I G Introduction

THE GUNNAR URANIUM DEPOSIT was discovered in July 1952 and commenced production in September 1955. In the three year interval, diamond drilling outlined an orebody then valued in excess of 130 million dollars; some 20 million dollars was expended for construction and installation of a mining and treatment plant; an open pit mine was developed for production, and a 1250-ton mill was brought into operation. This was the first uranium mill and the first major uranium mine developed in Canada by private enterprise in the post-war period, and on completion it doubled uranium productive capacity in Canada and in North America. It is appropriate that this discovery and development occurred under the aegis of Gilbert A. LaBine, former President of Gunnar Mining Limited, who had pioneered the radium and uranium industry in Canada some 20 years earlier by the discovery and development of the pitchblende and silver deposit on Great Bear Lake, the establishment of a radium refinery at Port Hope, Ontario, and production of the uranium which played such a significant role in ushering the world into the atomic age.

Production has been continuous since 1955. The initial treatment plant was expanded by 1957 to a rated capacity of 1650 tons per day, and subsequent operational improvements have brought it to its present capacity somewhat in excess of 2000 tons per 24 hours. By year end of 1962 some 4.8 million tons of ore had been treated; revenue in excess of 125 million dollars had been earned; a 19.5 million dollar senior financing loan had been retired; dividends totalling 21 million dollars had been paid to shareholders; 21 million dollars had been paid in wages and salaries; and working capital had been increased to 27.8 million dollars.

All ore was supplied from the open pit prior to 1958, and thereafter the pit continued to provide the major part of mill requirements until its completion in October of 1961. The underground mine was developed slowly to replace the pit and is now the sole source of mill feed.

Construction and development of the mining plant was of necessity accompanied by the parallel construction and development of a townsite adequate for a community of 800 people. Notwithstanding alleged severe unemployment in Canada, isolated communities such as this must be in all respects superior to their comparable sized counterpart in more populated areas to attract and maintain a stable working force. The Gunnar townsite is entirely company-owned and includes, in addition to homes and dormitories, a hospital and medical services, shopping facilities, a school, postal and banking facilities, extensive recreational facilities and accommodation for religious worship. Transportation of supplies, personnel and effects is provided by Gunnar-owned non-profit transportation companies. Communication is by company-owned radio facilities through existing Government channels. Such provisions are not unique in this area nor elsewhere in Canada but to the operator of an enterprise in an unpopulated area, dependent on urban centers for supplies and equipment, the problems of transportation and communication can become paramount.

