METHODS AND COSTS OF SINKING
BUNKER HILL AND SULLIVAN MINING AND CONCENTRATING COMPANY'S
CRESCENT SHAFT

A THESIS SUBMITTED TO THE FACULTY OF THE UNIVERSITY OF NEVADA IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF ENGINEER OF MINES

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ACKNOWLEDGMENT

I wish to acknowledge the kindness of Mr. S. W. McDougall, Manager of Mines of the Bunker Hill and Sullivan Mining and Concentrating Company, in giving his permission to publish this information and also his invaluable aid in organizing the shaft sinking job.

INTRODUCTION

This paper describes the methods and costs of deepening the Crescent three-compartment shaft from the 1,275 foot level to the 3,275 foot level. A noteworthy rate of advance was achieved by the use of mechanical mucking and an intermediate dump.

The Crescent Mine is located in the Coeur d'Alene Mining District of Shoshone County, Idaho, seven miles east of Kellogg. The adit level (Hooper Tunnel) portal and surface buildings are located on the east slope of the Big Creek Canyon. The collar of the Crescent shaft is 4,000 feet west of the portal of the Hooper Tunnel level at an elevation of 2,709 feet. The shaft was sunk to the 1,275 foot level in 1939. Unwatering and repairing of the shaft was started March 26, 1953. Deepening of the shaft from the 1,275 foot level was started June 24, 1953. On May 27, 1954 the shaft sinking was completed with 2,000.5 feet of new shaft to the 3,275 foot level. The work was done by the Bunker Hill and Sullivan Mining and Concentrating Company with the aid of a Defense Minerals Exploration Administration loan.

The area to be explored lies between the Bunker Hill Mine and the Sunshine Mine. A tremendous potential exists of developing large lead, silver and copper ore bodies with deep exploration. The contract with the Defense Minerals Exploration Administration also calls for 9,300 feet of drifting and crosscutting, and 22,400 feet of diamond drilling all of which is to be done at an elevation
of 400 feet below sea level. The Defense Minerals Exploration Administration insisted the entire project be completed in four years.

PURPOSE OF THE SHAFT

Crosscutting and drifting will be done to and along the Alhambra Fault at 400 feet below sea level. The production from the Crescent Mine in the past has been along the Alhambra Fault.
The Crescent shaft is located 5,300 feet westerly from the Sunshine Mining Company's Jewell shaft, and 11,000 feet easterly from the nearest workings of the Bunker Hill Mine. In the Sunshine Mine and Bunker Hill Mine ore has been found on faults and on veins that link between major faults, or branch from major faults. Many of these veins do not outcrop on the surface. Crosscutting and diamond drilling will be done to explore the area west of the shaft for link or branch type veins.

**GEOLOGICAL FORMATIONS**

The entire shaft was sunk in steeply dipping beds of argillaceous quartzites of the St. Regis formation. The shaft is oriented so that its long axis is normal to the strike of the bedding planes. With the shaft so oriented the only slabby ground of any consequence was along the short axis of the shaft. Excellent fragmentation with little overbreak from blasting the bench rounds, can be largely attributed to the orientation of the shaft to the bedding planes. The St. Regis quartzite is relatively hard and abrasive to drill. It stands well and no trouble was encountered in having up to sixteen feet of rock shaft below timber. Very little water was encountered in sinking.

**SURFACE AND UNDERGROUND PLANT**

The old Crescent Mine office and change house, conveniently located near the portal of the Hooper Tunnel, were rehabilitated. A charging panel to handle the 30 Edison cap lamps was installed in the north end of the old shop building. The yard tracks were repaired and a one and one-half ton electric driven chain lift was installed on a "I" beam over the surface tail track. This expedited the handling of supplies and equipment which were
hauled from the Bunker Hill and Sullivan Mining and Concentrating Company warehouses and shops at Kellogg. All machine shop work and timber framing was done in the Kellogg shops. All timber was "packaged." The bands were not broken until the timber was ready to be taken down the shaft.

About 300 feet of the old waste track trestle was repaired and a dump put in that would handle the Bunker Hill type bottom dump cars. A 400 ton capacity bin was built by using the slope of the hill with wings and facing at the bottom of the slope. A chute lip was installed in order to load into a dump truck. For final disposal it was necessary to use an Ingersoll-Rand 20 horsepower three-drum tugger hoist with a $2$ inch Pacific scrapper to slush the waste to the chute lip. The waste had to be trucked about one-fourth mile to a suitable dumping location.

