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**DESIGN, FABRICATION, AND TESTING OF A SYSTEM TO DEMONSTRATE  
THE EFFECTIVENESS OF RESPIRABLE DUST CONTROL ON LONGWALL  
SHEARERS BY THE USE OF WATER PIPED THROUGH THE SHEARER DRUM**

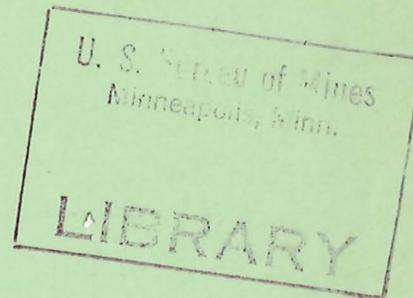
**(BCR Report L-735)**

**Prepared for**

**UNITED STATES DEPARTMENT OF THE INTERIOR  
BUREAU OF MINES**

**By**

**BITUMINOUS COAL RESEARCH, INC.  
350 Hochberg Road  
Monroeville, Pennsylvania**



**Final Report for the Period May 1973-May 1976**

**On**

**USBM Contract No. H0230031**

**OFR  
76-91**

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The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies or recommendations of the Interior Department's Bureau of Mines or the U. S. Government.

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**BITUMINOUS COAL RESEARCH, INC.**  
**PITTSBURGH, PENNSYLVANIA**

**JAMES R. GARVEY**  
PRESIDENT  
**JOHN W. IGOE**  
EXECUTIVE VICE PRESIDENT  
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January 21, 1976

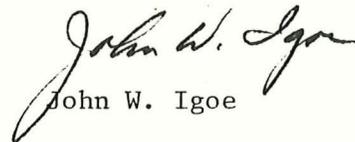
Mr. David J. Askin  
U.S. Bureau of Mines  
Section of Contracts  
Building 20, Denver Federal Center  
Denver, Colorado 80225

Dear Mr. Askin,

Submitted herewith is the final report, BCR Report No. L-735, to Contract No. H0230031, "Design, Fabrication, and Testing of a System to Demonstrate the Effectiveness of Respirable Dust Control on Longwall Shearers by the Use of Water Piped Through the Shearer Drum."

This report covers in detail all work accomplished under this contract. The information and data obtained have been evaluated and conclusions and recommendations have been made.

Yours very truly,

  
John W. Igoe

JWI:KLW/cwg

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### FOREWORD

This report was prepared by Bituminous Coal Research, Inc., Monroeville, Pa., under U.S. Bureau of Mines Contract H0230031. The contract was initiated under the Coal Mine Health and Safety Program. It was administered under the technical direction of Twin Cities Mining Research Center, with Mr. Kelly Strebig acting as Technical Project Officer. Mr. David Askin, Denver Federal Center, was the contract administrator for the Bureau of Mines.

This report is a summary of the work recently completed as part of the contract during the period May 23, 1973 to December 31, 1975. This report was submitted by the authors on January 21, 1976.

BITUMINOUS COAL RESEARCH, INC.  
SPONSORED RESEARCH PROGRAM

DESIGN, FABRICATION, AND TESTING OF A SYSTEM TO DEMONSTRATE  
THE EFFECTIVENESS OF RESPIRABLE DUST CONTROL ON LONGWALL  
SHEARERS BY THE USE OF WATER PIPED THROUGH THE SHEARER DRUM

I. INTRODUCTION

This report is in fulfillment of Contract H0230031 awarded to Bituminous Coal Research, Inc., on May 23, 1973. The scope of work to be performed under this contract was divided into four phases: Phase I - Design, Phase II - Construction, Phase III - Field Demonstration, and Phase IV - Analysis and Final Report.

During Phase I, an agreement was finalized with the Rochester and Pittsburgh Coal Co. for conducting field tests of the proposed shearer spray systems on a longwall panel in the company's Jane Mine in Indiana County, Pa. A drum was then designed which could be used on the Eickhoff shearer, Model EW170-L, being used on this longwall and which would utilize the following spray systems:

1. One spray nozzle located in front of each cutter bit with the jet directed at the cutting surface.
2. One spray nozzle located in back of each cutter bit with the jet directed at the back of the bit.
3. Standard Eickhoff nozzles located in a header along the drum scrolls.
4. A fixed header mounted on the shearer directly behind the drum to simulate the spray system originally used on the Eickhoff shearer.

During Phase II a test drum incorporating the USBM-approved design was constructed, and a sampling plan was formulated and submitted to the Bureau for review and approval.

After shop testing of the test drum and approval of the sampling plan, the field demonstration, Phase III, was initiated on June 7, 1974. Operational problems with the drum developed quickly and sampling was suspended on June 18. R & P Coal Co. personnel decided that the drum scrolls must be reversed, and a modified test drum was designed and fabricated. Testing with the new drum was initiated on January 6, 1975. Sampling continued until January 23, when the panel was mined out. The test drum was removed and some minor modifications made to improve the drum's sumping characteristics. Sampling was resumed on a new panel on August 25, 1975 and concluded October 9, 1975. Because of delays, the contract was extended from its original completion date of May 25, 1975 to December 31, 1975.

## II. SUMMARY

### A. Objective

1. Determine whether spray systems using the bit flushing principle are more effective in controlling respirable dust levels than the standard spray systems currently used on longwall shearers.
2. Determine the effect of water flow rate on the performance of the spray systems.

### B. Field Demonstration

In Table 1, the 94 production shifts sampled during the field demonstration are summarized. Data from 63 shifts, which attained the required production and water flow requirements, were used to analyze the spray systems. The respirable dust data were collected using personal samplers, MRE gravimetric samplers, and midget impinger samplers. Details of the sampling phase of the project are discussed in Section V of this report.

### C. Conclusions

The conclusions briefly stated below are discussed more fully in Section VII.

1. With the exception of the fixed nozzle spray header, no major maintenance or operating problems were experienced with the spray systems.
2. The standard spray system is superior to the bit-flushing systems for use on longwall shearers for the following reasons:
  - a. The more simple design of the water delivery system is preferable even though the bit-flushing nozzles behind the bits showed comparable effectiveness in respirable dust control, particularly at the high water flow rate.
  - b. This system does not require water channels in the bit blocks, keeping the cost of the blocks to a minimum.
  - c. This system uses the smallest number of sprays, which minimizes potential operating and maintenance problems.
  - d. The nozzles are located more remotely from the cutting action and are exposed to less damage from impingement by coal particles.
3. The most significant factor in reducing respirable dust is the volume of water used.
4. The fixed sprays mounted on the shearer body were impractical because:

TABLE 1. SUMMARY OF SHIFTS SAMPLED

<u>Shift No.</u>	<u>Drum Used</u>	<u>Illustration</u>	<u>Sampling Period</u>	<u>Valid Shifts</u> *	<u>Invalid Shifts</u> **
1-5	Original BCR Test Drum	Figure 18, Page 29	6/7/74-6/18/74	0	5
6-20	R&P Drum - Standard Eickhoff Design	-	9/16/74-10/17/74	11	4
21-43	Redesigned BCR Test Drum	Figure 18, Page 29	1/6/75-1/23/75	15	8
44-94	Redesigned Drum with minor modifications	Figure 28, Page 38	8/25/75-10/9/75	37	14

\*Shifts which meet the production, waterflow, and airflow requirements

\*\*Shifts which did not meet one or more of the production, waterflow, or airflow requirements

a. Coal was deposited on top of the shearer during cutting operations, blocking the sprays.

b. When the sprays were not blocked, the spray and mist from the nozzles obstructed the vision of the operator.

#### D. Recommendations

Recommendations resulting from the project are given in Section X of this report.

### III. PHASE I - DESIGN

The work accomplished during Phase I consisted of the following tasks:

1. Finalize the agreement with R&P Coal Company to permit BCR personnel to conduct an underground demonstration of bit-flushing sprays on the longwall section of the Jane mine.
2. Develop a design to modify the drum used on the Eickhoff shearer at the Jane mine to incorporate three bit-flushing spray systems in addition to the system normally installed by Eickhoff, Inc.
3. Locate commercially-available spray nozzles or design new ones for use in the bit-flushing systems and design bit blocks to accommodate these nozzles.
4. In conjunction with R&P Coal Company personnel, develop specifications for the water supply system.

Details of all work accomplished during completion of these tasks were described in a Phase I report, BCR Report L-557, and submitted to the USBM for review and approval.

The specific details of the Phase I work are discussed in the following sections.

#### A. Agreement with Rochester and Pittsburgh Coal Company

On August 30, 1973, a formal agreement was concluded with Rochester and Pittsburgh Coal Company, Indiana, Pa., which gave BCR permission to conduct tests in their Jane No. 1 mine and specified that R&P would supply, at a prescribed cost, any maintenance personnel or material required in the performance of the tests.

The original agreement covered the period from August 30, 1973 to February 1974. However, delays encountered during the underground test period required an extension of the contract to December 31, 1975.

#### B. Modification of Shearer Drum

The equipment used in the Jane mine and selected as the test machine was the Eickhoff single drum shearer, Type EW-170-L, with specifications shown in Table 2.

The contract specifications required that the test machine be equipped with at least three nozzle positions in addition to the manufacturer's standard system. Specifically, the contract defined the following spray locations: (1) in front of the bit blocks on the drum surface, (2) behind the bit blocks on the drum surface, and (3) pick face flushing.

TABLE 2. EICKHOFF LONGWALL SHEARER SPECIFICATIONS

	<u>Design</u>	<u>Actual<sup>1</sup></u>
Drum rpm	60	60
Drum OD over bits (in.)	56	56
Bit liner speed (ft/min)	880	880
Speed of advance (ft/min)	25	15.4
Width of cut (ft)	2	2
Bit penetration (in./bit/rev)	2.5	1.5
Cutting rate (tons/shift)		
Calculated <sup>2</sup>	1550	1170
Spray water flow (gpm)		
Drum	26.9*	--
Fixed	5.0	--
Spray water pressure (psi-maximum)	200	--
Seal life (minimum)	Panel life	--
Leakage rate during operation	None**	--

<sup>1</sup> Based on operation at R & P Coal Company's Jane Mine

<sup>2</sup> These rates calculated using following data:

    Total weight of coal mined per pass - 142 tons (R & P figure)

    Time to advance miner after pass - 15 min

    Speed of advance - as noted above

    Production time/shift - 5.5 hours

Actual production ranges from 400 to 900 tons per shift with an average of approximately 600 tons.

\* These figures do not agree with tests conducted at BCR, and underground tests must be conducted to determine actual figures.

\*\* Based on Eickhoff's experience, there is no leakage unless the seal fails.

In compliance with this requirement, tests were conducted at BCR to investigate possible nozzle locations to flush the bits located on the drum scrolls and on the drum end ring illustrated in Figure 1. As a result of these tests, five possible nozzle locations for the scroll-mounted bits and three locations for the end-ring bits were developed. These locations are illustrated in Figures 2 through 5. The spray patterns of the proposed locations were determined by flow tests conducted at BCR with a simulated shearer drum test facility, and the results were reviewed with Mr. K. Strebis, Technical Project Officer. The spray locations finally chosen for the field trials were as follows:

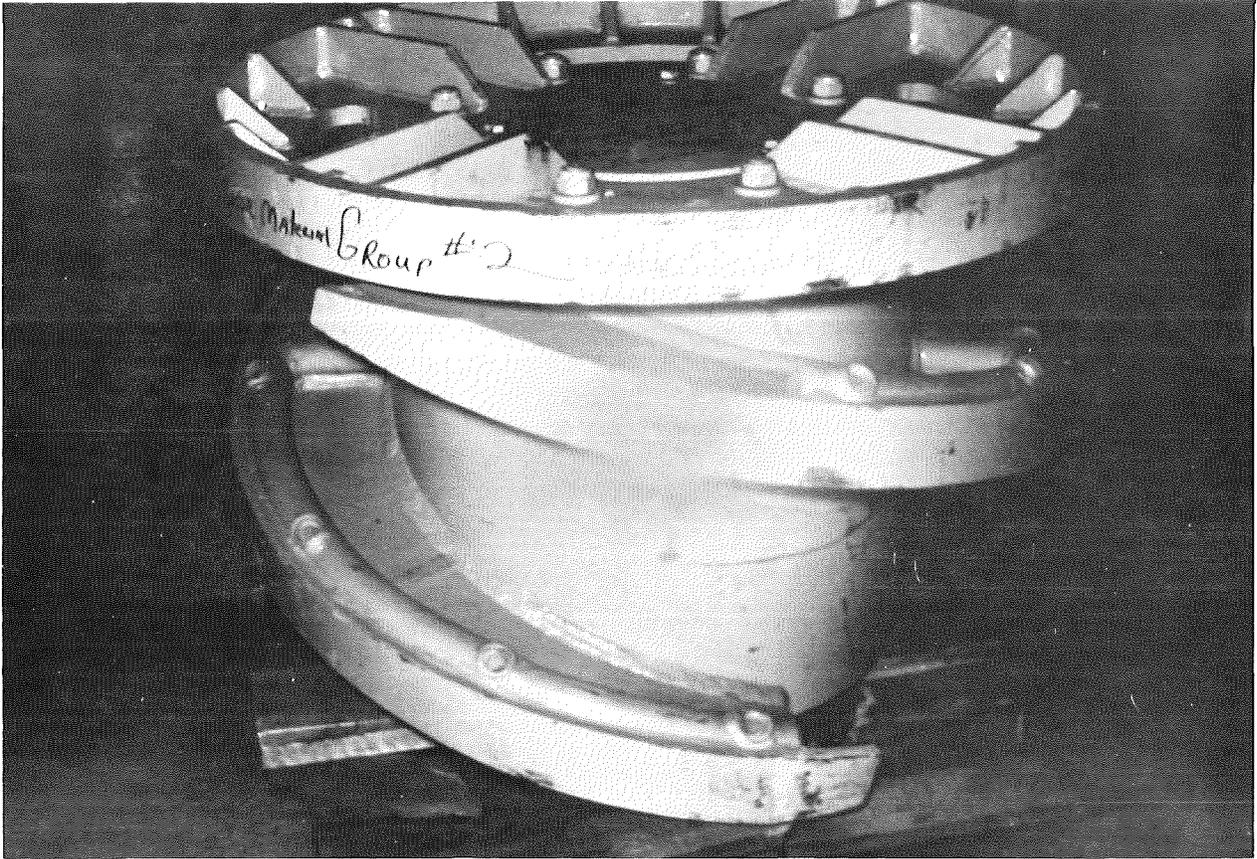
1. Figure 2, Location No. 1 and Figure 4, Location No. 6 - The nozzles are located in the bit block immediately behind the bits, and are considered a variation of the bit-flushing concept. As shown in Figure 6, the nozzle jet impinges on the back of the bit, resulting in part of the water flowing up over the bit and off the tip of the cutting surface, while the rest of the water forms a relatively fine spray over the end of the bit. This is not a true bit-flushing arrangement since the jet does not flush the bit cutting face, but should provide intimate contact of coal and water prior to, during, and immediately after the cutting process.

2. Figure 2, Location No. 2 and Figure 4, Location No. 7 - The nozzles are located in the bit blocks immediately in front of the bits and are a true bit-flushing design since, as shown in Figure 7, all of the water impinges on and flushes the cutting surface of the bit and then forms a fine mist around the tip of the bit. This provides wetting of the coal prior to, during, and after the cutting process.

In theory, the wetting action of both bit-flushing locations should promote wetting of the coal particle surfaces and increase agglomeration of dust particles.

3. Figure 8, Standard Eickhoff Spray System - The nozzles are located in a header mounted along the edge of the scrolls with the spray directed radially from the drum and generally parallel to the bits. The concept of these sprays, basically a cavity filling system, is to saturate the airstream flowing around and past the drum with water droplets. These droplets will impinge on the dust particles liberated into the airstream during cutting, promoting agglomeration and fallout, and reducing dust levels. Although this system does not wet the coal prior to or during cutting, it should insure quicker and more intimate mixing of the water and coal particles than fixed nozzles located more distant from the bits. This "cavity filling" system was, therefore, selected to provide an evaluation of the dust abatement characteristics of the standard Eickhoff spray system by comparing its performance to that of the "bit-flushing" systems.

4. Figure 9, Fixed Sprays Mounted on the Shearer - This system, basically a variation of the standard system, is also a "cavity filling" system except that the nozzles do not rotate and are located considerably farther from the point of cutting. The advantages of this system would appear to



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**Figure 1. Left-handed Drum of the Same Design as the New R&P Drum Showing Scrolls and End Ring Configuration**

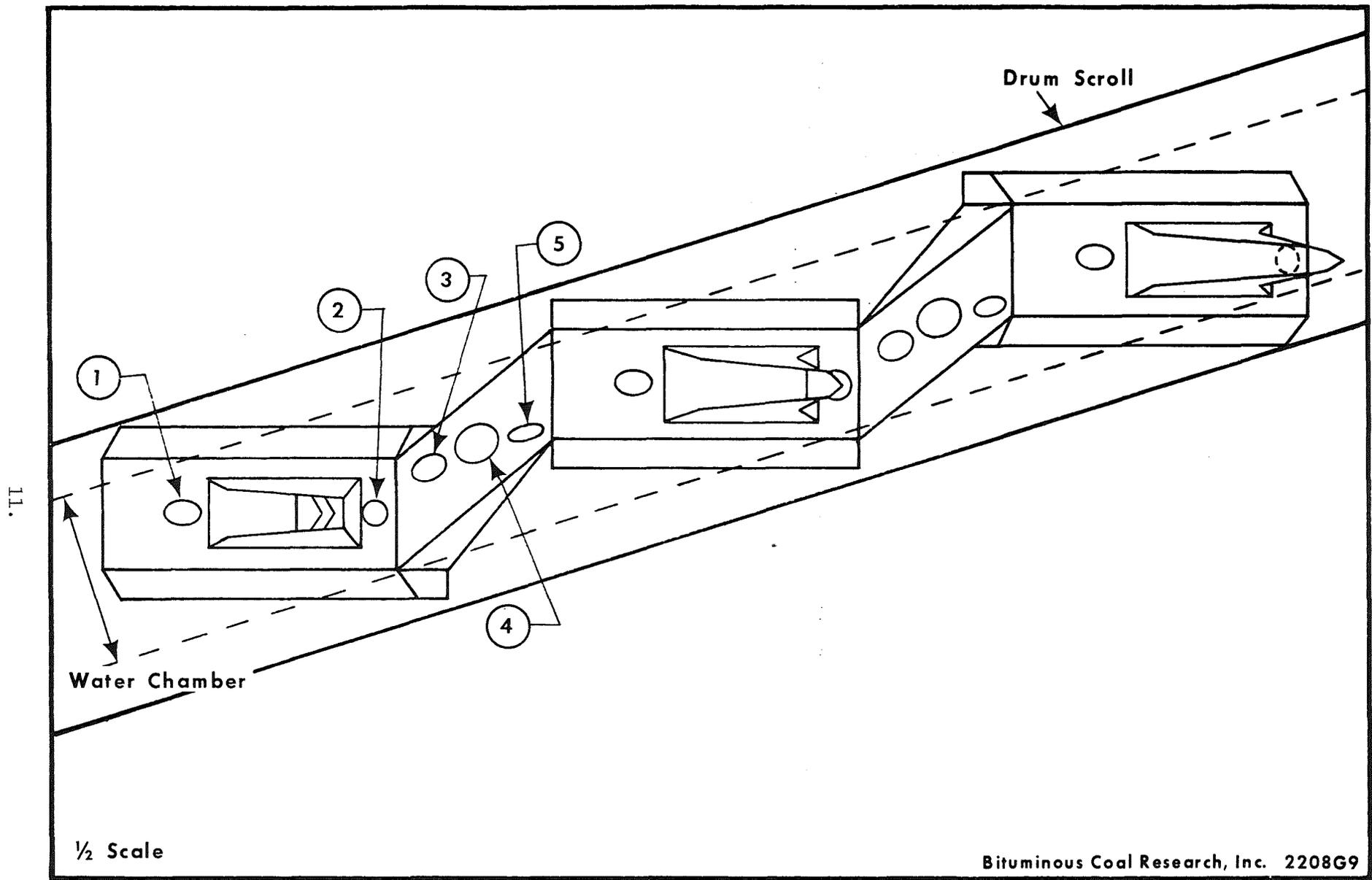
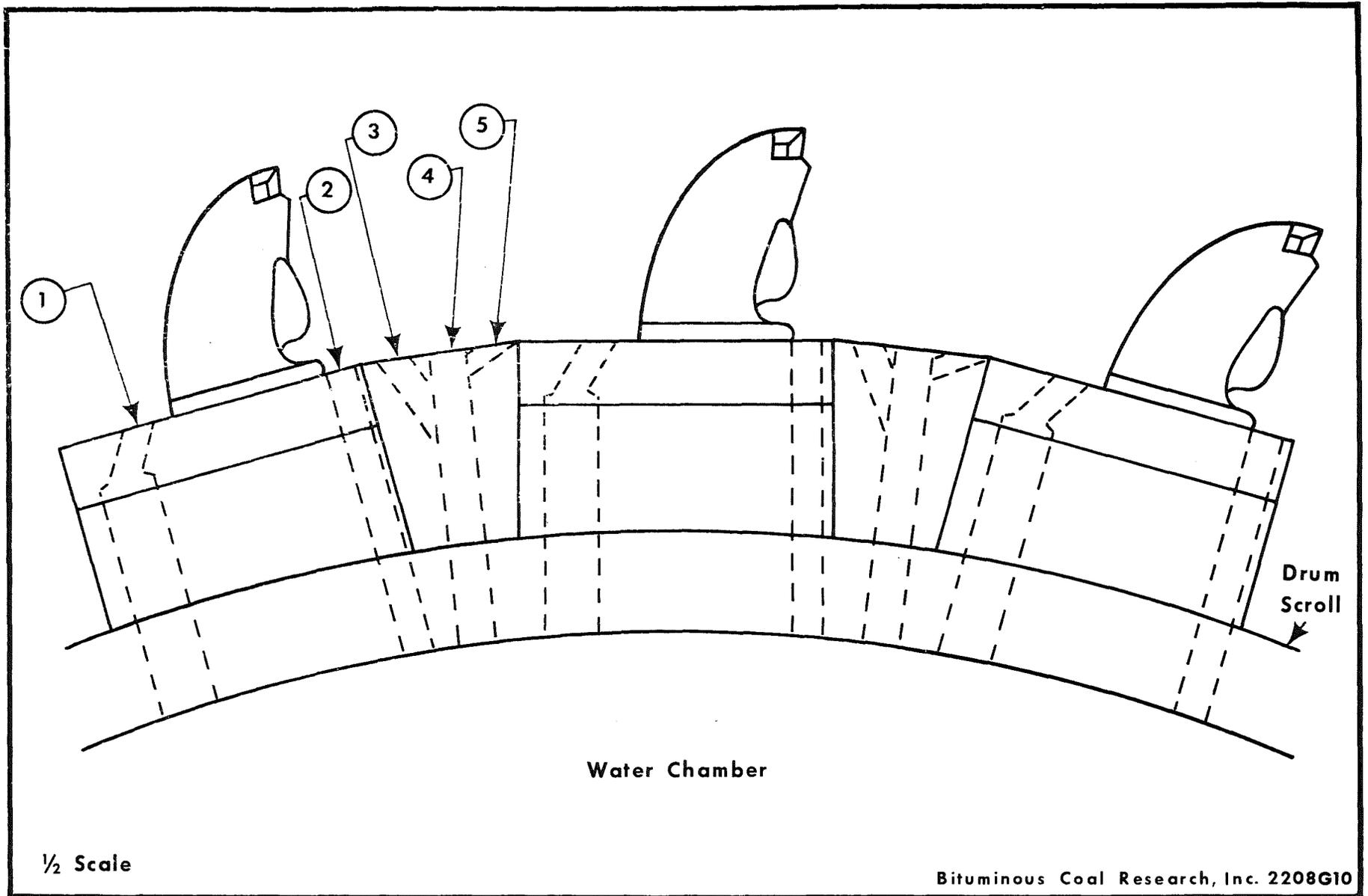


Figure 2. Plan View of the Bits Mounted on the Scrolls  
 Showing the Five Possible Nozzle Locations



1/2 Scale

Bituminous Coal Research, Inc. 2208G10

Figure 3. Elevation of the Bits Mounted on the Scrolls  
Showing the Five Possible Nozzle Locations