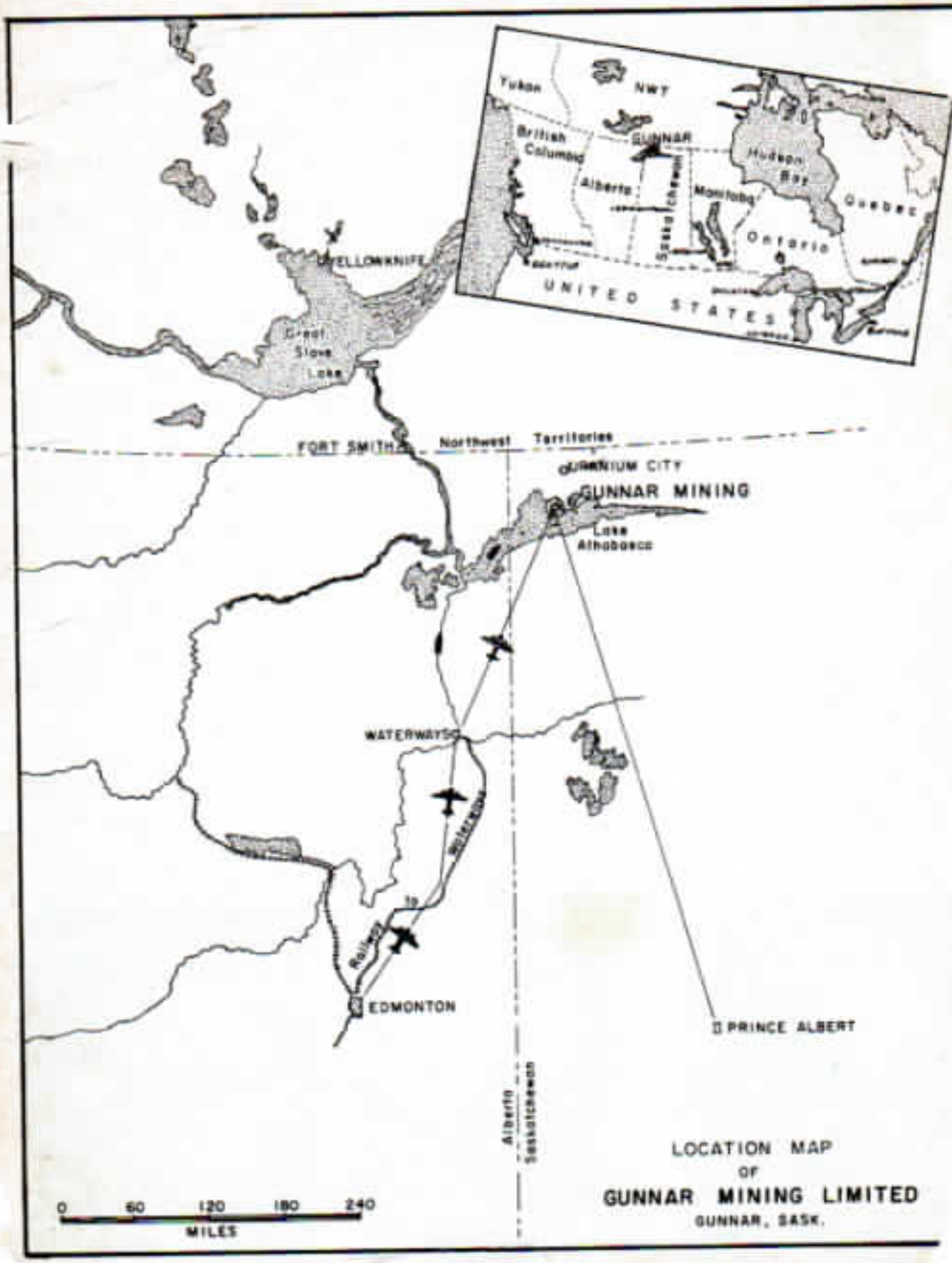
HISTORY

Gunnar Mining Limited was incorporated as Gunnar Gold Mines Limited in October 1933 with an Ontario

J. F. IRWIN
Mine Manager

J. R. O. WALLI
General Superintendent

E. F. EVOY
Production Superintendent



LOCATION MAP
OF
GUNNAR MINING LIMITED
GUNNAR, SASK.

XV

Camp and Community

THE GUNNAR COMMUNITY extends for a distance of about 5,000 feet along the lakeshore to the west of the mine and plant site. All buildings are supplied with steam heat, hot and cold water, sewage disposal lines, electricity, and in some cases with telephones.

HOUSING

Seven bunkhouses, identical in construction, provide accommodation for 448 men. The buildings are two-storey structures and have three exits on the upper floor and four exits on the lower one. Each floor is provided with shower and sanitary facilities. Two men occupy each room, and each is provided with a bed, dresser and closet. The staff house of similar design has rooms for 49 men, and the balance of the floor space is occupied by a lounge. Nurses, stenographers, and other office girls occupy single rooms above the hospital and in a separate girls' residence. Waitresses from the catering staff have living quarters above the dining hall of the cookery building.

In order to attract and maintain a stable staff and a nucleus of good operating personnel, the company has provided accommodation for 118 families in the form of single dwellings and apartment suites. Houses are two or three bedroom ranch-style homes, with floor area varying from 700 to 1300 sq. ft. Two apartment blocks each contain 16 suites and these are comparable in size to the private homes and may have one, two or three bedrooms. Each apartment block is divided into two mirror-image halves separated by a concrete fire wall. Four utility rooms provide laundry facilities in each block. From eight to ten dwelling units are required for non-company personnel including the doctor, store and bank managers, school teaching staff and contractors. The balance of the homes approximately evenly divided between staff and hourly rated employees.

The rocky terrain and the general absence of any depth of overburden was a deterrent to efforts at landscaping and gardening. To overcome this, the company has collected and hauled soil from wherever available, and has even brought in barge loads of earth from Waterways, Alberta.

HOSPITAL

A modern seven-bed hospital with resident doctor and nursing staff is operated by the company and provides first aid and out-patient services as well as hospitalization. The doctor is a member of the Uranium City Medical Clinic and most surgery is done by the Clinic in the Uranium City Hospital. Severe cases are flown to Edmonton for treatment. The normal nursing complement consists of a matron and three registered nurses. The hospital recorded 40 operating room hours during 1962, and 145 children have been born in the hospital to the end of that year. All employee medicals and X-rays are done locally with the exception of the pre-employment examination which is completed before the employee arrives on the property.

SCHOOL

In 1956 a school with three classrooms and a science laboratory was constructed by the company. Two additional classrooms were added in 1958. The school is operated by the Municipal Corporation of Uranium City and District under the direction of the Saskatchewan Department of Education. A Gunnar School Committee of five members elected from the community assists and advises the Uranium City Educational Services Committee in running the affairs of the Gunnar School. Classes range from Grade I to Grade X and there is a teaching staff of five. Enrolment for the current year is 100 pupils. An unauthorized kindergarten conducted by mothers with previous teaching experience has operated for the past three years and is highly regarded by parents and teachers alike.

SHOPPING & COMMUNITY CENTRE

All shopping and most recreational facilities are housed in a shopping and community centre which was built in May 1957. The building measures 200' x 200' and contains a Hudson's Bay Company department store; a Post Office; a branch of the Canadian Imperial Bank of Commerce; a coffee shop, dining room, bakery and butcher shop operated by Canus Services Limited; and a combined barber shop and beauty parlour operated by local personnel. These are all independent businesses which operate under contract arrangements with the company. The remainder of the building is utilized for community activities and the facilities include a large auditorium, bowling alley, pool

Aerial view of plant looking west over townsite — the snow k... ...end ...y lat).

