- Permafrost Tunnel
- Powder Metallurgy Research
- Controlled Particle Movement
- Process Development and Operating Costs
- Academic and Physical Fitness Education
KERMAC SOLVES AMBROSIO LAKE SLIMIES WITH TELLURIDE TYPE CARS

Kermac Nuclear Fuels Corporation is operating four major wet mines in the Ambrosio Lake area of New Mexico. Stop-forming shale lenses interbedded in the ore help form a watery muck that flows easily when handled but sticks tightly to machinery, pockets and car bodies when allowed to settle. To solve this tough problem, Card furnished a string of 40 special “Telluride Type” cars that feature a solid body for side dumping and intense shaking. The cars range from 77 cu. ft. to 110 cu. ft. capacity.

Following successful introduction of the first lot of these 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.

Solve your haulage with an economical Card design. Our engineers can supply an efficient car to meet your most difficult specifications.
Make your mine openings self-supporting with CF&I Rock Bolts

CF&I Rock Bolts reduce the need for costly and clumsy mine timbering. Mine openings may be smaller or the space saved will allow freer, more efficient movement of machinery. Ventilation is improved, too.

But most important, CF&I Rock Bolts with the Pattin Shell provide safe and sure support for walls and roofs. The double expansion of the Pattin Shells makes continuous contact along the entire length of the shell. You get maximum anchorage in any type of rock. The Pattin design also provides maximum resistance to load with minimum displacement of the shell. Mine records have shown that the use of CF&I Rock Bolts with lagging of Realock Metallic Fabric results in cost savings of about 35% over timbering. For complete information on threads, diameters, lengths, price and delivery, contact your local CF&I sales office.

CF&I also makes a complete line of 1" Wedge Type Rock Bolts, as well as 1/4" expansion type slusher pins.

OTHER CF&I STEEL PRODUCTS

CP&I Grinding Balls • CF&I Grinding Rods • CF&I Mine Rail and Accessories • CF&I Wire-Nail Wire-Rope • CF&I Industrial Screens • CF&I Grarer Blades

A 30-minute Reax Bolting color movie "Make Mine Safety" is available for showing at no charge, through the CF&I office nearest you.

THE COLORADO FUEL AND IRON CORPORATION

Volume 1
March, 1960
Number 3

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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.)
Vis 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 U₂O₅ 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 company 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 30 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 possible tonnage of bentonite 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 startup, including several months (Continued on page 17)

7000 degrees ... an inferno approaching that of the sun's surface has been created by the scientists of Union Carbide. The energy comes from the intensely hot carbon arc. Through the use of mirrors, the heat is reflected to form a single burning image of the electric arc at a convenient point. Called the arc-image furnace, it extends the limits of high-temperature research on new materials for the space age.

For years, mammoth carbon and graphite electrodes have fired blazing electric furnaces to capture many of today's metals from their ores and to produce the finest steels. But, in addition to extreme heat, the carbon arc produces a dazzling light that rivals the sun. In motion picture projectors, its brilliant beam floods panoramic movie screens with every vivid detail. But we are not through with the arc yet. Its electric force can cut through heavy alloys and create any shape.

In Canada, Union Carbide & Carbon, Limited, Toronto, is using the arc to reduce calcium crucibles to their basic element, carbon. The people of Union Carbide will carry on their research to develop even better ways for carbon to serve everyone.
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Miscellaneous: Public Lands Section promises to be the best yet. The Workmen’s Compensation will be reviewed by Frank Van Poptllet. 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 (two 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 Thomas H. Kahn, chairman of the Society of Mining Engineers’ Education Committee and secretary of AIME’s Council on Education; Prof. Niles E. Grovenot, who presented a paper, “A Method for Determining the True Tensile Strength of Rock”; Professors Lute J. Parkinson, H. Gordon Pode and Robert H. Carpenter, who acted as chairman of committees or technical sessions; Prof. Charles M. Shull, Jr., of the chemistry department, and Mr. Harold Bloom, special lecturer in the geology department.

Students attending were: Mr. Erskine, Bob Green, Don Longshore, Bill McComic, John Selten, and John Etkin, who received a prize for a student paper on cement 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 be increasing more as long as engineering freshman enrollment remains how each succeeding year.

“Therefore, it becomes important to consider what can be done to encourage enrollment in mineral engineering. This is primarily the responsibility of the technical schools and colleges of mining engineering.

Dr. Vanderwilt said industry promotion programs solved earlier, similar problems in electrical and aeronautics engineering fields.

