15/05/002/007

NOTICE

The information contained in this report is regarded as confidential and proprietary. It is provided subject to the provisions regarding confidential, proprietary information contained in the Research Agreement among the Participating Parties.

CONFIDENTIALITY RELEASED

CONOCO INC.

DATE 2/11/92

SOCONY MOBIL OIL COMPANY, INC.

RESEARCH DEPARTMENT

TECHNICAL MEMORANDUM NO. 66-1

# TEST OF JOY MANUFACTURING COMPANY ROTARY PERCUSSION DRILLING UNIT IN ANVIL POINTS MINE

ANVIL POINTS OIL SHALE RESEARCH CENTER

Rifle, Colorado

January 17, 1966

Author:

G. R. Haworth

Approval:

R. H. Cramer
Program Manager

## NOTICE

The primary object of the Anvil Points Oil Shale Research Center TECHNICAL MEMORANDUM is to advise authorized personnel employed by the Participating Parties[1] that various activities are in progress or that certain significant data have been obtained within the Research Center.

These TECHNICAL MEMORANDA have been prepared to provide rapid, on-the-spot reporting of research currently in progress at Anvil Points. The conclusions drawn by project personnel are tentative and may be subject to change as work progresses. The TECHNICAL MEMORANDA have not be edited in detail.

[1] Socony Mobil Oil Company, Inc., Project Manager

Humble Oil and Refining Company

Continental Oil Company
Pan American Petroleum Corporation
Phillips Petroleum Company
Sinclair Research, Inc.

# TEST OF JOY MANUFACTURING COMPANY ROTARY PERCUSSION DRILLING UNIT IN ANVIL POINTS MINE

## TABLE OF CONTENTS

# INTRODUCTION

The primary purpose of carrying out this series of drilling tests on a Rotary-Percussion Drill was to determine if any improvement could be made on drill penetration rates attained by the U. S. Bureau of Mines. During the Bureau's mining project, it was established that straight percussion drill performance would range between one and two feet per minute depending upon bit size. The Bureau of Mines also carried out preliminary testing on a rotary drill of their own design, and attained penetration rates up to five feet per minute, though there was insufficient testing to be conclusive.

Drill penetration rates are important in planning any future mining operation because they affect the entire sequence of operations. The length of time it takes to drill out a heading, preparatory to blasting, is an inverse function of the drill penetration rate. The face drilling time affects the number of drills, drill crews and working headings which are necessary to maintain a given level of production. The more numerous the working headings the greater the need for mobility of loading and hauling equipment. All these factors seriously affect mining methods and costs.

Joy Manufacturing Company produces a rotary percussion drill which has a much improved performance over that of the standard percussion drill. When Joy was willing to make available a demonstration rotary percussion drill rig for demonstration at Anvil Points, it was decided to take this opportunity for carrying out a drill test program.

The test procedure was set up with a view to optimizing the penetration rate as a function of bit thrust, rate of rotation, bit diameter, bit type, shale oil content, drilling direction and hole flushing media. Due to the lack of adequate measuring devices on the drill jumbo and also to numerous maintenance problems, it was found impossible to adhere to the experimental design laid out. However, it was possible to obtain significant information on penetration rates.

The tests were started on March 17, 1965 and were concluded on March 31, 1965. The drill was operated by Joy Manufacturing Company representatives under the direction of P. G. Zambas of Socony Mobil Oil Company, Inc.

## SUMMARY

### The RPD Drill:

It appears that this type of drilling may be used in oil shale. Further testing may show that an improved type of bit would yield better results. Also, it is possible that better penetration rates may be obtained if the machine is kept in better repair than the demonstration unit appeared to be during the test.

### The Cobra Boom:

This is a very versatile boom. It can be rotated and positioned at practically any location on the face. There is one disadvantage associated with this boom, that it is activated by a three-point support structure. This arrangement makes it impossible to move the boom in either the horizontal or the vertical direction. The boom moves along the arc of a circle. This feature, however, can be changed if a jumbo is to be designed for drilling a particular round.

### The Rig:

The entire rig is mounted on a truck. Since this is a demonstration rig and has to be transportated from mine to mine, it has been designed with specific reference to highway specifications rather than to the requirements that might be imposed by an underground operation. For such an operation, additional booms (and drills) can be installed on the same carriage and constructed in such a way as to drill a particular round on a face of predetermined dimensions.

### The Operators:

It was apparent that the people who operated the rig had a thorough knowledge of the characteristics of the machine. It was noticed, however, that the entire unit was in poor repair. The lack of any maintenance program on the rig itself was probably the main reason for the poor performance of the rig during the major portion of the test.

### Servicing:

During the test it became obvious that the operators of the rig did not receive all the possible help from the local representatives of the manufacturer. Even the main offices of the company seemed to be lax in their support of the unit and its operators. A number of items that were needed for the demonstration (and which were ordered from the main Joy factory) were not sent out to the location as soon as they could have been.

## CONCLUSIONS

Although the final results of this series of tests are not as detailed or as accurate as originally hoped for, they are significant and quite important in terms of their applicability to the evaluation of the possible mining costs of oil shale. These results indicate that a less conservative drilling rate might be assumed in mining cost calculations, possibly as high as 8 to 10 feet per minute compared to a rate of three to five feet per minute that was accepted prior to these tests.

The results also indicate that larger diameter holes can be drilled at higher penetration rates than smaller holes, within the limits of the size ranges tested (1 5/8 inch to 2 inches). The probable reason for the increase in drilling speed is that the drill cuttings clear better out of larger diameter holes thereby improving the cutting ability of the bit.

Finally these tests show that penetration rate varies with the oil content of the shale.

## RECOMMENDATIONS

It is recommended that a plain rotary drill be tested in oil shale. It is entirely possible that better results may be achieved with a plain rotary than were attained with the Rotary-Percussion Drill. If this does not prove to be the case, it is recommended that additional testing be done with the Rotary-Percussion Drill so that more accurate data can be obtained on the performance of this type of drill.

It is also suggested that a series of blasting experiments be planned with the object of determining the optimum hole diameter that should be used in drilling headings, as well as bench rounds, in oil shale. Once such an optimum diameter is determined (for best fragmentation, optimum size distribution of the broken ore, minimum explosive usage, minimum drilling cost, etc., etc.) then all drilling tests can be confined to that size.

## GENERAL

| | |
|---|---|
| Equipment: | Rotary-Percussion Demonstration Unit of Joy Manufacturing Company |
| Place: | Anvil Points Oil Shale Mine<br>Cross-cut No. 9, between "Able" and "Charlie"<br>Cross-cut No. 8, between "Charlie" and "Easy"<br>Cross-cut No. 8, "Easy" |
| Time: | The tests started on March 17, 1965 and were concluded on March 31, 1965. |
| Operators: | The machine was operated by: J. Douglas and J. Pillsbury, both of Joy Manufacturing Company |

Observers:

| | | |
|---|---|---|
| 3/15/65 | P. G. Zambas | Socony Mobil Oil Company |
| 3/16/65 | R. Frazer | Joy Manufacturing Company |
| 3/19/65 | G. Zumwalt | Socony Mobil Oil Company |
| 3/19/65 | J. H. Haddad | Socony Mobil Oil Company |
| 3/22/65 | F. N. Fagan | Socony Mobil Oil Company |
| 3/22/65 | H. Gilliland | Continental Oil Company |
| 3/22/65 | C. Knutson | Continental Oil Company |
| 3/22/65 | B. Martin | Continental Oil Company |
| 3/22/65 | H. Wahl | Continental Oil Company |
| 3/22/65 | P. Williams | Joy Manufacturing Company |
| 3/23/65 | J. Hentla | Joy Manufacturing Company |
| 3/25/65 | M. Ludwick | Climax Molybdenum Company |
| 3/25/65 | H. Patterson | Climax Molybdenum Company |
| 3/25/65 | A. Smith | Climax Molybdenum Company |
| 3/31/65 | T. Lehner | Joy Manufacturing Company |

The original purpose of this series of drilling tests was to determine the rate of penetration of a Rotary-Percussion Drill (RPD) in oil shale. The variation of this rate was to be determined as a function of a number of machine and rock variables such as:

a. Amount of thrust on the bit
b. Rate of rotation
c. Type and size of bit used
d. Oil content of the shale
e. Orientation of the drilling direction with respect to the bedding plane of the shale
f. Type of drilling - wet, dry, or semi-wet
g. Line pressure applied to the drill

In addition to the above, a number of time elements were to be measured such as:

a. Steel retraction time
b. Steel re-positioning time
c. Bit life between re-sharpenings
d. Amount of water used per minute or foot of hole

e. Time needed to drill a round
f. Time needed to drill a hole for a roof bolt
g. Approximate cost of fuel per operating hour of the drill

Unfortunately, after discussing the proposed program for the tests with the operators of the rig, it became apparent that it would be impossible to obtain detailed and accurate information on a number of the variables described above due to the lack of adequate measuring devices on the rig itself. As a result of this, the scope of the test was severely curtailed. Nevertheless, a series of tests was decided upon which would still yield sufficient and significant information on penetration rates and its variation in the different beds of oil shale.

When the machine was taken into the mine and put into operation, a number of breakdowns occurred which further limited the scope of this test series. Briefly, the following items failed and caused delays:

a. The hydraulic motor could not deliver the required RPM to the drill.
b. A new (higher speed) motor was installed but could not fit on the gear box.
c. The circulating water system froze in the piping of the machine.
d. A leak developed in one of the hydraulic cylinders of the drill boom.
e. A Nitrogen Accumulator (for back-up pressure on the boom) was defective. When repaired it lasted for about six holes and became defective again.
f. A new accumulator was ordered and installed.
g. The hydraulic pressure was found inadequate and caused the motor to stall.
h. The filter on the hydraulic system was found completely plugged and had to be cleaned and replaced since a new one was not available.

Because of all these breakdowns, the only significant results were obtained in the last two to three days of the test.

Nonetheless, at the end of the tests it became apparent that this type of drill would perform satisfactorily in oil shale. A number of significant readings were taken. These readings are probably sufficient for the drawing of a number of curves that would describe relationships between the rate of penetration and the operating variables. Although these results may not be conclusive to the degree that a decision to buy one of these machines can be based on them, they are significant enough to be used as a basis for primary economic calculations of the cycling times, and the cost for the drilling part of mining oil shale.