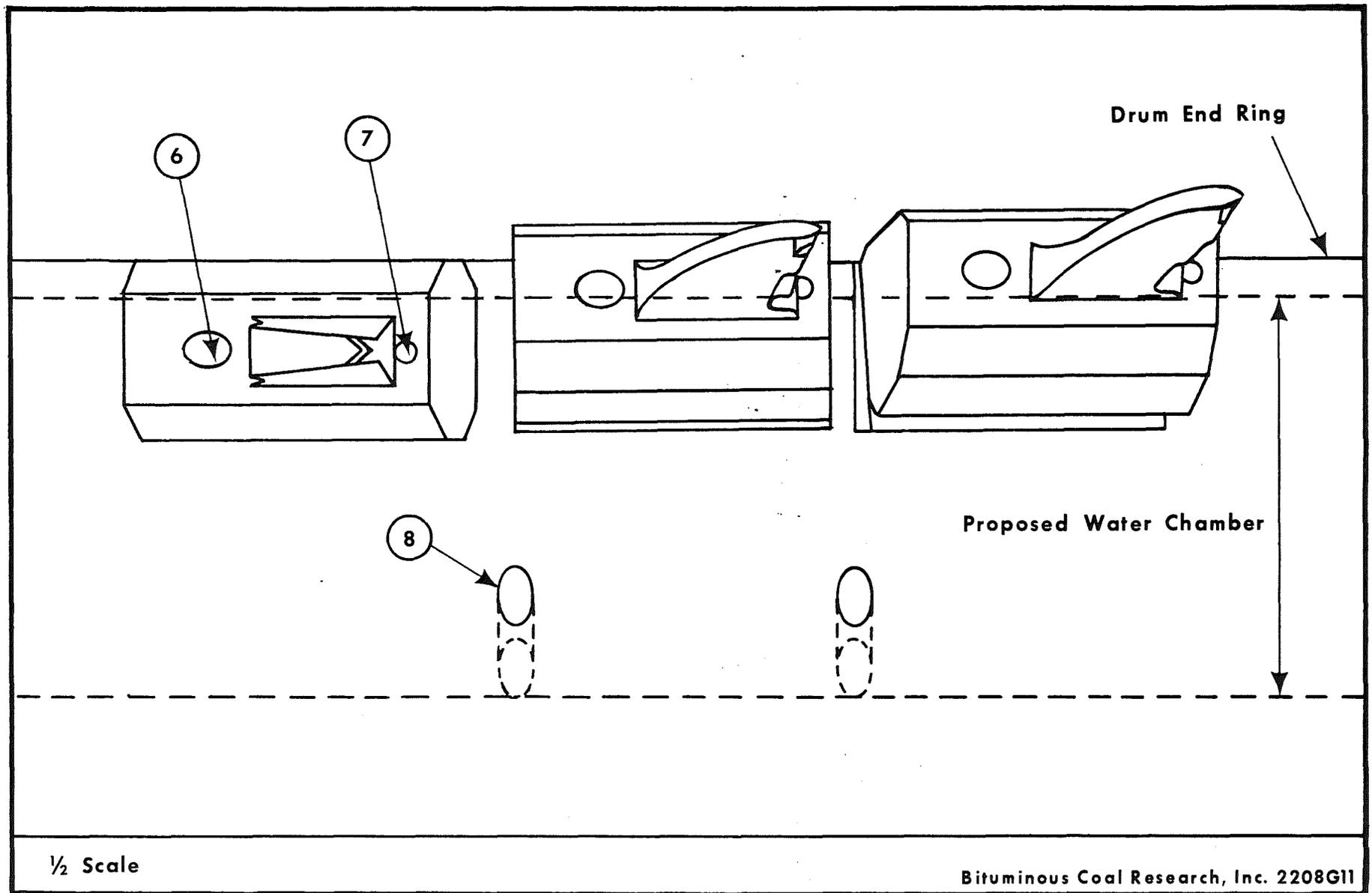


Figure 4. Plan View of the Bits Mounted on the End Ring  
Showing the Three Possible Nozzle Locations

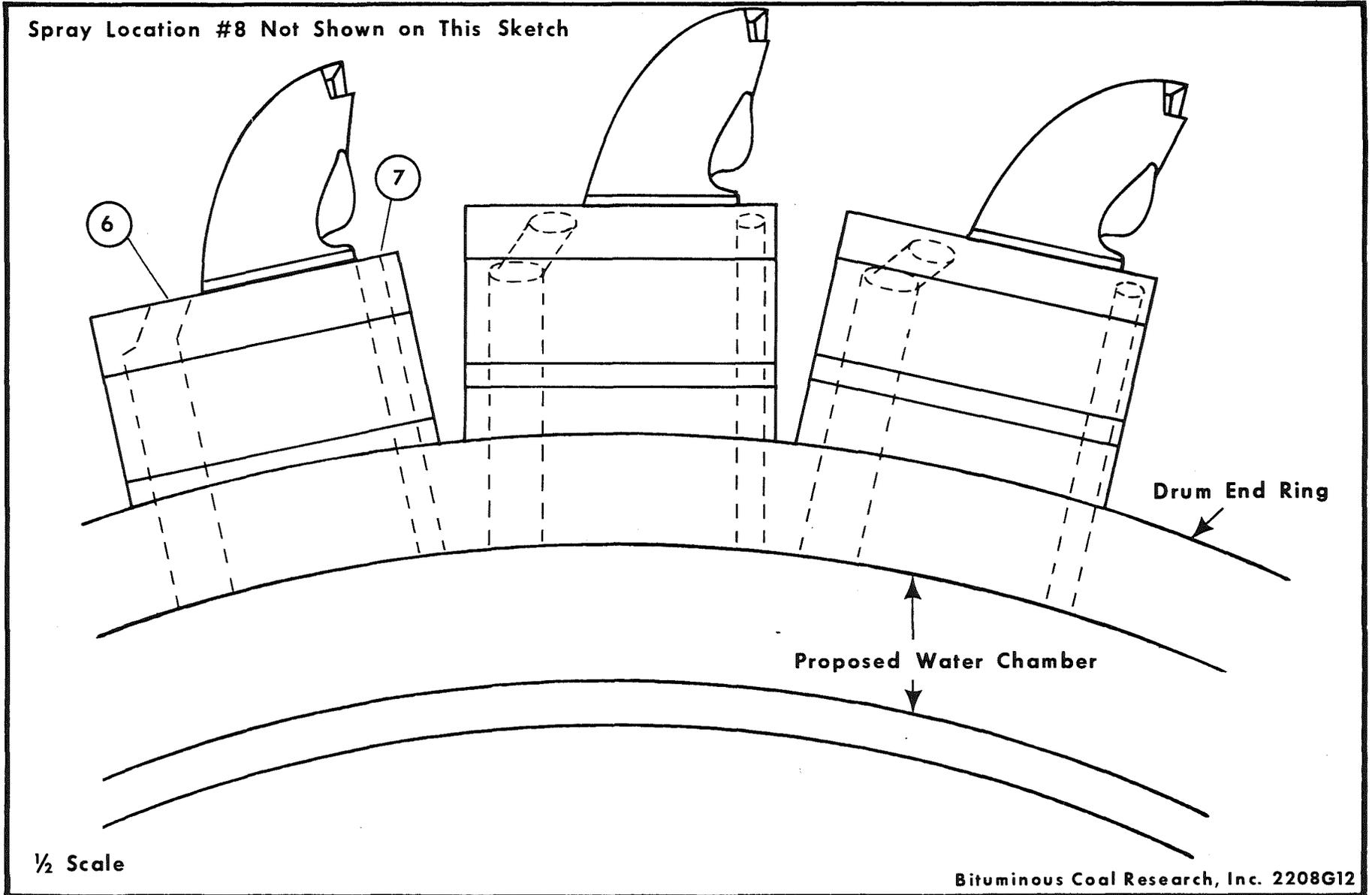
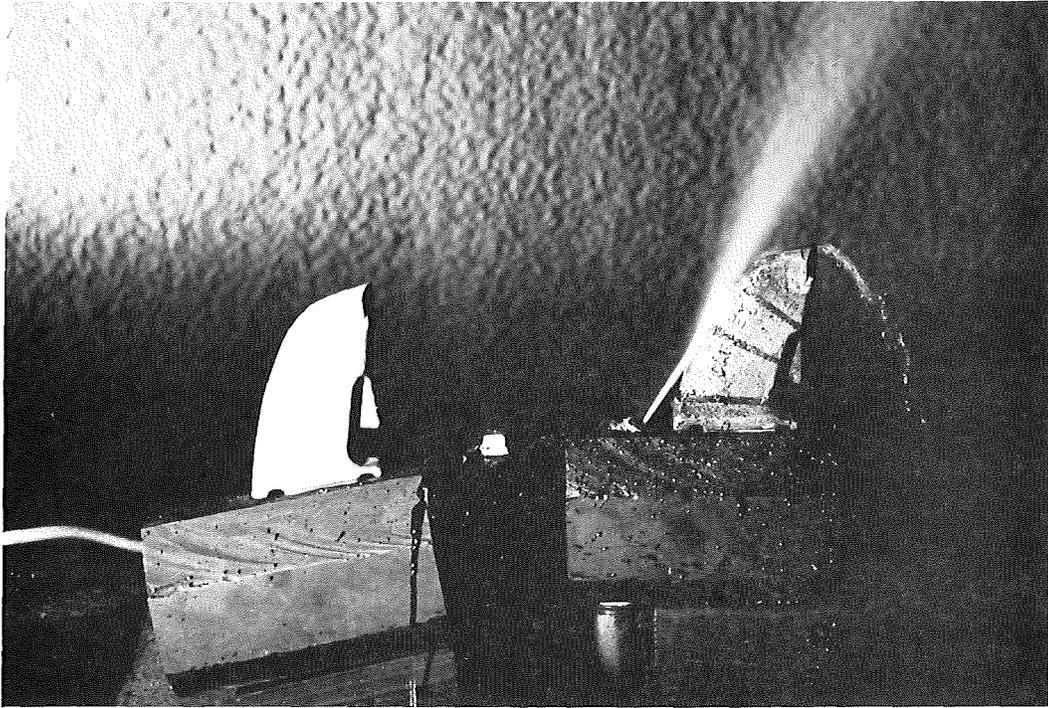
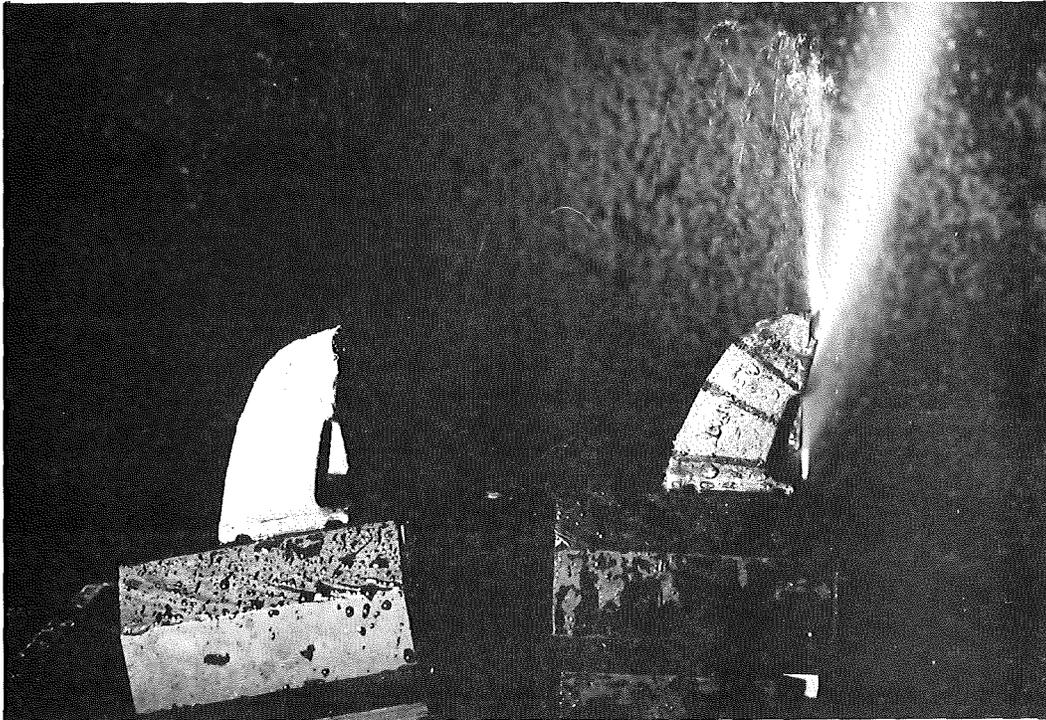


Figure 5. Elevation of the Bits Mounted on the End Ring Showing Two of the Three Possible Nozzle Locations



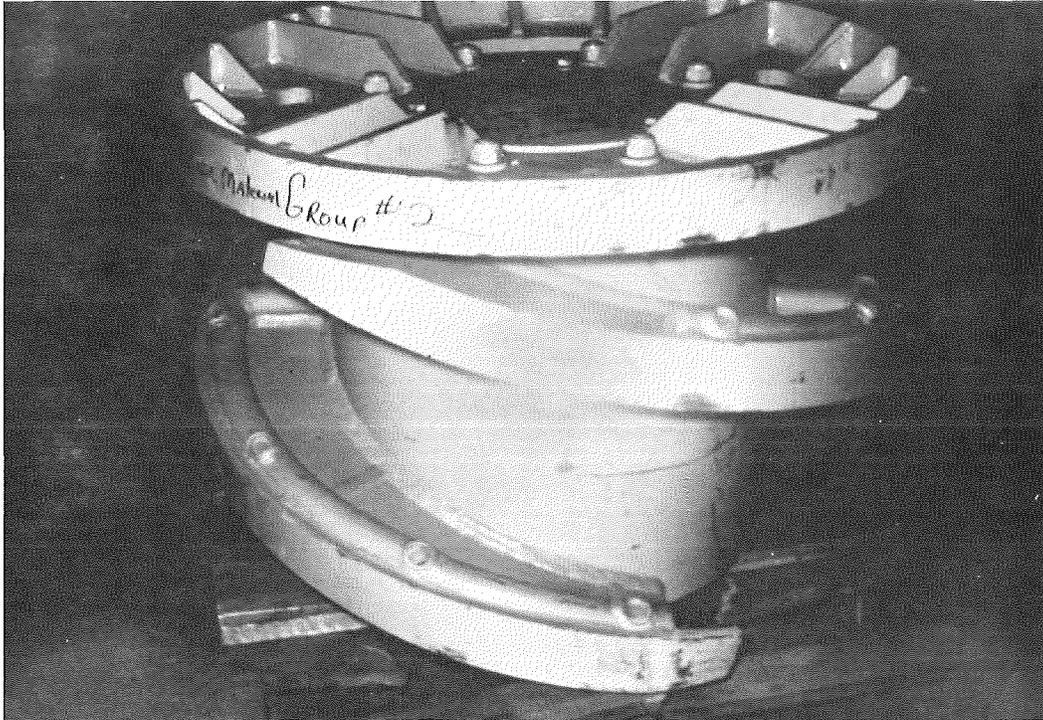
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Figure 6. Spray Pattern of Nozzle Located Behind Bit