The shortage distribution of engineering manpower, Dr. Vanderwilt asserted, “will favor those industries, which provide a wide variety of career opportunities, have a good story to tell in the competition for additional mineral engineering manpower resources. They are the ones that are now 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 placement for the Colorado School of Mines graduates during 1959 and 1960. In a group of 40 graduating geologic engineers, for example, more than one job offered, while on the other extreme, two were without job offers until the end 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 school, were employed.

“Thus far this year,” Dr. Vanderwilt said, “inquiries from interviewers 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 graduate 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 1927, Dr. Wheeler is known as a consultant to government defense agencies. During World War II, his research on the atomic bomb 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, structural action of collisions of atomic nucleus and elementary particles. His work in mathematics resulted in recognition of him as the “genius of the game.”

Oil and Gas Corrosion Problems Solved

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.

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

March 15 During the 16th Annual Conference, National Association of Corrosion Engineers’

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The addition of comprehensive and cutting edge facilities in Salt Lake City brings to THREE the number of Silver Service centers for steel and aluminum. Complete handling and transportation facilities, fast delivery thruout the four-state area, you need not carry large inventories. Permit us to show how we can save you money on your inventory costs.

RUSSELL K. H. BERNSTEIN, President

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THE MINES MAGAZINE • MARCH, 1960
Permafrost Tunnel

By

JOHN F. ABEL, JR., '56

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 SIPIRE).

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

Purposes of the USA SIPIRE 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.

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 CR 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 staking a shaft or driving an inclined tunnel, both of which would have presented more difficult mining problems.

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 CR 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 staking 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.

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 SIPIRE. 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. F. 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 mucking assistants and as excavator and compressor operators.

In addition to the shift personnel, the USA SIPIRE 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. 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 the shop building was completed June 15, 1959.

A basic hard rock mining method was used during all mining operations including portal, tunnel, and mucking operations. The different unit operations involved in the method included drilling out the blast holes, loading the blast holes, blasting the drill sound, ventilating the tunnel to remove the fumes from blasting, trucking (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 tunnel and unconsolidated active zone which required support to prevent caving. The second phase of the mining operation was the straight-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 1,680 cubic yards, 334 cubic yards of which were excavated during the portal construction, 606 cubic yards during the tunnel excavation, and 336 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 unconsolidated active zone adjacent to the tunnel area. This zone was 25 ft. wide and 6 ft. thick in the area adjacent to the tunnel. The presence of the zone required the use of temporary support in the area beyond the zone adjacent to the portal. The temporary support was 4 ft. wide by 4 ft. high by 10 ft. long. The temporary support was installed on a 1 ft. bed of gravel and was removed after the tunnel had been completed in this area. The extended tunnel completed was 300 ft. long having a cross section 10 ft. wide by 9 ft. high.

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.

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 SIPIRE. 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. F. Brown.

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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 slots from the face of the hill. These slots were blasted during 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 away approximately 6 ft. of the hillside, falling in the tunnel, breaking the protective layer as an underground tunnel face. It was necessary to remove this protective lagging in case of future roof failure in the wide span area. This protective laggating was required to prevent loose material from over the portal and loosened ground from falling on the tunnel. The lagging of the experimental set was required to protect the men 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 frozen bed from glacial till and 2 ft. of the unconsolidated active layer. The first tunnel round was excavated on June 20, 1959.

Drilling equipment, drill-round patterns, and explosives were determined by drying, desegregating, and sieving the entire sample. This material was considered unsatisfactory since the temperature of the permafrost was low enough to prevent freezing in the tunnel. The experimental blasting record is presented by Table 2. The tunnel blasting experiments were to be found a workable round for the production of experimental work and to develop a 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

<table>
<thead>
<tr>
<th>Name</th>
<th>Detonation Velocity</th>
<th>Cartridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gelamite 1-X</td>
<td>11,500 ft/sec</td>
<td>112</td>
</tr>
<tr>
<td>Dynaflow 5-D</td>
<td>12,200 ft/sec</td>
<td>113</td>
</tr>
<tr>
<td>Dynaflow 6-D</td>
<td>12,400 ft/sec</td>
<td>113</td>
</tr>
<tr>
<td>Hydrostatic 5-D</td>
<td>11,800 ft/sec</td>
<td>112</td>
</tr>
<tr>
<td>Hydrostatic 6-D</td>
<td>12,000 ft/sec</td>
<td>113</td>
</tr>
</tbody>
</table>

The determination of a satisfactory round was based on whether or not secondary blasting was required. On any secondary blasting was required, the round was considered unsatisfactory. Secondary blasting was required throughout the experimental work. The ability of the rock material to be drilled or if fragments were dislodged too large to be loaded by the 4-3/4 cubic foot capacity mine car loader was required. While no quantitative data are available about fragmentation sizes, observations indicate that much of the fragmented material was loosened and would be considered unsatisfactory. Secondary blasting was required throughout the experimental work. The ability of the rock material to be drilled or if fragments were dislodged too large to be loaded by the 4-3/4 cubic foot capacity mine car loader was required. While no quantitative data are available about fragmentation sizes, observations indicate that much of the fragmented material was loosened and would be considered unsatisfactory. Secondary blasting was required throughout the experimental work.
permafrost apparently absorbed the force of the explosions and the boulder was dislodged without being broken. The higher detonation-velocity explosives apparently broke the boulders before the softer portions of the permafrost could absorb the shock of the blast.