## ANALYSIS OF DATA

### Description of the Test Runs

Only those tests which are considered significant are included.

a. Drilling the same bed of shale the following quantities were varied:
Thrust - (80 - 100 psi)
Rotation - (400 - 420 RPM)
Bit size - (1 3/4" - 2")
(3/18/65)

b. Drilling in three different beds of shale the following quantities were varied:
Thrust - (90 - 100 psi)
Oil Content - (14 to 16 gal/ton)
Bit size - (1 5/8" - 2")
(3/25/65)

c. Drilling in three different beds of shale the following quantities were varied:
Thrust - (50 - 100 psi)
Rotation - (480 - 520 RPM)
Oil Content - (15 to 50 gal/ton)
Bit size - (1 3/4" - 2")
(3/29/65)

d. A complete face round was drilled in "Easy" to the specifications shown in Appendix I. A time study was taken while this round was being drilled. Also a record was kept of the amount of water used during this test.
(3/30/65)

e. Drilling in ten different shale beds the following quantities were varied:
Thrust - (70 - 90 psi)
Rotation - (500 - 510 RPM)
Oil Content - (5 - 60 gal/ton
Direction - (Parallel, perpendicular, and 45° to the bedding plane)
(3/31/65)

### General Results:

1. The penetration rate is related to the amount of thrust applied to the bit. This relationship can be seen on Figure 2, Appendix II. The optimum amount of thrust seems to be in the area of 70 - 80 psi (applied to the feed motor).

2. The penetration rate is related to the rate of rotation of the bit. The data obtained for this part of the experiment was limited. Furthermore, the rate of rotation was not

constant during the various runs. An attempt has been made to draw an inferred curve from the data available, see Figure 3, Appendix II. The only conclusion that can be made is that higher penetration rates can be obtained in the higher rotation speed ranges of 470 to 510 RPM.

3. There seems to be a variation in the rate of penetration with different drill bits. Only three bits were tested and the rate of penetration varied from 9.45 to 11.3 feet per minute. Unfortunately no conclusion can be drawn from the limited data.

4. The penetration rate is related to the diameter of the bit used. The penetration rate increases as the diameter increases. This is related to the amount of space that is used for cleaning the cuttings from the hole. Because the same size steel was used at all times, this space was larger with a larger bit. The relation between the penetration rate and the bit diameter is shown on Figure 4, Appendix II.

5. The penetration rate varies from one oil shale bed to another. This can be shown to be related to the oil content of the oil shale. Figure 5 shows that penetration increases as the oil content increases.

6. The penetration rate at right angles to the bedding plane of the oil shale is different from the rate in holes drilled parallel to the plane. An insufficient number of tests were performed at right angles (and at 45°) to the bedding plane. From this limited testing, however, it is indicated that the rate is lower in these directions than in the direction parallel to the beds.

7. A very limited number of holes was drilled "dry". The results of this particular test indicate that there is no difference in the rate of penetration between drilling "dry" and "wet".

8. The average time required to move the drill from one (completed) hole and to position it at the next hole was 1.33 minutes. This number, however, is considerably inflated because the operator was not familar with the pattern he was to drill on the face. As a result he had to be guided continuously; this made it necessary for him to spent considerably more time in moving the boom from one hole to the next. In view of the above, a figure of 0.663 minute per hole is considered more representative.

9. The average time required to retract the bit and steel from a completed hole was found to be 0.273 minutes per hole (or 0.0248 minutes per foot).

10. The average time required to collar each hole was found to be 0.275 minutes. However, the comments under Item 8 above apply to this item also, and a figure of 0.218 minute per hole is considered more representative.

11. Three bits were used to the point where they were ready to be resharpened. The footages attained were: 358 feet, 534 feet, and 319 feet (average: 404 feet per bit). Two additional bits were destroyed (carbide inserts were sheared off) at footages of 238 feet and 221 feet (average 230 feet per bit).

12. The amount of water used during the drilling operation was approximately 15.3 gallons per hole. However, this quantity is quite inflated, due to the special piping arrangements existing on the experimental rig. A more realistic figure would be 13 gallons per hole.

13. One round was drilled off on a face in the mine, as shown in Appendix I. A time study was made during this part of the testing series. Five time elements were considered: Drill, Retract, Reposition, Collar, and Delay. The "Drill" element should be taken at face value (100%). The "Retract" element should also be taken at face value (100%). The "Reposition" element should be taken at only 50% value in line with the remarks made under Item 8 above. The "Collar" element should be taken at 80% value in line with the remarks under Item 8 above. The "Delay" time includes time that was primarily spent in moving the truck closer to, and further away from, the face. This was necessary because of the special design of the demonstration rig. A production rig would be so designed as to require a minimum amount of moving back-and-forth to the face. For this reason, this item should be taken at only 10% value. The following table summarizes the above:

| Item | Measured Min. | Value % | Weighted Min. | % of Total | Per Hole Min. |
|---|---|---|---|---|---|
| Drilling | 81.94 | 100% | 81.94 | 52.28% | 1.413 |
| Retracting | 15.94 | 100% | 15.94 | 10.17% | 0.275 |
| Repositioning | 76.91 | 50% | 38.46 | 24.54% | 0.663 |
| Collaring | 15.93 | 80% | 12.74 | 8.13% | 0.220 |
| Delays | 76.55 | 10% | 7.66 | 4.88% | 0.132 |
| Totals | 267.27 | | 156.74 | 100.00% | 2.703 |

Discussion:

When the rig was moved into the Anvil Points Mine, the operators suggested (on the basis of their previous experience in oil shale) that the optimum rate of penetration could be obtained at a thrust equivalent to a 95 to 100 psi air pressure supplied to the feed motor. This is the reason for the very high number of holes drilled at 90 and 100 psi. However, as testing continued, it became obvious that good results were possible at lower pressures also. The results are tabulated in Appendix II and plotted on Figure 2. From the curve it can be seen that the optimum thrust for an "average" rate of penetration is about 75 to 80 psi. Since the number of holes drilled under identically the same conditions was very limited, the tabulation and the curve were constructed with all the available points. Thus, the "average" curve includes points for different bit diameters, rates of rotation, oil contents, etc. It is assumed that the operator of the drill would be in a position to vary the rotation and the thrust during the drilling of a round. Therefore, the average curve can be thought of as an "overall" curve for the entire face at an oil content varying between 3.1 and 52 gallons per ton.

The rate of rotation recommended by the operators was 485 RPM. Such high rotation was not possible with the hydraulic motor already installed on the rig (Motor No. 1). A new motor was installed later during the tests. The RPM of the hydraulic motor was entirely dependent on the RPM of the truck engine, see Figure 1, Appendix II. During the tests the truck-engine RPM varied considerably. This accounts for the scattered appearance of the points on Figure 3. As a result only a very preliminary conclusion can be reached on the effect of rotation speed on the rate of penetration.

Two types of two-inch bits were used in the tests. Both types of bits had a 30° leading angle (30°/30° - see Notes and Description of Bits Used in Appendix III), with the center hole plugged. Bits Numbers 5, 6, and 9 had four side holes 3/16 inch in diameter. Bit Number 8 had two of the four side holes enlarged to 7/32 inch in diameter. Taking all the results for the two-inch bit, it appears that the rate of penetration was the same for Bits Number 5, 6, and 8, but different for Bit Number 9 which was the same type as Bits Numbers 5 and 6. It is quite possible that Bit Number 9 was a much newer bit. However, it is also possible that the type of carbide insert in that bit was different. Since sufficient data is not available at this time, only a preliminary conclusion can be reached, to the effect that the type of bit used has an effect on the rate of penetration. This was to be expected.

In the past, it has been generally assumed that the larger the diameter of the bit used the slower the rate of penetration would be, since a larger amount of energy is required to drill a larger area of hole. However, in addition to the energy required for drilling the hole, the space available for cleaning the rock cuttings out of the hole is a consideration which has an effect on the rate of penetration. Since the same size steel was used for the various hole diameters, the space available for cleaning the hole was larger with the larger bit diameters. Thus, the rate of penetration is shown to increase with increased bit and hole diameter. Most of the drilling for this portion of the tests was done in oil shale containing approximately 15 gallons per ton.

The oil content of the shale has a significant effect on the rate of penetration of the bit in the rock, see Figure 5. The points on the curve include only those holes drilled with a two-inch bit. The rate of rotation that would give the maximum penetration was different in the various shale beds. Again it is assumed that the drill operator (under actual operating conditions) would be in a position to vary the rate of rotation as needed for drilling into the various beds.

The rates of penetration at right angles and at a 45° angle to the bedding planes appears to be lower than the rate for drilling parallel to the bedding planes. However, the data collected for this mode of operation is very scant and the results cannot be conclusive. Further testing of this point is indicated.

The time required to position the drill was discussed under "General Results". It is estimated that if the operator had had the opportunity to drill eight or ten rounds before being timed, the positioning time would be cut to half. For general purposes, therefore, it is assumed that a time element of 0.663 minutes per hole can be considered as a representative figure for "removing the boom from one hole location, moving it to the next hole location at the correct distance, positioning it at the correct angle, and stinging the face" (stinging means applying pressure on the boom to make it stationary on the face).

The average time required to retract the bit and steel from a completed hole was found to be very consistent and equal to 0.273 minute per hole. If this is converted on a per foot basis, it becomes: 0.0248 minute per foot, or the steel is being retracted at the rate of: 40.3 feet per minute. This last figure can be applied directly to any length of hole. The retracting time starts at the instant when the hole is completed and ends at the instant when the bit emerges from the hole.

