SUBJECT: Operating Research Department - Year 1957

Mr. J. S. Westwater
Manager, Michigan Mines

Dear Sir:

I would like to submit to you a report on the work that has been done by the Operating Research Department in 1957.

First, I will summarize the various projects that we have been working on throughout the year, and following the summary is a discussion of various projects with the savings that can be justified as a result of the efforts of this department.

INCENTIVES

1. Mather Mine "B" Shaft - Excavation of 10th Level crusher station plat.
2. Mather Mine "B" Shaft - Payment of miners on drilling footage incentive versus cars per shift.
5. Cliffs Shaft - Loading and Tramming incentive for front end loader.
7. Bunker Hill - To determine incentive, proper crew size and best operating procedure in 2102 Block.

TIME STUDIES

1. Republic Mine - Comparison between Gardner Denver DH-143 Air Trac and Jet Piercer.
2. Humboldt Mine - Comparison of the Joy Rotary rig with the DH-143 Air Trac.

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TIME STUDIES - cont'd.


8. Bunker Hill Mine - Several different carbide insert bit tests.


10. Cliffs Shaft Mine - Comparative study on 11 different makes of drill machines and jacklegs.

11. Mather Mine "B" Shaft - Comparative bit tests.

12. Mather Mine "B" Shaft - Comparative study on six different makes of American made drill machines.


GENERAL PROJECTS

1. Chain Conveyors.

2. Auger Miner.


4. Raise Cage.

5. Yieldable Arches - Bethlehem Steel and Toussaint-Heintzmann.

6. Revision of Company's safety rules.

7. Vibrating bars for barring mills.

8. Vibrating plates in the foot of mining raises to avoid build-up of ore.

9. Chain conveyor and scraper hoist maintenance records.

10. Chain mill blocking devices.


12. Designed new pan for chain conveyors.


15. Cascade development.
Before proceeding into the discussion of the various projects which show the savings that are attributable to the efforts of this department, I would like to recap these savings below:

**RECAP OF SAVINGS FOR YEAR 1957**

1. Chain Conveyors – Operating Labor (See p.4) ....... $ 152,941.82
2. Chain Conveyors – Maintenance (See p.4) ............. 53,061.70
3. Chain Conveyors – Specific Cases:
   - Mather Mine "A" Shaft – Motor Crews ............... 7,409.44
   - Mather Mine "B" Shaft – Caving Drift ............... 8,983.92
   - Bunker Hill – Accelerated Drawing of Block – Reduction in Drift Repairs .... 48,000.00
4. Incentives – Maas Mine Long Hole Drilling .......... 35,145.82
5. Incentives – Mather Mine "A" Shaft – Labor Supplies .... 25,000.00
7. Caging Method of Raising – Mather Mine "B" Shaft ...... 7,574.00

**GENERAL SAVINGS USING CHAIN CONVEYORS**

- Average number of chain conveyors in operation at a time at all properties ........................................ 17 Chains
- Number of Chains working steady every day ............... 7 Chains
- Balance of chains working ½ time/shift – 10 chains x 1/2 = 5 chains working full time .......... 5 Chains
- Total chain conveyors working full time ................. 12 Chains
- Average saving in labor per shift per chain ............... 1 Man
- Shifts Per Day ................................................ 3 Shifts
- Average operating days in 1957 for all properties excluding Bunker Hill January shutdown period ........... 232 Days
GENERAL SAVINGS USING CHAIN CONVEYORS - contd.

Average Rate/ Hour for the man eliminated by chain conveyor operation = Job Class 8 ......................... $2.289 Per Hour
(Transfer Scraperman - J.C. 6 / Stope Scraperman-J.C. 10)
12 chains x 232 days x 3 shifts x 8 hours/shift x $2.289 =
Total Labor Saving realized by the C.C.I. Co. by using chain conveyors instead of scraper hoist operation = $152,941.82

For a general comparison of cost of maintenance between chains and scrapers, a basis has been established at the Mather Mine "B" Shaft. Repair costs for a scraper hoist operation is $.063 per ton of ore handled while it costs only $.006 per ton to maintain the chain conveyors. This amounts to a saving of $.057 per ton or a saving of $53,061.70 for 932,907 total tons of ore handled at all properties by chain conveyors in 1957.