The area was then surveyed to determine the extent of damage from the detonations, and it was observed that the boulder had been dislodged by a series of explosions. The boulder was not broken into smaller pieces by the detonation, but it was dislodged from its position in the tunnel. This was confirmed by the absence of fragments in the surrounding rock.

Drilling Investigation

Blunt holes were drilled with air mounted percussion drills and diamond drills were used as part of the Permafrost Tunnel project. The diamond drills were used to drill hard rock, but the permafrost drills were used to drill soft rock formations. The diamond drills were more efficient than the permafrost drills, but they were more expensive to operate. The permafrost drills were used to drill through the permafrost, and the diamond drills were used to drill through the hard rock.

Drilling rates were recorded for both the permafrost and diamond drills. The average drilling rate for the permafrost drills was 2.3 feet per minute, while the average drilling rate for the diamond drills was 2.5 feet per minute. This indicates that the diamond drills were more efficient than the permafrost drills.

Several satisfactory drill rounds were developed. The loading information for these rounds is presented in Table 2. The drill rounds which used the lower velocity, 30 and 60 per cent, were not recommended because of poor fragmentation. The blast holes were 50 per cent nitroglycerine. 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.

Figure 8a. Recommended V-cut drill pattern.

Figure 8b. Recommended V-cut drill pattern.

Table 2. Experimental Blasting Record

<table>
<thead>
<tr>
<th>Powder</th>
<th>Number</th>
<th>Factor</th>
<th>Number</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>30%</td>
<td>6</td>
<td>3-5</td>
<td>6</td>
<td>3-5</td>
</tr>
<tr>
<td>60%</td>
<td>6</td>
<td>3-5</td>
<td>6</td>
<td>3-5</td>
</tr>
<tr>
<td>80%</td>
<td>6</td>
<td>3-5</td>
<td>6</td>
<td>3-5</td>
</tr>
<tr>
<td>90%</td>
<td>6</td>
<td>3-5</td>
<td>6</td>
<td>3-5</td>
</tr>
</tbody>
</table>

Table 3. Satisfactory Drill Rounds

<table>
<thead>
<tr>
<th>Explosive</th>
<th>V-Cut</th>
<th>Burn Cut</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30%</td>
<td>6</td>
<td>4-2</td>
</tr>
<tr>
<td>60%</td>
<td>6</td>
<td>4-2</td>
</tr>
<tr>
<td>80%</td>
<td>6</td>
<td>4-2</td>
</tr>
<tr>
<td>90%</td>
<td>6</td>
<td>4-2</td>
</tr>
</tbody>
</table>

Table 4. Test Bit Data

<table>
<thead>
<tr>
<th>Burning</th>
<th>Number</th>
<th>Net Drilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>5</td>
<td>212</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>212</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>212</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>212</td>
</tr>
</tbody>
</table>

Figure 9. Percussion drill bits, showing typical wear pattern. A—new 14 ft. diamond burr drill bit, B—drill bit, C—stages of wear to destruction.

Drill steel consumption during the construction of the permafrost tunnel amounted to 35 pieces of drill steel, five each of the 6-l, 7-1, and 8-ft. drill steels used, 15 pieces were broken and 20 pieces were rendered useless by plugging of the water hole with permafrost. The steel cost averaged $2.5 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 $32.3.

Conclusions and Recommendations

The excavation of frozen glacial till is feasible by conventional tools, but a freezing anti-freeze-water drill fluid. Diamond drilling with cooled diesel fuel is recommended for drilling of cleaned well holes in the frozen glacial till.

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

Bibliography


California Mineral Production Drops 4.5 Per Cent in 1959

According to preliminary estimates submitted by individual producers to the California Bureau of Mines, the total value of California mineral production dropped 4.5 per cent from the 1958 level. The mining production was calculated as $1.06 million.

(Continued on page 26)
Powder Metallurgy Research

By DR. CHOH-YI ANG * A '43 & '47

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 the other's field of activities. The lack of evidence of sound applied research in powder metallurgy is probably due to lack of understanding in this branch of metallurgy has not been closed. The gap between pure research and practical engineering is not very much different from that of reaching and necessity of metals or steelmaking a few decades ago. 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 technologists.