The rolling stock consisted of seven timber trucks, eight $1.2$ ton capacity Bunker Hill type bottom dump cars, one General Electric $6$ ton Battery Locomotive, and one speeder (battery powered 32 volt locomotive for transportation of men only).

The underground equipment consists of a Bunker Hill and Sullivan manufactured 250 horsepower hoist with the necessary grids and switch gear. The $2,300$ volt A. C. powered hoist is equipped with D. C. dynamic braking. The drums of the double drum hoist are each four feet in diameter and four feet long. The drums each carry $3,817$ feet of $7/8$ inch wire rope of flat-tended strand construction. A $112$ foot rope raise on a $47$ degree slope connects to the top of the shaft where there are two $68$ inch diameter sheaves. Because of the slow rope speed of the hoist and the depth of the shaft, intermediate dumps were used which will be described later in this paper.

A 30 inch diameter Jeffery Aerodyne fan powered by a 50 horsepower
motor is located west of the shaft (Figure 1). This delivered 28,000 c.f.m. of air into the main adit (Hooper Tunnel) level. The air was exhausted through old workings to the No. 4 adit level, 565 feet above the Hooper Tunnel level.

Two Ingersoll-Rand 90-B compressors furnished 810 cubic feet of free air per minute at 115 pounds pressure. Each compressor was driven by a 2,300 volt, 100 horsepower General Electric motor. The compressors were located between the collar of the shaft and the Jeffrey fan (Figure 1). Between the two compressors and two air receivers was located a water cooled aftercooler and a Nicholson Automatic unloading trap. The water for the aftercooler was circulated from the drainage ditch by a 1/3 horsepower sump pump.

Sixty feet above the collar of the shaft in the manway compartment was a Coppus T.M. 9, 25 horsepower Blower. This fan would deliver about 6,000 cubic feet of air per minute to the 3,200 foot level station through the 20 inch Naylor, Spiral Weld, pipe. On the collar station was installed another Coppus T.M. 9, 25 horsepower Blower that would, by regulating dampers, exhaust about 5,300 cubic feet of air per minute from the 3,200 foot level station.

On the collar station were two, one and one-half ton chain blocks on "I" beam crawls used to unload from the timber trucks the "packaged" timber, equipment and supplies. Located in the hoist room (Figure 1) was a General Electric Motor Generator Set for charging the locomotive battery.

Electric power was provided by the Washington Water Power Company. The power entered the mine adit in an armored No. 2-0 three conductor cable at 2,300 volts. Power was taken down the shaft in a No. 2 three conductor bore hole type varnished cambric lead sheathed cable.
Two pumps were installed on the old 1,200 foot level. One was an Ingersoll-Rand 2 1/2 NT 6, powered by a 150 horsepower General Electric motor with a capacity of 380 gallons of water per minute at 1,260 foot head. The other was an Ingersoll-Rand 2 1/2 COTA 6, powered by a 150 horsepower General Electric motor and has a capacity of 320 gallons per minute at 1,250 foot head. The pumps were set with electrical switches to operate automatically. However, during the shaft sinking they were started manually by the skiptenders during the drilling cycle. This prevented the pumps from running during the mucking or hoisting cycle which eliminated an excessive power demand. A selector switch made it possible to use one pump one day and the other pump the next day. About 75 gallons per minute were pumped from the 1,200 foot level, most of which came from the old workings.

**SHAFT SINKING**

The 2,000.5 feet of timbered shaft from the 1,275.5 foot level (bottom of the old Crescent shaft) to the 3,276.0 level was accomplished in 28½ operating days. This included the time required to cut four pump stations, one intermediate dump station with a skip loading station and pocket raise, and a portion of the main 3,200 foot level station, loading station and pocket raise.