DR. V. HAY-ROE
Medical Doctor

Radio room.

W. B. DANIELS
Recreation Superintendent

room, games room, lounge, library, handicraft club room, camera club room, and radio broadcasting room.

A recreation superintendent is responsible for the maintenance of recreational facilities, and the organization of all activities under the Gunnar Community Club. He is assisted by a bowling alley and poolhall attendant, a stenographer, and part-time and voluntary help. Most participant activities are organized on an individual club basis with club officers, but all receive direction and assistance from the recreational staff. All funds are controlled by central accounting under the Community Club.

The auditorium is 110 feet long and 60 fe[illegible]de and has seating capacity for 700 people. It serves as the theatre for five separate shows each week including a children's Saturday morning matinee. The chairs are collapsible and portable, and when removed the area serves as a gymnasium and the floor is marked for full size basketball, volleyball and badminton courts. The Gunnar School is permitted the use of the room for their gymnastic classes three times weekly, and after-school sports are provided for the children four times each week. Classes are conducted in basketball, volleyball, badminton, tumbling and boxing under Community Club supervision.

Other major activities include the following:

— A bowling alley comprising four standard alleys, and a pool room with four tables is open from noon until 11:00 p.m.

— A library containing over 2,250 books is open three nights a week and Saturday afternoons.

— A radio station operating as a line carrier with a 2-watt output broadcasts music, news and items of local interest to the camp for 17 hours each day.

— The Camera Club room with studio, dark-room and an enlarging room is fully equipped and highly utilized.

— A Handicraft room measuring 30 feet by 60 feet provides a club room for one of the most active groups in camp. In addition, it serves as meeting room for the Boy Scouts, Girl Guides and other miscellaneous organizations, and as church for both Roman Catholic and Protestant services. Clergymen fly in from Uranium City to hold weekly services.

In addition to the leisure hour facilities in the Shopping and Community Centre, the camp boasts a three-sheet curling rink with heated waiting room and gallery, an open air skating rink and a large playing field for summer sports. A picnic and camping ground has been prepared on a small lake about three miles from the camp. The lake had a soft, muddy bottom, but a beach was built by bulldozing sand from an adjacent esker onto lake spring ice to a depth of about two feet and permitting this to settle as the ice thawed.

FIRE PROTECTION

A volunteer fire department with a fully equipped fire truck provides fire protection for the community. The volunteer members are chosen to ensure that some are on shift at all times and include garage personnel who are working only a few feet from the location of the fire truck in warm storage. The members of the brigade have received special training and regular practices are held. The positions of fire chief and two deputies are rotated among the electrical superintendent, machine shop foreman and garage foreman.

A high pressure 8-inch water line is carried in main pipe boxes for the full length of the property with heated, housed hydrants strategically located throughout the plant and camp. Each hydrant is equipped wi[illegible] sufficient hose to reach all buildi[illegible] within its designed radius.

Open pit and surface plant.

spoil were not readily available. Accordingly, monitoring was reserved for final clean-up of ore surfaces which was necessary to avoid deleterious effects in the mill circuit.

Tractors and scrapers successfully stripped the muskeg and some of the silt, but they were hindered by the permafrost which necessitated rotating scraping areas while the frost melted. When the permafrost was penetrated the underlying silt would not withstand haulage over it. When continued use of scrapers became impossible, a drag-line was used and it was necessary to build roads of rock fill across the silt to support the drag-line and trucks. The roads in turn were removed as the drag-line retreated. Where the silt was underlain by waste rock, much of it was left in place to be blasted and picked up with broken rock in the normal course of mining. Approximately 353,000 cubic yards of overburden were ultimately removed by these combined methods.

PIT EQUIPMENT

Use of diesel equipment was favoured because of the lack of hydro power sources and the necessity of generating all electricity on the job site. Its use, in turn, permitted complete mobility and independence for each unit and resulted in a certain amount of desired flexibility.

Major equipment employed in the open pit operation included:

- 6 X-72 Ingersoll-Rand blower drifter wagon drills
- 2 DH-123 Gardner-Denver wagon drills with RMC-10 tower, chain feed and hydraulic jacks
- 3 DM-2-OHD-500 Ingersoll-Rand Drillmasters
- 2 DHD-275 "Down-the-Hole" drills for use with the above Drillmasters
- 2 DR-600 Ingersoll-Rand Gyroflo portable compressors
- 3 101-M Marion 3 cu. yd. shovels
- 9 36TD 22-ton Euclid rear dump trucks with torquematic transmission
- 1 D6 Caterpillar tractor
- 1 D7 Caterpillar tractor
- 1 Model C LeTourneau Westinghouse Tournadozer
- 1 No. 12 Caterpillar grader
- 1 Fordson Major farm tractor
- 1 1,000 gallon fuel wagon
- 1 ½-ton Ford pick-up truck

The X-72 Wagon Drills were not purchased for pit work but were on the job for surface rock excavation for building foundations. These drills were used in the pit for a short period only for reducing the irregular surface of the bedrock down to the first common bench datum which was at elevation 700 feet.