There are many facets in powder metallurgy; but, to serve as examples for discussion, one may select some important topics such as powder characterization, pressability, sintering and infiltration. By bringing out the basic principles governing some of the phenomena involved with the powers of the basic research and practical powder metallurgy will be accelerated.

Powder Characteristics

While it is generally recognized that the sinterability of a material is important in powder metallurgy, there are other influences which must be considered, such as the particle size, shape, distribution on the bulk density, pressing characteristics, and sinterability. Sinterability, one finds spongy or irregularly shaped particles, for example, having a lower degree of densification than those which are nearly spherical in shape.

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 desires highly regular shaped particles. For good compactability, 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. In slip casting of metal powders, one may again find that spherical particles give optimum results. In slip casting, the interlocking effect of irregularly shaped particles is desired. For good compactability, 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.

In the past decade much work has been done on the mechanisms of sintering. The interlocking effect of irregularly shaped particles is desired. For good compactability, 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. In slip casting, the interlocking effect of irregularly shaped particles is desired. For good compactability, 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.

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Sintering

It is now fairly well established that sintering (volume, surface or grain boundary) is the most influential method of material transport in the densification process. The term is not really a constant; in fact, it has

$E = 16.5 \ln \frac{p}{p_2}$

where $r$ is the rate of the process; $r_0$ the rate coefficient; $E$, the activation energy in calories per mole; $R$, the gas constant; $T$, the absolute temperature in $K$, and $e$, the base of logarithms.

One variable in the above equation, the temperature $T$, may appear to be the easiest to change, but to a precision engineer, it is the most critical and the most difficult to control. White sintering temperature always affects the final properties of the product. Infiltration is the application of the Clausius-Clapeyron equation. As mentioned before, this type of equation may also be derived from the consideration of the amount of released latent heat of fusion to determine the instantaneous temperature of sintering. The empirical observations of the type in the area of chemistry and physics of metals is also 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 infiltration processes are used to solve some of the problems of shape distortion and availability of high temperature products. This step can be taken into consideration to improve the consolidation process, and the following equation.

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Controlled Particle Movement In Counter-Current Flow Heating

By 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 equipment for the purpose will require a knowledge 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, as built, that a desired cross-section of the 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 outflow:

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

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 minimized to either of these methods.

On the other hand, cone flow produces varying conditions of velocity and direction. These include individual particle movement and produce stress. This tends to break up into 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 5. It was more nearly in balance than the cone illustrated by Figure 6.

When outlet #1 was closed and outlet #2 opened a different type of imbalanced cone flowed as illustrated by Figure 6. It was more nearly in balance than the cone illustrated by Figure 4. Draw through outlets 2, 3, 5, 8, 9, 12, 14 and 15 will produce imbalanced cones with patterns similar to Figure 4. Draw through outlets 6, 7, 10, 11 may produce balanced cones similar to Figure 5. If all the cones were drawn at different rates and directions, mostly non-vertical.

THE AUTHOR

Although he is a native of Colorado, Harry K. Savage received his technical education at Stanford University where in 1920 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, 727 (7), for distillation, by the use of a sufficient amount of scavenging gases. Mass flow in the main is minimized to either of these methods.

On the other hand, cone flow produces varying conditions of velocity and direction. These include individual particle movement and produce stress. This tends to break up into 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 5. It was more nearly in balance than the cone illustrated by Figure 6.

When outlet #1 was closed and outlet #2 opened a different type of imbalanced cone flowed as illustrated by Figure 6. It was more nearly in balance than the cone illustrated by Figure 4. Draw through outlets 2, 3, 5, 8, 9, 12, 14 and 15 will produce imbalanced cones with patterns similar to Figure 4. Draw through outlets 6, 7, 10, 11 may produce balanced cones similar to Figure 5. If all the cones were drawn at different rates and directions, mostly non-vertical.

THE AUTHOR

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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 5.)

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 8. 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 4b proceeded from 4b-1 to 4b-2; 4b to position 4b-3 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 important 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.

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 produces satisfactory flow lines.
2. Sequential draw brings about transfer of particles from one cone to another, resulting in a change in velocity and a change in the pattern of flow. Velocity and flow in the patterns occur at the same time.
3. Sidewall friction caused either by the walls of the container or by the perimiter of the cone itself 
4. Lateral flow due to the effect of the walls or the cone itself.

When evaluating a new project, several stages are considered in its progress from a prospect or a research project to an operating property. There are: 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 into one 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 from plus or minus 50 percent to plus or minus 10 percent.

