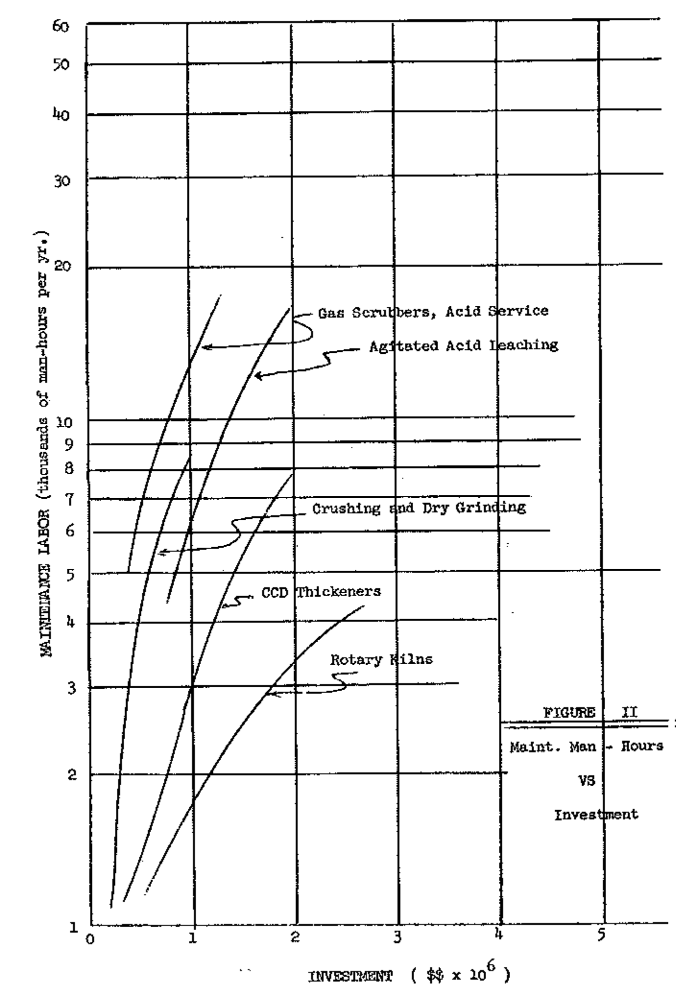


Figure 2.

A few of the factors we have found useful in preparing preliminary operating cost estimates are listed below:

Labor—Hourly, \$2.00 to \$2.50 per man-hour, depending on the labor market. Salaried, according to company salary scales, and list of staff personnel.

Maintenance supplies—Annual cost one to five percent of capital cost, according to process and complexity of plant.

Maintenance labor—Equal to maintenance supplies; less if special materials of construction are used extensively.

Payroll overhead—Twelve to 16 percent of total labor, depending on the area and company policies.

Taxes and Insurance—Annual cost 1½ percent of plant capital cost. This can vary widely, depending on the area and the type of plant.

Communications—Five hundred to \$2000 per month, depending on plant size and location.

One of the biggest uncertainties in operating cost estimates is maintenance cost. Short of building the plant and operating it there is no completely accurate method of predicting maintenance costs. Engineering design, selection of equipment and quality of labor are all important but intangible variables. The relationship between capital investment, type of operation and annual maintenance man-hours has been discussed by R. L. Glauz, Jr. in *Chemical Engineering Progress* (March 1955). By using this concept, a series of graphs may be prepared using data from existing plants which will give a reasonably good basis for maintenance cost estimates. A typical graph of this type is shown in *Figure 2*.

Typical Project Evaluation

As an illustration of a typical project evaluation consider a hypothetical project in which the exploration department has found an ore body containing 3,600,000 tons of ore with one percent metal content. The mining department advises that the ore can be mined most efficiently at a rate of 1000 tpd for a cost of \$10 per ton, and a market is available for all that can be produced at a price of \$2.50 per lb. of metal.

Laboratory work indicates that the ore can be treated by a well-developed process that would get 75 percent recovery. It is also reported that a new scheme will probably recover 95 percent of the values, but will take about two years to develop at a cost of \$500,000.

Preliminary estimates of capital cost and operation cost prepared for each case indicate that a plant using the old process will cost \$5,000,000 and will operate for \$10 per ton, whereas the cost of the plant using the new process will be \$8,000,000 and operating cost will be \$12 per ton.

Using the data given above, net income and return on investment are calculated on an annual basis as shown below:

	Case A	*Case B*
Tons of ore fed	360,000	360,000
Lb. metal in feed	7,200,000	7,200,000
Recovery, percent	75%	95%
Metal recovered, lb./yr.	5,400,000	6,840,000
Sales, \$000	13,500	17,100
Mining cost, \$000	–3,600	–3,600
Operating cost	–3,600	–4,800
Operating margin	6,300	8,700
Plant depreciation	– 500	– 800
Net before tax	5,800	7,900
Tax at 52 percent	–3,016	–4,108
Net income	2,784	3,792
Percent return on investment	56%	38%

If the only criterion is return on investment, obviously Case A is more desirable. However, a comparison of the present worth calculations shown in *Table II* for the two cases indicates a present worth of about \$22,800,000 for Case B and only about \$19,500,000 for Case A. Since the present worth concept considers investment, income and timing, it is apparent that the higher present worth of Case B makes it more desirable than Case A.

TABLE II
PRESENT WORTH COMPUTATION
(thousands of dollars)

YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12
A.													
Expenditures													
Working Capital		–1,000											
Plant Construction	–5,000												
Research & Dev.													
Income													
Net after Tax		+2,784	+2,784	+2,784	+2,784	+2,784	+ 2,784	+ 2,784	+ 2,784	+ 2,784	+ 2,784		
Depreciation		+ 500	+ 500	+ 500	+ 500	+ 500	+ 500	+ 500	+ 500	+ 500	+ 500		
Working Capital											+ 1,000		
Net Cash Flow	–5,000	+2,284	+3,284	+3,284	+3,284	+3,284	+ 3,284	+ 3,284	+ 3,284	+ 3,284	+ 4,284		
Discount Factor, 6%	1.000	.971	.916	.864	.816	.769	.725	.685	.646	.609	.575	.542	.512
Present Worth	–5,000	+2,218	+3,008	+2,837	+2,680	+2,525	+ 2,381	+ 2,250	+ 2,121	+ 2,000	+ 2,463		
Cumulative Present Worth	–5,000	–2,782	+ 226	+3,063	+5,743	+8,268	+10,649	+12,899	+15,020	+17,020	+19,483		
B.													
Expenditures													
Working Capital				–1,000									
Plant Construction			–8,000										
Research & Dev.	– 250	– 250											
Income													
Net after Tax				+3,792	+3,792	+3,792	+ 3,792	+ 3,792	+ 3,792	+ 3,792	+ 3,792	+ 3,792	+ 3,792
Depreciation				+ 800	+ 800	+ 800	+ 800	+ 800	+ 800	+ 800	+ 800	+ 800	+ 800
Working Capital													+ 1,000
Net Cash Flow	– 250	– 500	–8,000	+3,592	+4,592	+4,592	+ 4,592	+ 4,592	+ 4,592	+ 4,592	+ 4,592	+ 4,592	+ 5,592
Discount Factor	1.0	.971	.916	.864	.816	.769	.725	.685	.646	.609	.575	.542	.512
Present Worth	– 250	– 243	–7,328	+3,103	+3,747	+3,531	+ 3,329	+ 3,146	+ 2,966	+ 2,797	+ 2,640	+ 2,489	+ 2,863
Cumulative Present Worth	– 250	– 493	–7,821	–4,718	– 971	+2,560	+ 5,889	+ 9,035	+12,001	+14,798	+17,438	+19,927	+22,790

A critical value in present worth computations is the discount rate used. Referring to the example, it is apparent that a higher rate would favor Case A, and conversely, a lower rate would make Case B more attractive. Selection of a discount factor is dependent on a company's capital structure, the cost of capital and the earnings from other available investment opportunities.

As pointed out in the article by Bates and Weaver, previously referred to, a complete evaluation must consider both the amount and the timing of cash flows, and present worth is an accurate and versatile criterion. Anyone interested in mineral economics would do well to spend some time exploring the effect of various factors in analyses of this type.

Colorado School of Mines Alumni Association Officers in 1960

EDWIN H. CRABTREE, JR., '27
President

President's Message

I want to express my appreciation to all members for electing me president of the Alumni Association this year. You may be sure that I will give my best efforts to this job, as have my predecessors.

I believe we are very fortunate to have Colonel Wendell Fertig as our new Executive Manager. Wendell's long association with the School and with the Alumni Association will be of particular benefit in working out our problems. We plan to move the Association offices to Guggenheim Hall this summer which should further increase our close relationship with the School to our mutual benefit.

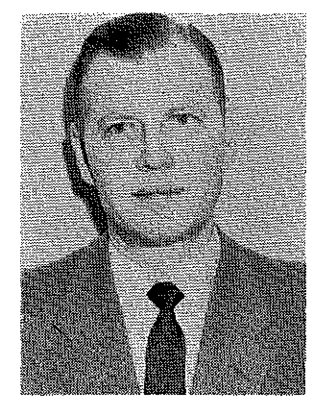
Your Association occupies an enviable position. Yet, we cannot say that all Alumni are doing their share, nor that the Alumni Association cannot be improved. As always, one of our main problems is the need to increase our membership.

You may be surprised to know that of the 4,910 living graduates of the Colorado School of Mines, only 2,900, or 59.2 per cent are affiliated with the Alumni Association.

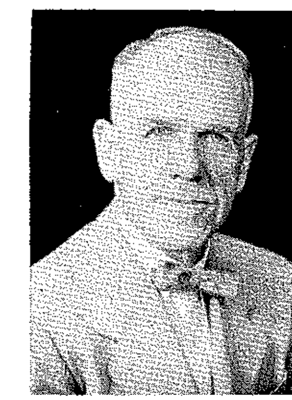
I am sure that many of these graduates who are not members could be persuaded to join, and I appeal to each of you to assist us in persuading these people to become members and enjoy the benefits of the Association.

In succeeding issues of the Mines Magazine we will keep you advised of our activities.

ROBERT W. EVANS, '36
Executive Committee



JOHN M. PETTY, '42
Vice-President



HARVEY MATHEWS, '13
Executive Committee

ROBERT H. WATERMAN, '28
Treasurer

JAMES A. MULLINAX, '47
Secretary

S. M. DEL RIO, '28
Executive Committee

Annual Business Meeting

Colorado School of Mines Alumni Association

The annual business meeting of the Alumni Association and installation of new officers for 1960 was held at the Denver Athletic Club on Thursday evening, Jan. 28. There were 46 members present with classes being represented from '01 through '59 for a range of some 58 years.

Alumni drifted in about 6 o'clock for a few cocktails and stimulating conversation before sitting down to a roast beef and mince pie dinner served at 7 o'clock.

President Frank E. Briber called the meeting to order at 8 p.m. with the observation that he was glad to see members of the faculty present because "as alumni we appreciate what they are doing through the Foundation to build up the School, which has no equal in its field." (Present were Prof. Paul H. Keating of the Geology Department; Prof. Clark F. Barb, head of the Petroleum Engineering Department; Prof. Lute J. Parkinson, head of the Mining Department; Fritz Brennecke, director of athletics; Dave C. Johnston, former faculty member.)

President Briber then touched upon the work of the various committees and said he was sure he was speaking for all alumni in commending committee members for their conscientious efforts in behalf of the Association. He said he especially wished to commend the work of the publications committee for a job well done and to express appreciation to the nominations committee for putting up an extremely strong slate of officers as evinced by the close vote.

"We have been fortunate," President Briber declared, "in securing the services of outstanding men to serve as executive manager. When George Roll asked to be relieved as executive manager, a committee was appointed to select his successor and Col. Wendell W. Fertig has agreed to accept the position as of Feb. 1."

Colonel Fertig replied that while he didn't have any panaceas to offer, he would work to strengthen the Association.

After thanking alumni for the privilege of serving as their president during the past year, President Briber called for committee reports.

In the absence of Robert H. Waterman, Treasurer, George Roll presented the report covering 1959 financial results by separate account functions as follows:

Alumni division receipts were $11,539.39 with disbursements of $11,452.60 for a net gain of $86.79. Magazine division revenue totaled $30,200.59, expenses $29,997.43 (with printing and salaries being the major disbursements) for a profit of $203.16. The 1959 Directory account had receipts of $2,755.00 and disbursements of $2,723.71 for a net gain of $31.29.

Assets at Dec. 31 totaled $14,596.46 largely offset by 1960 deferred dues, magazine and directory subscriptions accumulated at year's end.

Savings account (to which dividends are deposited as received from securities in the Alumni Endowment Fund) held a bank balance on Dec. 31 of $1,130.99.