The Cummins NHRBIS 300 hp supercharged engine was adopted for the Euclid trucks and the Marion shovels and a spare Cummins engine was maintained on hand at all times. The General Motors 671 diesel engine was standard for the Drillmas-

...rtable compressors and the ...rnadozer, and a spare GM engine was kept on hand for these units.

The two Caterpillar tractors, the Tournadozer, the grader and the Fordson tracter were used wherever required on the job and not exclusively in the open pit.

MINING METHODS

The X-72 Wagon Drills were used for foundation excavations and for the first pit bench. Air was supplied by portable compressors. Lugged round drill steel of 1¼-inch diameter in 9-, 18- and 27-foot lengths was used with 2-inch tungsten carbide bits. The burden and spacing for this work ranged from 4' × 4' to 5' × 6' depending on the length of the hole. The holes were generally over-drilled by 2 feet to maintain grade. Fragmentation of this surface rock was often poor as a result of frost-widened fractures which not only caused poor fragmentation within the pattern but also caused considerable overbreak. When the original pit surface had been reduced to a reasonably level plane, use of the small drills was discontinued and they were replaced by the Gardner-Denver Tower Drills and the Ingersoll-Rand Drillmasters.

Experimental Work

Over a period of two years test work was done to establish criteria for optimum productivity, and these were then incorporated as operating standards. This work included investigation into:

1. Drilling — size of hole, burden and spacing, over-drill;
2. Blasting — top versus bottom detonation, decked charges, use of Primacord, double capping, cap patterns, high and low density explosives, alternate velocity blasting, ammonium nitrate and fuel oil mixtures.
3. Perimeter patterns — hole spacing and powder distribution;
4. Ramp pattern and box cuts;
5. Drill steel and bits.

Establishment of standards resulted in a marked increase in operating efficiency as work became routine through repetition, and errors and waste time were reduced.

Drilling

Drilling in ore was done by the Drillmasters drilling a 4-inch hole with the OHD500 drill on a 10' × 10' square pattern with three feet of over drill, (i.e. holes drilled to 33 feet). Drilling in waste was done by th... Drillmasters drilling a 4¾-inch hol... with the DHD-275 "Down-the-Hole" drill on a 13' × 13' square pattern with four feet of overdrill. In each case the outer 21 feet around the periphery of each bench was overdrilled to one foot only. This is the area which forms the berm of the succeeding bench, and it was found that normal overdrill caused excessive back break into the next berm.

Perimeter drilling patterns adjacent to all walls consisted of three rows of holes comprising the perimeter row, a second row four feet inside, and a third row which was seven feet inside the second row. Hole spacing in the rows was at 4-, 6-, and 9-foot centres respectively. This pattern was the same whether in ore or waste, and was not blasted separately but formed the outer edge of a larger ore or waste pattern.

Haulage roads were cut as rampways to provide access to succeeding benches, and at the prescribed grade of 8% had a horizontal length of 375 feet per bench. They were drilled with 4-inch holes beginning with a burden and spacing of 4' × 4' and expanding this progressively to 10' × 10'. Ramps were normally carried beyond the required length by drilling holes up to 45 feet deep to facilitate the beginning of the subsequent ramp, and to avoid the necessity of drilling very short holes.

The DHD-123 Wagon Drills drilled only 4-inch holes and were used for most of the perimeter drilling, for angle holes required in front of the pattern where back break left insufficient room for a Drillmaster, and for drilling off any high bottom or high toe.

Loading and Blasting

Holes in ore were loaded with four sticks of 3" × 16", 75% Forcite followed by seventeen sticks of 3" × 16", 75% Dygel to produce a continuous column loading in a 4-inch hole. This left approximately eight feet of collar which was stemmed with drill cuttings. W...

Drillmaster drills 4 in. & 4¾ in. holes.

... diameter of the new wear sleeve was 4⅝ inches whereas the diameter of a new bit was 4¾ inches. Care was taken to maintain in excess of ⅛ inch tolerance between bit gauge and the hammer wear sleeve gauge to assure a sufficiently large annular ring to blow the cuttings up the hole. Partially worn bits were saved and used with worn hammer sleeves. Drill operators were supplied with calipers to check bit and hammer diameters. These bits were Ingersoll-Rand 4¾ inch splined "X" bits and when worn out they were reconditioned by Kennametal Tools and Manufacturing Company Limited of Hamilton. Kennametal built up the bit body, machined new insert seats and set new tungsten carbide inserts for approximately one-half the cost of the original bit.