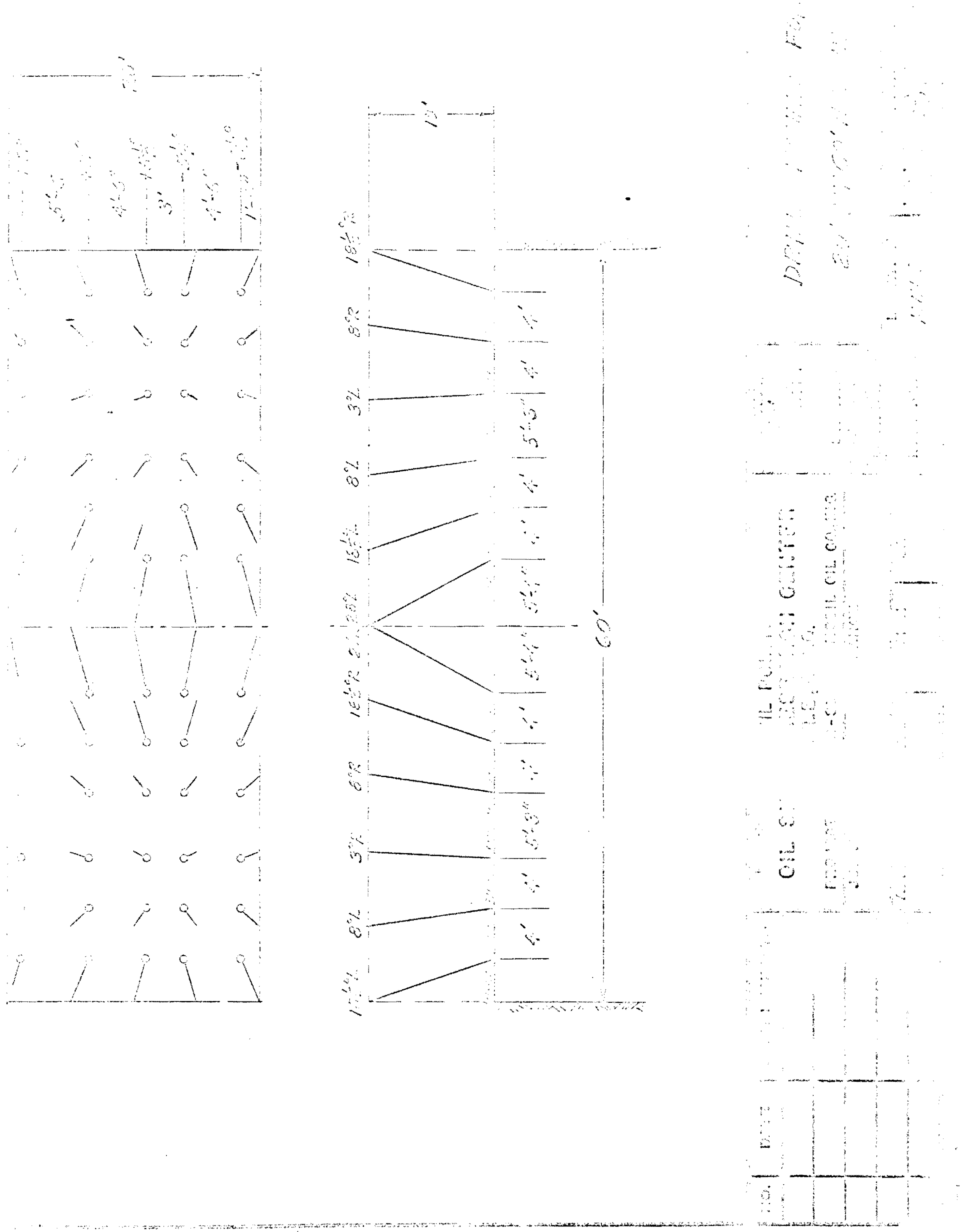
Of the eleven bits used, six drilled for a total of 699 feet of hole. None of these six bits was worn enough to be ready for resharpening. Two more bits drilled for a total of 459 feet of hole and then the carbide inserts were sheared off. (Average: 230 feet per bit). The last three bits drilled for a total of 1,211 feet of hole and then were removed to be resharpened. Taking the last category only the average life per bit between resharpenings appears to be slightly over 400 feet. The bits that sheared off will not be considered representative, since they were used during the time when the optimum thrust and optimum rate of rotation were being investigated and, therefore, were subjected to undue rotational and thrust conditions. It is suggested that a more conservative figure of 300 to 530 feet be used. The operators indicated that each bit would take six to twelve resharpenings before being discarded. If the average number of nine is used, the life of a bit can be calculated to be about 3,000 feet of hole. At an indicated cost of $14.00 per bit (bought in quantity) the cost of the bit on a per foot basis is about $0.0050 plus the cost of resharpening. This figure can be applied to holes of any length.

A 500-gallon water tank was used in conjunction with the rig but only 452.5 gallons could be used at one time. This amount of water was sufficient for 29.5 holes. The average consumption of water was, therefore, calculated to be 15.3 gallons per hole. However, the piping connections on the experimental rig were such as not to allow the flushing of the hole with air. This is done in actual production drilling as soon as the bit reaches the bottom of the hole. Since that was impossible during this test, the operator was forced to keep flushing with water while retracting the steel from the hole. This increased the water consumption considerably. Since the time spent in drilling alone represents about 85 percent of the time required for drilling and retracting, it is suggested that the actual water consumption under operating conditions would be in the order of 13 gallons per hole, or 0.87 gallon per foot of hole.

Part of a regular round was drilled in the mine, see Appendix I. The data from this round and a short discussion appear under "General Results". It is interesting to note that the average time required to drill one hole was 1.413 minutes compared to a low of 0.87 minute that was achieved on one hole during the test. The items: Repositioning, Collaring, and Delays can be used on a "per hole" basis for any round that may be designed. The items: Drilling and Retracting, however, must be converted to a "per foot" basis first, applied to the length of the holes for the round in question, and then used on a "per hole" basis.

On the basis of this performance of the demonstration rig in drilling the round (58 holes 10 feet long) it is estimated that it would take about 7 1/2 hours for a complete (60 feet by 39 feet) round of 15 feet holes. If more than one drill is incorporated on the rig, this time can be reduced considerably. One man can operate one drill at about 95 percent efficiency, and can probably operate two drills at about 80 percent efficiency. Thus, it is estimated that one man with a two-machine rig could drill a round in about 4 1/4 hours.