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

The overall value of the nonmetallic mineral industry in New Mexico produced commodities valued at $607 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, nonmetallic minerals 14 per cent, and metals 14 per cent.

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Process Evaluation

Process selection is probably the most critical point, since it is here that the 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, reserves and expected range of production rates.
3. Economics—geographic, climate, labor, market, transportation, availability of water, fuel, power and raw materials.

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 economies 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 relate 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 one year from now is worth only $0.94 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 for which no return is expected for five years, the amount paid back must be more than $1,438,689 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. 116-123).

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: 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.

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rates. Using these figures and such criteria as payment
times, it is possible to make an investment decision.

Costs

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
...
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 hour, depending on the labor market. Salary, according to company salary scales, and list of staff personnel.

- Maintenance supplies—Annual cost one to five percent of capital cost, depending on size 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 area and company policies.

- Taxes and Insurance—Annual cost 1.5% to 2.5% 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 has been discussed by R. L. Glaux, Jr, in Chemical Engineering Progress 

### TABLE II

<table>
<thead>
<tr>
<th>Year</th>
<th>Present Worth</th>
<th>Present Worth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
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<td>11</td>
<td></td>
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</tr>
</tbody>
</table>

(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 7.

#### Typical Project Evaluation

As an illustration of a typical project evaluation consider a hypothetical project in which the exploration department has found ore containing 5,000,000 tons of ore with one percent metal content. The mining estimate is 1.2 million tons of ore with one percent metal content. It is also reported that a new scheme will 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

<table>
<thead>
<tr>
<th>Case A</th>
<th>Case B</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2,700,000</td>
<td>$3,000,000</td>
</tr>
<tr>
<td>$1,000,000</td>
<td>$1,000,000</td>
</tr>
<tr>
<td>$2,500,000</td>
<td>$1,500,000</td>
</tr>
<tr>
<td>$7,000,000</td>
<td>$8,000,000</td>
</tr>
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<td>$10,000,000</td>
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<tr>
<td>$13,000,000</td>
<td>$13,000,000</td>
</tr>
<tr>
<td>$16,000,000</td>
<td>$16,000,000</td>
</tr>
<tr>
<td>$17,000,000</td>
<td>$17,000,000</td>
</tr>
</tbody>
</table>

Tons of ore fed 
Li. metal in feed 
Recovery, percent 
Metal recovered, lb./yr. 
Salaries 
Mining costs 
Operating cost 
Operating margin 
Plant depreciation 
Net before tax 
Taxes at 52 percent 
Net income 
Return on investment 

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 present worth of Case B makes it more desirable than Case 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 as a more accurate and versatile criterion. Anyone interested in mineral economics would do well to spend some time understanding the effect of various factors in analysis of this type.
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. 26. About 100 members present with 546 ballots were cast, representing 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 roast beef and mashed potatoes 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. Kneiting of the Geology Department; Prof. Clark F. Barr, head of the Petroleum Engineering Department; Prof. Lute J. Parkinson, head of the Mining Department; Fritz Beroonico, 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 efforts, their hard work, and the fact that alumni were more interested in the work being done than in the monetary reward involved. Mines Alumni Association has always been true to its motto: "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 its size, size of the graduating classes.

Back in 1940, Edie Reul 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 alumni 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, (those present personally and those who should be, will contribute wholeheartedly. For it or not, you are marked as a 'Mines Man.'

George Roll, who has been your executive manager for nearly three years, has come to you as your representative. He has in the past served as a clerk from the close cooperation with the administration of Mines, and at the present time. Based on the influence that our association should have if MINES is to continue to dominate the field of mineral engineering.

We must accomplish the impossible requires only the support of each individual alumni.

EXECUTIVE MANAGER'S MESSAGE

COL. WENDELL F. FERTIG

My decision to accept the position of executive manager was motivated by the challenge offered rather than the monetary reward involved. I have always been true to my heart, and it is my belief that it should increase in stature and influence in proportion to its size, size of the graduating classes.

Back in 1940, Joe Reul 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 alumni 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, (those present personally and those who should be, will contribute wholeheartedly. For it or not, you are marked as a 'Mines Woman.'