The break down of time was as follows:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft sinking</td>
<td>238 2/3 days</td>
</tr>
<tr>
<td>Station cutting</td>
<td>41 1/3 days</td>
</tr>
<tr>
<td>Breakdown time</td>
<td>1 day</td>
</tr>
<tr>
<td>Total operating time</td>
<td>28½ days</td>
</tr>
</tbody>
</table>

The rate of progress was 8.4 feet of shaft per shaft-sinking day and 7.1 feet per total operating day.
The overall dimensions of the three-compartment shaft were 5 feet 10 inches by 15 feet. The two hoisting compartments were 54 inches by 18 inches, inside measurements, while the manway compartment was 52 inches by 54 inches. (Figure 3.)

The wall plates, end plates and dividers were framed from 8 inch by 10 inch timber. The panel lacing was 2 inch lagging held in place by two 3 inch cleats running the full length of each wall plate and end plate. All framed portions of the timber were treated with Copper-nate timber preservative.

Four 7/8 inch hanging rods were used on each set. Bearing sets were put in every 400 feet. The bearing sets (Figure 4.) consisted of eight 1 1/2 inch rock bolts six feet long with an eye welded closed on the end of each rock bolt. These rods were driven into holes drilled about 50 degrees from the horizontal and near the end of each wall plate. The drill holes were of sufficient length and located so that the eye was over the middle of the wall plate and about a foot above it. Placed through vertical holes drilled in the wall plates were 1 1/2 inch bolts with a hook formed in one end which would hook into the eye of the rock bolt. Split cedar lagging was then cribbed between the vertical bolt, the rock bolt and the rock wall. A 4 inch by 6 inch steel plate was used as a washer and a nut was used to tighten the vertical bolt.

The ventilation line carried in the manway was 20 inch Naylor, Spiral Weld, Wedge-Lock Coupling pipe. Also carried in the manway was a 6 inch pump column, a 6 inch air line, and a 2 inch water supply pipe.

The hoist, having a rope speed of only 800 feet per minute, accounted for the use of an intermediate dump which allowed as good a rate of advance.
from the 3,200 foot level as from the start of the job. The intermediate dump was first installed on the old 1,200 foot level and the old 1,200 foot level loading pocket was used. When the shaft reached the 2,100 foot level a pocket raise was driven and the intermediate dump was moved to the 2,000 foot level.

The intermediate dump (Figure 3.) consisted of two steel aprons (one in each hoisting compartment) semicircular in shape. Each pan was fastened at the bottom on a hinge and was lowered across the shaft or brought up into a clear position by a 5 horsepower electric motor through a screw drive. Limit switches were installed on both ends of the screw drives so the aprons would automatically stop in their correct positions, either up (clear of the shaft) or across the shaft. The operator merely had to push a switch button to start the aprons in motion, either up or down. The 21 cubic foot capacity muck bucket would be hoisted from the bottom to point just above the intermediate dump apron. The apron would then be put into position across the shaft, the muck bucket lowered until an iron ball, suspended from the bottom of the bucket by a chain, hooked in a V slot in the apron. This caused the bucket to dump itself in a position completely outside the main shaft. The bucket would then be hoisted clear of the apron and the apron raised to its clear position. The complete dumping operation took about twenty seconds during which time the other bucket was in the bottom of the shaft being filled.

The muck from the intermediate dump pocket was hoisted with skips during the drilling cycle. In order that the men could work safely in the bottom of the shaft while the muck was being hoisted from the intermediate dump pocket, a lagging bulkhead was put across one hoisting compartment and a
The man-deflection door was installed in the other hoisting compartment. The man-way compartment was lagged off from the loading pocket to the bulkhead. The muck bucket, traveling cross head, cage and skip are shown in Figure 6.

"Telatalk" communication was maintained between the hoistman, the intermediate dumping station, and the intermediate dump loading pocket. "Vocatron" communication was installed in the hoist room and the bottom pump station. By means of a switch on the hoist bridge the hoistman could signal the bottom crew with the bottom light and the bottom crew could, of course, signal the hoistman with the shaft signal system.