For the Alumni Endowment Fund, the principal account held a bank balance of $4,275.19 and investments at a cost of $15,881.14 having a market value on Dec. 31, 1959 of $41,649.

Alumni Loan Fund held a balance in checking account of $395.15 and a savings account of $9,444.79 or a total of $9,839.94. Loans outstanding total $2,122.50 giving total assets of $11,962.44.

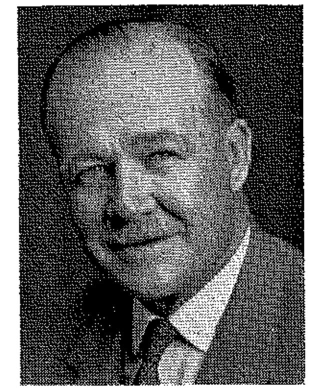
Recognition Fund holds cash in savings account of $943.51.

Kirk Forcade, Chairman of the Publications Committee, reported that the Committee's main concern in 1959 pertained directly to the problem of how the administration of the CSM Alumni Association and its operating staff could enhance Mines Magazine and thereby maintain and foster a better relationship between the Magazine and the Association members at large. He said that problem has many facets—all of which can be cured with money and finances, and this resolves itself into one simply of acquiring additional advertising for Mines Magazine. He reported that the Committee had prepared a recommendation which pertained to a policy and procedure for operation and publication of Mines Magazine. Mr. Forcade said that while such a report (presented to the Executive Committee on Dec. 21) can expect modification, it does establish a basis for operation which is necessary for a successful enterprise.

In the absence of Newell H. Orr (who was transferred to Pittsburgh), Chairman of the Membership Committee, Mr. Roll reported that membership subscriptions to the magazine to Nov. 1 were 2,660 but that 200 alumni were removed from the list on Nov. 1 for nonpayment of dues. Active alumni now total 2,537 and in addition there are about 900 miscellaneous subscribers. Since moving to Golden, the alumni stencil mailing list has been combined with that of the School, and "we have really done a job for the School in bringing their list up to date."

Ron Lestina, Chairman of the Athletic Committee, reported that an average of 37 Mines men had been attending the weekly Tuesday noon meetings of the Denver Quarterback Club during the football season. He said that these meetings, which have been a big factor in reactivating the Denver Section, are now being held at the Denver Press Club on the third Tuesday noon of each month. Lestina reported terrific competition from Ivy League colleges in recruiting athletes for Mines, and said that if each Section could send Mines one athlete per year, the athletic recruiting problem would be solved. He reported seven loans outstanding for $2,122.50 and almost $10,000 on deposit in the bank. He noted a correlation

Executive Manager's Message



COL. WENDELL W. FERTIG

My decision to accept the position of executive manager was based upon the challenge offered rather than the monetary reward involved. Mines Alumni Association has always been dear to my heart, and it is my belief that it should increase in stature and influence in proportion to increased size of the graduating classes.

Back in 1940, Eddie Brook was president of the Association and he said: "Our Alumni Association is a unique organization. Based upon collective effort, it is composed of members fundamentally individualistic in attitude and action." My own experience confirms this, the average Mines alumnus is an individualist. Yet our problem is to divert this individual energy into a team effort. That can be done only if each of you, both those presently active and those who should be, will contribute wholeheartedly. For like it or not, you are marked as a "Mines Man."

George Roll, who has been your executive manager for nearly three years, has done a fine job, and we will miss him. By moving into Guggenheim, we will be in position to profit from the close cooperation with the administration of MINES, and at the same time begin to exert the influence that our association should exert if MINES is to continue to dominate the field of mineral engineering.

To accomplish the impossible requires only the support of each individual alumnus.

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between high attendance at athletic events on the one hand and an increase in Mines enrollment and alumni activity on the other.

Warren Prosser, Chairman of the Public Relations Committee, presented his report (in part) as follows:

"Perhaps this Committee's most commendable effort has been to maintain an even keel and be helpful instead of rocking the boat . . . The Alumni Banquet was held at the University Club May 21 and was well attended . . . The steadily increasing support of the Alumni for the Horizon Plan is good and certainly all should participate and encourage more bequests and greater success for the plan . . . We learned this year that the duties of this Committee should include the problems of the School in relation to the public as well as those of the Alumni Association, especially when those problems are of mutual concern . . . Along legislative lines, we are confined in our activities to inquiry and suggestions with relation to friendly legislators . . . One of our Committee members, Charles Rath, passed away recently and unexpectedly . . . It reminds us of the limitations of life and the usefulness of the Alumnus relentlessly placed thereon. We should learn from this to endeavor to do everything we must do while we can do it."

In the absence of E. S. Hanley, Chairman of the Alumni Endowment Fund Committee, Mr. Roll reported a balance on deposit of $4,275.19 as of Dec. 31.

Bill Cullen, Chairman of the Nominations Committee, reported that on Oct. 15 the Committee submitted a slate of qualified members of the Association as candidates for election to the offices. On Jan. 9, 1960, the Committee with the assistance of George Roll, Robert H. Ferguson and C. H. Jenkins, counted the ballots and certified as elected officers the following candidates who received a majority of the votes cast for each office:

President	Edwin H. Crabtree, Jr., '27
Vice-President	John M. Petty, '42
Secretary	James A. Mullinax, '47
Treasurer	Robert H. Waterman, '28
Member Executive Committee	S. M. del Rio, '28
Director CSM Foundation	Edward J. Brook, '23

President Briber then turned the chair over to the incoming president, Ed Crabtree, who said that he greatly appreciated the honor of serving as Alumni president during the coming year. "I know we have a lot of problems," he said, "but Frank Briber has made progress in solving some of them and with your continued support, I hope to continue that progress. If you have any suggestions or any criticisms, call me at any time."

After being introduced by President Crabtree, Dr. John W Vanderwilt presented an informative review of Mines' activities. "We all realize," he asserted, "that building up the School of Mines is largely one of *keeping up*. Nothing stands still, least of all engineering, and the Board of Trustees is aware that the School must keep abreast of the times."

Dr. Vanderwilt said he had recently attended a meeting in Colorado Springs of the National Council for Education, whose purpose is to bring to the attention of industry the financial problems of education. Representatives of educational institutions at this meeting agreed that alumni play a leading role in providing financial assistance and in inducing industry to make financial contributions to institutions of higher learning.

"As a result," Dr. Vanderwilt asserted, "U. S. Steel Corp. has a foundation whose 'gifts' to education have increased from $50,000 to $2,500,000 per year, and 25 per cent of all alumni who have graduated from U. S. universities contribute another $125,000,000 per year. The close association between a School and its alumni is illustrated by the detail of the mailing list—working together is mutually beneficial."

Mr. Roll, out-going executive manager of the Association, said he would like to make a few comments which might be controversial but which should at least be considered.

"In the first place," he observed, "we might reconsider our definition of 'associate' member. I suggest we provide for automatic membership of men who have attended Mines two, three or four semesters depending on the standards set up by the Association.

"My second suggestion," he continued, "is that we have an Alumni Association Fund administered by alumni trustees to serve the special needs of the activities of the Association as they arise. Such a fund would consolidate all present funds and would eliminate the present system of earmarked funds for definite purposes."

The meeting was closed by the President at 10 p.m.

Those present were:

Dr. John W Vanderwilt; Frank C. Bowman, '01; Tenney C. DeSollar, '04; Warren Prosser, '07; Arthur W. (Pop) Buell, '08; Harvey Mathews, '13; Neil M. MacNeill, '14; Ben C. Essig, '15; Frank E. Briber, '16; Carl A. Blaurock, '16; George H. Roll, '19; Prof. Paul H. Keating, '21; Prof. Lute J. Parkinson, '23; E. J. Brook, '23; Prof. Clark F. Barb, '25; Russell H. Volk, '26; Oran L. Pack, '26; E. H. Crabtree, '27; S. M. del Rio, '28; Cecil R. Walbridge, '29; Parke O. Yingst, '30; Elmer J. Garbella, '30; B. M. Bench, '30; Carl I. Dismant, '31; R. S. Spalding, '33; Jim Colasanti, '35; K. C. Forcade, '36; A. W. Cullen, '36; Wilbur Howard, '36; John N. Gray, '37; F. L. Weigand, '39; W. F. Distler, '39; Walter E. Redmond, '40; W. K. McGlothlin, '40; J. M. Petty, '42; Ralph Bradley, '47; John Bernstein, '47; Ron Lestina, '50; Wendell W. Fertig, '51; Robert E. Johnson, '52; Fred M. Fox, '54; Louis L. Scher, IV, '56; George C. Welch, '59; William H. Smith, '59; Fritz Brennecke, CSM athletic director; Dave Johnson, retired faculty.

ALUMNI ENDOWMENT FUND
Principal Account
December 31, 1959

RECEIPTS

Cash on hand January 1, 1959	$ 1,429.69
One Life Membership	200.00
Alumni Contributions	2,645.50
Balance on Deposit	$ 4,275.19

INVESTMENTS

Securities at Cost	$15,881.14
Market Value of Securities, Dec. 31, 1959	$41,649.00

SAVINGS ACCOUNT
of
Endowment Fund Income
December 31, 1959

RECEIPTS

Cash on hand in bank January 1, 1959	$ 986.54
Interest earned, 1959	39.79
Income from Endowment Fund Securities, 1959	1,489.50
	$ 2,515.83

DISBURSEMENTS

Custodian Fee for Securities	$ 68.22
Transfer to General Fund to cover Capital expense of purchase of Visi-record equipment for Alumni record cards	516.62
Transfer to General Fund of $225.00 to cover extraordinary expense of 1959 Annual Banquet and letter to alumni for replacement of Executive Manager and $575.00 as credit for surplus account to reimburse a balance of 1958 moneys required to pay 1957 expenses	800.00
	$ 1,384.84
Balance on hand and in bank, December 31, 1959 (At Golden Savings & Loan Association)	$ 1,130.99

ALUMNI LOAN FUND
Statement of Funds
December 31, 1959

RECEIPTS

Cash on hand and in Bank, January 1, 1959	$10,340.89
Alumni Contributions	60.00
Payments on Loans	100.00
Interest earned (Savings Account)	350.02
	$10,850.91

DISBURSEMENTS

Loans made in 1959	$ 900.00
Transfer to General Fund to cover cost of football charms awarded to 1958 Co-champions at Athletic Banquet	110.97
	$ 1,010.97
Balance on deposit, December 31, 1959	*$ 9,839.94
Loans outstanding	2,122.50
Total Assets of Alumni Loan Fund	$11,962.44
On deposit—First National Bank of Golden	$ 395.15
On deposit—First Federal Savings and Loan Association	9,444.79
	*$ 9,839.94

RECOGNITION FUND
Statement of Funds
December 31, 1959

Balance on hand January 1, 1959	$ 906.46
Interest earned, 1959	37.05
Balance on deposit, December 31, 1959 (At First Federal Savings & Loan Assn.)	$ 943.51

COLORADO SCHOOL OF MINES ALUMNI ASSOCIATION STATEMENT OF CONDITION
December 31, 1959

ASSETS

First National Bank in Golden		$10,813.39
Petty Cash		50.00
Accounts Receivable		280.30
Furniture & Fixtures	$5,711.83	
Less Reserve For Depreciation	2,361.99	3,349.84
Prepaid Ins. & Bond Premium		102.93
		$14,596.46

LIABILITIES

Deferred Dues—1960		$ 4,585.00
Deferred Magazine Subscriptions 1960		5,725.25
Deferred Directory Subscriptions 1960	$952.00	
Balance 1959 Carried forward to 1960	31.29	983.29
Deferred Prof. & Special Adv.		407.00
Payroll Taxes Withheld		259.69
Surplus		2,336.50
Exchange Accounts		9.78

ALUMNI MAGAZINE TOTAL

Receipts	$11,539.39	$30,200.59	$41,739.98	
Disbursements	11,452.60	29,997.43	41,450.03	
Net Gain	$ 86.79	$ 203.16	$ 289.95	289.95
				$14,596.46

C.S.M. ALUMNI ASSOCIATION STATEMENT OF OPERATIONS
December 31, 1959

ALUMNI DIVISION

RECEIPTS	1959 Total Ended Dec. 31, 1959
Dues	$10,871.50
Banquet	231.00
Unclassified	436.89
Total	$11,539.39

DISBURSEMENTS

Depreciation	$ 389.74
Banquet	362.78
Entertainment & Travel	14.30
Payroll Taxes	220.06
Postage	626.24
Salaries	8,088.04
Supplies	715.40
Taxes	106.56
Telephone	349.73
Unclassified	579.75
Total	$11,452.60
Net Gain (or Loss)	86.79

MAGAZINE DIVISION

RECEIPTS

Advertising	$11,798.46
Prof. & Spec. Adv.	1,500.00
Cuts	5.30
Copies	266.15
Subscription	16,630.08
Unclassified	.60
Total	$30,200.59

DISBURSEMENTS

Discounts	$ 187.92
Cuts	861.94
Payroll Taxes	232.35
Postage	621.00
Printing	16,867.13
Salaries	9,565.28
Supplies	344.75
Telephone	217.86
Wrapping Expense	878.50
Unclassified	220.70
Total	$29,997.43
Net Gain (or Loss)	203.16
TOTAL GAIN	$ 289.95

DIRECTORY ACCOUNT—1959

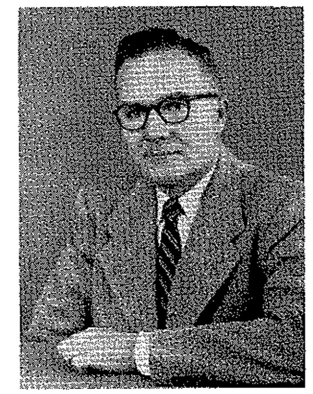
Receipts—Subscriptions	$ 2,755.00
Disbursements	2,723.71
Balance available—1960	$ 31.29

ALUMNI NEWS

Denver Section Schedules Mines Dinner, April 21

Denver Section, CSM Alumni Association, will hold its annual Colorado Mining Convention dinner on Thursday, April 21, at 6 p.m. at the Denver Press Club, 1330 Glenarm Pl.