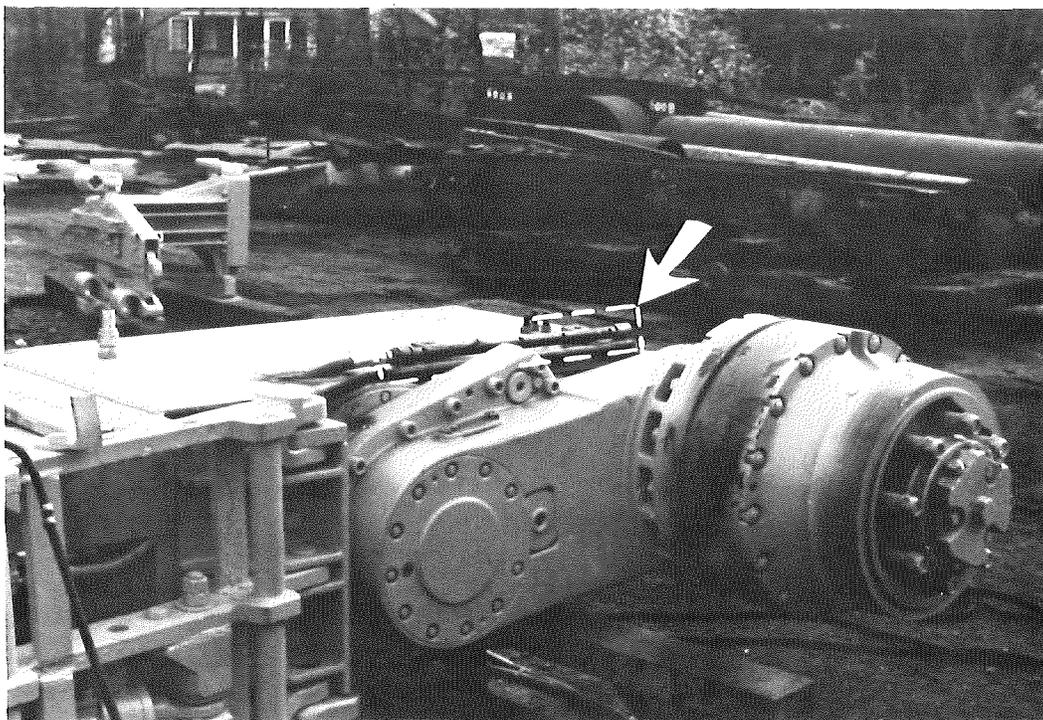
2208P47

Figure 7. Spray Pattern of Nozzle Located  
in Front of Bit



2208P100

**Figure 8. Standard Spray System Header Mounted on the Scroll of Shearer Drum**



2208P96

**Figure 9. Shearer Spray Header Location for Use in Conventional Fixed Spray System Tests**

be that the droplets should saturate a larger volume of the airstream, providing greater opportunity for contact with the particles. However, this is offset by water's being carried away before it can contact any particles and by agglomeration of the water droplets, reducing their effectiveness for dust control. This location was chosen because it was essentially the spray system originally used on the shearer and would provide a comparison between the "cavity filling" system of "fixed" sprays on a "dry" drum, and both the "cavity filling" and "bit-flushing" systems on a "wet" drum.

### C. Modification of Shearer Drum to Incorporate Test Spray Systems

With the establishment of the spray systems to be tested, the task of adapting them to the Eickhoff shearer was undertaken and involved (1) finding a suitable rotating seal for use at the point where the spray water flows from the shearer to the drum, (2) incorporating a supply header in the drum for the bit-flushing nozzles, and (3) designing a header for the fixed spray system. Later developments during the field demonstration, Phase III, resulted in major modifications to the shearer drum. Therefore, the discussion of the tasks listed above will deal first with those which were not affected by drum modifications and then those which did require design changes.

1. Rotating Water Seal - The criteria set for an effective water seal were that it must have a reasonable service life, at least through the mining of one panel, and water leakage during operation must be essentially zero. In reviewing the Eickhoff seal design, Figure 10, the following design features were noted which indicated that it would be adequate for the test program.

a. It is small, 35 mm OD x 25 mm ID x 7 mm thick (1.378 in. x .984 in. x .275 in.) which minimizes the possibility of leakage and, if leakage does occur, the amount of water loss should be small.

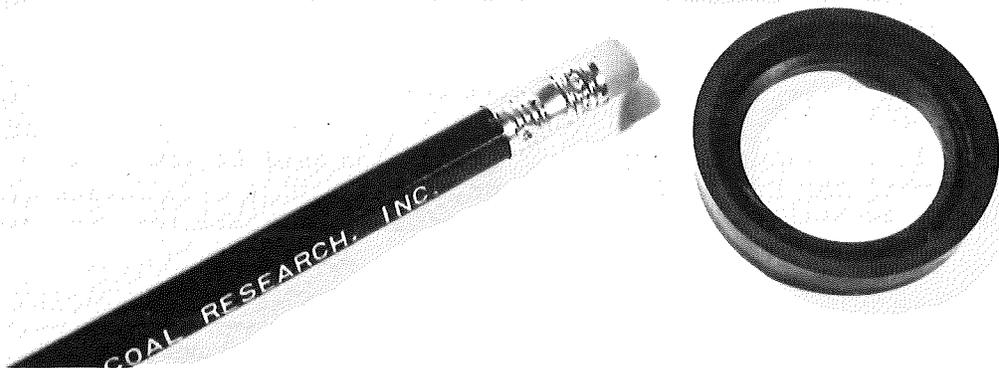
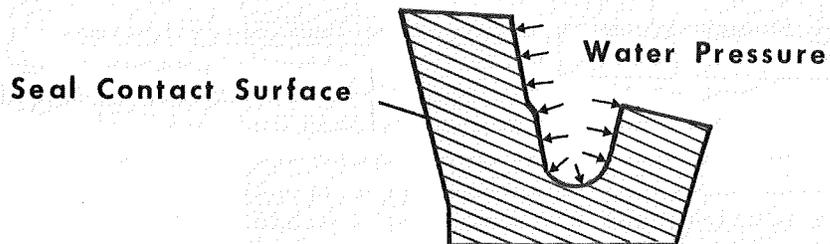
b. The seal is of the self-energizing lip design that utilizes the water pressure to assist the sealing action, which has proved to be a good seal design in similar applications.

c. The surface against which the seal acts is ground to a 1 to 2 micron finish, which provides a good sealing surface and minimizes abrasive wear on the seal.

d. The speed of the rotating member, 60 rpm, is low, as is the linear speed, for this type of seal; and the contact surfaces are water cooled, which should minimize any heat build-up that may tend to deteriorate the seal material.

e. The design of the water tube is such that the tube, which is fixed, and the rotating part will be held concentric, which minimizes the possibility of failure due to misalignment. (See Figure 11)

# CROSS SECTION



2208P57

Figure 10. Rotating Seal Currently in Use on the Eickhoff Longwall Miner

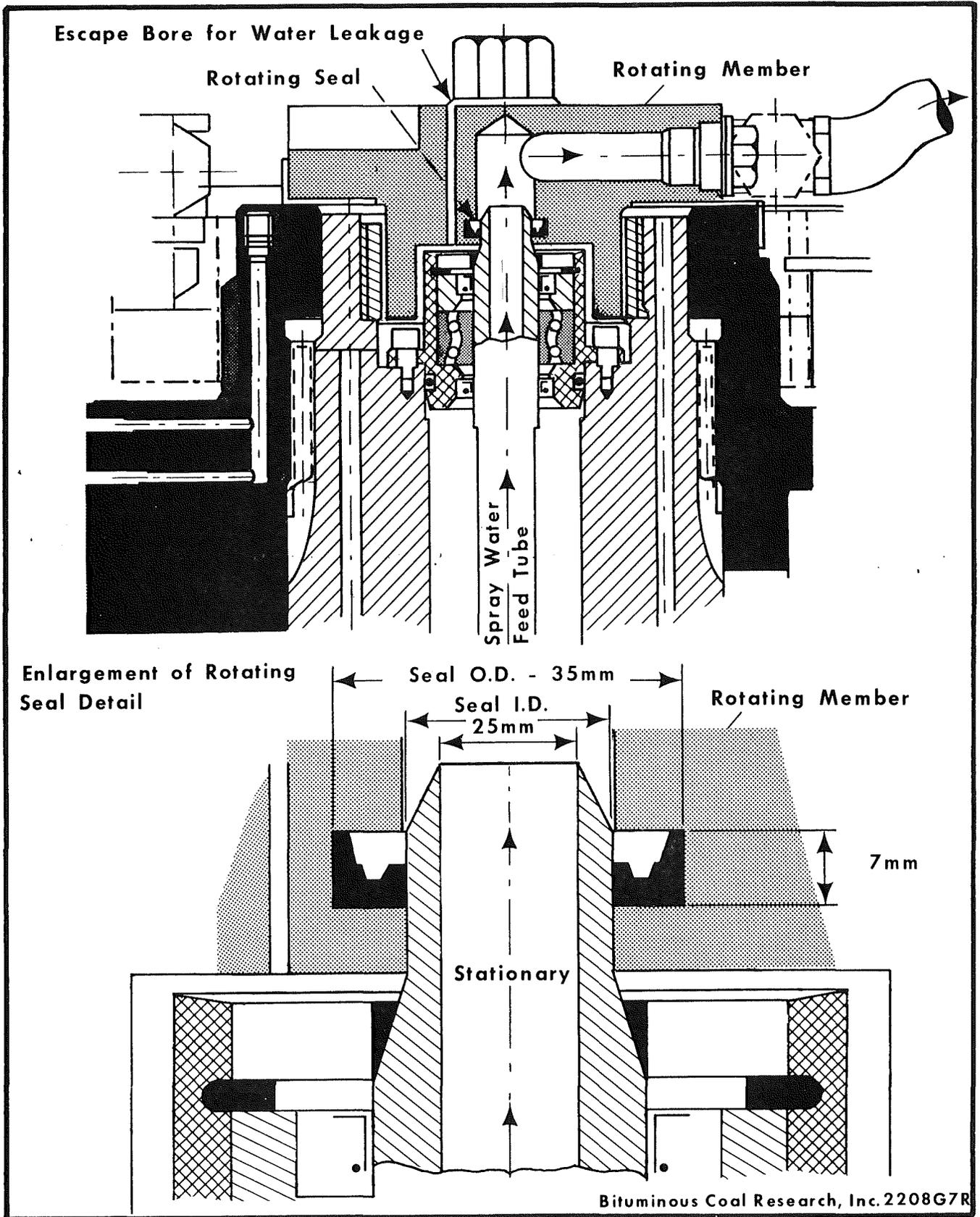


Figure 11. Configuration of the Rotating Seal with an Enlarged Section of the Seal

The seal environment also appeared to be favorable, in that:

a. The water used underground is passed through a settling pond and subsequently is passed through a 60-micron filter before it reaches the shearer. An analysis of a water sample from the supply to the section, Table 3, contains no particles above 20-micron diameter. This indicates that there would be a minimum of problems from large particles getting under the seal and causing leakage and eventual failure from abrasion.

b. The seal is located in a position which is shielded from external contamination--dust, moisture, heat, etc.--which would cause deterioration of the seal.

Based on these observations, the seal was judged to be adequate and no changes were proposed.

2. Modification of Shearer Drum to Incorporate a Water Supply Header - Two test drums were fabricated for this contract. The first drum was patterned after the original Eickhoff drum design which used the scroll support members as a water chamber to supply the dust sprays mounted on the sides of the scroll supports, Figure 12. This design required only that holes be drilled through the scroll bit-block mounting surface into the existing water chamber, Figure 13, and water could be delivered to the scroll sprays.

Delivery of water to blocks mounted on the drum end ring required the fabrication of a special chamber under the end ring, Figure 14, and the addition of a pipe to deliver water to this chamber, Figure 13. Again delivery of water to the blocks was accomplished by drilling holes through the end ring into this chamber, Figure 15.

Some bits located on the end ring are mounted at an angle toward the coal face to improve the sumping characteristics of the drum. These bit angles were maintained and water was supplied to the nozzles by inserting bars of the proper thickness for the angle desired under one side of the block, and filling in around the block perimeter with weld, thus creating a void through which the water could flow to the nozzle. This condition is also illustrated in Figure 15.