**CYCLE OF OPERATIONS**

The average cycle time in sinking the Crescent shaft was as follows:

**Drilling Cycle:**
- Actual drilling time: 2 Hours
- Loading: 30 Minutes
- Set up and tear down: 30 Minutes
- Smoke time: 30 Minutes
- Total: 3 Hours 30 Minutes

**Mucking Cycle:**
- Mucking: 1 Hour
- Bar down and wash down wall plates: 30 Minutes
- Total: 2 Hours 0 Minutes

**Timber Cycle:**
- Lower "battleship": 1 Hour
- Hand and block set: 12 Minutes
- Lower mucker: 10 Minutes
- Dividers and lacing: 13 Minutes
- Short guides: 30 Minutes
- (3rd set long guides - 35 Minutes): 8 Minutes
- Total: 2 Hours 13 Minutes

**TOTAL TIME**
- 7 Hours 43 Minutes

Pipe and Manway (4th or 5th Set)
- 3 Hours 0 Minutes

* Intercommunication systems.
DRILLING

Figure 7 shows the type of bench round drilled. A round, consisting of thirty 8 foot holes arranged in a pattern of 5 rows of 6 holes each, was drilled to break the bench round. The average bench broken for the job was 6.2 feet or 3.1 feet of full bottom. The bench type method of drilling has many advantages over the full bottom round. All hand mucking is eliminated with the bench type round. When a round has been mucked out the bench is swept clean with a blow pipe and a natural sump is formed. This leaves the bench to be drilled clean and dry.

Ingersoll-Rand DA-30 power feed, 30 inch change drifters were used. A 3 inch pneumatic bar placed horizontally across the short axis of the shaft supported the two drills that were used to drill the bench round. To prevent the bar from rotating, one end was equipped with two steel stingers which were inserted into short holes drilled in the wall. An Ingersoll-Rand JA 35 Jackhammer was used to drill the short stinger holes and do any plugging that was necessary. The pneumatic bar was set about 30 inches from the end of the shaft and a complete bench round was drilled from one setting up of the bar. All holes were drilled with Ingersoll-Rand 1 5/8 inch Carset (Tungsten-Carbide insert) bits on a 1 1/8 inch round, lugged, hollow drill steel. Excessive thread wear on drill rods and bits was soon noticed. This condition was corrected by changing the drifters to down stroke rotation.

Casing cut from old 2 inch pipe was used to start nearly every hole. To start a hole, an Ingersoll-Rand 2 1/2 inch Jackbit on a 42 inch drill rod was drilled into solid rock. A 12 inch, 16 inch or 24 inch casing, depending upon the length of the starting hole, was then driven into the hole.
by the drifter using a casing driver. The casing driver was a 30 inch drill rod with a flanged collar attached to it.

Tests were run with three types of drill steel with the following results:

- Crucible "Ca" alloy - 170 feet of hole per rod.
- Crucible "551" (Experimental) alloy - 215 feet of hole per rod.
- Crucible "Crusca" (high carbon steel) - 215 feet of hole per rod.

The high carbon steel was considered the best under the conditions the rods were being used. It was the least expensive steel and less bits were lost. The most common failure in the alloy rod was a spalling of the threads which often resulted in a lost bit. In the high carbon steel the most common failure was in the rod itself and the bit could be retrieved.

Water for drilling was obtained from the old 1,200 foot level sump. Pressure reducing valves were installed at intervals in the line to protect the equipment from excessive pressure.

The air pressure at the compressors was kept between 110 and 115 pounds. A 50 foot Eimco Wire Braid 1 1/2 inch, inside diameter, hose supplied compressed air from the bottom length of air column to a manifold that had outlets for the pneumatic bar, drifters and blow pipe.

Actual drilling time averaged about two hours per bench round. Set up and tear down time accounted for thirty minutes. Four shaft men did the drilling during which time the skiptender was hoisting rock from the intermediate dump pocket to the collar pocket.

**BLASTING**

Blasting was done with Du Pont electric detonators. Two milisecond
delays were used in the first holes, one to ten delays were used in the rest of the round. The rounds were loaded with either DuPont or Atlas 45 percent semi-gelatin dynamite. The cartridges were 1 1/8 inches by 8 inches in size.

The rounds were detonated by a DuPont Condenser Discharge No. 30 blasting machine. The blasting machine was kept on the bottom pump station which resulted in not over 500 feet of blasting line being used at any one time. The blasting line was General Electric No. 1/4-2 Royal Cord and was hung in the shaft side compartment away from any other electrical lines.

Just before the blast the T.M. - 9, 25 horsepower Coppus Blower fan was shut off and the T.M. - 9, 25 horsepower Coppus exhaust fan started. By adjusting two dampers the 20 inch Naylor pipe became an exhaust system. About thirty minutes were required to exhaust the gases.