Dr. Ben H. Parker, '24, Elected AAPG President



Dr. Ben H. Parker, president of the Colorado School of Mines Board of Trustees, has been elected president of the American Association of Petroleum Geologists. He will assume direction of the 15,000 member organization at the close of the 45th annual meeting of the Association, to be held at Atlantic City, N. J., April 25-28.

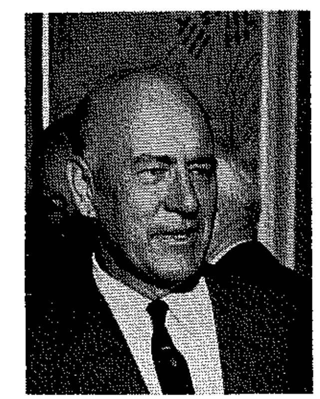
A member of AAPG since 1928, Dr. Parker has served on the Research Committee, the Nominating Committee, and the Business Committee, of which he was co-chairman in 1948; and in 1956 he was vice-president of the Association. He was chairman of the Code of Ethics Committee in 1957, and is presently chairman of the Membership Advisory Committee.

Now vice-president and director of the Frontier Refining Co., Dr. Parker received his E.M. degree in 1924 and his D.Sc. in 1934 from the Colorado School of Mines, and the LL.D. in 1948 from Colorado College. Employed from 1924-31 as a geologist by Marland and Gypsy Oil Companies, he returned (1932-35) to Mines, where he completed work on his doctor's degree while serving as an instructor. In 1935-36 he joined Gulf Oil Corp. as reconnaissance geologist, later returning to Mines as assistant professor of geology (1936-39). From 1939-40 he was assistant chief geologist for Yacimientos Petroliferos Fiscales in Argentina, returning to Mines in 1940 as assicoate professor of geology.

Dr. Parker became vice-president of Frontier in 1942 and director in 1951. Combining the academic and industrial life, he served as president of Mines, 1946-50. He has been a member of the CSM Board of Trustees since 1950 and president of the board since 1957.

Dr. Parker is a fellow of the Geological Society of America, and a member of the American Institute of Mining and Metallurgical Engineers, the Mining and Metallurgical Society of America, the American Petroleum Institute, and the Rocky Mountain Association of Geologists, of which latter organization he was president in 1944.

Mattson, '26, Will Manage Kerr-McGee Mining-Milling



Vernon L. (Bill) Mattson, '26, manager of mineral development and research at Kerr-McGee Oil Industries' research laboratories in Golden, Colo., has been promoted to manager of mining and milling at the company's home office in Oklahoma City. In his new post, Mattson will be in charge of all of Kerr-McGee's mining and milling activities. Wayne C. Hazen, research engineer at the Golden laboratories, will succeed Mattson as manager of mineral development and research.

A 1926 graduate of the Colorado School of Mines, where he majored in mining and metallurgical engineering, Mattson also studied mechanical engineering at Carnegie Institute of Technology, Pittsburgh, Pa.

He joined Kerr-McGee in 1955, after serving six years as director of the Colorado School of Mines Research Foundation. Prior to this, he was chief engineer at the Consolidated Feldspar Corp., Trenton, N. J., and was general manager of a mining company in Burnsville, N. C., for many years.

Since 1954 Kerr-McGee has operated a 500-ton a day uranium mill at Shiprock, N. M. This plant was recently remodeled to include a vanadium recovery unit. The company also has extensive uranium holdings in Wyoming and operates a number of small uranium mines in the Lukachukai Mountains of Arizona. For several years Kerr-McGee has been interested in the development of a major potash property in the Carlsbad District. Other mineral interests include coal deposits in eastern Oklahoma and Arkansas, lithium deposits in the eastern U. S., and borax and other non-metallic mineral deposits at various locations.

Kermac-Nuclear Fuels Corp. operates the largest uranium mill in the United States. The company's mill and five underground uranium mines are located in the Ambrosia Lake District of New Mexico.

Kellogg, '43, Chief Geophysicist For Fairchild Aerial Surveys

William C. Kellogg, '43, has been named chief geophysicist for the newly-formed Exploration Services Department of Fairchild Aerial Surveys Inc., a wholly-owned subsidiary of Fairchild Camera and Instrument Corp.

A 1943 graduate geological engineer from the Colorado School of Mines, Mr. Kellogg first joined Fairchild in 1948 as a member of the Airborne Magnetometer Department. Between 1949 and 1958 he did private consultant work specializing in mining. Prior to his new job as chief geophysicist for the Exploration Services Department, he was a mining specialist in the Geophysical Sales Department. His home address is 3301 N. Marengo, Altadena, Calif.

Donald R. Seals, x-'51, Named Research Chemist for Cook Co.

Donald R. Seals, who attended the Colorado School of Mines (x-'51), has been named research chemist of the Frank R. Cook Co. of Denver, aviation-electronics manufacturing firm. A part of Mr. Seal's duties will be to guide research and development of performance of the Cook firm's batteries, used as electrical power sources on many American missiles. He was formerly chief chemist of Climax Molybdenum Co.

Aldrich, '48, Named Manager Ohio Oil International Sales

Frederick C. Aldrich, '48, has been named manager of Ohio Oil Co.'s newly established International Oil Sales Department with headquarters in London, England. After May 1, 1960, this department will be in charge of all sales of Ohio Oil Co. crude and petroleum liquids in all areas of the world except the United States and Canada.

After graduating as a petroleum engineer from the Colorado School of Mines, Mr. Aldrich was assigned by Ohio Oil to their operations in the Big Horn Basin, subsequently being transferred to Rawlins, Wyo., as gas engineer for the Rocky Mountain Gas Co. (former Ohio Oil Co. subsidiary).

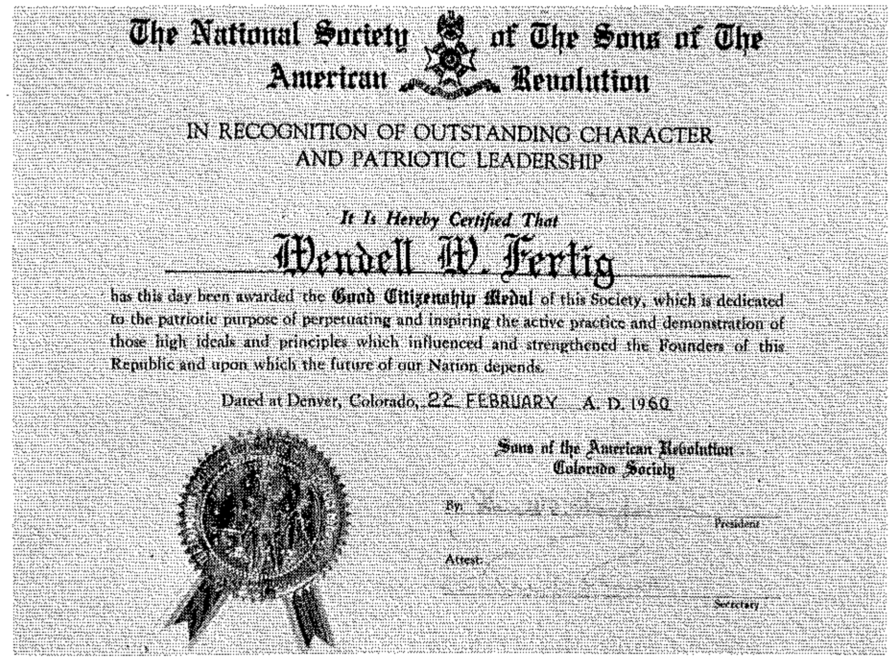
In 1951 he was named production engineer of the Casper Division. Later, he was assigned to the staff of the chief petroleum engineer at the general offices in Findlay, Ohio. His next assignment was supervisor of the Engineering and Contracts Department of the Natural Gas Division. About a year ago he was named manager, Sidney Production Division, Sidney, Nebr.

Colasanti, '35, Becomes President of New Company

James Colasanti, who received his metallurgical engineering degree from the Colorado School of Mines in 1935, became president and treasurer Aug. 1, 1959 of Metal Treating & Brazing Co. of Grand Junction, Colo. H. Carl Flood of Grand Junction is vice-president and secretary of the new company.

Metal Treating & Brazing Co. has its manufacturing operations in Grand Junction and acts as a subcontractor to Western Alloy Products Co. The company's principal product is detachable percussion bits for jackhammer use.

Mr. Colasanti has owned and managed Metal Treating & Research Co. of Denver, Colo., since 1945.



The National Society of The Sons of The American Revolution

IN RECOGNITION OF OUTSTANDING CHARACTER AND PATRIOTIC LEADERSHIP

It Is Hereby Certified That

Wendell W. Fertig

has this day been awarded the Good Citizenship Medal of this Society, which is dedicated to the patriotic purpose of perpetuating and inspiring the active practice and demonstration of those high ideals and principles which influenced and strengthened the Founders of this Republic and upon which the future of our Nation depends.

Dated at Denver, Colorado, 22 FEBRUARY A. D. 1960

Sons of the American Revolution
Colorado Society

By: ______ President

Attest: ______ Secretary

▼Shown above is the Good Citizenship award presented Feb. 22 to Col. Wendell W. Fertig, executive manager of the Colorado School of Mines Alumni Association, by the National Society of the Sons of the American Revolution.

Col. Fertig, '51, Awarded Good Citizenship Medal

Col. Wendell W. Fertig, executive manager of the Colorado School of Mines Alumni Association, was honored at the annual Washington's birthday banquet (Feb. 22) of the Colorado Society of the Sons of the American Revolution. He received the organization's Good Citizenship Medal and a Citation which read in part:

"Wendell W. Fertig, native son of Colorado, mining engineer, soldier, author, lecturer, educator and outstanding citizen of our State and Nation . . . enrolled in 1917 in the College of Engineering of the University of Colorado . . . later transferring to the Colorado School of Mines. In 1924 having qualified as a mining engineer, he began the practice of his profession, working thereafter in most of the western states and also in the Philippine Islands.

"Prior to the outbreak of World War II, having held a commission as a reserve officer in the Army of the United States since 1924, he volunteered for active duty with the Philippine Department of the U. S. Army. After the surrender of the American Forces in May of 1942, Colonel Fertig . . . set about organizing and equipping ground forces to disrupt, disorganize, delay and confuse, and ultimately defeat the Japanese Forces in the Philippines. In September 1942, he became Commander of the Philippine Regular and Guerrilla Forces in the Southern Philippines . . . After more than three years of resistance, Colonel Fertig's Forces recaptured most of the Island of Mindanao . . .

"Colonel Fertig was integrated into the regular Army in 1947 and was assigned as PMS&T at the Colorado School of Mines, and during the last year of his tour also served as Assistant to the President of said School . . . In 1951 he was awarded the Honorary Degree of Doctor of Science by the Colorado School of Mines . . .

"Colonel Fertig's military activities, in addition to those mentioned above, include the following: Chief of Construction Division AFPAC, responsible for all construction west of Hawaii, Deputy Chief of Psychological Warfare, and as such was responsible for the organization, activation and training of the Army's Special Forces Command . . . He originated and delivered a series of lectures on Psychological and Guerrilla Warfare which have become the standard for U. S. Service Schools. In 1954-55 he served as Deputy Director, Joint Staff PROVMAAG-Korea. He retired from the U. S. Army in January 1956 with the rank of Colonel, Corps of Engineers.

"Colonel Fertig, in recognition of your demonstrated and dedicated devotion to your Country in peace and war, and in appreciation of your outstanding service as an American Citizen, the Colorado Society of the Sons of the American Revolution is proud to award you our 1959 Good Citizenship Medal and Citation."