Mather Mine "A" Shaft

In a mining area where the practise had been to scrape directly into cars, the application of a chain conveyor in an inclined crosshaul drift eliminated the need for a steady motor crew in a congested traming area by delivering the broken ore to a sub level belt conveyor.

According to the Mather Mine "A" Shaft figures, the following calculation is the saving realized on a three shift operation in three months time.

Cost of one motor crew for 3 months on a three shift schedule ........................................... $ 7,409.44

Actually, the chain conveyor enabled mining this area to completion in one-half the estimated time allotted for a scraper-tram operation.

Mather Mine "B" Shaft

At the Mather Mine "B" Shaft in #35 contract above the 7100 Cross-cut on 7th Level near the 7C Block from September 15, 1957 to October 29, 1957, it was possible to observe a chain conveyor operation handling ore from the mills in a caving drift directly to a sub-level belt conveyor. Previously, a scraper hoist operation had been studied in the same area under exactly the same conditions.

During the six weeks time the chain conveyor was operating in the caving drift, a total of 20,418 tons of ore were pulled from the mills on one side of the drift. The saving per ton realized ($0.53 scraping - $0.09 chain) was $0.44 per ton or a total of $8,983.92.

The maximum daily production from this caving drift was 2,088 tons. It should probably be pointed out that this is an exceptionally high daily production. However, the reason special mention is made of this high rate of production with this type of continuous ore transportation system underground, is to substantiate the planning programs the superintendents of the soft ore properties have for future continuous belt tramming with chain conveyors in caving or transfer drifts feeding these sub level gathering belts. This accelerated production will minimize the amount of repairs in these caving drifts.
GENERAL SAVINGS USING CHAIN CONVEYORS -contd.

Bunker Hill-Mesa Mine

In checking over the labor savings in the chain conveyor applications at this property, we can calculate a 1.1 man saving per chain, but for practical purposes we'll call it a saving of one man as is the case at the other properties.

One of the bigger savings that the Bunker Hill can justify is the saving in repair costs. As an example, an average block caving drift would normally require two complete repair jobs for the life of the block. The average condition in a Bethlehem yieldable arch drift requires only one repair with a chain conveyor operation, initially, because accelerated drawing of the ore alleviates ground pressures, and secondly, the chain can operate in a much more confined drift than a scraper. The average cost to repair a transfer approximately 150' long is $6,000 per repair job. This situation has been true in 8 different transfers which indicates a saving of $48,000.00 in repairs.

Mention should be made of the chain mill blocking device that was designed as a safety measure in caving drifts that have chain conveyors installed in them.

We have designed a new pan section for the chain conveyors, and if the proposed pan proves successful, we will be able to make our own pans for approximately $100 cheaper than our purchase price. This would be a saving of $4,600 on each 250' chain conveyor.

This project will be continued in 1958.

Vibrating Plates in Mills

In conjunction with chain conveyors in caving drifts, we have designed a vibrating plate which is installed on the foot of the mining raises or mills, that has completely eliminated the build-up of ore on the foot. It also serves to keep the ore moving out of the raise so that a minimum amount of baring of the mills is necessary except for large chunks that require blasting. From a safety standpoint, this set-up could greatly reduce the number of leg and hand injuries that plague this type of work.

One of these plates was used in #85 contract above 7th Level at the Mather "H" when they were making their production record of 2,088 tons per day from one caving drift.

Prior to the use of the vibrating plates, we tried to perfect a mill bar with a small vibrator on the baring end to use in baring down mills, but it didn't work out too well. It would have required heavier construction which would have been too heavy to handle safely.

INCENTIVES

Prior to the time that time studies were used to establish incentive rates, the method of figuring these rates was based on past experience, comparisons with similar types of work, and common sense. This, however, did not eliminate the possibility of "run away" rates, especially after the reclassification of jobs in 1952.
INCENTIVES —contd.

When an incentive rate is established by time study methods, every movement of the persons involved in the operation is timed and recorded for a period of several weeks or as long as is necessary to determine an average time for each movement or duty performed in a cycle or shift. From the study, all productive and unproductive time is calculated. From these records, it is possible to determine what unproductive time can be eliminated from the cycle. It is also possible to check over the production time to determine if the method of performing different tasks in the cycle can be improved. With the deletions of unproductive time and improved methods, an average performance can be established and, in turn, an average incentive rate that will be fair to the company and to the worker.