A steel blasting set or "battleship" was used to protect the bottom timber from flying rock. It was built of 3/4" steel plate (Figure 2), rectangular in shape, 15 feet long by 5 feet 10 inches wide, conforming in plan to the exact size of the shaft timbers. Four chains held the "battleship" against the bottom of the lowest shaft set. Wedges were driven between the chains and the timber to further tighten the blasting set.

MUCKING

Permission was granted by Mr. J. Murray Riddell, the inventor and exclusive licensing agent of the mechanical shaft mucking machine covered by U. S. Patent No. 2,326,172, to use his mucking machine.

The job was started with only one experienced shaft mucking machine operator; however, within a few weeks two men on each of the three shifts could handle the machine adroitly. The shaft mucker in operation is illustrated in Figure 2. The mechanism consists of three principal parts: (1) the
carriage, (2) the frame; and (3) the clam shell digging bucket. The design of the mucking machine is based on practically the same principle as the more familiar overhead traveling cranes. The clam shell bucket is suspended, lowered and elevated by means of a Model HMK Gardner-Denver air-powered hoist mounted on a movable carriage. A second identical hoist, also on the carriage, is used to open or close the clam shell bucket. The third air-driven engine on the carriage, a Gardner-Denver Model MPH, moves the carriage and suspended load back and forth along the long axis of the shaft. This is accomplished through a chain drive to the flanged wheels of the carriage. The four flanged wheels ride on the frame. (Figure 2.)

The three motors are operated by one man riding on the carriage, requiring the use of both hands and his right foot which operates the carriage travel motor control valve.

The frame and carriage were lowered one set at a time, the frame normally being on the second set of timber from the bottom. The frame was attached to the sinking bucket in the middle compartment by four chains hooking over the rim of the bucket. Two of the chains being longer than the other two caused the frame to go into an inclined position when the sinking bucket was hoisted a short distance up the shaft. This inclined position was sufficient enough to allow the frame and carriage to clear the end plates and be lowered to the next set. When the mucker was in place on a set, safety chains were hooked around the end plates and the ends of the frame. The average time required to lower the mucker and have it ready for operation was thirteen minutes.

The 3/8 cubic yard clam shell bucket was made by the Blaw-Know Company of Pittsburg, Pennsylvania. It was their Model No. 663, heavy duty type
equipped with bottom, side and corner teeth. In our own shop \(3/4\) inch mild steel bars were welded around the attachment end of the bottom teeth. This helped to prevent the shearing of the teeth bolts. The bucket was reeved in a three part line with Roebling, \(6\) by \(19\), independent wire rope center, \(1/2\) inch wire rope.

The clam shell bucket delivered the broken rock to the cylindrical, barrel-shaped sinking buckets, each having a capacity of \(21\) cubic feet. Normally three passes of the clam shell bucket were required to fill the sinking buckets and the time required to do this varied from one to one and one-half minutes. Thirty sinking buckets an hour filled, hoisted and dumped, was about the average. The average mucking cycle required two hours. During the mucking cycle a skiptender operated the intermediate dump, a shaftman operated the mucking machine, a shaftman sat on a wall plate just above the carriage to ring bells, and two shaftmen stayed in the bottom. One "tagged" the clam shell bucket (rotated it when necessary by means of a rope) and the other barred and picked down the walls. As soon as the bench was exposed it was cleaned off with a blow pipe. The clam shell bucket was hoisted up under the carriage and chained to the carriage. The shaft was then ready for another drilling cycle or timber.

The intermediate pump stations and loading stations were excavated below the bottom shaft set and the broken rock mucked with the clam shell. The 2,000 foot station and the 3,200 foot station had crosscuts driven below the bottom shaft set, the rock from which was handled with the clam shell. Pocket raises were driven to connect with the back of the crosscuts and the balance of the station excavation was handled through the pocket raises.
TIMBERING

The blasting set or "battleship" was also used for a timbering platform. It was lowered by hooking four chains on the rim of the center shaft compartment bucket and suspended from the bottom shaft set on four chains. Lagging was used as decking for a platform.