McKinnis, '59, Top Man In Chemical Corps Class

Charles H. McKinnis, 1959 Mines petroleum engineering graduate, recently completed the officers course at the U. S. Army Chemical School, Fort McClellan, Ala., as top man in his class. McKinnis, commissioned as a second lieutenant through the Mines ROTC program, competed against 41 other Chemical Corps officers from schools throughout the nation. Lieutenant McKinnis is currently assigned to two years active duty in the U. S. Army.

Hustang Farkham, '39, Deputy Director Iranian Oil Co.

Hustang Farkhan, a 1939 petroleum engineering graduate of the Colorado School of Mines, is deputy exploration and production director of National Iranian Oil Co. He is also a member of the board of directors of Iran Oil Co. and a member of the board of directors of SIRIP (Irano-Italian Oil Co.). His mailing address is c/o National Iranian Oil Co., North Villa Ave., Khabir St., Tehran, Iran.

CLASS NOTES

(Continued from page 2)

ROLF H. HANSON, '32, has changed his mailing address from Ranli, Honduras, to c/o Rosita Mines Ltd., Siuna via Managua, Nicaragua, C. A.

EDGAR C. NORMAN, '33, is metallic materials engineer for Thiokol Chemical Corp. with mailing address 555 S. 7th West, Brigham City, Utah.

JAMES S. KENNEDY, '34, has moved from Stamford, Conn., to 916 Abbott St., Latrobe, Pa.

PHILIP B. PEYTON, '35, has moved from Los Angeles to 836½ N. Van Ness Ave., Hollywood 38, Calif.

LLOYD T. ANDREW, '35, engineer for Crosley-Arco Corp., has left St. Louis, Mo., for 1586 Crest Hill Ave., Cincinnati 37, Ohio.

JACK S. CORLEW, '39, has moved from Darien, Conn., to 4520 Garland St., Arvada, Colo.

I. C. SLEIGHT, '40, is manager of manufacturing, Solid Rocket Plant, Aerojet-General Corp., with mailing address 960 Los Molinos Way, Sacramento 25, Calif.

GENE MEYER, '37, research engineer, Kerr-McGee Oil Industries, Box 215, Wheat Ridge, Colo., was a recent visitor at the alumni office.

1941-'45

COL. LOUIS DEGOES, '41, is chief, Terrestrial Sciences Lab., Geophysics Research, ARDC, L. G. Hansom Field, Bedford, Mass. His mailing address is 21 Hamilton Rd., Lexington, Mass.

F. W. O'MALLEY, '42, formerly with Tidewater Oil Co. in Turkey, has joined Iran Pan American Oil Co. as exploration manager. His new address is P. O. Box 1466, Tehran, Iran.

KARL M. BUEHLER, '42, has changed his mailing address from Wheat Ridge, Colo., to c/o Katex Oil Co., 313 Lancaster Bldg., Calgary, Alberta.

ROGER B. PATRICK, '42, design engineer for Kermac Nuclear Fuels, Grants, N. M., was called to Denver by the death of his father, William B. Patrick, '09. While in the Denver area, he visited the Alumni office.

1946-'50

JOHN F. SCHULTZE, '48, has changed his mailing address from Ducktown, Tenn., to Box 12, Isabella, Tenn.

MILTON E. WARREN, '48, sales engineer, Electric Boat Division of General Dynamics, has moved from Fairfield, Conn., to 105 College St., Old Saybrook, Conn.

RODNEY L. SAMUELSON, '48, is mechanical engineer, University of California, Rad. Lab., with mailing address 3720 Riviera Ave., Las Vegas, Nev.

HARRY E. LAWRENCE, '48, recently resigned his position as smelting superintendent for Goldsmith Bros. Division of National Lead, Chicago, Ill., to accept the position of assistant superintendent of melting and refining at the U. S. Mint in Denver. He is presently residing with his wife, Carmen, and two sons at 5075 Dover, Arvada, Colo.

R. M. FROST, '48, has moved from Merriam, Kans., to 2425 W. Spring, Lima, Ohio.

FREDERICK F. DUESER, '49, is division production superintendent for Grarioge Corp. with mailing address Box 752, Breckenridge, Texas.

JOHN D. MITILINEOS, '49, lives at 2110 Stuart St., Brooklyn, N. Y.

JOHN R. NEWBY, '49, is metallurgist for Armco Steel Corp. His home address is 2405 Flemming Rd., Middletown, Ohio.

C. M. CHAPPELL, '49, formerly with Shell Oil Co., has opened a geophysical consulting service specializing in geological - geophysical, stratigraphic - structural interpretations. His home address is 3603 S. Hudson St., Denver 22, Colo.

KARL LAMBERTSON, '49, has left Maybell, Colo., and now receives his mail at Box 264, Craig, Colo.

CLEMENT R. HOFMANN, '49, has moved from Denver, Colo., to 4971 S. Elati, Englewood, Colo.

DONALD R. SILJESTROM, '49, has moved from Lakewood, Colo., to 2930 Indiana, Golden, Colo.

MERTON I. SIGNER, '50, is living at 1337 Oxford St., Deerfield, Ill. He was formerly in Esterhazy, Canada.

PAUL S. PLUMB, '50, is senior geophysicist for Guatemala California Petroleum Co. His address is Apartado 1307, Guatemala City, Guatemala.

HENRY P. EHRLINGER, III, '50, has moved from El Paso, Texas, to Tecolotes Club, Santa Barbara, Chih., Mexico.

DONALD H. BLAIRE, x-'50, party chief for Continental Oil Co., receives mail at P. O. Box 1985, Andrews, Texas.

HUBERT E. BERNINGHAUSEN, '50, may be addressed at Room 605, Ritzflower Hotel, 813 S. Flower St., Los Angeles 17, Calif.

HOWARD A. ANDERSON, JR., '50, major in the U. S. Marine Corps, is inspector-instructor, 9th Engr. Co. USMCR, Phoenix, Ariz. His mailing address is c/o Navy Marine Corps Reserve Training Center, 2042 W. Thomas Rd., Phoenix, Ariz.

BILLIE L. BESSINGER, '50, field engineer for Hughes Tool Co., gives his new home address as 2612 Willow Brook Lane, Birmingham 9, Ala.

BILLY G. BAUGH, '50, has been transferred by Seismograph Service Corp. from Caracas, Venezuela, to Tulsa, Okla. His mailing address is P. O. Box 1590, Tulsa, Okla.

RALPH L. "Buzz" BOYERS is now working for Ball Associates as a petroleum engineer. Prior to joining Ball Associates, he was in Midland, Texas for eight months. The Boyers (they were married Jan. 1, 1960) live at 2620 S. Sherman St., Denver 10, Colo.

1951

ROBERT W. DIETLEIN, is President of Components Engineering & Manufacturing Co. His home address is 2904 Harmony Pl., La Crescenta, Calif.

FRANK M. DUBINSKY, geologist for Standard Oil of Calif., has moved from Charleroi, Pa., to 1051 Eugene Dr., Fullerton, Calif.

CHARLES D. HOYT, who was Assistant Professor of Mining at The Technical Institute, Bandung, Indonesia, has returned to the United States. His new address is 271 Jordan Ave., Montoursville, Pa.

WAYNE E. McNEELY is production supervisor for Mobil Oil Co. His home address is 1027 Gibson, Alice, Texas.

EDWIN H. MONTGOMERY has moved from Arvada, Colo., to 2200 Saranac St., Adelphi, Md.

JAMES C. TIFFANY has moved from Fairplay, Colo., to Sunshine Star Rte., Kellogg, Idaho, where he is employed by Sunshine Mining Co.

GERALD J. PORT has left Midland, Texas, for 82 N. Elm St., Manchester, Conn.

LT. COL. JOHN E. VEATCH, Army Planner on Cinc Pac Staff, may be addressed at 3519 Pauka Mauka Dr., Honolulu, Hawaii.

1952

BURTON W. BARNES has moved from Bellaire, Texas, to 5726 Belrose, Houston 35, Texas.

RAYMOND W. GOVETT received a Ph.D. in geology from Oklahoma University and has returned to his position of geologist with Phillips Petroleum Co. His home address is 230 Southeast Elmhurst, Bartlesville, Okla.

EDGAR W. DAVIS, who has been working with the inspection department of Lago Oil & Transport Co. at Aruba, Netherland Antilles, has returned to Mines to complete his graduate work in mining engineering. His current address is No. 9, Prospector Park, Golden, Colo.

WILLARD A. MAXEY is a member of the staff of Battelle Memorial Institute. His address is 4953 Fairway Ct., Columbus 14, Ohio.

RODERICK A. THOMAS, JR., was awarded a Master of Science degree at the Jan. 31 commencement ceremonies of Pennsylvania State University. His mailing address is P.O. Box 635, Port-of-Spain, Trinidad, W.I.

1953

HAROLD P. DUNN, petroleum engineer for Standard Vacuum Oil Co., has moved from New York City, to Tatomuck Rd., Pound Ridge, N. Y.

ADOLPH "Joe" FRISCH is district engineer with Belco Petroleum Corp. with mailing address 1824 N. 19th St., Grand Junction, Colo.

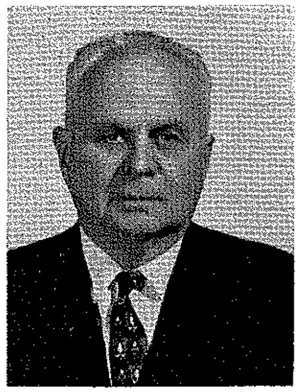
LAWRENCE M. LEE may be addressed at P. O. Box 714, Cascadia, Ore.

LE MOYNE G. LOSEKE has moved from Denver to 2060 Alkire St., Golden, Colo.

(Continued on page 43)

IN MEMORIAM

Raymond Victor Whetsel



R. V. Whetsel, who received his E.M. degree in 1916 from the Colorado School of Mines, died Jan. 12 at St. Mary's Hospital in Grand Junction, Colo. Services were held at the Federated Church in Paonia, Colo., with interment in Cedar Hill Cemetery where an honor guard comprised of members of Wilson-Head Post 97, American Legion, conducted graveside rites.

A 1949 recipient of the Colorado School of Mines' Distinguished Achievement Award, Mr. Whetsel retired in 1958 after serving 17 years as manager of the foreign department of Cities Service Petroleum Corp. Officerships held by Mr. Whetsel included those of vice president and general manager, Venezuela-Cities Service Petroleum Corp.; vice president and director, Mexico-Cities Service Petroleum Corp., Canada-Cities Service Petroleum Corp., Cities Service Mid-East Oil Corp., Colombia-Cities Service Petroleum Corp., Dhofar-Cities Service Petroleum Corp. and Peruvian Pacific Petroleum Corp.

Mr. Whetsel was born at Fortville, Ind., Dec. 29, 1891 and was a graduate of both Mines and Purdue University. A veteran of World War I, he served in the U. S. Army Field Artillery. From 1916 to 1918 he was field geologist, Burma Mines, Ltd., Northern Shan States, Burma, India; from 1919 to 1920, geologist, tool dresser, production superintendent and field superintendent, Cities Service Co., Mexico; from 1925 to 1929, assistant general manager and then general manager of Cities Service properties in Mexico; from 1929 to 1932, European manager with headquarters in Paris, France; from 1932 to 1941, manager of Cities Service properties in Mexico and special investigator in Texas, New Mexico and Louisiana; from 1941 to 1958, manager, foreign department, Cities Service Petroleum Corp.

Organizations to which he belonged included American Institute of Mining and Metallurgical Engineers, American Association of Petroleum Geologists, American Petroleum Institute, Sigma Chi, Theta Tau, Tau Beta Pi, Masonic Lodge, American Legion, and Rotary Club. The R. V. Whetsel Foundation, to be administered by Rotarians of Paonia, will grant loans to deserving high school seniors to enable them to continue their education.

Survivors include his wife, Ethel Bell Fronk Whetsel of Paonia; three daughters, Louise (Mrs. Robert Goss of New York City), Janet (Mrs. R. I. Curts) of Washington, D. C., and Elizabeth (Mrs. Richard Boyt) of Grimes, Iowa; his 93-year-old mother, Mrs. Hattie Whetsel of Indianapolis, Ind., and two sisters, Mrs. Hortense Kelly and Mrs. Gertrude Blackburn, both of Westfield, N. J.

Axel Emil Anderson

Axel Emil Anderson, a 1904 mining engineering graduate of the Colorado School of Mines, died Jan. 10 in Seattle General Hospital after a long illness.

An internationally known explosives expert, Mr. Anderson was a consultant for various governments throughout the world as well as the United States Army. He was decorated by the Belgian, Peruvian and Chilean governments and was the recipient in 1949 of the Colorado School of Mines' Distinguished Achievement Award.