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ALUMNI ENDOWMENT FUND
Principal Amount
December 31, 1959

RECEIPTS
Cash on hand January 1, 1959 $1,426.69
One Life Membership 200.00
Loan Endowment 1,041.73
Balance on Deposit $ 7,275.19

INVESTMENTS
Securities at Cost $15,881.14
One Life Membership 200.00

VALUATION ACCOUNT
Balance on deposit, December 31, 1959 $ 9,839.94

ALUMNI MAGAZINE TOTAL RECEIPTS $11,519.89
Discounts $ 1,010.97
Subscription 29.65
Unclassified 1,055.83
Net Gain 1,384.84

ALUMNI MAGAZINE STATEMENT OF OPERATIONS
December 31, 1959

RECEIPTS
Discounts
Subscription
Total

DISBURSEMENTS
Discounts $ 187.92
Printing 217.86
Salaries 9,565.28
Prof. & Spec. Adv. 1,500.00
Unclassified 60.00
Telephone 217.86
Subscription 16,630.08
Copies 266.15
Cuts 5.30

Net Gain (or Loss) $ 1,384.84

ALUMNI LOAN FUND
Principal Amount
December 31, 1959

RECEIPTS
Cash on hand and in Bank January 1, 1959 $984.56
Interest earned 1959 349.73
Income from Endowment Fund Securities, 1959 $1,449.30
Balance on Deposit $ 2,113.85

DISBURSEMENTS
Custodian Fee for Securities $ 62.22
Transfer to General Fund to cover Capital expense of purchase of Videotape equipment for Alumni used years ago $ 61.62
Transfer to General Fund of $225.00 to cover extra expenditure of $191.00 of 1959 Alumni Association to be used in letter to alumni for replacement of Executive Manager’s former office as excise tax for such use to reimburse a balance of 1958 monies appropriated to that purpose $ 225.00
Balance on hand and in bank, December 31, 1959 $1,738.64

ALUMNI LOAN FUND
Principal Amount
December 31, 1959

RECEIPTS
Cash on hand and in Bank, January 1, 1959 $10,182.90
Alumni Contributions 2,087.00
Interest earned (Savings Account) 79.02
Balance on Deposit $10,182.90

DISBURSEMENTS
Loans made in 1959 $900.00
Transfer to General Fund to cover cost of football uniforms awarded to PHB Coaches at Athletic Banquet $ 4,012.97
Balance on deposit, December 31, 1959 $ 8,193.94
On deposit—First National Bank of Golden $11,562.84
On deposit—First Federal Savings and Loan Association $948.75

RECOGNITION FUND
Principal Amount
December 31, 1959

RECEIPTS
Cash on hand and in Bank January 1, 1959 $ 564.46
Interest earned 1959 17.05
Balance on deposit, December 31, 1959 $ 581.51
(At First Federal Savings & Loan Assoc.) $ 945.15
Col. Fertig, '51, Awarded Good Citizenship Medal

Col. Wendell W. Fertig, executive manager of the Colorado School of Mines Alumni Association, was honored by 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, industrial executive, lecturer, educator and outstanding citizen of our state and nation, was born in 1917 in the College of Engineering at the University of Colorado . . . ."transferred to the Colorado School of Mines. In 1941 being qualified as a mining engineer, he began the professional work, working thereafter in most of the important mines and also in the Philippines.

"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 served with the Philippine Department of the Army. Upon the enlargement of the American Forces in May of 1942, Colonel Fertig, . . . set about organizing and equipping ground forces to disrupt, disorganize, delay and confine, and ultimately defend the Japanese Forces in the Philippines, which was achieved with the Philippine Department of the Army. In September, 1945, he became Commander of the Philippine Regular Forces, and during that period the army achieved full victory over the Filipinos. Later, he was assigned to the post of Director of the Colorado School of Mines.

McKinley, '59, Top Man in Chemical Corps Class

Charles H. McKinney, 1959 Mines petroleum engineering graduate, recently completed the officers course at the U. S. Army Chemical School, Fort Benning, Georgia, where he will be a major. In his class, McKinney, commissioned as a second lieutenant in the Army Marine Corps ROTC program, competed against 41 other Chemical Corps officers from the nation's leading universities for the position. Lieutenant McKinney is currently assigned to two years active duty in the U. S. Army, where he has been assigned to the Chemical Corps.

Hustung Farkham, '39, Deputy Director Iran Oil Co.

Hustung Farkham, 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 Irn Oil Co. and a member of the chief petroleum engineer at the Sales Department with headquarters in Tehran.

"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."
IN MEMORIAM

Raymond Victor Wheelet

R. V. Wheelet, who received his E.M. degree in 1916 from the Colorado School of Mines, died on Sept. 23 at St. Mary's Hospital in Grand Junction, Colo. Services were held at the Fostetl Memorial Church in Paonia, Colo., with interment in Cedar Hill Cemetery where an honest gem捡出了 many of Wilson's classmates Post 97, American Legion, conducted graveside rites.