A complete set of timber could be lowered from the collar in one trip. The two wall plates were hung under the cage on two timber clevises. The end plates, posts, panel lacing, blocks and wedges were loaded in the bucket and cage. Dividers were not placed in the bottom three sets as they would interfere with the operation of the shaft mucker. As soon as the mucker was dropped down a set dividers were placed in the fourth set from the bottom. Five and one-half foot guides were carried for the bottom two sets. On the third set the standard ¼ inch by 6 inch by 16½ foot guides were put in. The bottoms of the standard guides were at the last dividers installed or the fourth set off the bottom.

PUMPING

The shaft made about ten gallons of water per minute.

The pumps on the old 1,200 foot level have been previously described. Every 400 feet below the 1,200 foot level intermediate pump stations, 15 feet long by 15 feet wide by 10 feet high, were excavated. Ingersoll-Rand 1 1/2 MRV - 25 horsepower motor pumps were used on these stations, pumping from a steel tank 3 feet wide by 4 feet high by 10 feet long. An Ingersoll-Rand air-driven No. 35 sump pump was used in the bottom of the shaft. When the bottom of the shaft reached a point about 240 feet below an intermediate pump, a temporary manway pump was put in until the next intermediate pump was installed. The manway pump was also an Ingersoll-Rand 1 1/2 MRV - 25

11.
horsepower motor pump. Its tank was three, 4 foot sections of the 20 inch Naylor, Spiral Weld, Wedge-Lock Coupling pipe used for the ventilation line. This tank was set on a base that was attached to and directly over the motor pump. The discharge from the pump was connected to the pump column by a 2 1/2 inch fire hose. This compact unit was readily installed or moved to the desired elevation in the manway. All the motor pumps were operated automatically by electrode switches.

SHAFT SINKING CREW AND BONUS SYSTEM

The sinking crew was as follows:

<table>
<thead>
<tr>
<th>Number of Men</th>
<th>Classification</th>
<th>Wage Rate for Classification For 8 Hr. Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Shaftmen</td>
<td>$15.82</td>
</tr>
<tr>
<td>3</td>
<td>Skiptenders - Cagers</td>
<td>$14.62</td>
</tr>
<tr>
<td>1</td>
<td>Mechanic</td>
<td>15.82</td>
</tr>
<tr>
<td>3</td>
<td>Hoistmen</td>
<td>15.90</td>
</tr>
</tbody>
</table>

On each of the three shifts were 4 shaftmen, 1 skiptender and 1 hoistman. The crews changed shifts every two weeks. The mechanic worked on straight day shift. The crews worked eight hours a day (portal to portal) with twenty minutes allowed for travel time. The crew schedule was as follows:

Day Shift 7:00 A.M. to 3:00 P.M.
Afternoon Shift 2:10 P.M. to 10:10 P.M.
Graveyard Shift 10:20 P.M. to 6:20 A.M.

This schedule permitted the change of shifts on the job in the shaft. The mechanic, day shift skiptender and day shift hoistman went on shift at 6:00 A.M. to service the shaft mucker and clam shell bucket. The mechanic and skiptender ended their shift at 2:00 P.M. The hoistman worked until 3:00 P.M.
and was paid one hour overtime. Occasionally, if a mucking cycle was in operation it would be necessary for the skiptender to work until 3:00 P.M.

In operations such as shaft sinking and drifting in order to get and hold an able and competent crew and insure faster progress it is a district custom to put the men on a bonus incentive basis.

Speed on this project was of prime importance. The Defense Minerals Exploration Administration would only allow four years for the completion of the project. The project includes deepening the Crescent shaft 2,000 feet, driving 9,300 feet of drifts and crosscuts on the minus 400 feet below sea level elevation, and 22,600 feet of diamond drilling all on the minus 400 foot level.

There were no current costs available on deep shaft sinking in the district. However, reviewing older costs and applying current wages, it was felt $80.00 per foot for shaftmen labor would be a good figure to shoot at. $70.00 per foot was the bonus incentive pay for the 12 shaftmen. The final cost for shaftmen was $80.47 per foot which included overtime and time lost due to breakdowns. The $70.00 per foot was divided equally among the 12 shaftmen as follows:

Assuming an average of 8 feet of progress per day was made for a pay period (1st of month to 16th or 16th to end of month). A shaftman's earnings per day for that period would be \( \frac{\$70 \times 8 \text{ feet}}{12} = \$46.67 \).