APPENDIX I

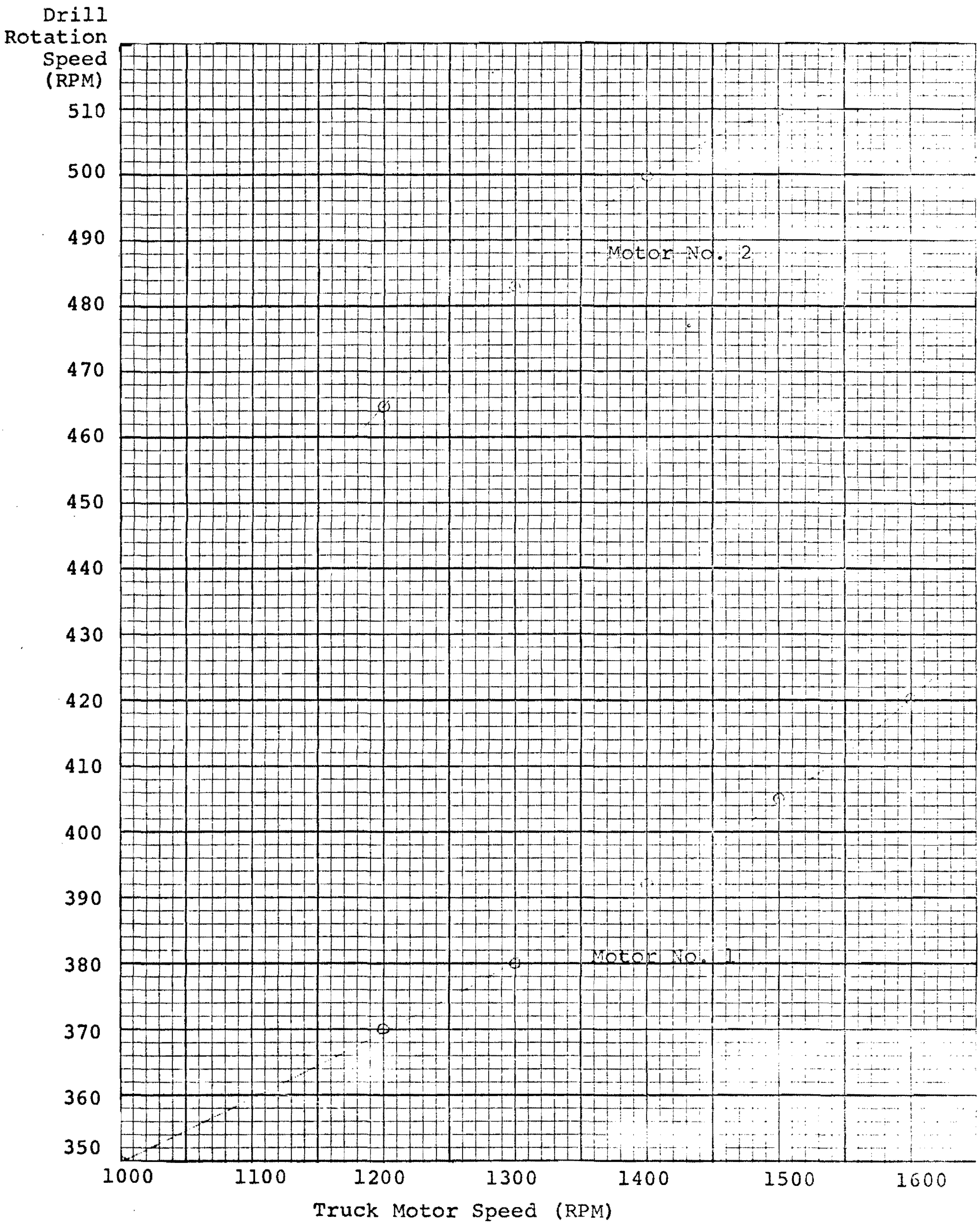


# APPENDIX II

## GRAPHICAL REPRESENTATION OF DRILLING RESULTS

Figure 1

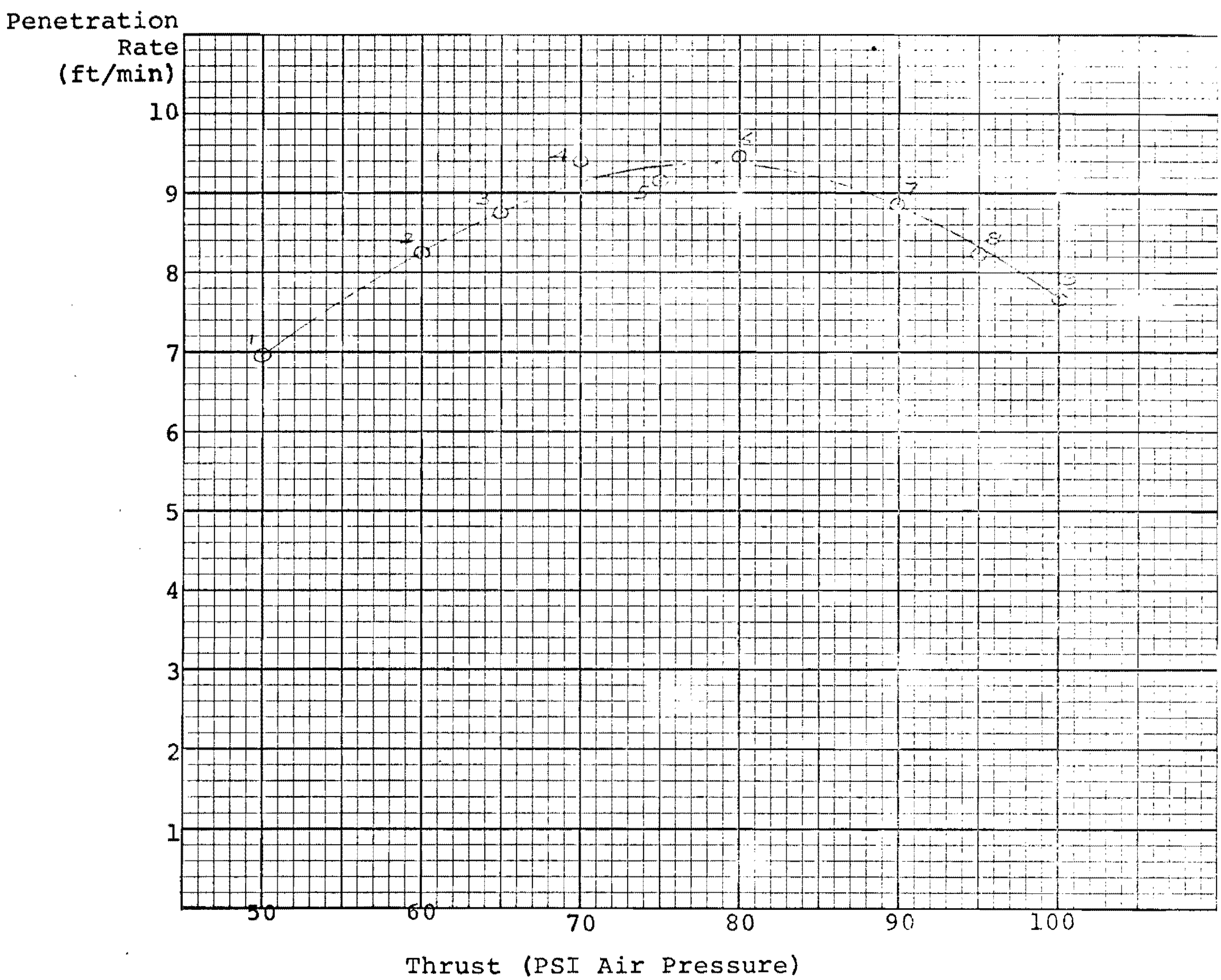
EFFECT OF TRUCK MOTOR SPEED ON DRILL ROTATION SPEED




Test of Joy Manufacturing Company Rotary Percussion Drill in Anvil Points Mine

Figure 2

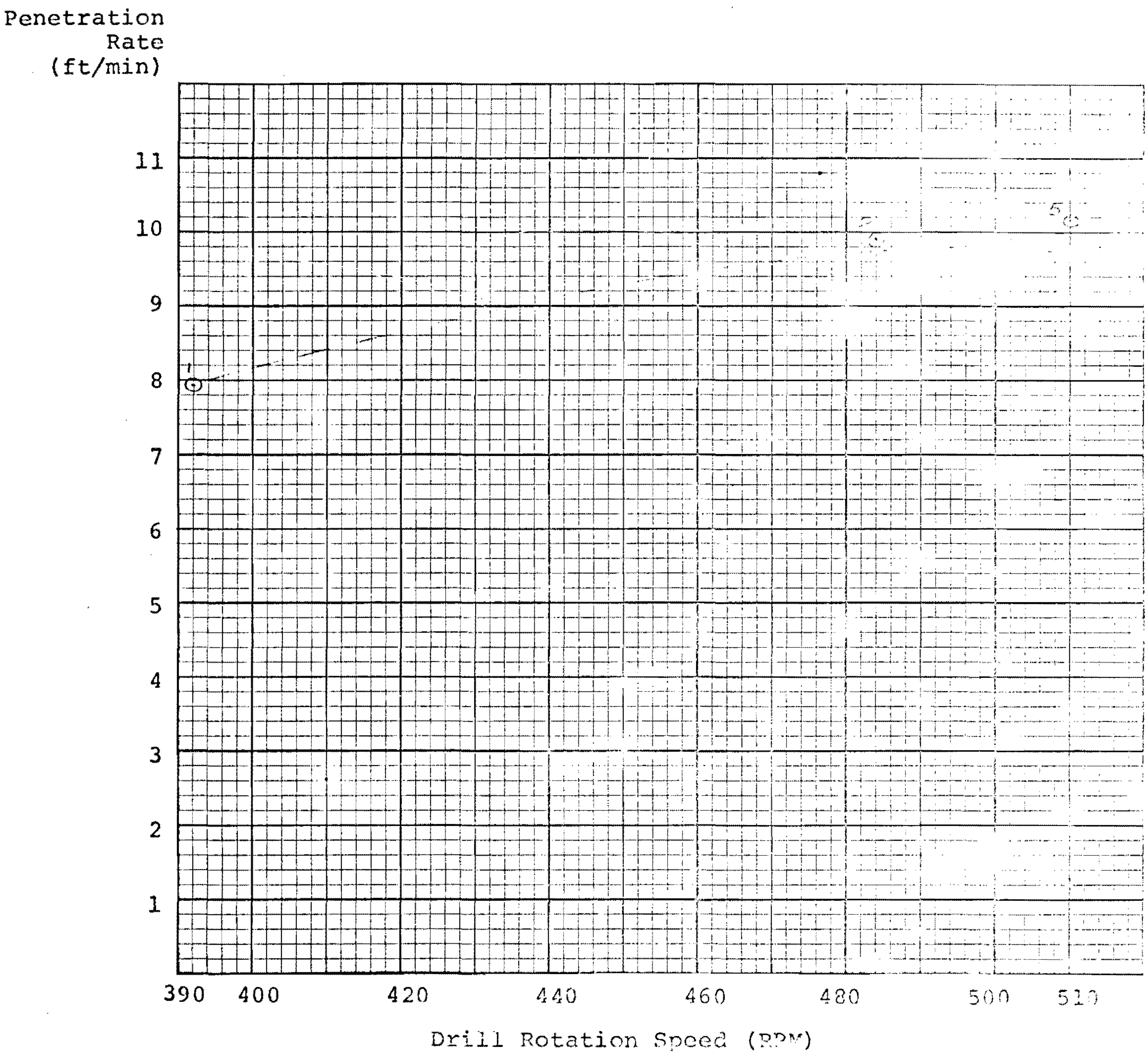
EFFECT OF THRUST ON PENETRATION RATE




Test of Joy Manufacturing Company Rotary Percussion Drill in Anvil Points Mine

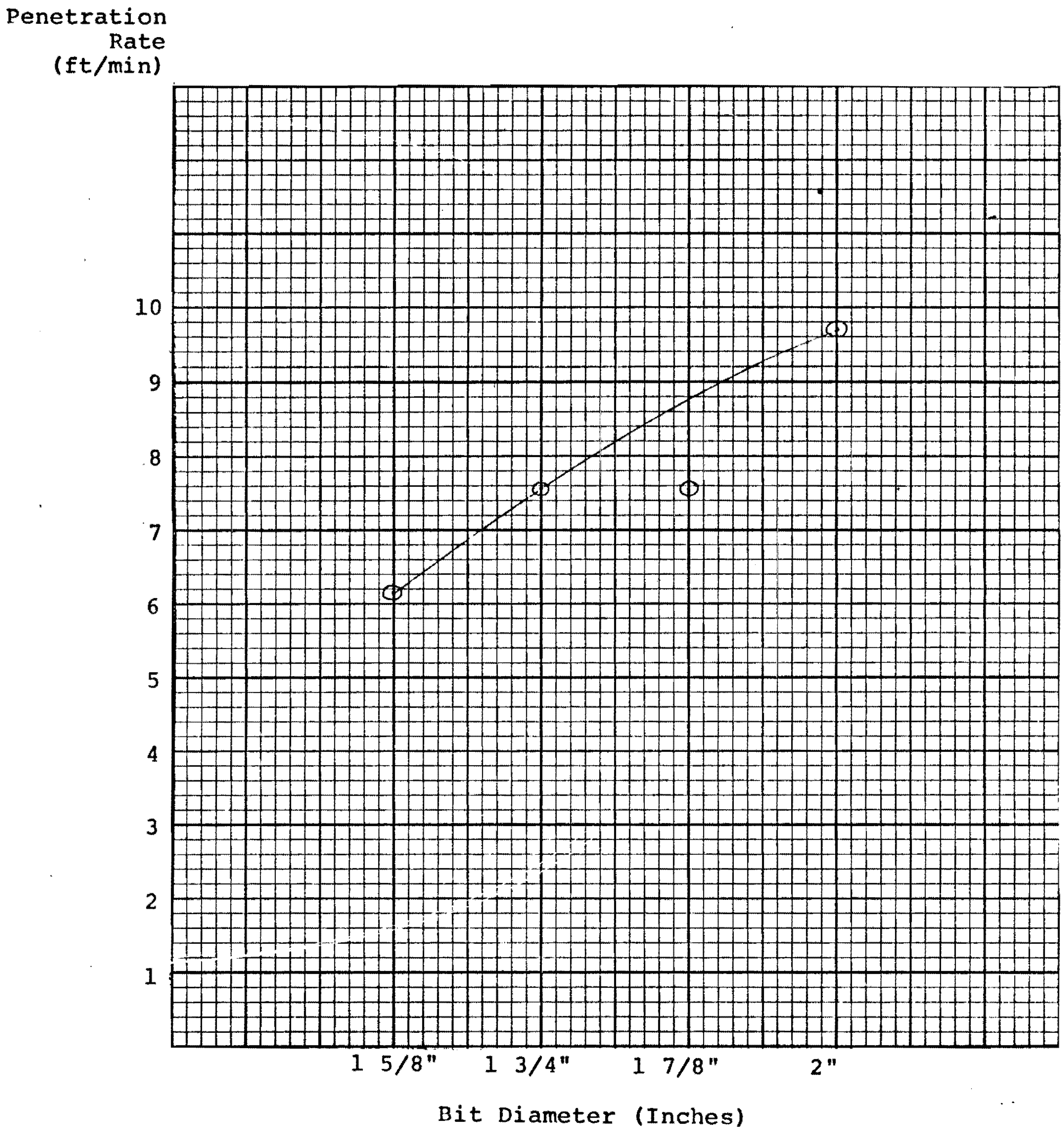
Figure 3

EFFECT OF DRILL ROTATION SPEED ON PENETRATION RATE



<u>Figure 4</u>

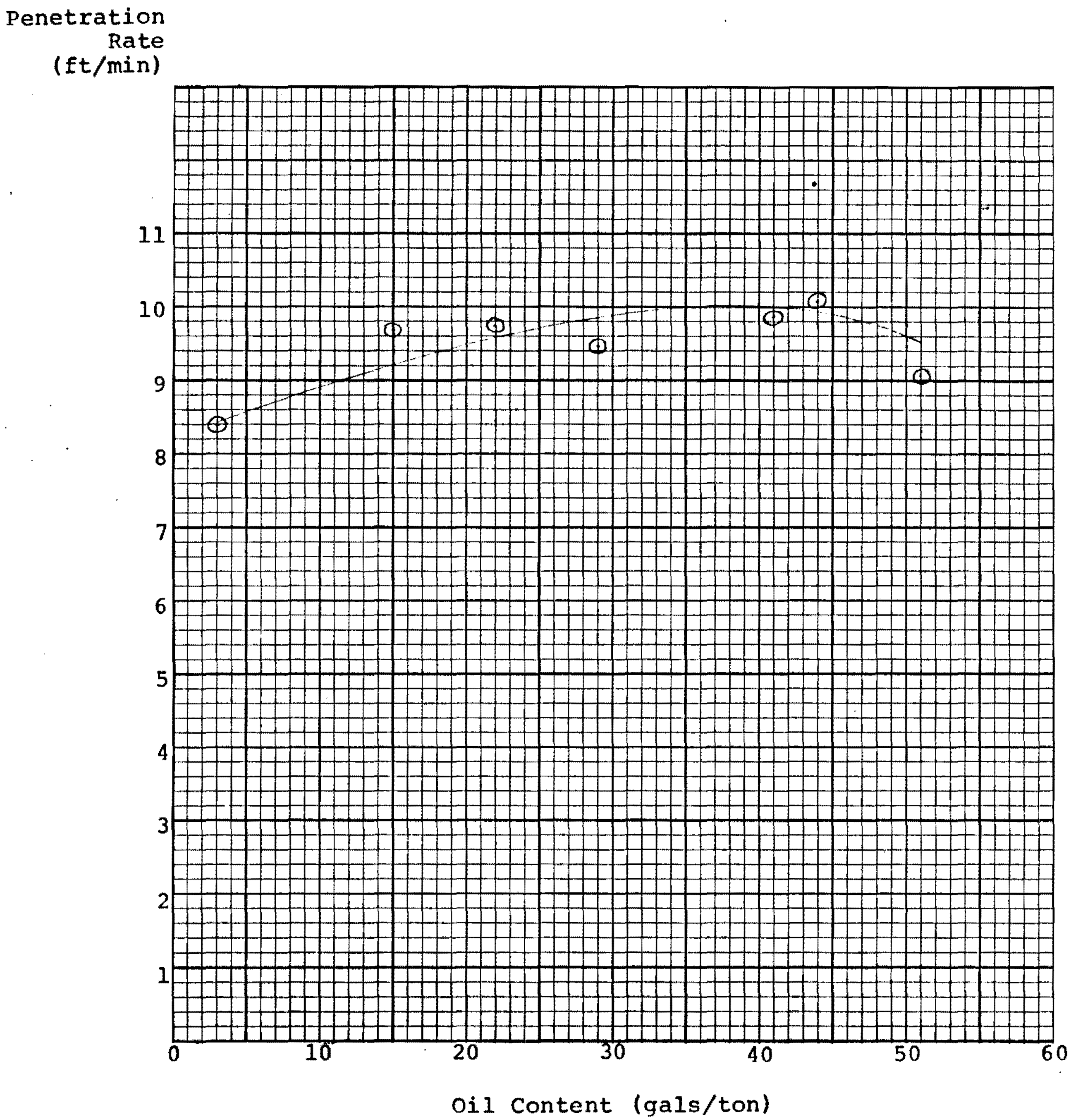
EFFECT OF BIT DIAMETER ON PENETRATION RATE




Test of Joy Manufacturing Company Rotary Percussion Drill In Anvil Points Mine

Figure 5

EFFECT OF OIL CONTENT ON PENETRATION RATE




Test of Joy Manufacturing Company Rotary Percussion Drill In Anvil Points Mine

# APPENDIX III

## TABULATION OF DRILLING RESULTS

Column Headings Used:

1. Run - hole number. All numbers beginning with "O" represent holes drilled in the face round shown in Appendix I. The second two digits correspond to the hole numbers shown on the drawing.

2. Motor - two motors were used.
   No. 1: Slow RPM
   No. 2: High RPM

3. Bit Number - three types and four sizes of bits were used. For the description and size of the various bits see Page v.

4. Direction - drilling direction relative to the bedding planes - Parallel (P), Perpendicular (R), Angled (A)

5. Location - drilling area in the mine -
   XC-9 between "Able" and "Charlie", North rib (9)
   XC-8 between "Charlie" and "Easy", North rib (8)
   XC-9 between "Able" and "Charlie", South rib (9S)
   XC-9 between "Able" and "Charlie", Floor (9F)
   XC-8 in "Easy", North Face (E)
   XC-8 in "Easy", East Rib (8E)
   XC-8 in "Easy", Floor (8F)

6. Oil Content - in gallon per ton from samples obtained during drilling.

7. Conditions - Wet (W), Dry (D).

8. Truck Engine RPM - this is ± 50 RPM.

9. Steel RPM - from calibration curves on Figure 1, Appendix II.

10. Thrust - air pressure (psi) on the feed motor.

11. Length of hole, in feet.

12. Cumulative length of hole, in feet - for the same bit.

13. Time - drilling time measured in minutes between collaring and heading to bottom of the hole.

14. Penetration rate in ft/min.

15. Retracting time in minutes from bottom to collar.

17. Unuseable - runs marked "X" were discarded from useable data.

18. Collar - time consumed from the moment the "stinger" touches the face to the moment when the bit starts the hole, in minutes.

19. MM ± - approximate distance from Mahogany Marker, in feet.

20. Repositioning time in minutes counted from the moment the bit is out of the hole to the moment when the "stinger" is positioned on the next hole. Note that the collaring, and retracting times are defined above (15, 18).

21. Delays given in minutes.

22. Remarks - addition notes etc. on Page iii.

## NOTES

1. The bit was removed. Two of the four holes were plugged but the bit did not need resharpening yet (218 feet).