A 1949 recipient of the Colorado School of Mines' Distinguished Achievement Award, Mr. Wheelet retired in 1958 after serving 17 years as manager of the foreign department of Cities Service Petroleum Corp. Officers held by Mr. Wheelet included that of vice president and general manager, Venezuela-Cities Service Petroleum Corp.; vice president and director, Mexico-Cities Service Co.; and assistant manager of the Belgian, Peruvian and Chilean sales representative was assigned to the technical laboratory exhibit at the 1904 World's Fair in St. Louis. From 1904 to 1907 he worked successfully 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 Wilimington, Del., in 1910, 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, a position he held and served in that capacity until his retirement on pension at Seattle General Hospital after a long illness.

Recalled to service a few months later, he served two years as general manager of Compania Sud-Americana de Explotaciones (Du Pont subsidiary) in Peru and Chile.

Surviving are his wife, Ethel Bell Frank Wheelet of Paonia; three daughters, Louise (Mrs. Robert Goss of Portland, Ore., a sister, Mrs. Jida 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 ail­

ment Dec. 25, 1959, at Seattle General Hospital, in Seattle, Wash.

He was born in 1886 in Garfield, Colo., and was a graduate of both Mines and Purdue University. A member of the American Institute of Mining Engineers, serving as chair­

man of the North Pacific Section 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 Metallic Club of Denver, the West Chamber of Commerce, the Western Athletic Club, the Theta Chi Fraternity, and the Grand Junction Episcopal Church.

Mr. Burgess retired in 1937 and entered the consulting engineering service of the Frey Co. at Stamford, Conn. After serving as exp­

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

Caracas Section

Petroleum engineers and mining men attending the regular luncheon meeting of the Denver Section were: Warren Prosper, x-97; Harvey Mathews, x-97; George Rehl, x-97; Don L. Pack, x-97; Hugh A. Watkins, x-97; Frank Coakley, x-97; Bill Cullen, x-97; Sam Griffin, x-97; Herb Staats, x-97; James A. Mulvaney, Frank Scott, x-97; James A. Firm, x-97; N. John, x-97; James M. Taylor, Rene Leon, Dick Martin, Ralph Jones, x-97; Bert E. Vokes, x-97; Howard K. Loxacht, Wendell W. Forte, Charles M. Stoudall, x-97; A. Kunde, Drexel Lee, x-97; J. B. Perine, x-97; Fred M. Fox, x-97; and George Wink, x-97.

Also attending were Vincente P. Toure, Mines' Little All American football player; Fritz Brenneck, CSM athletic director, and Jim Sankovitz, CSM public information editor. (See picture and story in Out-of-Diggers Sports.)

Grand Junction Section

Joe Hopkins, Jr., secretary, reports that Grand Junction Section had its party on Jan. 23 with cocktails at Simpson's and dinner at the Carson Cafe. Everyone had prime rib and 37 dinners were served. Danke.

Maid was prepared by Gordon Miner and Joe May and Dwight Underwood. Marge and David Cole, x-92, have a new home address at 1530 E. Sherman Room.

Denver Section

The Denver Section held its first meeting of the year on Feb. 2 at the Denver Rail Restaurant, 40th and Park. Twenty-five alumni were present. They were: J. A. Kanzig, x-92; Barry H. McNeill, x-92; Dale Nix, x-97; C. A. Weinger, x-97; George Ordonez, x-97; Ben F. Zwick, x-97; Bill Wallis, x-97; James Boyes, x-97; Harry Parson, x-97; Charles N. Bellin, x-97; T. P. Turner, x-97; Bert E. Vokes, x-97; Ralph C. Holmes and James G. Cox, x-97; John D. Gilmour, x-97; William D. Pembroke, x-97; Charles F. Poggy, x-97; Lew Ralling and David B. Mazer, x-97; Herb Goodman and Mel Warren, x-97; J. B. Perine, x-97; and James A. Mulvaney, Frank Scott, x-97.

A solicitation to Herbert Thorton from Mines' Tankski Sokoliewa, x-97, to 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, Mines' Zwick and Thornton requested donations from the New York alumni. However, several of the members requested that parties be made to the Zwick, x-97, to be used to finance the expenses of the New York Chapter.

Charles Gogary, vice president of Texas Gulf Sulphur Co., brought up the point that Longenecker had also mentioned, that the major responsibility should be given to the Student Fund or part to the Student Chapter, and part to the Foundation's General Fund or all to the Foundation's General Fund.

James A. Mulvaney, Frank Scott, x-97, and Alan M. Simpsons, x-44, spent a week in Las Vegas recently and the whole party had an excellent time. The Charles V. Woodards, x-44, now residing in Hawaii.

E. F. Reed, x-92; H. D. Squibb, x-94; C. W. F. M. Stephens, x-13; L. A. Stewart, x-15; J. S. Seward, S. C. Holmes, x-53; C. Sorvisto, x-57; Robert Turley, x-52; and Julian Simpsons, x-47, now residing in Honolulu.