The author of many texts and technical papers on explosives, he was a member of the American Institute of Mining Engineers, serving as chairman of the North Pacific Section in 1944 and 1945; a life member of the Colorado School of Mines Alumni Association, and held active membership in such organizations as the Seattle Chamber of Commerce, Washington Athletic Club, Corinthian Yacht Club, Beta Theta Pi fraternity, and St. Stephen's Episcopal Church.

Born Aug. 17, 1881 in Denver, Colo., he attended Denver elementary and secondary schools before receiving his E.M. degree from Mines in 1904. After graduation he took charge of the School of Mines' assay and chemical laboratory exhibit at the 1904 World's Fair in St. Louis. From 1904 to 1907 he worked successively for gold mines in Georgia, a coal company in Illinois and an engineering firm in Chicago as a mining engineer.

Mr. Anderson joined the Du Pont Company in Wilmington, Del., in 1907, and after a year as a sales representative was assigned to the technical division of the explosives department. In 1916 he was transferred to the Denver Branch as technical representative and later became assistant manager. In 1930 he was made assistant manager of Seattle district sales. He was appointed manager in 1940 and served in that capacity until his retirement on pension Sept. 1, 1947. Recalled to service a few months later, he served two years as general manager of Compania Sud-Americana de Explosivos (Du Pont subsidiary) in Vina del Mar, Chile.

Surviving are his wife, Janet S. of Seattle; a daughter, Mrs. Emil Cahen of Portland, Ore.; a sister, Mrs. Ida M. Anderson of Denver, and two grandchildren.

Charles W. Burgess

Charles W. Burgess, a 1909 mining engineering graduate of the Colorado School of Mines, died of a heart ailment Dec. 25, 1959 at the Swedish Hospital, in Englewood, Colo.

Born in 1886 in Garfield, Colo., now just a ghost town, he moved to Denver at an early age and graduated from West Denver High School in 1905. Following his graduation from Mines in 1909, he went to the Joplin mining district of southwest Missouri where he was active for the next ten years.

Leaving the lead and zinc mines of Missouri, he accepted a position as sales engineer with the Dorr Co. at Stamford, Conn. After serving as export manager for Dorr, he was promoted to manager of the Far East operations with headquarters at Baguio, Philippines. During World War II, he was interned for nearly four years by the Japanese. Upon his release he returned to the United States and resumed work with the Dorr Co.

Mr. Burgess retired in 1957 and entered the consulting metallurgy field in Missouri; later moving to Castle Rock, Colo., where he made his home with his brother, Ed Burgess.

Mr. Burgess was presented a Golden Anniversary diploma, commemorating his long interest in Mines, at the 85th annual commencement exercises last June.

FROM THE LOCAL SECTIONS

Minutes of Section Meetings should be in the Alumni Office by the 15th of the Month preceding Publication.

ALABAMA

Birmingham Section
Pres.: Joseph Hohl, '25
Sec.: Richard White, '42
249 Flint Dr., Fairfield

ARIZONA

Arizona Section
Pres.: Bob Thurmond, '43
V. Pres.: Gene Klein, '43
Sec.: John H. Bassarear, '50
c/o Pima Mining Co., Box 7187, Tucson
Annual meetings: First Monday in December; 3rd Sunday in May (annual picnic).

Four Corners Section
See New Mexico for officers

CALIFORNIA

Bay Cities Section
Pres.: John D. Noll, '51
V. Pres.: Ralph D. Eakin, '48
Treas.: Herbert D. Torpey, '51
Sec.: Charles G. Bynum, '26
2810 Loyola Ave., Richmond

Southern California Section
Pres.: W. C. Prigge, '42
V. Pres.: R. E. McGraw, '53
Treas.: J. R. Leonard, '42
Sec.: M. C. McKinnon, '52
9826 Corella Ave., Whittier

COLORADO

Denver Section
Pres.: Ed. Haymaker, '41
V. Pres.: M. John Bernstein, '47
Sec.-Treas.: Douglas Rogers, '48
TA 5-2307
Luncheon meetings held every 3rd Tuesday noon of each month at the Denver Press Club, 1330 Glenarm Pl.

Four Corners Section
See New Mexico for officers

Grand Junction Section
Pres.: John Emerson, '38
V. Pres.: Tony Corbetta, '48
Sec.-Treas.: Joe Hopkins, Ex-'37
1235 Ouray Ave., Grand Junction

DISTRICT OF COLUMBIA

Washington, D. C. Section
Pres.: Charles T. Baroch, '23
V. Pres.: Vincent G. Gioia, '56
Sec.-Treas.: Thomas E. Howard, '41
9511 Nowell Dr., Bethesda 14, Md.
Luncheon meetings held every 2nd Thurs. noon at Sphinx Club, 1315 K St., N.W.

ILLINOIS

Great Lakes Section (Chicago)
Next meeting on April 6; call Ray Watson, c/o Standard Oil Co., 910 So. Michigan Ave., Chicago 80, Ill.

KANSAS

Kansas Section
Pres.: Francis Page, '39
Sec.: James Daniels, '51, AM 5-0614
205 Brown Bldg., Wichita
Meetings: Called by Sec. Contact Sec. for date of next meeting

LOUISIANA

New Orleans Section
Pres.: George Burgess, '49
V. Pres.: Emory V. Dedman, '50
Sec.-Treas.: Thomas G. Fails, '54
Shell Oil Co., Box 193, New Orleans

MINNESOTA

Iron Range Section
Pres.: Paul Shanklin, '49
V. Pres.: Leon Keller, '43
Sec.-Treas.: James Bingel, '53
50 Garden Dr., Mt. Iron, Minn.
Exec. Com.: Wm. Gasper, '43 and Robert Shipley, '52

MISSOURI

St. Louis Section
Pres.: Earl L. H. Sackett, '33
Sec.-Treas.: E. W. Markwardt, X-'32
621 Union Ave., Belleville, Ill.

MONTANA

Montana Section
Pres.: John Suttie, '42
V. Pres.: John Bolles, '49
Sec.-Treas.: Wm. Catrow, '41
821 W. Silver St., Butte

NEW MEXICO

Four Corners Section
Pres.: Dick Banks, '53
V. Pres.: Tony King, '57
Sec. Treas.: Tom Allen, '41
2104 E. 12th St., Farmington

NEW YORK

New York Section
Pres. & Treas.: Ben F. Zwick, '29
Sec.: H. D. Thornton, '40
Union Carbide Corp.
30 E. 42nd St., New York City

OHIO

Central Ohio Section
Pres.: Roland Fischer, '42
Sec.-Treas.: Frank Stephens, Jr., '42
Battelle Mem. Inst., Columbus

Cleveland Section
Pres.: Charles Irish, '50
Treas.: Theodore Salim, '53

Pennsylvania-Ohio Section
See Pennsylvania for officers

OKLAHOMA

Bartlesville Section
Pres.: R. C. Loring, '37 and '39
V. Pres.: C. T. Brandt, '43
Sec.-Treas.: W. K. Shack, '51
4726 Amherst Dr., Bartlesville

Oklahoma City Section
Pres.: Lynn Ervin, '40
V. Pres.: Clayton Kerr, '30
Meetings the 1st and 3rd Tuesday of each month at the Oklahoma Club

Tulsa Section
Pres.: Parke Huntington, '26
V. Pres.: Jerry Diver, '52
Sec.-Treas.: Jim Newell, '52

PENNSYLVANIA

Eastern Pennsylvania Section
Pres.: Samuel Hochberger, '48
V. Pres., Sec-Treas.: Arthur Most, Jr., '38
91 7th St., Fullerton

Pennslvania-Ohio Section
Pres.: L. M. Hovart, '50
Sec.-Treas.: George Schenck, '52
7130 Thomas Blvd., Pittsburgh
Meetings upon call of the secretary

TEXAS

Houston Section
Pres.: Jack Earl, '53
V. Pres.: John C. Capshaw, '54
Sec.-Treas.: Nick Shiftar, '40
5132 Mimosa St.,
Bellaire, Texas

North Central Section
V. Pres.: Howard Itten, '41
Sec.-Treas.: Harley Holliday, '42
4505 Arcady Ave., Dallas 5
Sec.-Treas.: S Geffen, Ex-'42, Ft. Worth
Sec.-Treas.: John Thornton, '50
609-B Scott St., Wichita Falls

Permian Basin Section
Pres.: Van Howbert, '51
V. Pres.: Hal Ballew, '51
Sec.-Treas.: Tom McLaren, '52
P. O. Box 1600, Midland
Luncheon meetings held first Friday of each month at Midland Elk's Club.

South Texas Section
Pres.: James Wilkerson, '31
V. Pres.: Edward Warren, '50
Sec.-Treas.: Richard Storm, '53
1007 Milam Bldg., San Antonio

UTAH

Four Corners Section
See New Mexico for officers

Salt Lake City Section
V. Pres.: Joe Rosenbaum, '34
Sec.-Treas.: Kenneth Matheson, Jr., '48
614 13th Ave., Salt Lake City

WASHINGTON

Pacific Northwest Section
Pres.: Wm. Douglass, '11
Sec.: C. Ted Robinson, '53
16204 S.E. 8th, Belleview

WYOMING

Central Wyoming Section
Pres.: John Newhouser, '50
Sec.: Adolph Frisch, '53
2805 O'Dell Ave., Casper

LOCAL SECTIONS OUTSIDE U. S. A.

CANADA

Calgary Section
Pres.: R. F. Zimmerly, '47
V. Pres.: J. S. Irwin, Jr., '54
Sec.-Treas.: G. L. Gray, '50
1304 4th St. S.W., Calgary
Luncheon meetings held 3rd Monday of each month in Calgary Petroleum Club; visiting alumni welcome.

PERU

Lima Section

Pres.: Richard Spencer, '34
V. Pres.: Hernando LaBarthe, '42
Sec.-Treas.: Norman Zehr, '52
Casilla 2261, Lima
Meetings first Friday of each month, 12:30 p.m., Hotel Crillon (April through December), or on call.

PHILIPPINES

Baguio Section

Pres.: Francisco Joaquin, '26
V. Pres.: Claude Fertig, x-'27
Sec.: P. Avelino Suarez
Balatoc Mining Co., Zambales

Manila Section

Pres.: Anselmo Claudio, Jr., '41
V. Pres.: Rolando Espino, '41
Sec.-Treas.: Edgardo Villavicencio, x-'40

TURKEY

Ankara Section

Alumni visiting Turkey contact either: F. Ward O'Malley, '42, Explr. Mgr., Tidewater Oil Co., Kumrular Sokakb, Yenisehir Ankara; Tel. No. 21328.
Ferhan Sanlav, '49, Turkiye Petrolleri A. O. Sakarya Caddesi 24, Ankara; Tel. No. 23144.

VENEZUELA

Caracas Section

Pres.: William A. Austin, Jr., '27
V. Pres.: G. V. Atkinson, '48
Sec.-Treas.: T. E. Johnson, '52
c/o Phillips Petr. Co.
Aptdo 1031
Asst. Sec.-Treas.: R. L. Menk, '51
c/o Creole Petr. Corp.
Aptdo 889

Arizona Section

John H. Bassarear, acting secretary-treasurer, reports that the annual luncheon meeting of the Arizona Section was held Dec. 7 at the Old Pueblo Club in Tucson during the Arizona AIME convention. A total of 67 persons were at the luncheon, including 36 Miners, wives and guests.

Dean Truman H. Kuhn gave a talk which brought us up to date on the changes at Mines in recent years, including new buildings, changes in curriculum, and plans for the future. Dean Kuhn's remarks concerning a trial of offering calculus in the freshman year brought groans of despair from those who had suffered through the course as sophomores.

Miners attending the meeting were:

Irwin P. Jones, '08; H. D. Phelps, '10; F. M. Stephens, '13; L. A. Stewart, '15; E. F. Reed, '22; H. D. Squibb, '34; C. W. Gustafson, x-'34; W. D. Caton, '35; J. M. Pardee and J. E. Werner, 36; Sigmund L. Smith, J. R. Bonne, and Tench G. Swartz, '39; Walter E. Heinrichs, Paul Fillo, '40; L. S. Helms, Jr., '41; R. E. Simpson, '42; R. E. Thurmond, Gene Klein, '43; E. P. Jardine, '47; W. J. Coulter, '48; A. W. Ruff, '49; J. H. Bassarear, H. Johnson, F. D. MacKenzie, Roger Nelson, H. W. Olmstead, F. D. Rice, '50; Paul Musgrove, '51; F. A. Seward, S. C. Holmes, '53; C. Sorvisto, F. L. Stubbs, S. W. Towle, '54; H. M. Conger, '55; C. E. Stott, '56; C. A. Wenner, '57.

Billie L. Bessinger, '50, our former secretary-treasurer, has moved to Birmingham, Ala., as field engineer for Hughes Tool Co. Bob Thurmond has asked me to fill in as acting secretary-treasurer until our next election of officers in the spring.