It is difficult to say how much money has been saved by using time study methods for establishing incentive rates, but it is a known fact, that in every case except one, the time studied rate has been lower than anticipated. After these lower than expected rates have been introduced, they are found, as previously mentioned, to be fair and acceptable to both management and labor union.

As an example of savings from incentive rates established by time study methods, a new rate per foot of drilling in long hole stoping was requested by the Maas Mine. The Maas operators wanted to cut the price per foot because they thought it had become too high.

Rate per foot paid for long hole drilling before time study ........................................ $ 0.50 Per Foot
Rate per foot paid after time study and methods improvements ...................................... $ 0.31 Per Foot
Savings in Price Per Foot ................................................................. $ 0.19 Per Foot
Feet Drilled (Year) ......................................................... 184,978 Feet
Total Savings ......................................................... $35,145.82

An example of savings due to change in basis for paying the incentives is best illustrated by the Mather Mine "A" Shaft undercutting procedure. Originally, the miners were paid on a footage basis with an established pattern for each undercut blast. The supervisory personnel found that the miners were always pleading the case of longer and more holes to properly undercut a block. Our department was requested to study the situation and provide an answer. In the final analysis, we determined the original pattern for drilling to be adequate and proper, but that the miners were to be paid on a flat rate per ring blast rather than on a footage basis.

It was found that this new method of paying reduced complaints from the miners after they accepted it, and it also reduced the undercutting time by 25% per block. This saving was directly reflected in the cost of undercutting.

The following calculation is the estimated labor saving for 1957 realized by revising this method of incentive payment.

Approximate feet of undercut drift ......................... 12,000 Feet
One pattern for each 4' section of drift .................. 3,000 Patterns
INCENTIVES —contd.

Average incentive pay for Mather "A" pattern ........... $ 53.24

Total Cost of Labor for Undercutting Since New
Incentive ........................................... 159,720.00

Labor Saving in 1957 (Approx.) ......................... 53,240.00

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\frac{159,720 = \$212,960 - \$159,720 = \$53,240}{.75}
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There is also a saving of approximately $53,000 for supplies and equipment.

YIELDABLE ARCHES

In January 1957, this department initiated the investigation of the applicability of the Toussaint-Haintzmann yielding steel arches to our ground support problems. The Bunker Hill Mine operators were willing to try the T-H steel in an area where it would be possible to compare these yielding sets with the Bethlehem Steel sets. The "C" and "D" saving drifts of the 2102 Block above 12th Level were used for the comparison. A chain conveyor was installed in each drift so that the test would be in line with our present and future thinking for materials handling.

The results of the test showed that the Bethlehem yieldable arches cost 2.84 times more in labor and supplies to maintain as compared to the T-H arches. In actual money, it cost $2,113.00 to keep the T-H drift in repair as compared to $6,000.00 for the Bethlehem drift for a saving of $3,887.00.

The overwhelming superiority of the T-H sets over the Bethlehem sets has spurred the Bethlehem Steel Company to improve their product so that in the near future they hope to equal or out-perform the T-H yieldable sets. Until this comparison had been made, the Bethlehem Steel Company's sales representatives had been complacent and rather unimpressed with our mine operators' requests for heavier sections of the arches, but now they are willing to go all out to please us on any little request.

This development and the keeping of the price of ground supports and other mining equipment competitive is another important function of this department that cannot be measured in actual dollars.

CAGE METHOD OF RAISING

The first raise advanced by the cage method has been completed and a saving of $7,574.00 was realized for this 6' x 6', 200 foot long raise over the conventional method of raising. The saving in time was 50 shifts by cage versus 139 shifts by the old method.

This new system is presently gauged for naked raises and is therefore adaptable to ventilation and ore pass raises. However, it is our intent to try to apply it to the other types of raising as well. Presently, the properties that would use this method of raising would each require an average of two raises, varying in height from 200' to 400' per year. The savings could well amount to $30,000 to $40,000 per year.
CAGING SCHEDULE STUDY AT THE BUNKER HILL-MAAS

When the Bunker Hill and the Maas Mines were consolidated, the caging schedules at the beginning and end of the shifts became a problem, especially on day shift. The Bunker Hill personnel requested a time study and a suggested schedule for handling the Maas and Bunker Hill underground workers.