Operating techniques necessitated a minor but notable on-the-job modification to the "Down-the-Hole" drill. It was necessary to run the hammer as the drill was being raised and lowered in the hole and in so doing the back-head of the drill would vibrate loose causing extensive damage to the drill. It was found that three light tack welds were sufficient to hold the back-head tight resulting in a large saving of parts and down time.

Sandvik Coromant 1½-inch round extension steel with rope thread, two threads per inch, was adapted as standard for the Gardner-Denver Wagon Drills. Sandvik 4-inch, four wing "X" bits with rope thread were used thereby eliminating a bit adapter.

All steel used on the job was cut off and re-threaded as required. The combined life of some of the 2⅜-inch O.D. steel used for the Drillmasters is in excess of 30,000 feet.

COLD WEATHER EQUIPMENT MODIFICATIONS

The year round operation of an open pit in a sub-Arctic climate suggested the possibility of many formidable cold weather problems. Experience has proven these need not be a deterrent, and that pit costs and productivity can be kept reasonably independent of the seasons. To accomplish this Gunnar introduced a number of modifications to equipment already on the job and required manufacturers to incorporate others on new equipment purchased.

Lubricants

Despite a lot of continued research and excellent co-operation from manufacturers and distributors, lubricants for certain cold weather applications are still not available. The hydraulic systems of most standard equipment operate quite satisfactorily to about −20°F. but below this temperature difficulties arise which are compounded as the temperature falls lower. Hydraulic line blockage, starvation of hydraulic pumps and excessive build up of pressures in the discharge lines due to the increased viscosity of the fluid are all frequent troubles. During the first winter Imperial Oil Limited Polar 41 hydraulic oil was used but this was unsatisfactory and a substitute had to be found. The only oil available on the job which did not gel at −30°F. was Imperial Voltesso No. 35 transformer oil. This was not the proper oil for hydraulic applications but nevertheless it was used satisfactorily for the balance of the first operating winter. For the second year Imperial Aviation Univis J-40 hydraulic fluid was used with complete satisfaction but its cost dictated the continued search for a suitable substitute. After certain hydraulic line modifications and the realization that the equipment must either be left running or be warm-stored, it was found that Imperial Teresso 43 lubricating oil could be satisfactorily used and this became the standard hydraulic and compressor oil on the job.

The rotary head of the Ingersoll-Rand Drillmasters presented a particular problem. The rotary required a hydraulic fluid and lubricant, which not only lubricated the gear system but, pumped through ½-inch pilot lines also operated and controlled the air inlet valve to the vane motor. The rotary head was mounted on the drill tower and was thus away from any engine or compressor heat. On occasion the oil gelled and, in effect, seized the rotary gears. More often, the head merely became so stiff that it had insufficient power to rotate the gears at operating speed. The rotation valve control problem was overcome by stripping the pilot lines from the rotary head, eliminating the hydraulic pump and the rotation control valve, and replacing these with 1-inch air lines to each side of the vane motor and a three-way air valve in the cab of the Drillmaster with which the operator controlled the direction and amount of rotation. The fluid viscosity problem at cold temperatures was overcome by the use of Imperial Univis J-43 hydraulic fluid, which has a pour point of −80°F. The cost of Univis J-43 precluded its use in other applications. Prior to the above modifications and the use of Univis J-43, it was necessary to leave the heads rotating slowly between shifts and over week-ends.

Imperial Aros EP-40 rock drill oil was used during the early rock excavation but at low temperatures, due to the high pour point of the oil, it

Headframe in winter.

would ball up in hoses and a slug of hard oil would plug the valve ports of the machines. Fortunately, the low humidity during winter months permitted the use of Marvelube 5W motor oil as a rock drill oil. Blockages were reduced but there was some doubt as to the extent of proper lubrication to the machine. At Gunnar's request, Imperial Oil Limited developed and supplied Arox EP-38, with a pour point of −50°F., and this was found to be satisfactory.

The dipper sticks and main rotating gears of the Marion shovels required particular attention. It was found that a graphite compounded grease, Imperial Van Arctic No. 2, was the most suitable for winter temperatures. Surett No. 50 was used for summer lubrication of the dipper sticks and main rotating gear. For all open gear applications inside the shovel, Surett No. 7 was found suitable for winter and Surett No. 50 for summer operation.

Hydraulic Lines and Grease Seals

The plastic seal which is supplied with most modern equipment has a tendency to adhere to the shaft when a machine stands idle for any length of time at low temperatures. Immediately the machine is started, the seal ruptures but this may not be noticed until the machine comes up to operating temperatures or, in the case of outside housings, until warmer weather. Leather seals give more satisfactory service where they can be used. The field is still wide open for research into good all-weather seals.

Standard rubber hydraulic hoses become brittle at low temperatures and rupture through vibration or excessive pressure due to the high viscosity of the hydraulic fluid. All hydraulic hoses and many hydraulic lines on all equipment were replaced with Aeroquip 1503, a wire braid hydraulic hose. The high pressure of the hydraulic pump on the Drillmaster necessitated the use of Aeroquip 1509. The successful use of this hydraulic hose may be gauged by the fact that it was used on the dipper trip controls of the Marion shovels where it was continually wound and unwound and in this application gave very satisfactory service.