Denver Section

Mines men attending the regular luncheon meeting of the Denver Section were:

Warren Prosser, x-'07; Harvey Mathews, '13; George H. Roll, '19; Oran L. Pack, '26; Hugh A. Wallis, '28; Otto L. Schmitt, '35; Bill Cullen, '36; Sam Geffen, x-'42; Clyde V. Johnson, '45; James A. Mullinax, Frank Seeton, '47; John J. Flynn, '48; Norman L. Johnson, James M. Taylor, Ron Lestina, Dick Martin, Ralph Jones, '50; Boris S. Voukovitch, Howard K. Loenshal, Wendell W. Fertig, Charles M. Stoddard, '51; Marvin A. Kunde, Drexel Lee, '52; J. B. Fernstrom, '53; Fred M. Fox, M. S. Legge, '54; George Welch, '59.

Also attending were Vincent P. Tesone, Mines' Little All American football player; Fritz Brennecke, CSM athletic director, and Jim Sankovitz, CSM public information editor. (See picture and story in Ore-digger Sports.)

Grand Junction Section

Joe Hopkins, Jr., secretary, reports that Grand Junction Section had its party on Jan. 23 with cocktails at Alan Simpson's and dinner at the Caravan Cafe. Everyone had prime rib and 37 dinners were served. Dancing was to the electric organ.

Moab was represented by Gordon Miner and Jay Mayhew and wives.

Marge and David Cole, '52, have a new home address at 1530 E. Sherwood Dr. in Grand Junction. He commutes to Telluride weekly.

The Charles V. Woodards, '44, and Alan M. Simpsons, '44, spent a week in Las Vegas recently and the Woodards are now planning an Hawaiian excursion taking his parents as guests. They plan to visit the Julian Simpsons, '47, now residing in Hawaii.

A. George (Tony) Setter, '32, has been promoted from manager of the Grand Junction Branch of Western Machinery Co. to mining consultant of the firm for the Industrial Sales Division in the western United States. He will continue to headquarter in Grand Junction at least for the immediate future.

Houston Section

The following Mines men attended the luncheon on Feb. 2 at the Houston Club:

Albert G. Wolf, '07; D. M. Davis, '25; Bart DeLaat, '30; Donald Herbert, Merl Gilbreath, '33; R. A. Kerr, '36; W. B. Barbour, '37; S. A. Werkstrom, '38; John Biegel, '39; Nick Shiftar, J. Pawley, '40; J. N. Warren, '50; Robert Turley, '52.

No business was transacted.

Nick Shiftar, sec.-treas.

New York Section

The New York Section held its first meeting of the year on Feb. 2 at the Brass Rail Restaurant, 40th and Park. Twenty-five alumni were present. They were:

J. A. Clark and G. F. Kaufmann, '21; Harry L. McNeill, '24; Dale Nix, '26; C. A. Weintz, '27; George Ordonez, '28; Ben F. Zwick, '29; Bill Wallis, '30; James Boyd, H. C. Harris, '32; Frank Coolbaugh, '33; Charles N. Bellm, '34; T. P. Turchan, '35; Herb Stuart, '36; Brad Bailey, '37; Ralph C. Holmer and James G. Cox, '38; Van Donohoo, '39; Elmore M. Peloubet, '41; Charles F. Fogarty, '42; Lew Railing and David B. Mazer, 47; Herb Goodman and Milt Warren, '48; I. E. McKeever, '52.

A solicitation to Herb Thornton from J. D. Longenecker, president of the AIME Student Chapter at Golden, for funds to finance the trip of one student to the annual AIME convention in New York was discussed. As a result of this solicitation, Messrs. Zwick and Thornton requested donations from the New York alumni and collected $250. However, several of the members requested that part of their contributions be used to finance the expenses of the New York Chapter.

Charles Fogarty, vice president of Texas Gulf Sulphur Co., brought up the point that Longenecker had also solicited funds for the same purpose from individuals and companies, and reported his company had donated $400 to the AIME Student Fund.

Considerable discussion ensued regarding disposal of the contributions. Some said a portion of the funds should be given to the Student Fund and part to the Foundation. However, it was finally agreed that the Chapter President be authorized to send Dr. Vanderwilt a check payable to the Colorado School of Mines Foundation, Inc., asking him to use his judgment as to whether the total amount should be given to the AIME Student Fund or part to the Student Fund and part to the Foundation's General Fund or all to the Foundation. It was decided the amount of the check should be $230 with the difference going to pay Section expenses. At the meeting an additional $51 was collected to go into the general fund of the Section.

Ben F. Zwick, president

(Dr. Vanderwilt advised that the entire $230 was contributed to the general fund of the Mines Foundation.)

CAMPUS HEADLINES

Combination of Academic and Physical Fitness Education Stressed at Colorado School of Mines

By
JAMES L. SANKOVITZ
Editor, CSM Office of Public Information

Many people argue the value of physical education as a legitimate portion of higher education. Far too many examples of the trite "basket-weaving and underwater dancing" courses have left doubts in the minds of the public that college physical training has any value at all.

Nearly 5000 Colorado School of Mines graduates dot the globe and the great majority hold higher echelon positions in the world's mineral industries.

Mines graduates have had much to do with the prestige ranking which the School now enjoys. Not only have these alumni gained positions of high responsibility because of their professional training, but the majority have carried into their career the continuance of an educational process geared to the whole man. No small part of this total education is in the physical fitness area.

Mineral engineering, in many cases, takes place in the unchecked and far removed areas of the world. The human difficulties are obvious when one considers hewing away a forest to harness petroleum products or spending long weeks in mountainous terrain as part of a geological engineering crew. So too, as with the academic courses, physical fitness courses at Mines are prepared to meet professional life standards.

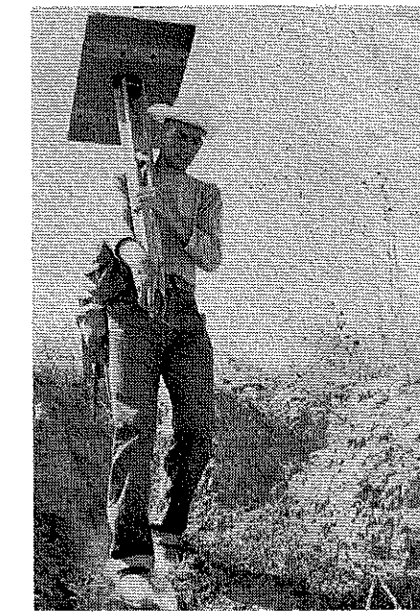
Physical Fitness Classes

This is accomplished through four means. Physical fitness classes, which meet formally two hours a week for all freshmen and sophomore students, are the basic requirements.

Participation in intramural sports is another means, and more than 200 students participated in this method of athletic activity last school year.

The third means is participation in intercollegiate sports, and some 175 will take part in this competition this year.

Together, the first three means account for nearly 1000 students, or 90 per cent of the student body, taking part in some form of physical exercise on a fairly rigid and consistent basis.



▼A geological engineering student includes many miles of hiking each day as a physical training duty.

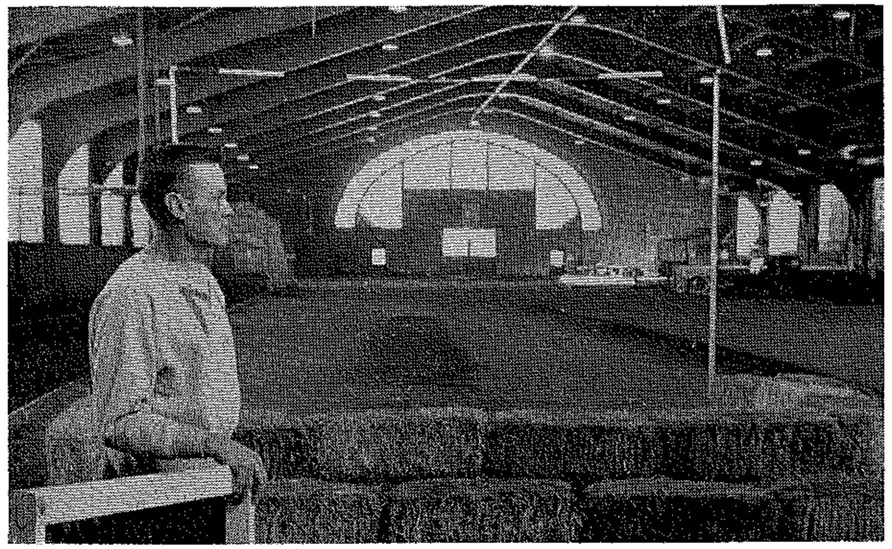
Informal Participation

Another means—and one which has gained in popularity to a great degree since the new Mines gymnasium was opened this year—is informal athletic participation.

Rare, indeed, is the evening that the new pool is not being used by single students, faculty families, student families or faculty groups. So too with other athletic facilities, such as the new indoor track in Steinhauer Fieldhouse, the handball courts (now as popular on the Mines campus as the Integral Club) or the gymnastics room.

Surprisingly, the least amount of time spent—in student-hours—is in the intercollegiate program. Gradu-

▼New one million dollar Colorado School of Mines gymnasium.



▼Joe Davies, associate professor of physical training, surveys the new indoor track area in Steinhauer fieldhouse. Davies supervised the laying of a 220-yard banked track, pits, and runways.

ates are well aware of the small amount of time available for formal practice. The majority of athletic-hours at Mines is spent by students who seek physical activity when their class schedules permit.

Coaching Staff Unique

The School's coaching and instruction staff is also unique. Athletic Director Fritz S. Brennecke has a master's degree in political science. His assistants have all performed advanced study, but few of the postgraduate study hours are in physical education. They range from arts and speech to zoology and medicine. Additional coaches and instructors come from the School's technical faculty.

In total, a Mines student may participate in any of the 20 sports offered at the School. Half are offered in the intercollegiate level.

Physical Training Important

Mines President Dr. John W Vanderwilt, who received his graduate degree at Harvard University, believes sincerely in the rigorous academic schedule, but just as sincerely stresses the importance of a well-trained person physically. "Our new gymnasium is merely a concrete example of a philosophy which this institution has followed for many decades. A student cannot meet the requirements of the mineral professions unless he is adequately trained in the physical fitness area.

"We have not dedicated our new gym to a person—but to a cause and a belief. We hope this gym will provide ample area in which a student may develop the athletic qualities necessary for the tough professional life he must enter."

Student-Athletes at Mines

It is not by a back-slapping design that news media in the sports field hear only of good student-athletes. This is the design of mines.

Older alumni will remember not only the athletic abilities of such men as standout and all American football players Edward McGlone and Lloyd Madden. McGlone, now executive vice president of Anaconda Copper, first proved his academic value at Mines. So too with Madden, now exploration manager for McElroy Ranch Co.

This year B+ and A— students have led Mines athletic teams. In football, Vince Tesone was named to the first team on the Associated Press Little All American squad. Tesone was also named to two scholastic teams for his 3.2 academic average in petroleum engineering.

Bruce Henry, Tesone's understudy, was also named an Academic All American as was center Bob Smith. Henry is a 3.65 student in geological engineering while Smith has a 3.2 average in petroleum.

The three gave Mines the distinction of placing more players on this year's Academic All American football team than any other college in the nation.

In basketball, the top player, scorer and rebounder is Dick Egen, a 3.7 petroleum engineering student and a cadet captain in the crack Mines ROTC detachment.

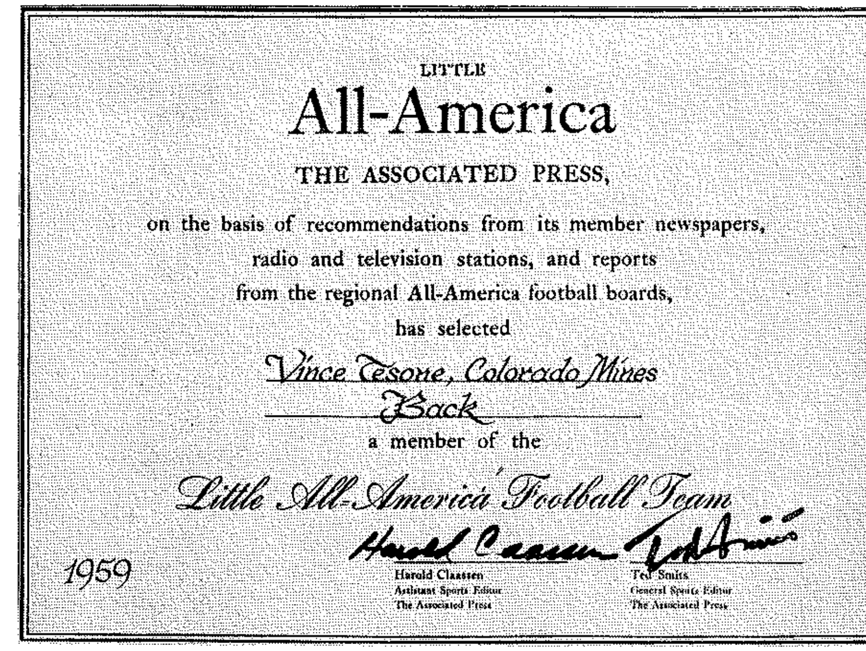
Swimming's academic leader is Bill Henry, the one-legged backstroke record-breaker who is tabbed the "finest mathematics student at Mines in a long time" by Prof. Ivan Hebel, math department head.