This drum was successfully shop-tested on May 17, 1974 with Mr. Brad Johnson, USBM, witnessing the test. Results of the test are given in the graph, Figure 16, and illustrated in Figure 17. The drum was taken underground and testing was initiated on June 7, 1974. After five shifts of sampling, operations with the test drum were suspended because:

a. An upward thrust was being exerted on the shearer when cutting from head to tail, causing unstable operation. This force was not evident with the original production drum.

b. During head to tail traverses, the drum appeared to be throwing an excessive amount of coal at the operator's position, with resultant

TABLE 3. PARTICLE SIZE ANALYSIS - R & P COAL COMPANY  
 JANE MINE NO. 1 - SPRAY WATER

<u>Particle Size, Microns</u>	<u>Particles Above Stated Diameter, Percent by Weight</u>
2.0	70.0
2.52	61.3
3.17	52.8
4.00	42.3
5.04	31.0
6.35	20.4
8.00	12.0
10.08	6.3
12.7	3.5
16.0	2.1
20.2	0.7
25.4	0.0
32.0	0.0
40.3	0.0
50.0	0.0

Analysis made on Coulter Counter Model "T" Particle Size Analyzer



2208P8

**Figure 12. Original Test Drum Showing Water Chamber  
Design Under Bit Scrolls**

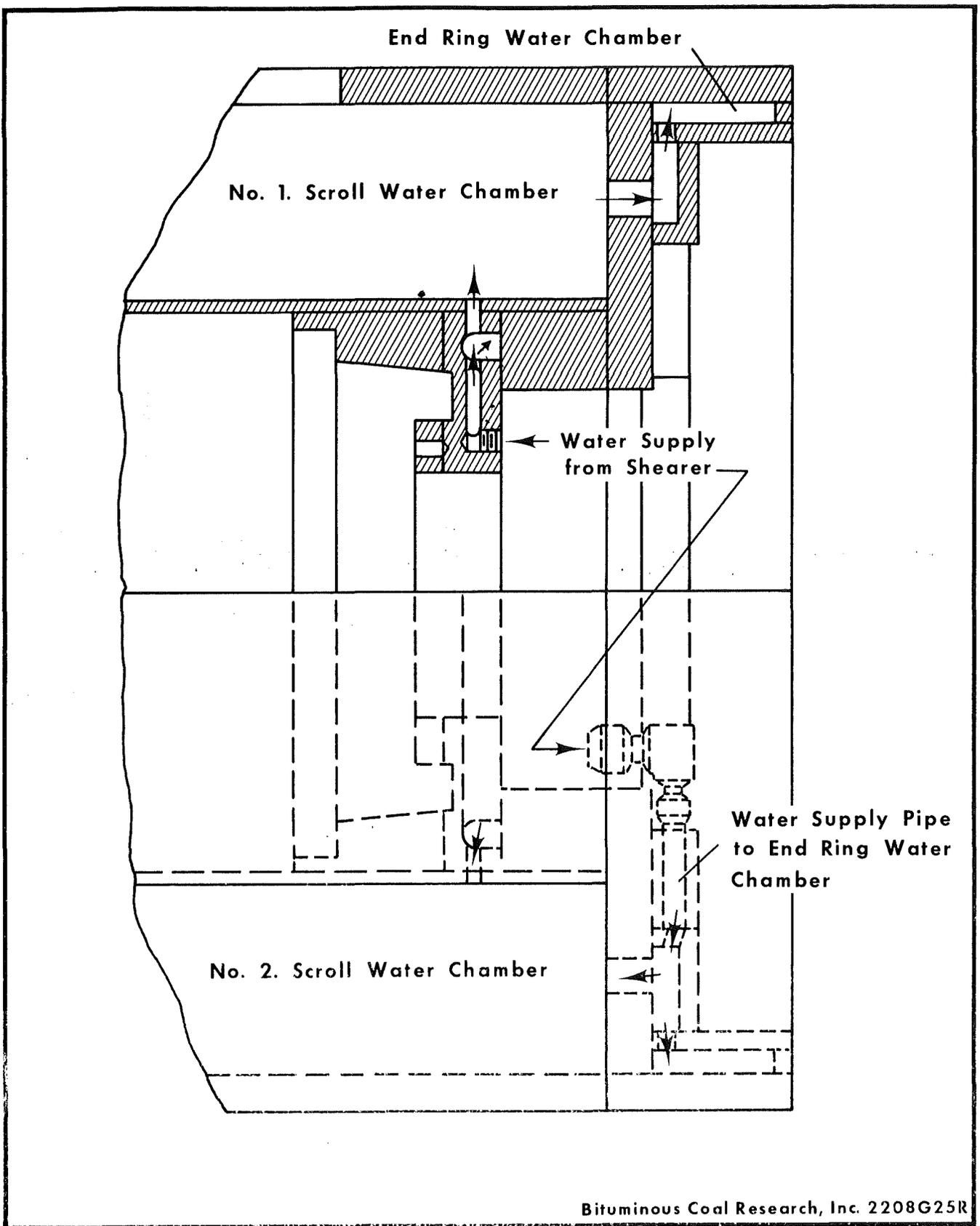


Figure 13. Test Drum Water Supply Configuration

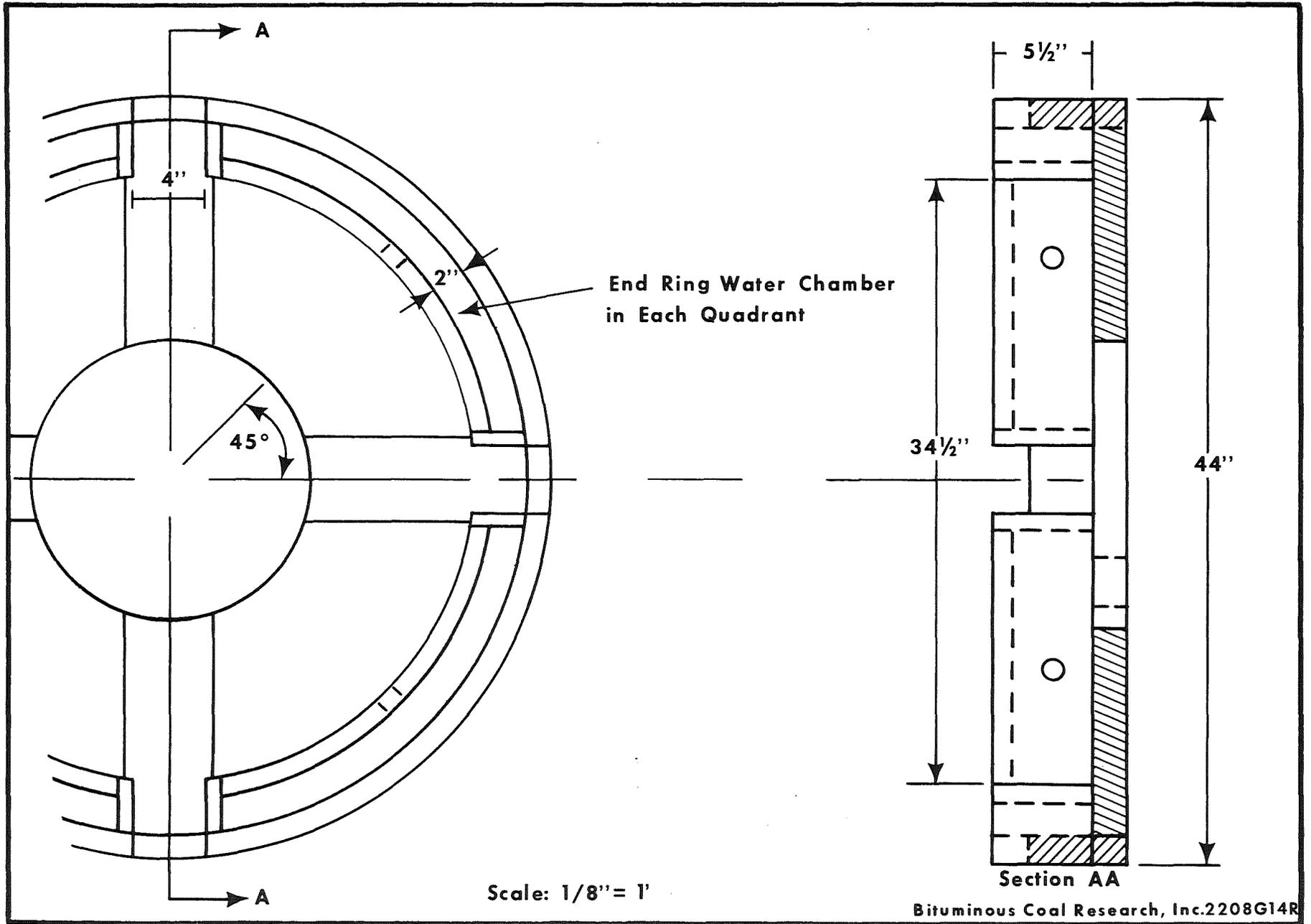
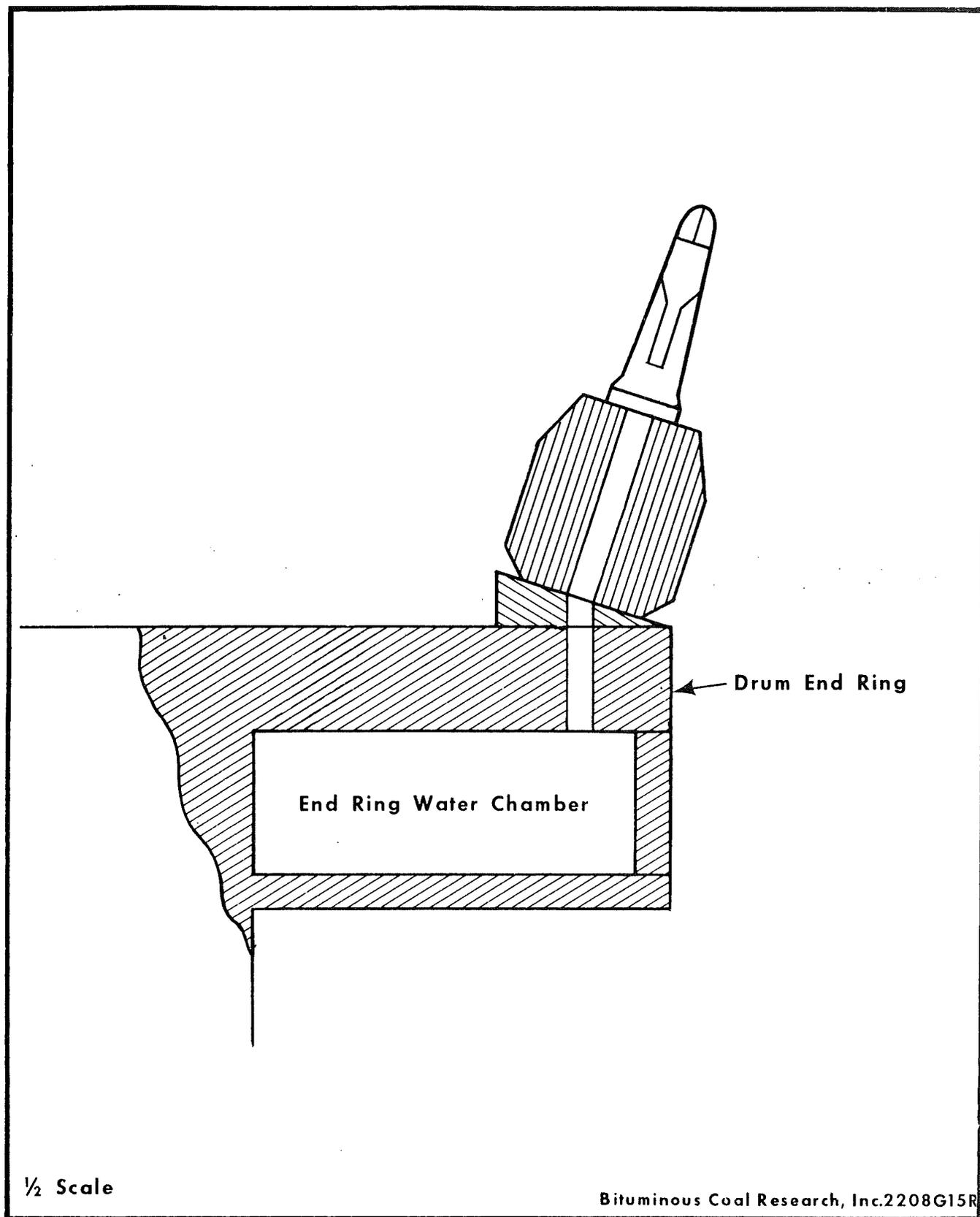


Figure 14. Modified End Ring Showing the Water Cavities Added to Provide Water for the End Ring Spray Nozzles



**Figure 15. Bit Block and End Ring Showing the Water Channels Drilled Through the Block, Spacer, and End Ring to Water Chamber**