Marion Shovels

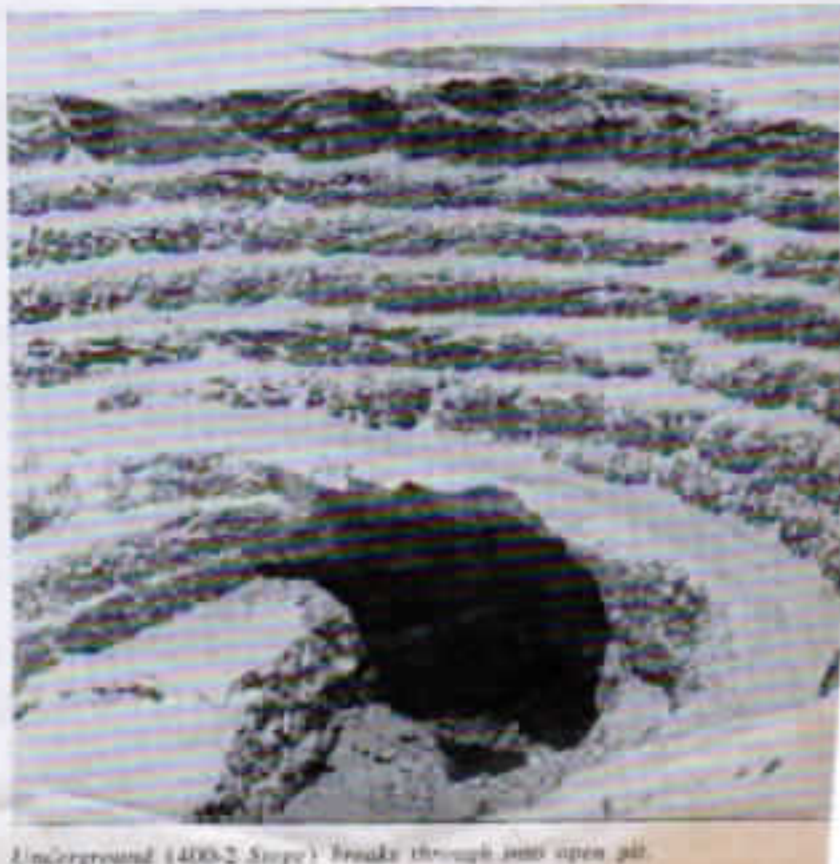
The Marion shovels were supplied with 24-volt electric starters and generators. Cold weather rendered these ineffective and battery maintenance was excessive. In 1957 the electric starting system was removed and replaced by Model 9-BM Ingersoll-Rand air starters which were efficient, positive and dependable.

The fuel system as supplied was a Cummins DD fuel pump with Woodward hydraulic governor. This was changed to the improved and more economical Cummins PT fuel system.

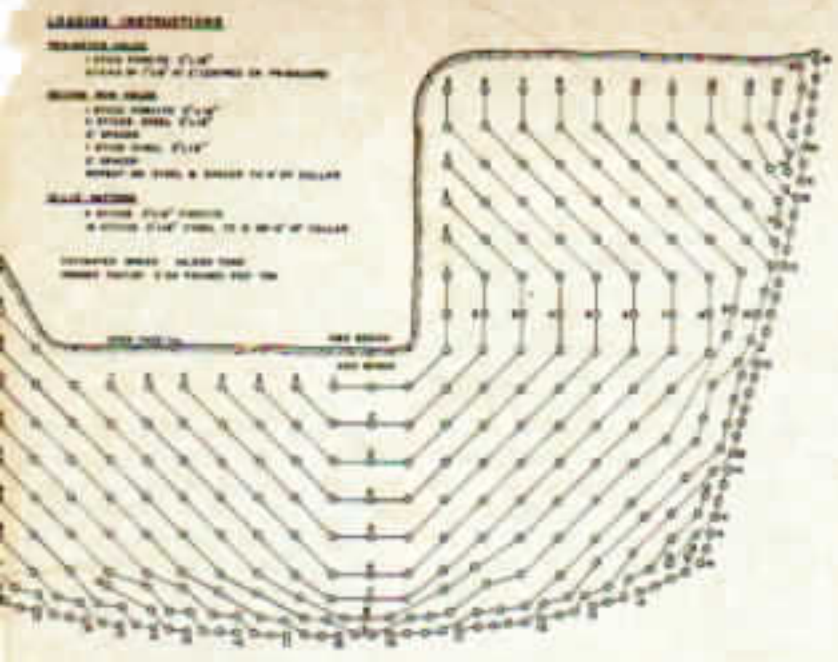
Since there are sixteen hours of darkness daily during the winter months in this locality, operating lights were critically important. The shovels were not equipped with operating lights by the manufacturer. The Kohler lighting plants initially installed were difficult to maintain in service, presumably due to shovel vibration, and they were hard to start in cold weather. A great deal of down time resulted solely from the breakdown of the Kohler plants. In 1957, 3 KW, 125-volt Thyrite constant voltage generators were installed. These were V-belt connected to the main engine and produced constant voltage and output through a range of 850 to 3200 rpm. Maintenance costs on the Thyrite generators have been negligible.