In wrestling, sophomore Tom Tisone has a nine and one dual meet record at 123 pounds—top record on the club. He also has a 3.83 academic average in metallurgical engineering and holds two academic scholarships to prove his worth.

Both currently and historically, it has been this combination of academic and athletic qualities which has keynoted the physical fitness education portion of a Mines training.

▼Mines football players are scholars too. This year 14 players held academic scholarships and three were named to academic All-American teams.

OREDIGGER SPORTS



▼Vince Tesone received this plaque from the Associated Press Feb. 16 at the regular monthly meeting of the Denver Mines Quarterback Club.

Vince Tesone Named by AP To Little All American Team

Although the football season has ended, monthly luncheon meetings of the Denver Quarterback Club and the Denver Section are being held the third Tuesday of each month at the Denver Press Club, 1330 Glenarm Pl. All alumni—both Denver residents and Visitors—are invited to attend. Ron F. Lestina, '50, chairman of the Athletics Committee, is in charge of the meetings.

At the Feb. 16 meeting, Vince Tesone received a plaque from Associated Press naming him to the Associated Press Little All American first team at quarterback.

Tesone Makes First Team Of All-American Academic

Vince Tesone received his finest Christmas gift Dec. 25 when he was named to the first team All-American Academic Team. Tesone, a "B" student in petroleum production engineering, was named to the squad which is sponsored jointly by the American Peoples Encyclopedia and the College Sports Information directors of America. He was the only Rocky Mountain area player named to the first team.

This fall Tesone was named to the squad's 33-man team as a quarterback. Voting was changed for the final team, into major and little college categories. Only three small college players were named to the earlier selection, and of those three only two made the first 11 in December.

To qualify for the team the players had to maintain a "B" or better classroom average and be outstanding on the football field. Only four of the 39-man little college Academic team came from the Rocky Mountain region—and Mines placed three of them.

Miners receiving honorable mention were junior tailback Bruce Henry (he was also given honorable mention on the fall major college selection) and senior center Bob Smith. Both are petroleum engineering students with "B+" averages.

Golden Bank Contributes To CSM Foundation, Inc.

The First National Bank in Golden has contributed $500 to the Colorado School of Mines Foundation, Inc. The contribution was announced recently by Dr. John W Vanderwilt, president of the mineral engineering college.

The gift—the fourth donation by the bank since 1956—came as an unrestricted gift.

In commenting on his bank's grant, Paul V. Pattridge indicated his bank was pleased with the manner in which the Foundation had used previous gifts.

CLASS NOTES

(Continued from page 37)

JOHN CEDRIC C. MATHEWSON, chief computer for Western Geophysical Co., has been transferred from Chateau, Mont., to Stanley, N. Dak. His post office box number is 537.

FRED R. SCHWARTZBERG is design specialist for the Martin Co. His home address is 1480 S. Jasmine Way, Denver 22, Colo.

ROBERT S. SOHON, formerly a graduate student in the Department of Geology, Pennsylvania State University, has moved to 469 Palmetto Rd., Bridgeport 6, Conn.

1954

ROBERT ABERCROMBIE, petroleum engineer for Mobil Oil Co., has changed his address from Shreveport, La., to 24 Beechwood Lane, Natchez, Miss.

PAUL V. BETHURUM is production foreman for Susquehanna-Western, Inv. His address is 936 Big Horn, Riverton, Wyo.

JAMES W. COOKSLEY, JR., field geologist with the Southern Pacific Railroad, has moved from Washington, Calif., to Needles, Calif. The new address will be in care of General Delivery.

MARIO GUERRA, who returned from Bolivia several months ago and who has been in California more recently, can now be reached at Climax Molybdenum Division, Climax, Colo.

RUDOLPH J. GULDE has moved from Concord, Calif., to 6230 Cole Ave., Carmichael, Calif. He is process control engineer for Aerojet-General Corp.

ROBERT M. HANES is field engineer for Holmes and Narver, Inc., with home address 2102 E. Owens Ave., North Las Vegas, Nev.

ARNOLD H. KACKMAN, project engineer for Universal Atlas Cement Division, lives at 2813 3rd Ave. South, Leeds, Ala.

CHARLES J. MARQUARDT advises us of a change of address: from Jackson, Miss., to 2009 Camellia St., McAllen, Texas.

CLYDE S. NEWELL has moved from Pensacola, Fla., to Waynesboro, Miss., with mailing address c/o Mobil seismic, P. O. Box 249.

R. T. BROWN has joined Boettcher & Co.'s Denver office as a security salesman. After trying uranium and copper, R. T. has come back to Denver. He was able to pass all examinations with excellent grades and is licensed in his new profession.

1955

JAMES P. DENNIS, engineer for Esso Research & Engineering Co., has moved from Linden, N. J., to 65 Woodlawn Rd., Sparta, N. J.

GORDON E. DUFFY may be addressed at 1330 S. Grand, Glenwood Springs, Colo.

ARTHUR P. FOSTER, JR., has been transferred from Dallas to Shreveport, La., where he will be district reservoir engineer in Texaco's Shreveport District. His mailing address is Box 1737, Shreveport, La.

GLEN R. GRAVES is geologist for Creole Petroleum Corp., Tia Juana, Zulia, Venezuela.

JOSEPH L. HARBISON advises that

(Continued on page 45)

PLANT NEWS

Babcock and Wilcox Co. Opens Denver Office

ROBERT L. SWINNEY

Babcock & Wilcox Co. is establishing a Boiler division district sales office in Denver, Colo. The new facility takes over steam generating equipment sales and service activities relinquished by Stearns-Roger Manufacturing Co. on termination of its sales agency agreement with the division on March 1. The formal agency relationship between Babcock & Wilcox and Stearns-Roger, which began more than 20 years ago, is being terminated by mutual consent.

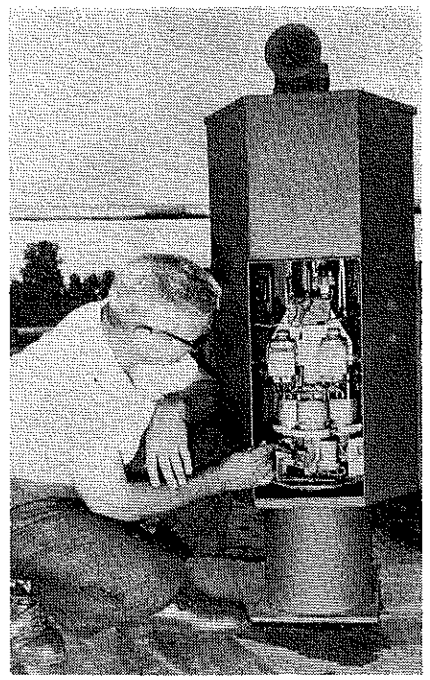
Appointed Denver district sales manager is Robert L. Swinney, sales engineer in Chicago for the past 21 years. The new office, with Mr. Swinney in charge, will be located at 1806 Tower Bldg., Denver U. S. National Center, 1700 Broadway.

Mr. Swinney will be responsible for a Boiler division sales district comprising the states of Colorado, Montana, New Mexico, Utah and Wyoming, and certain portions of Idaho, Nebraska, Nevada, South Dakota and Texas.

Babcock & Wilcox is a major supplier of steam generating equipment, tubular products, refractories and nuclear systems and components.

PTI Named Distributor For Manufacturing Companies

Robert Torpey, '49 Mines graduate and president of Power Transmission Inc. of Denver, Colo., announced that PTI has been appointed the exclusive Colorado and Wyoming distributor for the Erie Strayer Co. of Erie, Penn. and its complete line of portable trailer aggregate and cement batching plants, bulk cement plants and aggregate-cement elevators. PTI was also appointed as the Colorado and Wyoming distributor for the products of Stephens-Adamson Manufacturing Co. of Aurora, Ill. which include: carriers and return rollers, car pullers, holdbacks, loaders, pulleys, tellevels, winches and belt cleaners.



▼ Ingenious new self-leveling device for mammoth offshore platform is checked by an electrical engineer at R. G. LeTourneau, Inc.

Dual-Depth Offshore Platform Offers Economic Advantages

The nation's leading builder of mobile drilling platforms has announced a major break-through in the offshore oil industry's critical battle of "costs vs. production."

R. G. LeTourneau, Inc. of Longview, Texas, capsuled the development thus:

For drilling in waters 125 to 150 feet deep, a new wide base "slant-legged" platform can be produced for about the same cost as a conventional "straight-legged" type—the big difference being that the new type can be readily modified for greater depths later while the conventional type cannot.

As an example, a slant-legged tripod platform for 150 feet of water can be increased to 200-foot depths for only about 6 per cent additional cost.

It was less than three years ago that R. L. LeTourneau, vice president, announced that his company had worked out a practical slant-legged platform for drilling in waters up to 600 feet.

As a starter, the company aimed at production plans for water depths of 200 and 300 feet. These plans were completed a few months ago, and cost analysis this month prompted the announcement comparing the two types of LeTourneau platforms.

Asked if his company still believes it possible to build a platform for 600 feet, the vice president said:

"We are sure it is not only possible but completely practical. And we are looking forward to the day when super-deep-water activity will create a specific need for that platform."

Continental Oil Co. Donates $200,000 to Education

More than $200,000 is being given by Continental Oil Co. during the 1960-61 academic year as financial aid to education—including grants and fellowships for scientific and business research and scholarships for outstanding college students.

Scholarships for outstanding upper classmen were awarded the Colorado School of Mines and 28 other colleges and universities, with recipients of both the Conoco fellowships and scholarships being selected by the respective institutions.

Along with the company's overall financial aid to education plan is the Conoco Scholarship Program for children of employees. Instituted in 1951, the program awards each year $2,000 college scholarships to 15 graduating high school seniors who are sons and daughters of company employees. A total of 113 students have attended college to date under the program.

Conoco also will continue its corporate alumnus program inaugurated three years ago. Under this program, the company matches up to a maximum of $500 any annual contribution made by an employee to the college or colleges he attended.

Lyle Named Chief Engineer By American Cyanamid Co.

George L. Lyle, Jr., has been named chief engineer at American Cyanamid Co.'s Brewster, Fla. plant. Mr. Lyle succeeds W. J. Pace, formerly of Lakeland, who retired Jan. 1, 1960, after 15 years service with the chemical firm.

A 1940 graduate of Virginia Polytechnic Institute, Mr. Lyle served for seven years in the Corps of Engineers, attaining the rank of lieutenant colonel. He served as engineer for the Allied Airborne Army, consisting of all troops in the European theater, and later as construction engineer in the rehabilitation of West Berlin.

TECHNICAL SOCIETIES

(Continued from page 11)

are: "Corrosion Problems in the Use of Dense Salt Solutions as Packer Fluids," by C. M. Hudgins, W. D. Greathouse and J. E. Landers of Continental Oil Co.; "Stress Corrosion Cracking in Concentrated Sodium Nitrate Solutions," by R. L. McGlasson, W. D. Greathouse and C. M. Hudgins of Continental Oil Co.; "Cathodic Polarization of Steel in Various Environments," by A. R. Erben and R. A. Legault of Sun Oil Co.; "Stress Corrosion Cracking of High Strength Tubular Goods," by R. S. Ladley of Phillips Petroleum Co.; and "Anhydrous Ammonia Controls Vapor Space Corrosion in Unpacked Flowing Wells," by Rado Loncaric, D. R. Anthony, Fair Colvin and M. D. Folzenlogen, all of Atlantic Refining Co.

Other symposia with papers of special interest to oil production engineers are Marine and General Corrosion.

Petrochemical-Refining Exposition Planned for 1961

F. J. Van Antwerpen, secretary of the American Institute of Chemical Engineers, has announced that the Institute will sponsor a Petrochemical and Refining Exposition in connection with the National A.I.Ch.E. Meeting in New Orleans, Feb. 26 - March 1, 1961.

The A.I.Ch.E. exposition will be managed by Reber Friel Co., Philadelphia. It was authorized by the A.I.Ch.E. Council after careful study of suggestions from members in the petroleum and petrochemical industries. Its emphasis will be on petrochemical and refining production, design and development, Mr. Van Antwerpen said.