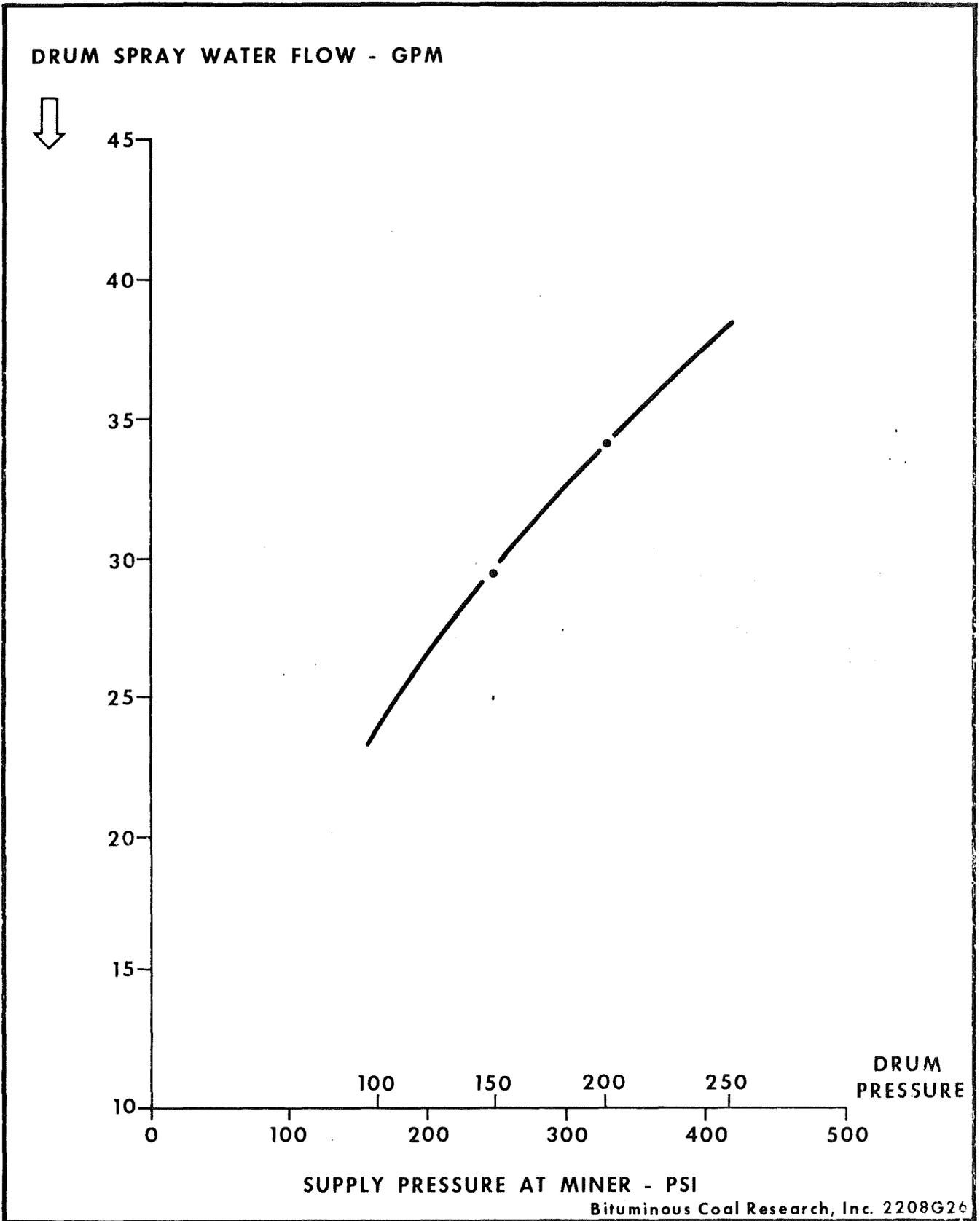
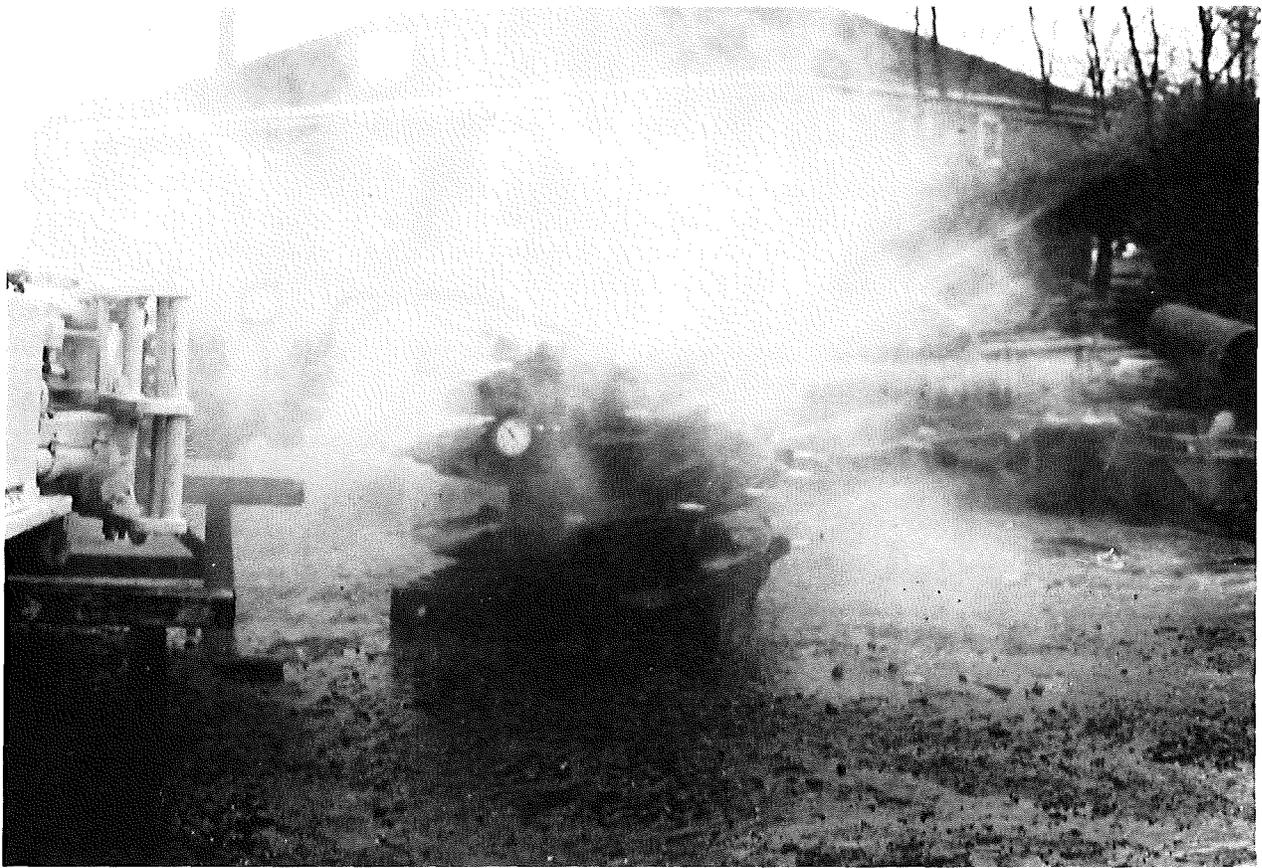


Figure 16. Flow Rates for Bit Flushing Configuration Based on Flow Tests of May 17, 1974 (Does not Include Oil-cooling Water Flow)



2208P95

**Figure 17. Spray Pattern Around the Test Drum With Bit Flushing  
Nozzles Mounted in Back of Bits  
(Flow Tests Conducted May 17, 18 1974)**

high dust levels, low visibility, and increased probability of the operator's being struck by a piece of coal.

c. A hydraulically operated gate, mounted on the shearer adjacent to the drum, scoops the loose coal deposited on the mine floor during cutting operations and forces it onto the face conveyor. This gate was misaligned with the drum, with the result that coal was left on the floor, which caused problems when moving the face conveyor against the coal face.

Because of the operating problems, Rochester and Pittsburgh Coal Company personnel decided to reverse the rotation of the shearer drum drive, which required that the direction of the drum scrolls also be reversed, so the drum would convey coal away from the face and onto the face conveyor.

Figure 18 shows the difference in scroll direction between the original test drum and the modified drum.

When the test drum was inspected at the machine shop where the scrolls were to be changed, several fabrication errors were noted, as follows:

a. The scroll angles were 9 degrees instead of the 18 to 20 degrees originally specified (Figure 19).

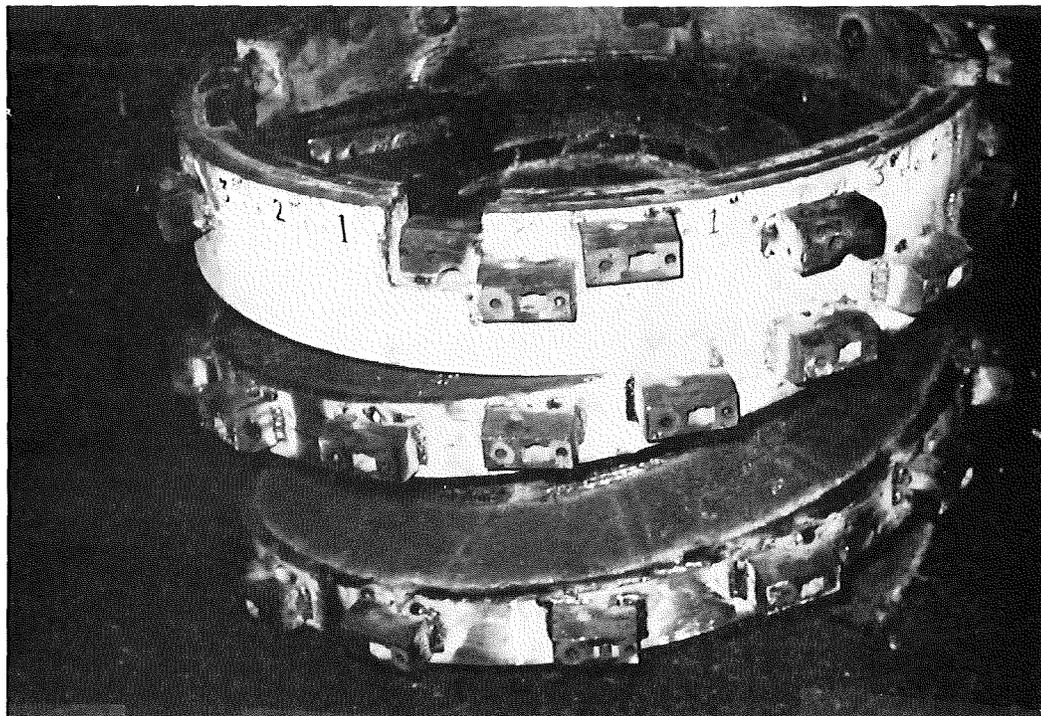
b. As a result of using the wrong scroll angle, the relative positions of the starting point and end of the scrolls were incorrect (Figure 20).

c. The smaller angle also required that the scrolls be longer than the scrolls oriented at 18 degrees from the drum coal-cutting plane to cover the same drum length, resulting in block spacing varying from 8-1/2 to 12 inches instead of 4-1/2 inches as originally specified (Figure 21).

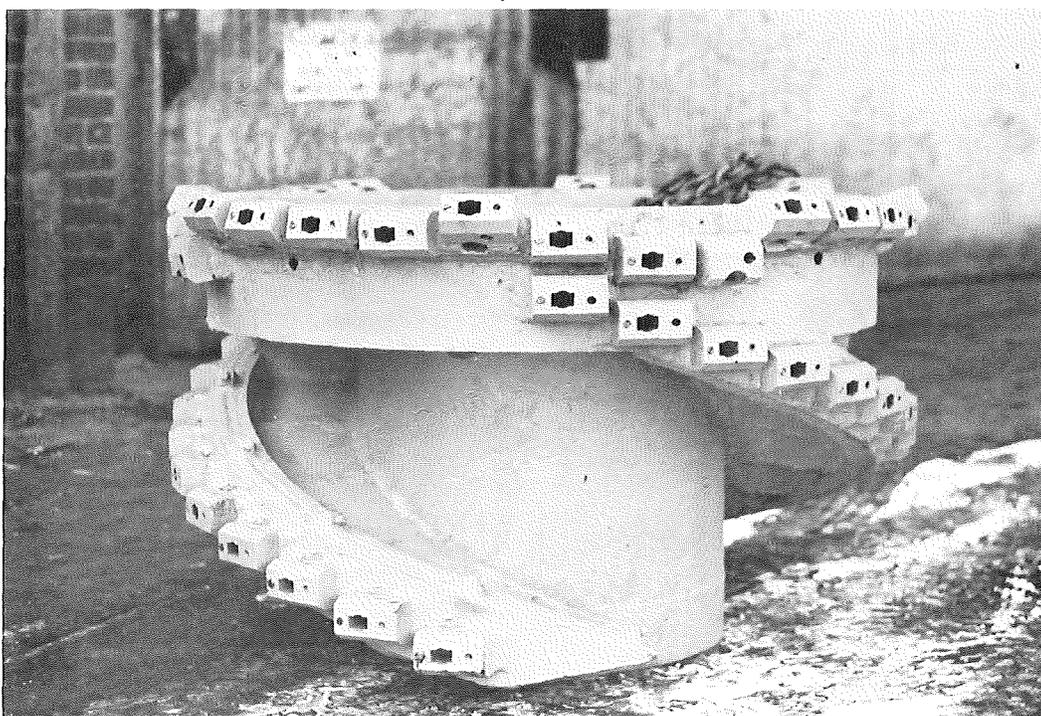
d. The mounting plate used to bolt the drum to the shearer was incorrectly positioned in the axial direction by 4 inches. This explains the misalignment of the drum with the shearer gate during operation (Figure 22).

e. In addition to design changes made to correct these errors, a design modification was made to make the test drum scrolls more closely match the R&P production drum. The total modifications to the drum included the following:

(1) The scroll bit-block mounting plate support configuration was changed to eliminate the box-type construction and the water chamber it provided. This was replaced with a single vertical steel member under the center of the mounting plate, with a small rectangular chamber fabricated under the mounting plate to supply water to the sprays (Figure 23). Water was supplied to this chamber by means of a pipe from the hub of the drum to the underside of the chamber (Figures 23 and 24).