There were approximately 200 men to be handled. At the Maas Mine, there were two different level stops and at the Bunker Hill Mine there were four stops.

When the study was completed and the new schedules were made, it was found that an average of 15 minutes per man per day was saved. For the 200 men affected, this would amount to a daily saving of approximately $140.00 or a saving for 1957 of an estimated $23,920.00.

AUGER MINER

After the Bunker Hill completed the installation of their new hoisting equipment in January, 1957, production with the auger miner was resumed. We were able to determine that the auger equipment had been constructed heavy enough to do the job of drilling the Bunker Hill ore. We were able to establish the best bit design, the proper speed of rotation, the correct size of hole to drill, and the most convenient method of handling flights, but we were not able to predict, induce or control the caving or settling action of the orebody. The only thing that we could determine about the ground in this particular block at the Bunker Hill was that it did not properly lend itself to auger mining.

One of the most important points that we did prove was that we could mine a good, clean high grade product with the auger.

With the Bunker Hill experience to guide us, we are of the opinion that a trial of the auger miner in the interbedded ore at the Mather Mine "A" Shaft will prove successful. This would make available a sizeable tonnage of desirable high grade ore that has been left behind because of the high cost and contamination previously encountered in mining this orebody.

Everybody concerned knows that we haven't realized any particular return on our investment, but we do feel that the auger, or some variation of the present equipment, will have an application in our soft ore mines for mining low-cost ore.

DRILL MACHINES, DRILL STEEL & BIT TESTS - UNDERGROUND & OPEN FIT

During the year 1957, there have been a great many tests of carbide insert bits in the underground mines, and our department has correlated the information and passed it on to all of the operators.

The most significant development in 1957 was in the performance of the Kenametal bits at the Bunker Hill and Cliffs Shaft properties. The Kenametal representatives brought us two different grades of carbide bits, one softer and one harder carbide, that they had developed and gave them to us to try at any properties we desired.

The first trial was made at the Bunker Hill Mine. The harder carbide bits performed 12% better than the Rok Bit which up to that time was performing the best at the Bunker Hill and was considered the standard bit.
In discussing the performance of the bits with the sales representatives, it was suggested to them that their flutes or waterways be enlarged to provide better removal of the drilled material from the face of the bit. The Kenametal people were willing to try our suggestion and we ground the waterways to what we thought would be the proper size without harming the overall structure of the bit. The results of the following tests proved that the Kenametal hard carbide bits out-drilled all others by 16 to 24% in Bunker Hill ground.

After the Bunker Hill tests were completed, the same type of Kenametal bits were used in a test at the Cliffs Shaft Mine versus the standard bit which was manufactured by Ingersoll-Rand. The results of this test proved that the softer Kenametal carbide bit was by far the best; out-performing the Ingersoll-Rand bit by 39.6% on a footage basis and 53.3% on a footage and cost comparison basis.

This would represent a reduction in bit costs at the Cliffs Shaft Mine of approximately 35% if the Kenametal bits were to be used in place of the Ingersoll-Rand bits in 1956. The total savings would amount to 35% of $36,483.47, which is the amount of money spent by the Cliffs Shaft on carbide bits in 1957, or $12,769.21.

An extensive test was conducted on six different American made jack hammer drilling machines mounted on integral jack legs at the Mather Mine "B" Shaft and on eleven different American and foreign made machines at the Cliffs Shaft.

In both tests the machines were compared in hard and soft ground, and they were judged on drilling performance and handling characteristics. When the tests were completed, the machines were all disassembled to determine the amount of wear on all parts.

The results proved conclusively which machines were best, because in both tests the same drills outperformed the others.

This is another case where our department has provided an important service to the company that cannot be measured in actual dollars at the present time.

Other drilling tests have been conducted at the open pits comparing the performance of the jet piercer, the rotary drill, the churn drill, and the percussion wagon drills.

As an example, the Joy rotary drill and the Bucyrus-Erie 29-T churn drill were compared at the Tilden Pit. It was determined that the rotary rig could drill holes, for both the 40' and 60' benches, 17.2% cheaper than the churn drill. This saving amounts to an average saving of $.80 per foot of hole drilled.