Bonus equals gross earnings minus day's pay or in the above example bonus equals $46.67 minus $15.82 or $30.85.

The shaftmen's bonus incentive rate for the station excavations was 12.4 cents per cubic foot of rock broken and $9.25 per lineal foot for pocket raises.

It was felt that by putting the service men, i.e. skiptenders, mechanic
and hoistmen, on a bonus incentive which would be dependent upon the shaftmen's bonus a minimum of bottom time would be lost. Also the service work and supervision could be done with fewer men. The three skiptenders and mechanic each received a bonus equal to 40 percent of the bonus received by a shaftman. The bonus paid each of the three hoistmen was 20 percent of that received by a shaftman.

The crew as outlined above was responsible for the shaft advance as well as the installation of the pump column, air line, water supply line and ventilation pipe. They were also responsible for the transporation of timber and supplies from the Crescent surface mine yard to the shaft and the broken rock delivered to the surface waste disposal bin. The mechanic did all mechanical maintenance that did not require shop work. Actually, a good portion of his time was spent handling timber, supplies and broken rock on the adit level.

**COST OF SINKING**

The shaft sinking was carried on a three-shift-a-day basis, six days a week. Time and one-half was paid to all labor for the sixth day of each week.

Table 1 shows the sinking costs and is followed by explanatory notes.

**TABLE 1**

**CRESCENT SHAFT SINKING COSTS**

<table>
<thead>
<tr>
<th>Mine Labor:</th>
<th>Cost per foot for 2,000.5 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Supervisory</td>
<td>$5.50</td>
</tr>
<tr>
<td>2. Shaftmen</td>
<td>80.47</td>
</tr>
<tr>
<td>3. Hoistmen</td>
<td>10.26</td>
</tr>
<tr>
<td>4. Mechanic</td>
<td>4.28</td>
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</tbody>
</table>
### TABLE 1
**CRESCENT SHAFT SINKING COSTS** (continued)

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost per foot for 2,000.5 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Skiptenders</td>
<td>11.56</td>
</tr>
<tr>
<td><strong>Total Mine and Machine Shop Labor</strong></td>
<td><strong>$125.67</strong></td>
</tr>
</tbody>
</table>

**Supplies:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost per foot for 2,000.5 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Explosives</td>
<td>9.59</td>
</tr>
<tr>
<td>8. Timber and Lagging</td>
<td>15.30</td>
</tr>
<tr>
<td>9. Bits and Drill Steel</td>
<td>6.70</td>
</tr>
<tr>
<td>10. Pipe</td>
<td>10.21</td>
</tr>
<tr>
<td>11. Pump Repair</td>
<td>.73</td>
</tr>
<tr>
<td>12. Drill Repair</td>
<td>1.95</td>
</tr>
<tr>
<td>13. Miscellaneous</td>
<td>20.11</td>
</tr>
<tr>
<td><strong>Total Supplies</strong></td>
<td><strong>$64.62</strong></td>
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</table>

**Miscellaneous:**

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<tr>
<th>Item</th>
<th>Cost per foot for 2,000.5 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. Labor</td>
<td></td>
</tr>
<tr>
<td>(a) C &amp; R</td>
<td>2.15</td>
</tr>
<tr>
<td>(b) Electrical</td>
<td>4.34</td>
</tr>
<tr>
<td>(c) Miscellaneous</td>
<td>4.73</td>
</tr>
<tr>
<td>15. Fringe Benefits</td>
<td>9.60</td>
</tr>
<tr>
<td>16. Garage</td>
<td>5.49</td>
</tr>
<tr>
<td>17. Engineering</td>
<td>1.29</td>
</tr>
<tr>
<td>18. Mucker Royalty</td>
<td>1.13</td>
</tr>
<tr>
<td>19. Electric Power</td>
<td>4.28</td>
</tr>
<tr>
<td>20. Other</td>
<td>.65</td>
</tr>
<tr>
<td><strong>Total Miscellaneous</strong></td>
<td><strong>$33.71</strong></td>
</tr>
</tbody>
</table>

18.
### TABLE 1
#### CRESCENT SHAFT SINKING COSTS (continued)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 21. | $37,606.87 was spent before shaft sinking started  
   | $37,606.87  
   | 2,000.5 feet  
   | $18.80  
| 22. | Total Direct Sinking Costs  
   | $205.20  
|   | ($224.00 - $18.80) |