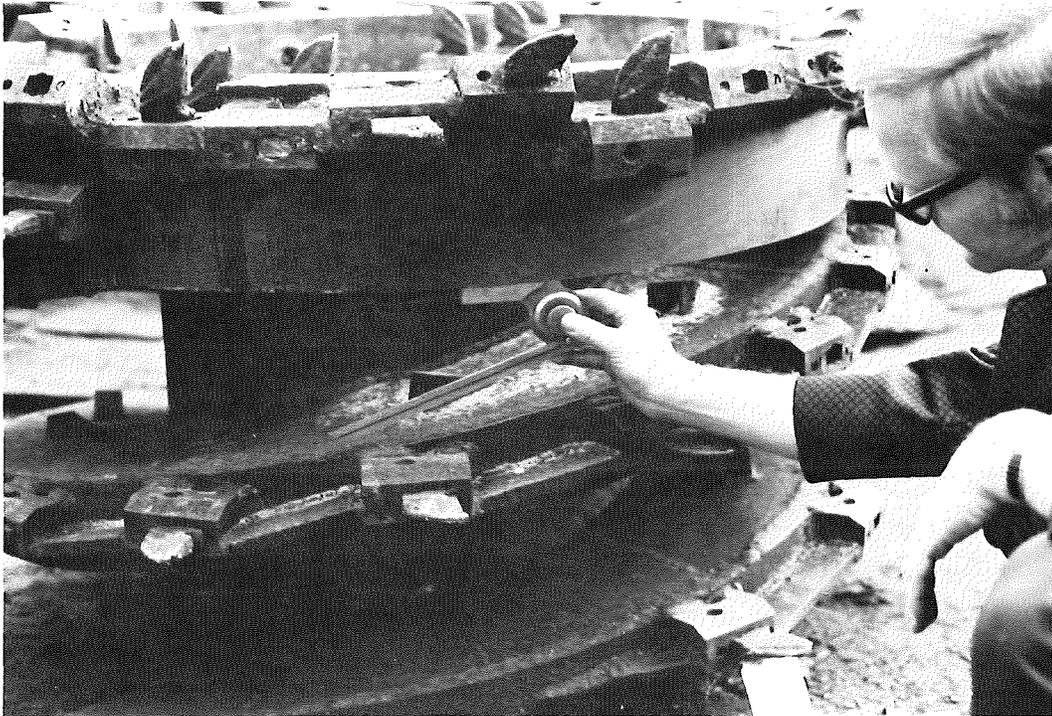


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2208P117

**Figure 18. Comparison of Drums Showing Direction of  
Scrolls on Original Drum (Top) and  
Revised Drum (Bottom)**



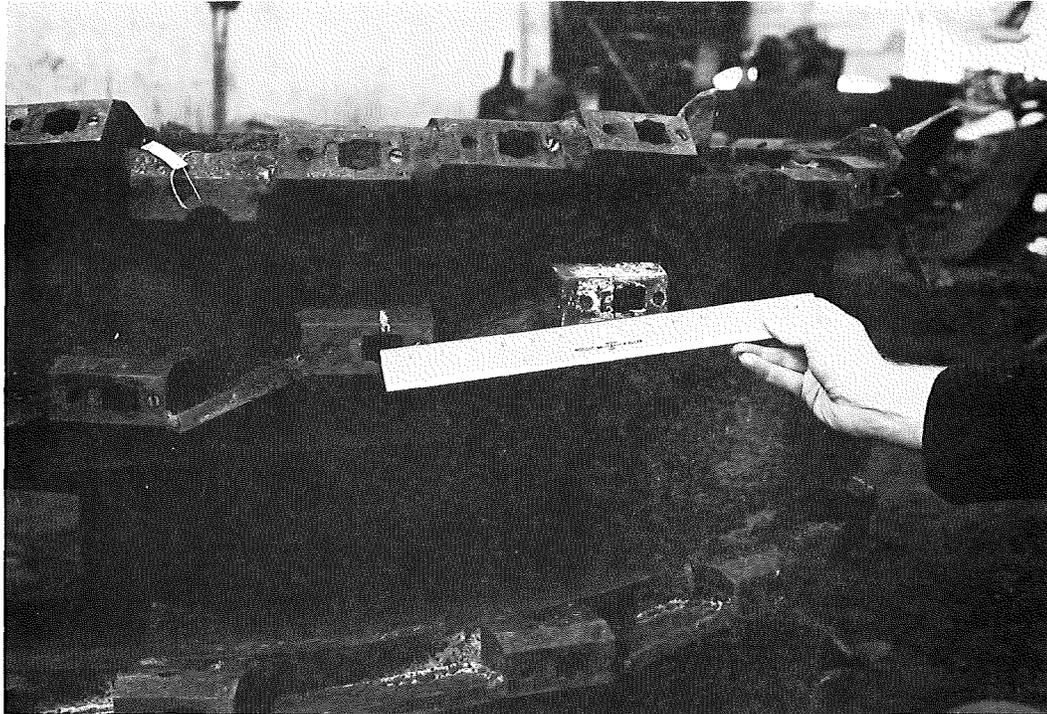
2208P103

**Figure 19. Original R&P Test Drum Showing Difference Between Actual Scroll Angle ( $9^\circ$ ) and the Specified Angle ( $18^\circ$ ) Set on the Protractor**

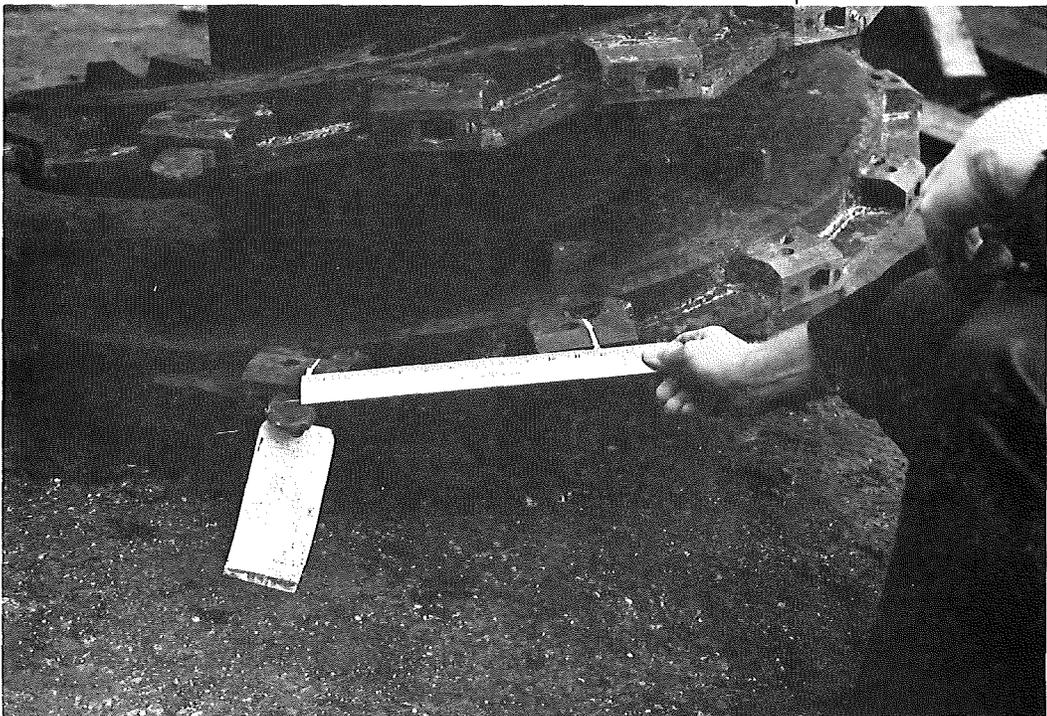


2208P105

**Figure 20. Original Test Drum Showing Positions of the End Blocks (White Blocks). Correct Scroll Angle Locates These Blocks  $180^\circ$  Apart**



2208P107



2208P108

**Figure 21. Block Spacing on Original Test Drum Showing  $8\frac{1}{2}$  Inch (Top) and 12 Inch (Bottom). Specification Called for a Uniform  $4\frac{1}{2}$  Inch Spacing**