This, however, was not the most important result of the test. It was also proved that the rotary rig could drill six times as fast as the churn drill. At an intermittent operating property such as the Tilden Pit, a machine such as the rotary rig can provide quick tonnages with a small crew in a much shorter length of time than the churn drills.

Again, it is hard to evaluate the actual savings achieved by a study of this nature, other than to say that for an estimated 1,000' of drilling per summer at the Tilden Pit the saving would be $800.00. However, it could be compared in this manner. Since the rotary rig drills six times as fast as the churn drill, one rotary rig and two men can do the work of six churn drills and twelve men in a days
DRILL MACHINES, DRILL STEEL & BIT TESTS - UNDERGROUND & OPEN PIT — contd.

time. This amounts to a saving of five machines and ten men per shift. In 1,000
of drilling, it would amount to a saving of 86 man shifts or $1,597.88.

Other tests at the open pits were conducted to help determine which type
of drill machine would best be adapted for the type of ground to be drilled. In
these cases, a direct saving in money on a cost per foot basis may not amount to
a great deal, but it helped the operators determine which machine would perform the
best. The savings again would be determined in drilling time.

DITCH CLEANER

This department redesigned a pulp loading machine into a ditch cleaner
that has quadrupled the output of the two men required for the operation. In other
words, this $2600 piece of equipment with two men will do the work of eight men.
This would amount to an annual saving of $19,920.00 on a four day per week schedule.

HOIST ROPE INSPECTION

This department initiated the study of the new hoist rope inspection with
the use of motion pictures. After our first few attempts, it was decided to ask
Mr. Dana Cory of the Electrical Department to help out because of the complex timing
and lighting that will be required to obtain the results desired. Mr. Cory is con-
tinuing the study with the cooperation of Mr. Lindquist of our department.

CONCLUSIONS

In the Recap of Savings, we show a total of $419,183.70 saved through the
efforts of the Operating Research Department with a net savings of $369,394.70.
However, we have also pointed out in the general discussions that additional savings
could be justified, but since these projects were completed during the latter part
of 1957 the savings will be reflected in 1958.

If these projected savings were to be totaled, it would amount to:

Chain Conveyor Fans (Replacement of 200) .................. $ 20,000.00
Cage Method of Raising ..................................... 30,000.00
Cliffs Shaft Savings on Carbide Bits ......................... 12,770.00
Rotary Drilling at Tilden .................................... 800.00
Ditch Cleaner .................................................. 6,000.00
T-H Sets or Comparable Bethlehem Set (Est.) ............... 20,096.00

Projected Savings ........................................... $ 99,666.00
Gross Savings - 1957 ........................................ 419,183.70
Total Gross & Projected Savings ........................................ $518,849.70
Less Expense ................................................ 49,789.00
NET SAVINGS ............................................... $469,060.70

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CONCLUSIONS -contd.

Not included in the gross savings figure is the 24% (Industrial Relations Department's calculations) that should be added to the cost of direct labor for fringe benefits. Of the $4,690,607.70 net savings shown in the table above, $382,004.34 is direct labor. Adding 24% for labor fringe benefits to the net savings figure, shows a total savings of $560,741.74.

Calculation:
Net Savings ........................................ $4,690,607.70
Fringe Benefits 24% x $382,004.34 (Labor) = 91,681.04
Grand Total Net Savings .......................... $560,741.74

Aside from placing a monetary value on the efforts of this department, it should be pointed out that from the day this department was organized in February, 1956, we have been constantly engaged in perfecting and adapting chain conveyors, the auger miner, and other equipment for use in our underground properties.

In the case of the chain conveyors, it was necessary for us to make this equipment work under all kinds of conditions, types of ground and various installations, but the biggest job was to educate the mining personnel at the properties in the use and care of chain conveyors.

It may seem odd, but many of our older mining supervisors and other underground employees are immediately opposed to anything new. In 1956 and the beginning of 1957, this situation was hard to buck, however, we have managed to prove to everyone that our prime purpose is to make their jobs more productive and safer.

As far as the operating personnel is concerned, we have had excellent cooperation from them from the very start.

In conclusion, it should be pointed out that in every case where new equipment or methods are introduced one of our primary goals is to improve safety conditions that may be affected by our efforts.

John M. Haivala
Operating Research Department