Grand Junction Branch of Western Mines men 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.

Informal Participation

Another means and one which has gained in popularity to a great degree since the Mines gymnasium was opened to all students is in formal athletic participation.

Rate, indeed, is the evening that the crew room is not being used by single students, faculty families, student groups or faculty groups for physical education as a legitimate part of this total education is in the physical fitness area.

Mineral engineering, in many cases, takes place in the underground room.

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Student-Athletes at Mines

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

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

The year R+ 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 scholar-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 nine 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 was Dick Egen, a 3.7 petroleum engineering student and a co-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, sophomores Tom Tyson has a nine and one dual meet record at 125 pounds—top record on the club. The club also has a 3.83 academic average in metallurgical engineering and holds two academic scholarships.

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.

Physical Training Important

Mines President Dr. John W. Van

Otter, a graduate of Harvard University, believes sincerely in the rigorous academic schedule, but just sincerely stresses the importance of a well-trained person physically. "Our new gymnastics is merely the carrying through of a philosophy which this institution has followed in many decades. A student cannot meet the requirements of the mining profession 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 rough professional life he must enter."

OREDIEGGER SPORTS

Ore Digger Sports

The Associated Press, on the basis of recommendations from its member newspapers, radio and television stations, and reports from the region's Associated Press bureau, has selected Vince Tesone, Colorado Mines, Black, a member of the Little All American Football Team.

\[\text{Continued from page 37}\\

\[\begin{array}{l}
\text{J. H. K.} \\
\text{\textsc{class notes}}}\\
\end{array}\]

\[\text{\textsc{class notes} (Continued from page 37)}\\

\[\begin{array}{l}
\text{JOHN CEDRIC C. MATHWESEN, chief consultant on the board of Continen­
\text{tal Grain,} N. Dak. His post office
\text{box is No. 573.}\\
\text{FRED R. SCHWARTZBERG is design
\text{specialist for the Missouri Co. His home
\text{address is 1488 S. JamestOWN Way, Denver
\text{22, Colo.}}\\
\text{ROBERT S. BOHON, formerly a gradu­
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PLANT NEWS

Babcock & 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, Inc., will specifically date back more than 20 years, is being terminated 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 Colorado and Wyoming distributor for the products of Stephens-Adamson Manufacturing Co. of Aurora, Ill., which includes: carriers and return rollers, car pullers, hoists, loaders, pulleys, tellevogers, winches and belt cleaners.

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Dual-Depth Offshore Platform Offers Economic Advantages

The nation's leading builders of mobile drilling platforms have announced a major break-through in the offshore oil industry's critical battle_of costs vs. production.

R. G. LeTourneau, Inc. of Longview, Texas, Texas, developed the platform concept. 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. The company matches up to a maximum of $500 any annual contribution from 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 Beverwijk, N.Y., plant. Mr. Lyle, a graduate of W. J. Pace, former of Lakeland, who retired Jan. 1, 1960, after 15 years service with the company.

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

TECHNICAL SOCIETIES

(Continued from page 11)

are: "Corrosion Problems in the Use of Sand Grains as Drilling Fluids," by C. M. Hudgins, W. D. Grashurst and J. E. Landers of the petroleum division, and "Corrosion Cracking in Concentrated Sodium Nitrate Solutions," by R. L. McGehee and C. M. Hudgins of Continental Oil Co. (Continued on page 43)

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JAMES STEWART HOLLINGSWORTH gives his address as Box 477, Colorado Central Power Co., Ainsworth & Sons, Inc., Wm. Metallurgist for Dov? Chemical. His home is now at 3619 Frederick St., Berkeley 4, Calif.

JAMES S. RANSOM, 914 14th St., Golden, Colo., has moved from Denver, Colo., to 5530 Holland Dr., Arland, Ore.

DONALD H. HOWELL has accepted a position as geologist with Standard Oil of Calif. 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., has moved from the alumni office before leaving Golden and became an active member of the Alumni Association.

Coors is America's Fine Light Beer.
Lower Pumping Costs...Higher Tonnages

Wilfley's versatile line of sand pumps give you economy plus increased output. If you require belt-driven, overhead V-belt driven, or direct driven pumps, Wilfley has them — available in 1”, 1½”, 2”, 2½”, 3”, 4”, 5”, 6”, 8”, and 10” discharge sizes. They may be fitted with interchangeable electric furnace alloy iron, special application alloys or rubber-covered wear parts.

Put a Wilfley Sand Pump to work—it guarantees continuous, maintenance-free service, stepped-up production, longer pump life, and quick, easy replacement of parts.

Every Installation Job Engineered for Maximum Pumping Economy.

Write, wire or phone for complete details.

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