Aeroquip No. 1503 hydraulic hose was installed throughout all Marion shovels.

The shovels were supplied with booms and dipper handles fabricated from Tri-Ten steel which has a critical low temperature range of −15°F. to −40°F. On one occasion, while operating at temperatures colder than −40°F. one boom fractured midway between the heel and the shipper shaft with a clean and almost total break. This was repaired by remo... stressed metal and replacing it with sections of USS "T-1" steel using an AWS-8016 welding electrode which contains 2½% nickel. This rod has proven very satisfactory for repairing equipment which is subject to low temperature conditions and the repairs do not require stress relieving. An unsatisfactory bumper block arrangement permitted the bucket to strike the boom and this initiated cracks which extended into the sides of the booms and necessitated frequent welding repairs. Equally responsible for a great deal of down time was tooth breakage in the main rotating gears. Usually a single tooth broke out, but on one occasion a section comprising seven teeth snapped out. Oddly enough, these metal failures generally did not occur during a very cold spell but immediately following a period of very cold weather. The entire problem was overcome by purchasing and installing dipper handles, booms, main rotating gears and steering lock shifters fabricated from "T-1" steel manufactured by United States Steel Corporation. The new main rotating gears were cut from a solid slab of "T-1" steel eight feet square and six inches thick. "T-1" steel is claimed to have superior mechanical properties and to have the ability to withstand impact abuse at temperatures much below that of stee



Underground (400-2 Stope) breaks through into open pit



...pattern and loading details for open pit ore blast.

...es were loaded with five sticks of ... × 16", 75% Forcite followed by ...nteen sticks of 4" × 16", 75% ...gel to produce a continuous col... load in a 4½-inch hole. The re...ning collar was approximately nine ... and was stemmed with drill cut...s. Detonation was by single Short ...iod cap placed in the second stick ...n the bottom of the hole. All ...rt Period caps were purchased ... 40-foot lead wires.

...erimeter holes on each bench were ...ded using a cushion blasting tech...ue which employed sticks of 1" × ... 75% Cilgel B explosive taped to ...macord at 24-inch centres (i.e. 16 ...es apart). A single stick of 3" × ..., 75% Forcite was tied to the end ... the Primacord and the explosive ...g was lowered into the hole. The ...r of the hole was plugged, the ...two feet was stemmed with drill ...ngs, and the shot was fired with ...gle Short Period cap taped to the ...acord at the collar of the hole. ... technique was remarkably suc...ful and resulted in clean, straight ... on which the trace of each hole ...sible. The stick of large powder ... the bottom of the string was suffi...nt to pull the toe of the hole.

...atterns were hooked up in "series-...parallel" circuits with 35 to 40 ...s per series. As many as ten series ...re connected in parallel. Each cap ... tested with a galvanometer before ...d after loading and again before ...ok-up. Series were tested with a ...tohmeter and required to read ...hin 5 ohms of the calculated re...ance. Trunk lines and then the ... hook-up were tested at the ...ine with a voltohm...

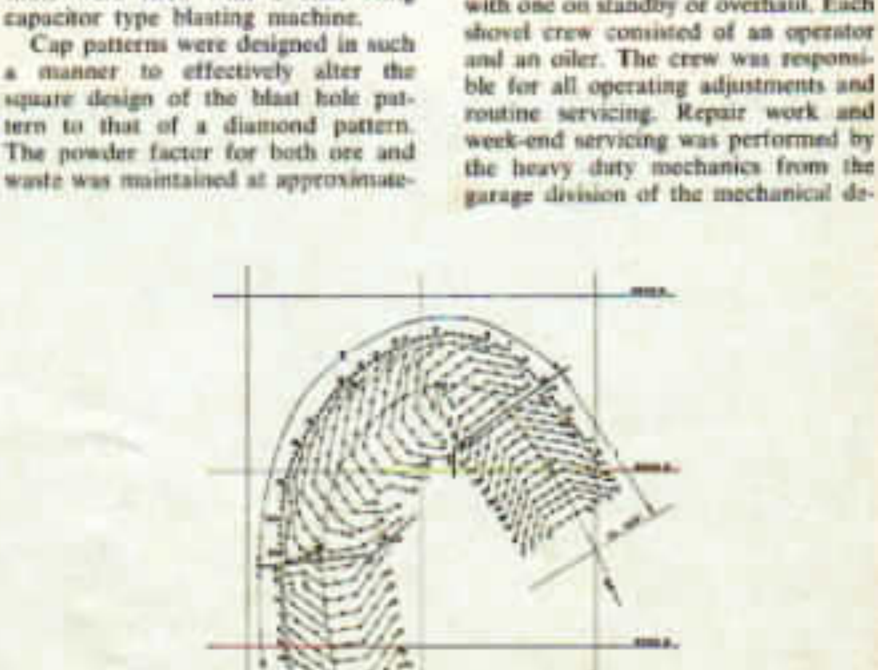
The final reading was required to be within 2 ohms. of the calculated reading before the shot was fired. All shots were fired with a Shot King capacitor type blasting machine.