IOCC Officers Elected

Governor George Docking of Kansas was elected chairman of the Interstate Oil Compact Commission for the year 1960, during the Commission's annual meeting in Philadelphia, Pa., Dec. 3-5. Other officers elected were Warwick M. Downing of Colorado, first vice-chairman; Miss Genevieve Blatt of Pennsylvania, second vice-chairman; Lawrence R. Alley, executive secretary, and Earl Foster, general counsel. The Executive Committee consists of governors or their representatives of Alabama, Arkansas, Colorado, Illinois, Kansas, Kentucky, Louisiana, New Mexico, N. Dakota, Oklahoma, and Texas.

CLASS NOTES

(Continued from page 43)

his address is c/o Ohio Oil Co., Lance Creek, Wyo.

ENRIQUE LEVY may be addressed at 1253 E. 4th South, Salt Lake City 2, Utah.

ALAN F. OSBORNE, exploitation engineer for Shell Oil Co., has been transferred from Glendive, Mont., to 2542 Lewis Ave., Billings, Mont.

DAVID RICE is development engineer for Richfield Oil Corp. He moved recently from New Cuyama, Calif., to 1005 Sunset Pl., Ojai, Calif.

EUGENE C. RISCH has left Hidden Splendor Mining Co., Riverton, Wyo., and is now working for Green Mountain Uranium Co., Jeffery City, Wyo. He writes that the company is developing an underground mine in the Crooks Gap area.

DOUGLAS P. WINSLOW, formerly of El Paso, Texas, has moved to 2417 Porter, Joplin, Mo.

1956

WILLIAM B. LUKER is sales engineer for Miracle Realty with mailing address Box 2130, Casper, Wyo.

MARIO A. MARCANIO has moved from West Allis, Wis., to 661 S. 65th St., Milwaukee 14, Wis.

MR. AND MRS. THOMAS O. MOHR and sons, Eric and Carl, have been visiting Mr. Mohr's parents in Golden, Colo. For the past six months the Thomas Mohrs have been in Tulsa, Okla., where Mr. Mohr has been doing research work for Standard Vacuum Co. Prior to that they lived two years in Sumatra. Following their vacation, the Mohrs expect to return to Pendopo, Sumatra, on another assignment for Standard Vacuum.

LOUIS L. SCHER, IV, who was in Golden and Denver on a two months' vacation from his job as drilling and petroleum engineer with Creole Petroleum Corp., Lagunillas, Zulia, Venezuela, was able to attend the annual business meeting of the Alumni Association and later to call at the Alumni office. It is always a pleasure to have visitors and to see our members first hand.

1957

RALPH A. AVELLANET, production engineer for Union Carbide Metals, has been transferred from Niagara Falls, N. Y., to Alloy, W. Va.

JAMES M. AYLARD is taking graduate work at the University of Colorado. His mailing address is 5330 E. 17th Ave., Denver, Colo. He was formerly employed as petroleum engineer for Magnolia Petroleum Co. at Lake Charles, La.

DAVID L. BRADFIELD has moved from Arvada, Colo., to 7700 Irving St., Denver, Colo.

LOUIS F. BREGY, whose address is Weston Rd., Weston, Conn., is assistant

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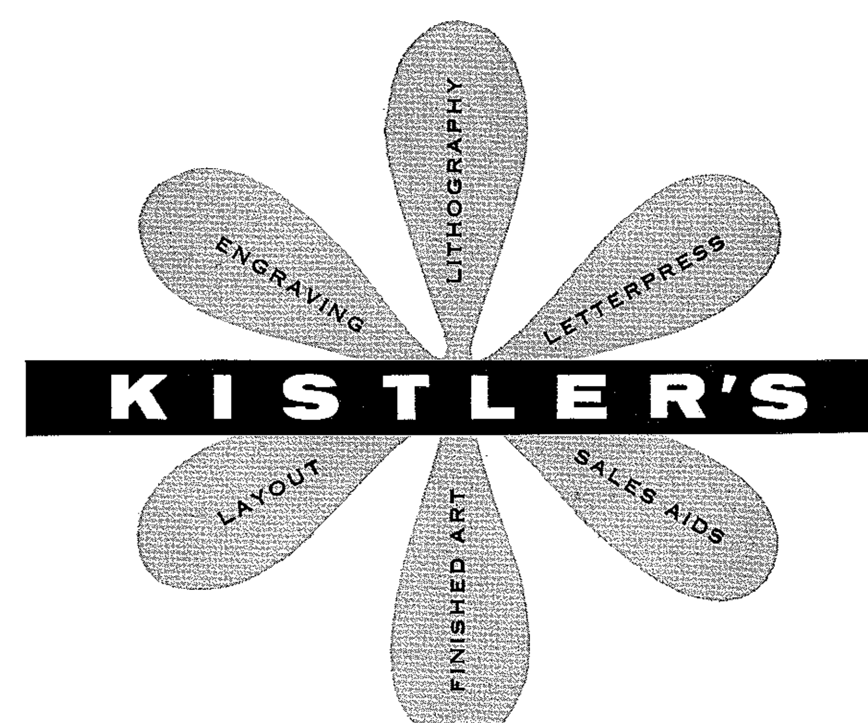


1636 CHAMPA • DENVER • MAIN 3-5161

research metallurgist for Bridgeport Brass Co.

CECIL C. DAVIS, JR., has moved from Denver, Colo., to 1719 Hazel St., Jackson, Miss.

NORMAN E. GOLDSTEIN has taken a leave of absence from Utah Construction and Mining Co. to begin graduate study and research at the University of California in the field of geophysics. His new address is International House, Berkeley 4, Calif.

WILLIAM D. SMITH may be addressed c/o Gunnison National Forest Service, Gunnison, Colo.

WILLIAM N. FINK, III, engineer for Western Electric Co., has moved from Littleton, Colo., to 3619 Frederick St., Omaha 5, Nebr.

CHARLES R. WOOD writes that he has been discharged from the Army and that his address is now 424 Otsego St., Ilion, N. Y.

1958

JAMES L. BACHMAN may be addressed Rt. 3, Box 160, Golden, Colo.

ROBERT B. BARKER is engineer-metallurgist for Dow Chemical. His home address is 2635 Mapleton Ave., Boulder, Colo.

DONALD E. ERIKSEN, engineer for Northern Illinois Gas Co., has moved from Mendota, Ill., to Aurora, Ill., where his address is 50 Fox St.

JAMES STEWART HOLLINGSWORTH gives his address as Box 477, Uravan, Colo., where he is a geologist for Union Carbide Nuclear Co.

JOHN L. HOLT has moved from Laconia, N. H., to 468 Union Ave., Lakeport, N. H.

JAMES E. JONES is product engineer for Hewitt-Robins with home address at 22 Bradford Ave., Passaic, N. J.

RICHARD P. KELLENBENZ writes that he has finished his "sentence" in the Army and is now working for Texaco, Inc. in the Casper Refinery. His address is 2044 Westwood Hill, Apt. 3, Casper, Wyo.

BOBBY G. KERR has notified us of a change in his mailing address: from New Orleans, La., to P. O. Box 446, La Habra, Calif.

MICHAEL DILEMBO, 2820 Thomas Ave., Cheyenne, Wyo., is now with the Wyoming State Highway Department as a highway designer. He called at the alumni office in the midst of our big snow storm on Feb. 22. After living in Wyoming, he would no doubt consider the heavy snowfall as routine operating weather.

DALE PORTINGA, 518 Seneca St., Bethlehem, Pa., is sales trainee for Bethlehem Steel Co. He was formerly in Portland, Ore.

RONALD R. WAHL has moved from Denver, Colo., to 5530 Holland Dr., Arvada, Colo.

OLIN D. WHITESCARVER, production engineer for Pure Oil Co., has been transferred from Van, Texas, to 1625 Worth St., Fort Worth 4, Texas.

DONALD E. WILSON, geophysical engineer for Mobil Oil Co., was transferred from Sanderson, Texas, to Pecos, Texas. His mailing address is Box 1806.

RICHARD E. WISTRAND may be addressed at 5901 E. Ocean Blvd., Long Beach 3, Calif.

1959

2ND/LT. RUSSELL E. BLOM may be addressed at 827 Kearney, Manhattan, Kans.

CHARLES A. HASKIN is petroleum engineer for The California Co. His mailing address is 1010 Main St., Box 852, Bottineau, N. Dak.

DONALD L. MATCHETT is construction engineer for Black & Veatch with address at 7914 Ward Parkway, Kansas City, 14, Mo.

HAROLD C. MENCK, JR., research and development engineer for Western Electric Co., lives at 568 Speedwell Ave., Morris Plains, N. J.

WILLIAM O. MERGENTHAL, 3836 Auburn Blvd., Sacramento 21, Calif., is technical service engineer for Aerojet-General Corp.

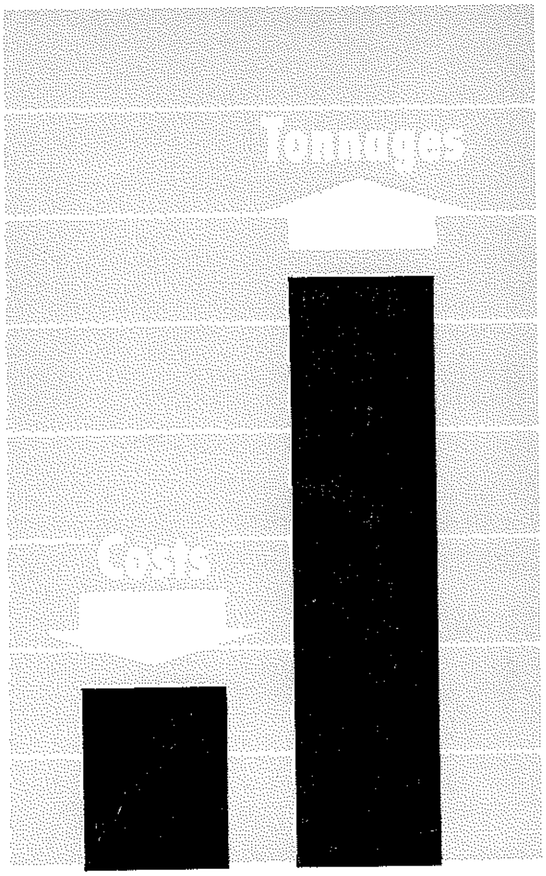
JERRY D. RICHARDS is engineer-trainee for Sunray Mid-Continent Oil Co. His address is 5313 S. Detroit St., Tulsa 5, Okla.

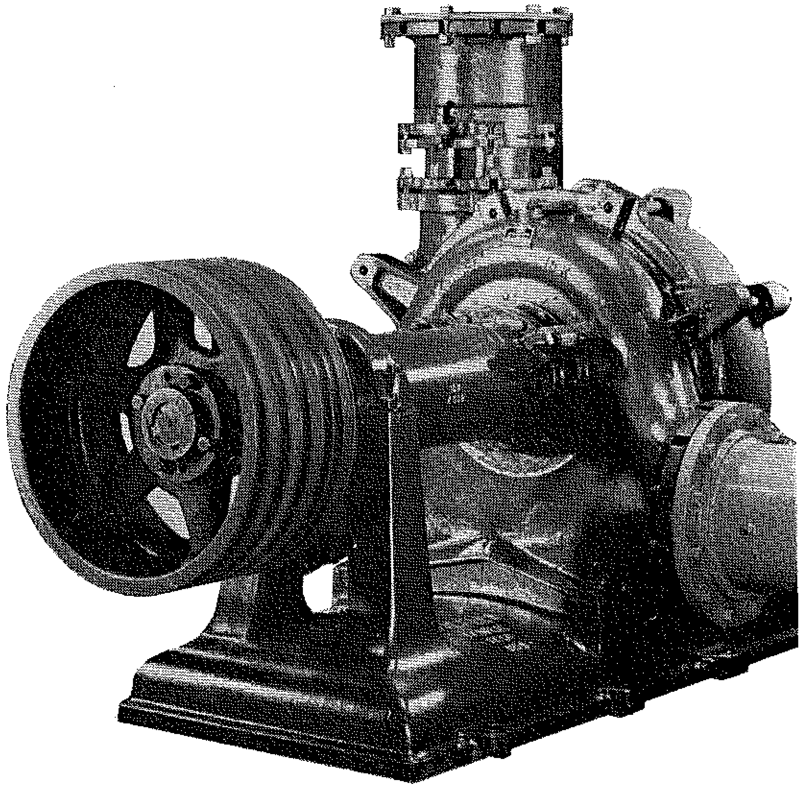
1960

DONALD H. HOWELL has accepted a position as geologist with Standard Uranium at Silverton, Colo. He paid a visit to the alumni office before leaving Golden and became an active member of the Alumni Association.

WILLIAM S. RANSOM, 914 14th St., Golden, Colo., dropped in the office the other day to become an active member of the Alumni Association.

ADVERTISERS' LISTINGS





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