2. Operators had trouble with the intake water swivel, it came loose.

3. The stinger was not working properly. This caused slippage at the face and resulted in arching of the steel. The friction between steel and walls on the hole reduces the penetration rate. All this is caused by a leak on the boom and a leak on the nitrogen accumulator which controls the stinger.

4. Operators decided to change the hydraulic motor in order to get higher RPM on the steel. New motor, however, did not fit. Therefore the old (1) motor was put back on again.

5. Had trouble with the water on Run 24. Water pressure was low, water came in spurts. That could be an indication that there was inadequate cleaning of the hole. Upon closer examination it was discovered that there was ice in the water lines. By drilling Holes 25 and 26 dry the above was verified. An air tank was used for pressurizing water from this point on.

6. Drilling was stopped for repair work to be done on the boom leak. Also the accumulator was removed and temporarily repaired. Work was resumed on Tuesday.

7. To eliminate the recurrent accumulator trouble, the hoses on the hydraulic system were connected to bypass the accumulator. Results improved for a few runs but deteriorated again.

8. Removed bit No. 2. It was ready to be resharpened. No appreciable loss in gauge. Carbide inserts were slightly blunted. The Joy operators claim that 6 to 12 resharpenings are common with this type of bit. The cost per foot of hole is $0.00648 (maximum) to: $0.00324 (Minimum). This does not include the cost of resharpening the bit.

9. The bit was destroyed: Two of the four carbide inserts sheared off completely. The remaining carbides were in fair shape.

10. One carbide insert was sheared off. The remaining inserts were in good condition. To the total footage of this bit (206 feet) must be added about 15 feet to account for two to three holes that were half-drilled and for which no record was kept. Total footage: 221 feet.

11. Bit No. 6 was a used bit which had been resharpened, the gauge was 1 31/32 inch ~ 2 inch.

12. The hydraulic motor started stalling. This places too much strain on the hydraulic system, reduces rotation, slows down penetration and causes the steel to arch badly.

13. At this point the strain imposed by the motor was too great. Tests were stopped. A new hydraulic motor No. 2 was put on the drill and the rig was moved to another location (XC-8).

14. There is something wrong with the hydraulic system. The motor stalls continuously and the hydraulic hoses vibrate very badly. The operators are afraid that the hydraulic pump is out of order. If that is so, any further experimenting is futile.

15. Removed the filter of the hydraulic circuit. It was completely plugged. There is a bypass valve. It is possible that oil could not get through the filter, it went through the bypass into the pump. Dirt in the pump could cause stalling and vibrations (See Note 14, above).

## DESCRIPTION OF BITS USED

All bits used were JOY RPD BLUE BITS, especially designed with a sharp leading edge angle.