Cap patterns were designed in such a manner to effectively alter the square design of the blast hole pattern to that of a diamond pattern. The powder factor for both ore and waste was maintained at approximately 0.95 pounds per cubic yard. Powder factors for ramps varied from 1.0 to 2.0 pounds per cubic yard.

The average blast contained about 35,000 tons and the largest ones contained some 60,000 tons but the only size limitations were those imposed by bench size and production schedules. Contrary to initial thinking, it was not necessary to muck out a blast before breaking the succeeding one, and in fact blasting into a muck pile resulted in better fragmentation. With hole depths closely controlled by survey, blast patterns normally broke well to bottom, and rarely was secondary drilling and blasting required to flatten pit floors prior to mucking or to drilling the next bench.

Shovel Loading

All loading was done by three Marion 101-M, 3-cu.yd. shovels powered by Cummins NHRBIS-600 supercharged diesel engines governed to 275 hp. at 1875 rpm., driving through a Torcon Model 1717 CKO torque converter. Throughout most of the pit life three or four machine shifts per day were employed using two shovels actively with one on standby or overhaul. Each shovel crew consisted of an operator and an oiler. The crew was responsible for all operating adjustments and routine servicing. Repair work and week-end servicing was performed by the heavy duty mechanics from the garage division of the mechanical de...



...attern and blasting ... road near pit bottom.

partment. From mid October to mid April the operating shovels were never shut down except for oil changes and repairs.

Hauling

Rock was hauled by nine Model 36-TD Euclid rear dump trucks powered by Cummins Model NHRBIS-600 supercharged diesel engines rated at 300 hp. at 2100 rpm., with Allison Torquematic transmissions. Additional equipment included air engine starters, thermatic engine fans, cab heaters and defrosters, rock ejector bars and exhaust heated boxes.

Eight Euclids were operated each shift with the remaining unit under repair or standby. All servicing of Euclids was done by the garage crew and this included re-fueling, tire gauging and radiator checks at the end of every shift. The Euclid operators were responsible only for the cleanliness of the cab and windshield. The operators were required to complete an equipment operators' form at the end of each shift and to list thereon every mechanical defect or suspected defect. These were checked by the shop crew and necessary repairs were effected between operating shifts.

Rock spill in the loading and dumping areas and on intervening roads was cleaned constantly by the LeTourneau Tournadozer to avoid excessive abuse to truck tires. Major clean-up following a blast was more effectively done by a D7 Caterpillar tractor with hydraulic blade.

Haulage Roads

Pit roads were built on a bedrock base with ramp patterns overdrilled by three feet. After blasting the broken rock was excavated to 1-foot subgrade. This in turn was backfilled with course crushed rock or underground development waste and top dressed with fine crushed rock. Haulage roads across benches were dressed with crushed waste over waste areas and with crushed ore over ore areas.

Haulage roads were graded as required and maintained in excellent condition by the grader. A hard packed snow surface was maintained on the roads for the winter months, but excessive snow was graded off to minimize the amount of thaw and soft road conditions in the spring. During the summer the roads became extremely dusty and it was estimated that 90% of the dust in the pit originated from such source. To overcome the problem, roads were oiled with discarded engine oil from the powerhouse which was saved thr[illegible] out the year for that purpose [illegible] effectively controlled the dust, a[illegible] turn, engine filter maintenance [illegible] reduced as well as other adverse [illegible]fects which result from equipment o[illegible]erating in a dust laden atmosphere.

In spite of the cold the winter se[illegible]son produced the best operating co[illegible]ditions for haulage equipment. Ro[illegible] surfaces were smooth and sn[illegible] packed producing almost negligi[illegible] tire wear, and the equipment was [illegible]erating in a dust free atmosphere.

Bits and Steel

The drill steel used with the OHD5 "Out-of-Hole" Drillmaster was Be[illegible]lehem 2¾-inch OD seamless mech[illegible]ical tubing. Rope threads were [illegible]chined and tempered on this steel [illegible] the company shops. The bits were [illegible]inch, four wing, "X" bits manuf[illegible]tured by Canadian Ingersoll R[illegible] Company Limited and A. C. Wi[illegible]man Limited. The "Down-the-H[illegible]" machine used drill rods made on [illegible] job from 3½-inch schedule 80 bl[illegible] iron pipe with API tapered threa[illegible] male and female ends machined [illegible] welded into the pipe. The outside [illegible] sleeves for the "Down-the-Hole" [illegible] were machined in the company sh[illegible] from 4-inch XXS black iron pipe.

Loading waste rock near Botto[illegible]