**EXPLANATORY NOTES FOR TABLE 1**

1. One shift boss plus $500 per month for superintendence.
2. Bonus incentive at $70.00 per foot plus overtime. Twelve bottom men.
3. Three hoistmen, day's pay, plus overtime, plus 20 percent of shaftmen's bonus.
4. One mechanic, day's pay, plus overtime, plus 20 percent of shaftmen's bonus.
5. Three skiptenders, day's pay, plus overtime, plus 20 percent of shaftmen's bonus.
6. Repair drills, pumps, shaft mucker, hoist, compressors, etc. Make hanging rods, pipe clamps, battleships, etc., and timber framing.
7. Powder, electric delays, blasting wire and blasting machines.
8. Includes all timber.
10. 6" air column, 6" pump column, 2" water supply column and 20" Naylor ventilation pipe.
12. Drill parts.
13. Includes spare unit for shaft mucker and all supplies not included in items 7-12 such as mucker cables, hose and fittings, small tools, lubricants, material for hanging rods and pipe hangers, electrical parts and supplies.
14. (a) Labor for building and waste bin maintenance, casing pipe and some timber handling.
11. (b) Labor for electrical installation and maintenance.

11. (c) Dry house attendant, track and tunnel maintenance.

15. 7 percent of all labor costs:
   - 2.7 percent for Social Security and taxes
   - 4.3 percent for Aetna Insurance, compensation insurance and additional hospital


17. Geological and surveying.

18. Royalty for use of shaft mucker to Mr. J. Murray Riddell.

19. Electric power for entire project.

20. Water and telephone, including installation.

21. $37,606.87 was spent preparatory to sinking the shaft:
   - Mine labor $10,725.72
   - Miscellaneous $4,380.61
   - Supplies 22,500.54
   Total $37,606.87

This includes labor for repairing 1,200 foot level station and labor for rebuilding shaft mucker to fit shaft.

Supplies include $3,000 paid to Hecla Mining Company for shaft mucker, hoisting ropes, Blaw-Knox Bucket, portable burning set and torch, 3 DA 30 driffers, 2 IR No. 35 sump pumps, 2 shaft sinking buckets and some spare parts for shaft mucker.

22. $205.20 total direct sinking cost does not include the purchase nor depreciation of service equipment such as compressors, adit level locomotive, hoist, etc.

### TABLE 3
#### PERFORMANCE DATA

<table>
<thead>
<tr>
<th>Time worked in shaft (2,000.5 feet)</th>
<th>238 2/3 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average progress per 24 hour day</td>
<td>8.4 feet</td>
</tr>
<tr>
<td>Average advance per shaftman shift</td>
<td>0.70 feet</td>
</tr>
<tr>
<td>Average advance per bench round</td>
<td>3.1 feet</td>
</tr>
<tr>
<td>Average number of buckets per foot</td>
<td>10.3</td>
</tr>
</tbody>
</table>
TABLE 3
PERFORMANCE DATA* (continued)

Average amount of time spent on dead work per foot** 17 minutes

* Does not include station work

** Time spent by shaftmen on work other than drilling, mucking and timbering, such as manways, piping, etc.

TABLE 4
ACCIDENT DATA

<table>
<thead>
<tr>
<th></th>
<th>Man Hours</th>
<th>Lost Time Injuries</th>
<th>Lost Days</th>
<th>Frequency Rate</th>
<th>Severity Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crescent Shaft Project*</td>
<td>50,349</td>
<td>4</td>
<td>235</td>
<td>79.45</td>
<td>4.67</td>
</tr>
<tr>
<td>State of Idaho**</td>
<td>5,947,084</td>
<td>953</td>
<td>55,262</td>
<td>160.25</td>
<td>9.29</td>
</tr>
</tbody>
</table>

* Includes 2,000.5 feet of shaft, seven stations and two pocket raises.

** All underground mining in the State of Idaho for 1953.
Air Receivers

Water Cooled
After Cooler

I.R. 90 B
Compressors

Basement Type Pump
Nickolson Automatic Unloading Trap

30" Jeffery Aero Dyne Fan

Signal for Compressor Intake
Location of UNDERGROUND EQUIPMENT

HOOPER LEVEL - CRESCEANT MINE