No. 1 Diameter: 1 5/8"
Carbides: 1 5/8" inserts, 30°/30° angle, "25 Hard" carbide
Holes: Center hole plugged
4 side holes enlarged to 7/32" diameter
New Bit: 358 feet

No. 2 Diameter: 1 3/4"
Carbide: 1 5/8", 30°/30° angle, "25 Hard" carbide
Holes: Center hole plugged
4 side holes enlarged to 7/32" diameter
New Bit: 358 feet

No. 2' This is the old No. 2 bit resharpened

No. 3 Diameter: 1 7/8"
Inserts: 1 3/8", 30°/30° angle, "10 Hard" carbide
Holes: Center hole plugged
4 side holes enlarged to 7/32" diameter
New Bit

No. 4 Diameter: 1 7/8"
Inserts: 1 7/8", 20°/30° angle, "10 Hard" carbide
Holes: Center hole plugged
4 side holes enlarged to 7/32" diameter
Used Bit

No. 5 Diameter: 2"
Inserts: 2", 30°/30° angle, "25 Hard" carbide
Holes: Center hole plugged
4 side holes 3/16" diameter
New Bit: 221 feet

No. 6 Diameter: 2"
Inserts: 2", 30°/30° angle, "25 Hard" carbide
Holes: Center hole plugged
4 side holes 3/16" diameter
Used Bit: Resharpened

No. 7 Diameter: 1 7/8"
Inserts: 1 7/8, 20°/30° angle, "10 Hard" carbide
Holes: Center hole plugged
4 side holes enlarged to 7/32"
Used Bit

No. 8 Diameter: 2"
Inserts: 2", 30°/30° angle, "25 Hard" carbide
Holes: Center plugged
2 side holes 7/32"
2 side holes 3/16"
New Bit: 534 feet

No. 8' This is the old No. 8 bit resharpened

No. 9 Diameter: 2"
Inserts: 2", 30°/30° angle, "25 Hard" carbide
Holes: Center plugged
4 side holes 3/16" diameter
New Bit

Remarks

Steel slightly arched.
Steel plugged.
Bit plugged
Steel slightly arched.
See Note 7.
Stinger slipped again.

Broke into another hole.

Stinger slipped.
Bit and steel plugged.
Steel slightly arched.
Steel slightly arched.

Steel slightly arched.
Steel slightly arched.
Steel badly arched.

Steel badly arched

New cast [illegible] is drilled.

Steel slightly arched.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 Unuseables | | X | X | | | | | | X | | | X | X | | | |
| 15 Retracting Time, Mins. | | | | | | | | | | | | | | | | |
| 14 Penetration Rate, ft/min | 5.38 | -- | -- | 7.33 | 7.43 | 7.19 | 6.79 | 7.48 | 6.25 | 7.38 | 7.24 | 8.57 | -- | 7.86 | 7.75 | 8.59 |
| 13 Time Drilling, Mins. | 1.87 | -- | -- | 1.50 | 1.48 | 1.53 | 1.62 | 1.47 | 1.28 | 1.49 | 1.52 | 1.05 | -- | 1.40 | 1.42 | 1.28 |
| 12 Cumulative Length, ft | 116 | 126 | 136 | 147 | 158 | 169 | 180 | 191 | 199 | 210 | 221 | 230 | 233 | 11 | 22 | 33 |
| 11 Hole-feet | 11 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 8 | 11 | 11 | 9 | 3 | 11 | 11 | 11 |
| 10 Thrust, psi | 100 | 100 | | | | 90 | 90 | 90 | 95 | 95 | 100 | 100 | 100 | | | |
| 9 Steel RPM | [illegible] | [illegible] | | | | | | | | | | | | | | |
| 8 Truck RPM | 1400 | 1300 | | | | | | | | | | | | | | |
| 7 Conditions | W | W | | | | | | | | | | | | | | |
| 6 Oil Content Gal/Ton | 15.1 | 15.1 | | | | | | | | | | | | | | |
| 5 Location | 9 | 9 | | | | | | | | | | | | | | |
| 4 Direction | [illegible] | [illegible] | | | | | | | | | | | | | | |
| 3 Bit No. | 2 | 2 | | | | | | | | | | | | 3 | 3 | |
| 2 Motor | 1 | 1 | | | | | | | | | | | | | | |
| 1 Run | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 Unuseables | | | | X | | | X | | | | | | | | | |
| 15 Retracting Time, Mins. | | | | | | | | | | | | | | | | |
| 14 Penetration Rate, ft/min | 7.10 | 7.91 | 6.40 | -- | 7.01 | 6.47 | -- | 9.17 | 9.17 | 8.53 | 8.73 | [illegible] | 9.09 | 8.33 | 8.33 | [illegible] |
| 13 Time Drilling, Mins. | 1.55 | 1.39 | 1.72 | -- | 1.57 | 1.70 | | 1.20 | 1.20 | 1.29 | 1.26 | 1.32 | 1.21 | 1.32 | 1.32 | 1.28 |
| 12 Cumulative Length, ft | 44 | 55 | 66 | 77 | 88 | 99 | 110 | 121 | 132 | [illegible] | [illegible] | [illegible] | 33 | 44 | 55 | [illegible] |
| 11 Hole-feet | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| 10 Thrust, psi | | [illegible] | 90 | 90 | 90 | | 100 | 100 | | | [illegible] | 105 | 95 | 95 | [illegible] | [illegible] |
| 9 Steel RPM | | | | | | | | | | | | | | | | |
| 8 Truck RPM | | | | | | | | | | | | | | | | |
| 7 Conditions | | | | | | | D | D | | | W | W | | | | |
| 6 Oil Content Gal/Ton | | | | | | | 15.2 | 15.2 | | | 14.4 | 14.4 | | | | |
| 5 Location | | | | | | | | | | | | | | | | |
| 4 Direction | | | | | | | | | | | | | | | | |
| 3 Bit No. | | | | | | | | | | [illegible] | | [illegible] | | | | |
| 2 Motor | | | | | | | | | | | | | | | | |
| 1 Run | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |

Remarks

Steel slipped badly.
Steel slightly [illegible]

[illegible] into [illegible] holes,
Drilling [illegible]
(Light [illegible])
Drilling in [illegible]
(Light [illegible]).
Bit plugged.

Steel slightly [illegible].
Steel slightly [illegible].

Steel slightly [illegible], Note 8.

Steel slightly [illegible].

[illegible] (?) [illegible]
[illegible]

[illegible]

[illegible]
[illegible]

| 1 Run | 2 Motor | 3 Bit No. | 4 Direction | 5 Location | 6 Oil Content Gal/Ton | 7 Conditions | 8 Truck RPM | 9 Steel RPM | 10 Thrust, psi | 11 Hole-feet | 12 Cumulative Length, ft | 13 Time Drilling, Mins. | 14 Penetration Rate, ft/sec | 15 Retracting Time, Mins. | 17 Unusables |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | 1 | 4 | 2 | 9 | 11.4 | W | 1,100 | 392 | 100 | 11 | 77 | 1.21 | 9.09 | | |
| 66 | 1 | 4 | 2 | 9 | 11.4 | W | 1,100 | 392 | 100 | 11 | 88 | 1.48 | 7.43 | | X |
| 67 | | | | | | | | | 95 | 11 | 99 | 1.22 | 9.02 | | |
| 68 | | | | | | | | | 95 | 11 | 110 | 1.41 | 7.80 | | |
| 69 | | | | | | | | | 95 | 11 | 121 | 1.52 | 7.24 | | |
| 70 | | 2 | | | 15.9 | | | | 100 | 11 | [illegible] | 1.[illegible]7 | 9.[illegible]0 | | |
| 71 | | 2 | | | 15.9 | | | | 100 | 11 | 255 | 1.[illegible] | 8.73 | | |
| 72 | | | | | | | | | | 11 | [illegible] | 1.27 | 8.66 | | |
| 73 | | | | | | | | | | 4 | 270 | [illegible] | [illegible] | | X |
| 74 | | | | | | | | | | 11 | 281 | 1.46 | 7.53 | | X |
| 75 | | | | | | | | | | 11 | 292 | 1.70 | 6.47 | | X |
| 76 | | | | | | | | | | 11 | 303 | 1.52 | 7.24 | | X |
| 77 | | | | | | | | | | 11 | 314 | 1.[illegible] | [illegible].21 | | |
| 78 | | | | | | | | | | 11 | 325 | 1.[illegible] | 8.33 | | |
| 79 | | | | | | | | | | 11 | 336 | 1.33 | 8.27 | | |
| 80 | | | | | | | | | | 11 | 347 | 1.34 | 8.21 | | |
| 81 | | | | | | | | | 90 | 11 | 358 | 1.25 | 8.30 | | |
| 82 | | 5 | | 28 | 11.1 | | | | 90 | 11 | 11 | 1.01 | 10.89 | | |
| 83 | | 5 | | 28 | 11.1 | | | | | 11 | 22 | 1.12 | 9.82 | | |
| 84 | | | | | | | | | | 11 | 33 | 1.09 | 10.09 | | |
| 85 | | | | | | | | | | 11 | 44 | 1.13 | 9.73 | | |
| 86 | | | | | | | | | | 11 | 55 | 1.08 | 10.19 | | |
| 87 | | 1 | | | | | | | | 11 | [illegible] | 1.68 | 6.55 | | |
| 88 | | 1 | | | | | | | | | [illegible] | 1.[illegible] | 7.03 | | X |
| [illegible] | | 5 | | | | | | | 1[illegible] | 11 | [illegible] | 1.[illegible] | 8.30 | | |
| [illegible] | | 5 | | | | | | | [illegible]0 | 8 | [illegible] | .92 | 8.[illegible]0 | | X |
| 91 | | | | | | | | | | 11 | [illegible] | 1.25 | [illegible].80 | | |
| 92 | | | | | | | | | | 11 | 96 | [illegible] | [illegible].22 | | |
| [illegible] | | | | | | | | | | 11 | [illegible]07 | [illegible] | [illegible] | | |
| [illegible] | | | | | | | | | | 11 | [illegible] | 1.50 | 7.[illegible]3 | | X |
| [illegible]5 | | | | | | | | | [illegible] | 11 | | 1.[illegible] | 9.[illegible]2 | | |
| [illegible] | | | | | | | | | [illegible]0 | 11 | | 1.[illegible] | 11.00 | | |

Remarks

Broke into another hole.

Plugged steel, bit is o.k.

No reading taken.

Stinger slipped, st 1 slightly arched.

Steel badly arched - Notes 1, 2, 3.

See Note 4.
Steel badly arched.
All 4 holes plugged.

See Note 5.

Steel badly arched and plugged
See Note 6.
Steel badly arched.
Steel badly arched.
Steel slightly arched.

| 1 Run | 2 Motor | 3 Bit No. | 4 Direction | 5 Location | 6 Oil Content Gal/Ton | 7 Conditions | 8 Truck RPM | 9 Steel RPM | 10 Thrust, psi | 11 Hole-feet | 12 Cumulative Length, ft | 13 Time Drilling, Mins. | 14 Penetration Rate, ft/min | 15 Retracting Time, Mins. | 17 Unuseables |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | P | 9 | 15.1 | [illegible] | 1400 | 392 | 80 | 11 | 11 | 1.74 | 6.32 | .27 | |
| 2 | 1 | 1 | P | 9 | 15.1 | [illegible] | 1400 | 392 | 80 | 11 | 22 | 1.89 | 5.82 | .28 | |
| 3 | | | | | | | | | 80 | 10 | 32 | 1.61 | 6.21 | .28 | X |
| 4 | | | | | | | | | 90 | 11 | 43 | 1.86 | 5.91 | .28 | |
| 5 | | | | | | | | | 90 | 11 | 54 | 1.88 | 5.35 | .28 | |
| 6 | | | | | | | | | 90 | 11 | 65 | 1.70 | 6.47 | .26 | |
| 7 | | | | | | | | | 100 | 11 | 76 | 1.87 | 5.88 | .28 | |
| 8 | | | | | | | | | 100 | 11 | 87 | 1.90 | 5.79 | .27 | |
| 9 | | | | | | | | | | 11 | 98 | 1.84 | 5.98 | .27 | |
| 10 | | | | | | | 1600 | 419 | | 11 | 109 | 1.91 | 5.76 | .26 | |
| 11 | | | | | | | 1600 | 419 | | 10 | 119 | 1.72 | 5.81 | -- | X |
| 12 | | | | | | | 1600 | 419 | | 11 | 130 | 1.80 | 6.11 | .26 | |
| 13 | | | | | | | 1500 | 405 | | 11 | 141 | -- | -- | .27 | X |
| 14 | | | | | | | 1500 | 405 | | 11 | 152 | 1.84 | 5.98 | .26 | |
| 15 | | | | | | | 1400 | 392 | | 11 | 163 | 1.41 | 7.80 | .27 | |
| 16 | | | | | | | 1400 | 392 | | 11 | 174 | 1.74 | 6.32 | .27 | |
| 17 | | | | | | | | | | 11 | 185 | 1.93 | 5.70 | .27 | |
| 18 | | | | | | | | | | 11 | 196 | 1.93 | 5.70 | .26 | |
| 19 | | | | | | | | | | 11 | 207 | 1.84 | 5.98 | .25 | |
| 20 | | | | | | | | | | 11 | 218 | 2.07 | 5.31 | -- | X |
| 21 | | 2 | | | | | | | | 11 | 11 | 1.79 | 6.15 | .27 | |
| 22 | | 2 | | | | | | | | 11 | 22 | 1.86 | 5.91 | .26 | |
| 23 | | | | | | | | | | 11 | 33 | 2.16 | 5.09 | | X |
| 24 | | | | | | | | | | 3 | 36 | -- | -- | | X |
| 25 | | | | | | D | | | | 11 | 47 | 1.15 | 9.57 | | |
| 26 | | | | | | D | | | | 11 | 58 | 1.26 | 8.73 | | |
| 27 | | | | | | W | | | | 11 | 69 | 1.37 | 8.03 | | |
| 28 | | | | | | W | | | | 4 | 73 | -- | -- | | X |
| 29 | | | | | | | | | 65 | 11 | 84 | 1.4[illegible] | 7.38 | | |
| 30 | | | | | | | | | 100 | 7 | 91 | 1.03 | 6.30 | | X |
| [illegible] | | | | | | | | | 100 | 3 | 94 | .32 | 9.38 | | X |
| [illegible] | | | | | | | | | 100 | 11 | 105 | 1.71 | 6.43 | | |

| 3 Bit No. | 1 Direction | 5 Location | 6 Oil Content Gal/Ton | 7 Conditions | 8 Truck RPM | 9 Steel RPM | 10 Thrust, psi | 11 Hole-feet | 12 Cumulative Length, ft | 13 Time Drilling, Mins. | 14 Penetration Rate: ft/sec | 15 Retracting Time, Mins. | 17 Unuseables | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | R | 9 | 14.4 | W | 1100 | 292 | 100 | 11 | 77 | 1.21 | 9.09 | | | |
| 4 | R | 9 | 14.4 | W | 1100 | 392 | 100 | 11 | 83 | 1.[illegible] | 7.13 | | X | Steel slipped [illegible] |
| | | | | | | | 95 | 11 | 99 | 1.22 | 9.02 | | | Steel slightly [illegible] |
| | | | | | | | 95 | 11 | 110 | 1.41 | 7.80 | | | |
| | | | | | | | 95 | 11 | 121 | 1.52 | 7.24 | | | |
| 2 | | | 15.0 | | | | 100 | 11 | [illegible] | 1.[illegible]7 | 9.40 | | | |
| 2 | | | 15.9 | | | | 100 | 11 | 255 | 1.[illegible] | 8.73 | | | |
| | | | | | | | | 11 | [illegible]6 | 1.27 | 8.66 | | | |
| | | | | | | | | 4 | 270 | [illegible] | — | | X | Broke into [illegible] |
| | | | | | | | | 11 | 281 | 1.46 | 7.53 | | X | Drilling in [illegible] (light [illegible] |
| | | | | | | | | 11 | 292 | 1.70 | 6.47 | | X | Drilling in [illegible] (light color [illegible] |
| | | | | | | | | 11 | 303 | 1.52 | 7.24 | | X | Bit plugged. |
| | | | | | | | | 11 | 314 | 1.34 | [illegible].21 | | | |
| | | | | | | | | 11 | 325 | 1.32 | 8.33 | | | Steel slightly [illegible] |
| | | | | | | | | 11 | 336 | 1.33 | 8.27 | | | Steel slightly [illegible] |
| | | | | | | | | 11 | 347 | 1.34 | 8.21 | | | |
| | | | | | | | 90 | 11 | 358 | 1.35 | 8.30 | | | Steel slightly [illegible] |
| 5 | | 98 | 15.1 | | | | 90 | 11 | [illegible] | 1.01 | 10.89 | | | |
| 5 | | 98 | 15.1 | | | | | 11 | 22 | 1.12 | 9.82 | | | |
| | | | | | | | | 11 | 33 | 1.09 | 10.09 | | | Steel slightly [illegible] |
| | | | | | | | | 11 | 44 | 1.13 | 9.73 | | | |
| | | | | | | | | 11 | 55 | 1.08 | 10.19 | | | |
| 1 | | | | | | | | 11 | [illegible] | 1.58 | 6.96 | | | |
| 1 | | | | | | | | [illegible] | [illegible] | 1.[illegible] | 7.03 | | X | [illegible] carbide (?) the bit, [illegible] |
| 5 | | | [illegible] | | | | 1[illegible]0 | 11 | [illegible] | 1.[illegible] | 8.90 | | | |
| 5 | | | [illegible].2 | | | | 1[illegible]0 | 8 | 7[illegible] | .92 | 8.[illegible]0 | | X | [illegible] |
| | | | | | | | | 11 | [illegible]5 | 1.25 | [illegible].80 | | | |
| | | | | | | | | 11 | [illegible]6 | [illegible] | [illegible].22 | | | |
| | | | | | | | | [illegible] | [illegible]7 | [illegible] | [illegible] | | | |
| | | | | | | | | 11 | | 1.30 | 7.[illegible]3 | | X | [illegible] |
| | | | | | | | [illegible]0 | 11 | | 1.[illegible] | 9.[illegible]2 | | | |
| | | | | | | | [illegible]0 | 11 | | 1.[illegible] | 11.00 | | | |

| 3 Bit No. | 4 Direction | 5 Location | 6 Oil Consumption Gal/Ton | 7 Conditions | 8 Truck RPM | 9 Steel RPM | 10 Thrust, psi | 11 Hole-foot | 12 Cumulative Length, ft | 13 Time Drilling, Mins. | 14 Penetration | 17 Unuseable | 18 Collar, Mins. | 19 M M ft, ft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | R | 98 | 51,2 | W | 1100 | 392 | 90 | 11 | 131 | [illegible],07 | [illegible],28 | | | |
| 5 | R | 98 | 3,1 | W | 1100 | [illegible] | 90 | 11 | [illegible] | 1,15 | 9,57 | | | |
| | | | 3,1 | | | | | 11 | 173 | 1,30 | 7,86 | | | |
| | | | | | | | | 11 | [illegible] | 1,40 | 7,86 | | | |
| | | | | | | | | 11 | [illegible] | 1,32 | 8,33 | | | |
| | | | | | | | | 11 | 206 | 1,44 | 7,61 | X | | |
| 6 | | | 11,4 | | | | | 11 | 11 | 1,26 | [illegible],73 | | | |
| 6 | | | 11,4 | | | | | 11 | [illegible] | [illegible] | [illegible] | | | |
| | | | | | | | | 9 | 31 | ,96 | [illegible] | X | | |
| | | | | | | | | 11 | [illegible] | [illegible] | 8,59 | | | |
| | | | | | | | | 11 | 53 | 1,52 | 7,24 | X | | |
| | | | | | | | | 11 | 64 | 1,26 | [illegible],73 | | | |
| | | | | | | | 100 | 11 | 75 | -- | -- | X | | |
| | | | | | | | 90 | 11 | 86 | -- | | X | | |
| | R | [illegible] | 45,0 | | | | 95 | 11 | 97 | 1,78 | 6,18 | | | |
| | R | 98 | 45,0 | | | | 90 | 11 | 108 | [illegible] | 6,18 | | | |
| | R | [illegible] | 45,0 | | | | 90 | 11 | 119 | [illegible] | 5,61 | | | |
| | [illegible] | [illegible] | 11,2 | | | [illegible] | 90 | 11 | 130 | 1,37 | 8,03 | | ,39 | [illegible] |
| | [illegible] | [illegible] | 11,2 | | 1300 | [illegible] | 100 | 11 | 141 | 1,21 | 9,09 | | | [illegible] |
| | | | | | 1300 | [illegible] | 100 | 11 | 152 | 1,09 | 10,09 | | | |
| [illegible] | | | | | [illegible] | [illegible] | | 11 | [illegible] | 1,32 | 8,33 | | ,25 | |
| | | | | | | | | 11 | [illegible] | 1,21 | 6,03 | X | | |
| | | | | | | | | 8 | [illegible] | [illegible] | [illegible],00 | X | ,32 | |
| | | | | | | | | 11 | [illegible] | [illegible] | 7,86 | | ,24 | |
| | | | | | | | [illegible] | 11 | [illegible] | [illegible] | [illegible] | | ,12 | |
| | | | | | | | [illegible] | 11 | [illegible] | [illegible] | [illegible] | | | |
| | | | | | | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | | |
| | | | | | | | [illegible] | [illegible] | [illegible] | [illegible] | | X | [illegible] | |
| [illegible] | | | | | | | | 11 | [illegible] | [illegible] | [illegible] | X | [illegible] | |
| [illegible] | | | | | [illegible] | [illegible] | | [illegible] | [illegible] | | [illegible] | X | [illegible] | |
| [illegible] | | | | | [illegible] | [illegible] | | [illegible] | [illegible] | | [illegible] | | [illegible] | |
| [illegible] | | | | | [illegible] | [illegible] | | [illegible] | | [illegible] | | | | |

| 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 17 | 18 | 19 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location | Oil Content Gal/Ton | Conditions | Truck RPM | Steel RPM | Thrust, psi | Hole-feet | Cumulative Length, ft | Time Drilling, Mins. | Penetration Rate, ft/min | Unuseables | Collar, Mins. | M M ±, ft | Remarks |
| 8F | 25.4 | W | 1500 | 510 | 80 | 11 | 165 | 1.22 | 9.02 | | | | |
| 8F | 25.4 | W | 1500 | 510 | 80 | 11 | 176 | 1.33 | 8.27 | | | | 45° to vertical. |
| 8F | 25.4 | W | 1500 | 510 | 80 | 11 | 187 | 1.39 | 7.91 | | | | 45° to vertical |

| 1 Run | 2 Motor | 3 Bit No. | 4 Direction |
|---|---|---|---|
| 161 | 2 | 9 | R |
| 162 | 2 | 9 | A |
| 163 | 2 | 9 | A |

| 3 File No. | 4 Direction | 5 [illegible] | 6 Oil Content Gal/ton | 7 Condition | 8 Rough RPM | 9 [illegible] RPM | 10 Thrust, psi | 11 Hole-Size | 12 Cumulative Length ft | 13 Time Drilling, Hrs. | 14 Penetration Rate, ft/hr | 17 Unusable |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | 2 | 3 | 11.6 | | [illegible] | 515 | [illegible] | [illegible] | 37 | [illegible] | [illegible] | X |
| 3 | 2 | 3 | [illegible] | | [illegible] | [illegible] | 90 | 11 | [illegible] | [illegible] | 12.[illegible] | |
| | | | | | [illegible] | [illegible] | [illegible] | 11 | [illegible] | [illegible] | 12.[illegible] | |
| | | | | | [illegible] | [illegible] | [illegible] | 11 | 70 | [illegible] | [illegible] | |
| | | | | | [illegible] | [illegible] | [illegible] | 11 | 81 | [illegible] | [illegible] | |
| | | | | | [illegible] | [illegible] | 75 | 11 | [illegible] | [illegible] | [illegible] | |
| | | | [illegible] | | [illegible] | [illegible] | [illegible] | 11 | [illegible] | [illegible] | [illegible] | |
| | | | 13.0 | | [illegible] | [illegible] | [illegible] | 6 | [illegible] | [illegible] | [illegible] | X |
| | | | | | [illegible] | | [illegible] | 11 | [illegible] | [illegible] | [illegible] | |
| | | | | | [illegible] | | 70 | 11 | [illegible] | [illegible] | [illegible] | |
| | | | | | [illegible] | 515 | 70 | 11 | [illegible] | [illegible] | [illegible] | X |
| | | | | | [illegible] | [illegible] | [illegible] | 11 | [illegible] | [illegible] | [illegible] | |
| | | | | | [illegible] | [illegible] | [illegible] | 7 | [illegible] | [illegible] | 7.[illegible] | X |
| | | | | | | | [illegible] | 11 | [illegible] | [illegible] | 7.[illegible] | |
| | [illegible] | [illegible] | 27.0 | | | | 80 | 11 | [illegible] | [illegible] | 8.[illegible] | |
| | [illegible] | [illegible] | 27.0 | | | | 80 | 11 | 193 | [illegible] | 6.71 | |
| | [illegible] | [illegible] | 27.0 | | | | [illegible] | 11 | 201 | [illegible] | [illegible] | X |
| [illegible] | | [illegible] | [illegible] | | [illegible] | [illegible] | 80 | 11 | [illegible] | 1.30 | [illegible] | X |
| [illegible] | [illegible] | [illegible] | 51.2 | | [illegible] | [illegible] | [illegible] | 11 | [illegible] | [illegible] | [illegible] | |
| | | | 13.5 | | | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | |
| | | | [illegible] | | | | 70 | [illegible] | [illegible] | [illegible] | [illegible] | |
| | | | [illegible] | | | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | |
| | | | [illegible] | | | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | |
| | | | | | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | |
| | | | | | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | |

| 21<br>Delays, Mins. | 22<br>Remarks |
|---|---|
| .47 | Steel stuck. |
| | Pinched hoses. |
| | Pinches hoses. |
| | Stinger loose. |
| 7.70 | Refill scrubber. |
| | Stinger loose-Note 15. |
| 12.29 | Move truck |
| 4.48 | Refill water tank - (30 holes). |
| 2.43 | Move truck. |
| 1.88 | No stinger. |
| .66 | Steel slipped repeatedly. |
| 18.88 | Steel slipped repeatedly. |
| | Extreme of boom travel. |
| 4.25 | Move truck-extreme. |
| 5.36 | Move truck-extreme. |
| | Air pressure dropped to 0. |

| 1 Run | 2 Motor | 3 Bit No. | 4 Direction | 5 Location | 6 Oil Content Gal/Ton | 7 Conditions | 8 Truck RPM | 9 Steel RPM | 10 Thrust, psi | 11 Hole - feet | 12 Cumulative Length, ft | 13 Time Drilling, Mins. | 14 Penetration Rate, ft/sec | 15 Retracting Time, Mins. | 17 Unuseables | 18 Collar, Mins. | 19 M M ±, ft | 20 Reposition, Mins. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01' | 2 | 8' | P | E | 22.0 | W | 1350 | 492 | 70 | 11 | 11 | 1.04 | 10.58 | .32 | | .39 | -23 | .58 |
| 02' | 2 | 8' | P | E | 22.0 | W | 1350 | 492 | 70 | 11 | 22 | 1.30 | 8.46 | .27 | X | .25 | -23 | 1.37 |
| 03' | | | | | 41.0 | | | | 70 | 11 | 33 | 1.35 | 8.15 | .29 | X | .29 | -18 | 3.52 |
| 04' | | | | | 41.0 | | | | 70 | 11 | 44 | 1.43 | 7.69 | .32 | X | .31 | -18 | 1.58 |
| 05' | | | | | 41.0 | | | | 80 | 11 | 55 | 1.35 | 8.15 | .27 | | .23 | -18 | 1.16 |
| 06' | | | | | 41.0 | | | | 80 | 11 | 66 | 1.13 | 9.73 | .28 | | .23 | -18 | .54 |
| 07' | | | | | 41.0 | | | | | 11 | 77 | 1.66 | 6.63 | .27 | X | .38 | -18 | 2.61 |
| 08' | | | | | 41.0 | | | | | 11 | 88 | 1.05 | 10.48 | .28 | | .32 | -18 | 1.06 |
| 09' | | | | | 44.6 | | | | | 11 | 99 | 1.22 | 9.02 | .22 | X | .25 | -15 | 1.81 |
| 010' | | | | | 44.6 | | | | | 11 | 110 | 1.12 | 9.82 | .27 | | .24 | -15 | .75 |
| 011' | | | | | 44.6 | | | | | 11 | 121 | 1.48 | 7.43 | .30 | | .51 | -15 | .66 |
| 012' | | | | | 44.6 | | | | | 11 | 132 | 1.26 | 8.73 | .29 | | .24 | -15 | .91 |
| 013' | | | | | 22.0 | | | | 90 | 11 | 143 | 1.05 | 10.48 | .30 | | .17 | -23 | 1.92 |
| 014' | | | | | 44.6 | | | | 90 | 11 | 154 | 1.16 | 9.48 | .28 | | .25 | -15 | 2.25 |
| 015' | | | | | 44.0 | | | | 90 | 11 | 165 | 1.09 | 10.09 | .28 | | .48 | -15 | 2.89 |
| 016' | | | | | 28.0 | | | | 90 | 11 | 176 | .93 | 11.83 | .28 | | .17 | -10 | .32 |
| 017' | | | | | 28.0 | | | | 60 | 11 | 187 | 1.49 | 7.38 | .28 | | .24 | -10 | 1.00 |
| 018' | | | | | 28.0 | | | | 40 | 11 | 198 | 2.63 | 4.18 | .24 | X | .16 | -10 | 2.69 |
| 019' | | | | | 28.0 | | | | 90 | 11 | 209 | 1.08 | 10.19 | .27 | | .22 | -10 | 1.90 |
| 020' | | | | | 28.0 | | | | 90 | 11 | 220 | 1.06 | 10.38 | .28 | X | .21 | -10 | 4.40 |
| 021' | | | | | 50.0 | | | | 75 | 11 | 231 | 1.55 | 7.10 | .26 | | .44 | - 5 | 1.81 |
| 022' | | | | | 50.0 | | | | 65 | 11 | 242 | 2.32 | 4.74 | .27 | X | .99 | - 5 | 1.50 |
| 023' | | | | | 50.0 | | | | 65 | 11 | 253 | 1.48 | 7.43 | .28 | X | .24 | - 5 | 1.82 |
| 024' | | | | | 50.0 | | | | | 11 | 264 | 1.80 | 6.11 | .25 | | .18 | - 5 | 1.55 |
| 025' | | | | | 50.0 | | | | | 11 | 275 | 1.94 | 5.67 | .26 | X | .33 | - 5 | .39 |
| 026' | | | | | 28.0 | | | | | 11 | 286 | 1.95 | 5.64 | .27 | X | .28 | -10 | .95 |
| 027' | | | | | 50.0 | | | | 60 | 11 | 297 | 2.54 | 4.33 | .44 | X | .22 | - 5 | 1.60 |
| 028' | | | | | 50.0 | | | | 60 | 11 | 308 | 1.55 | 7.10 | .29 | | .27 | - 5 | .75 |