2208P106

**Figure 22. Original Test Drum Showing the 6½ Inch Depth of the Drum Mounting Plate Instead of 2½ Inches as Specified**

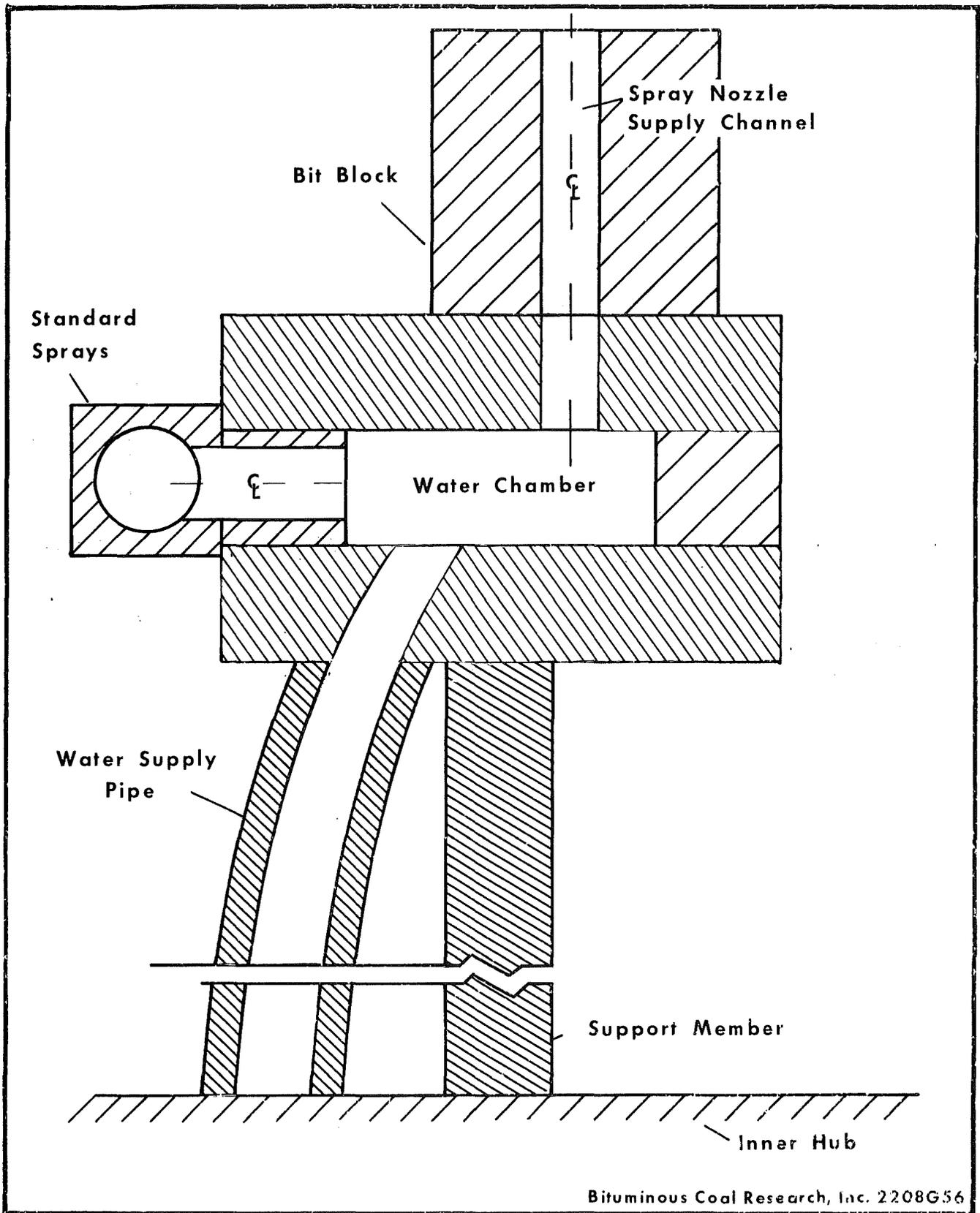
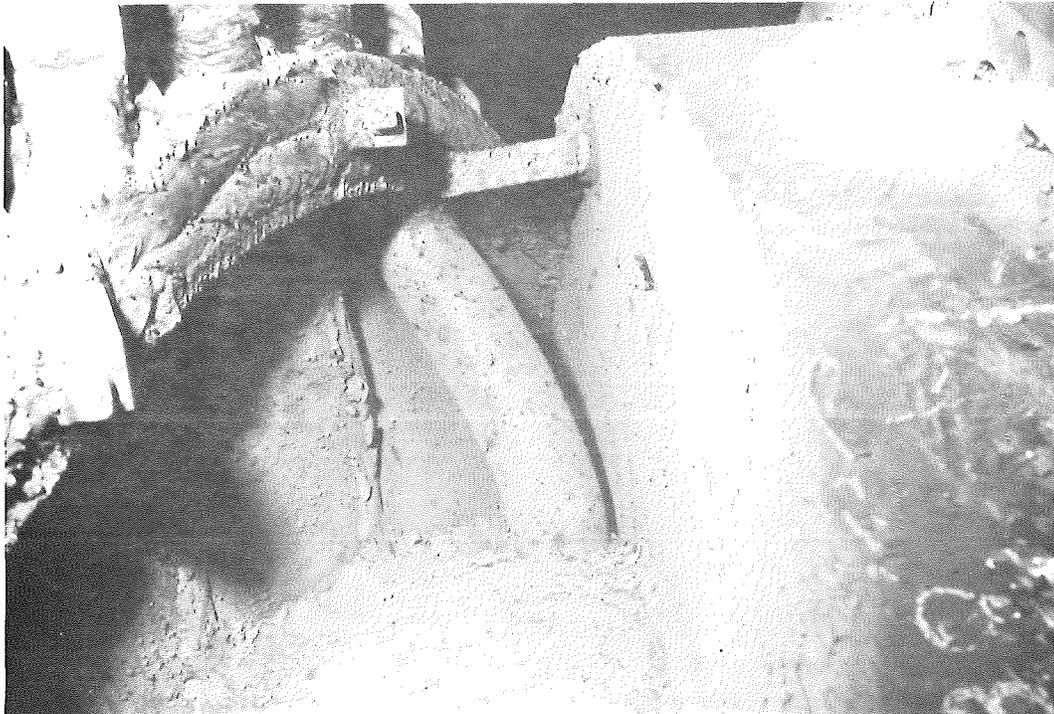
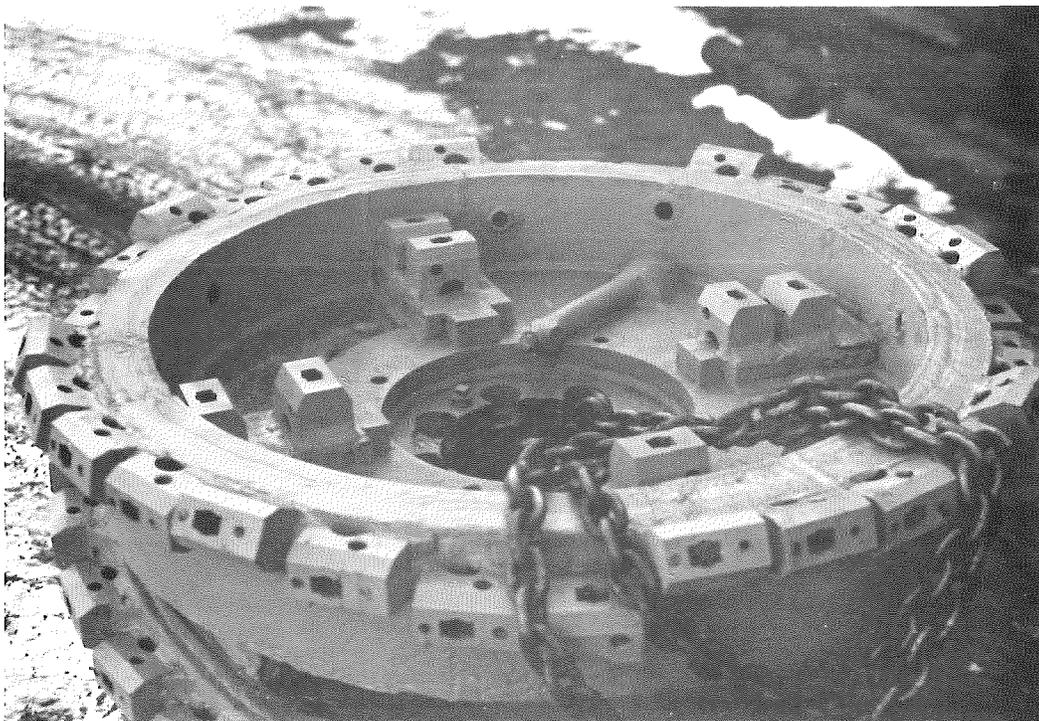


Figure 23. Modified Water Chamber Design on Test Drum



2208P114

**Figure 24. Water Supply Pipe to Scroll Water Chamber**



2208P119

**Figure 25. End Ring Water Supply Pipe Showing  
Straight Hose Fitting Instead of 90° Fitting**

(2) The bit lacing pattern was modified to reduce the spacing between the blocks on the scrolls, and the end ring lacing was modified to more closely match the R&P production drum's pattern.

(3) The direction of the scrolls was reversed and the scroll angle increased to approximately 19 degrees.

(4) The mounting plate was relocated to its proper axial position.

(5) The water inlet pipe supplying the end ring was modified by replacing the 90 degree fitting at the upstream end with a straight fitting. This was necessary because of the loss of clearance when the mounting plate was relocated (Figure 25).

Sampling with the modified drum was initiated January 6, 1975 and continued until January 23 when the panel was mined out. During this period 23 shifts were sampled. The following two minor problems were reported concerning drum operating characteristics.

a. There was interference between the panline and the last bit on each scroll, particularly during sumping.

b. The sumping characteristics of the drum were poor due to the lack of bits extending beyond the edge of the end ring toward the coal face. As a result, the drum was grinding the coal instead of cutting it during sumping operations.

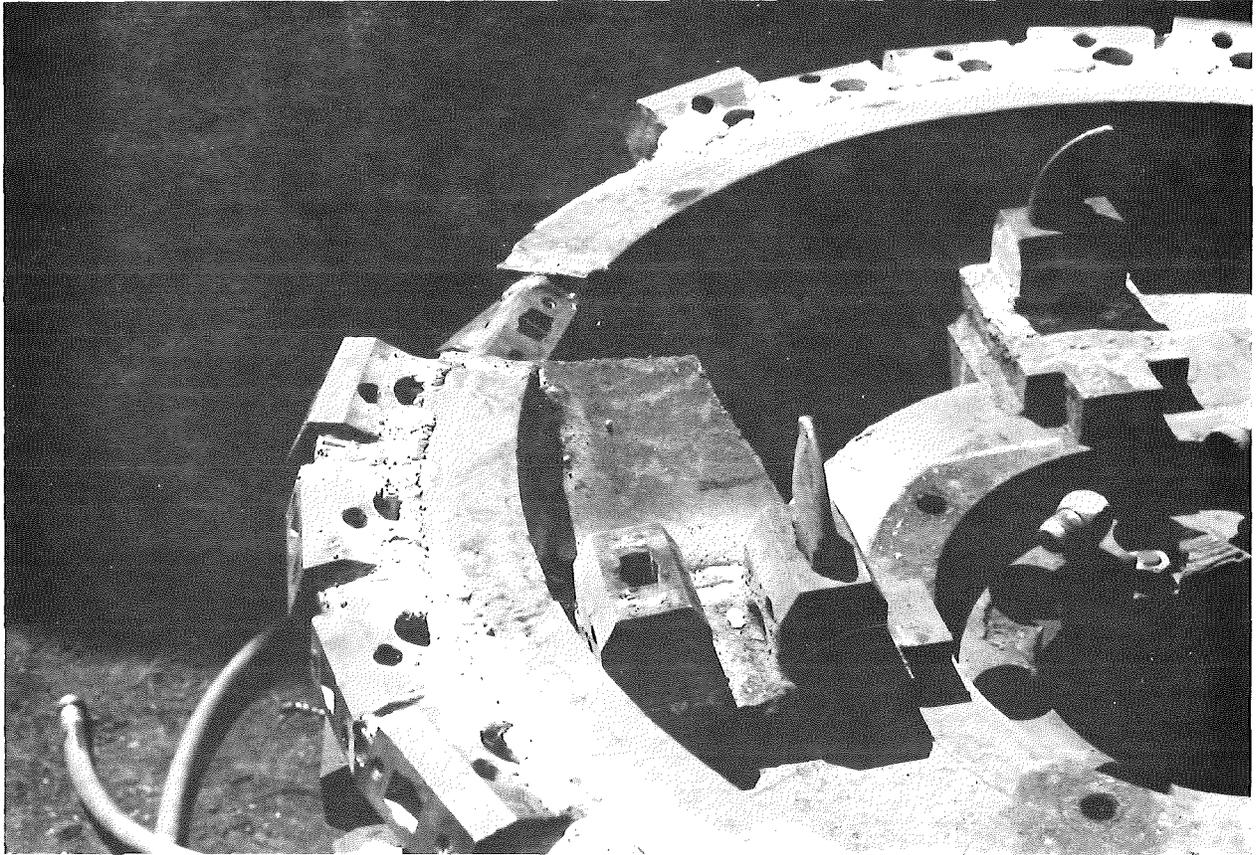
At this time the drum was removed from the mine and returned to the fabricator's shop for inspection, repairs to minor leaks, and some additional modifications. The modifications included:

a. Changing the bit lacing to improve the sumping characteristics. This required putting cutouts in the end ring and mounting bits in the cutouts that were essentially perpendicular to the coal face (Figure 26).

b. Removing the last bit block on each scroll and shortening the scroll to eliminate interference with the panline (Figure 27).

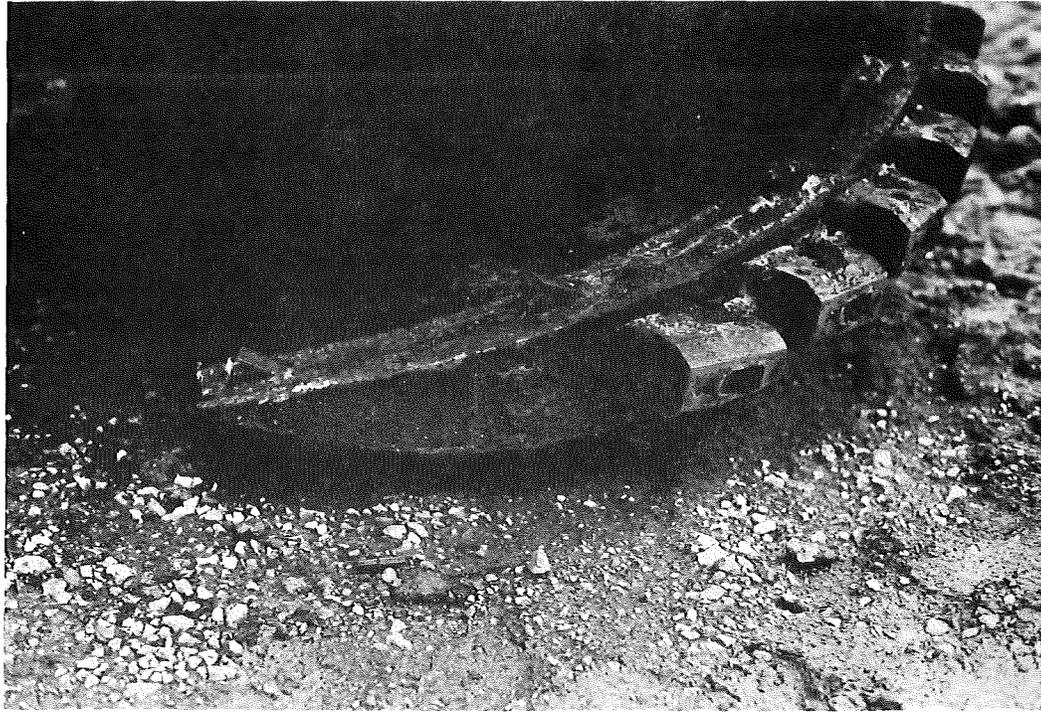
c. Changing the design of the standard spray system to have the jets directed radially, duplicating the R&P production drum, instead of tangentially (Figures 28 and 29).

Inasmuch as these changes did not affect the cutting characteristics of the machine during mining operations, the shifts sampled during the previous panel were not invalidated. With respect to the spray system changes, the standard system had not been tested on the test drum, so again no shifts were lost.

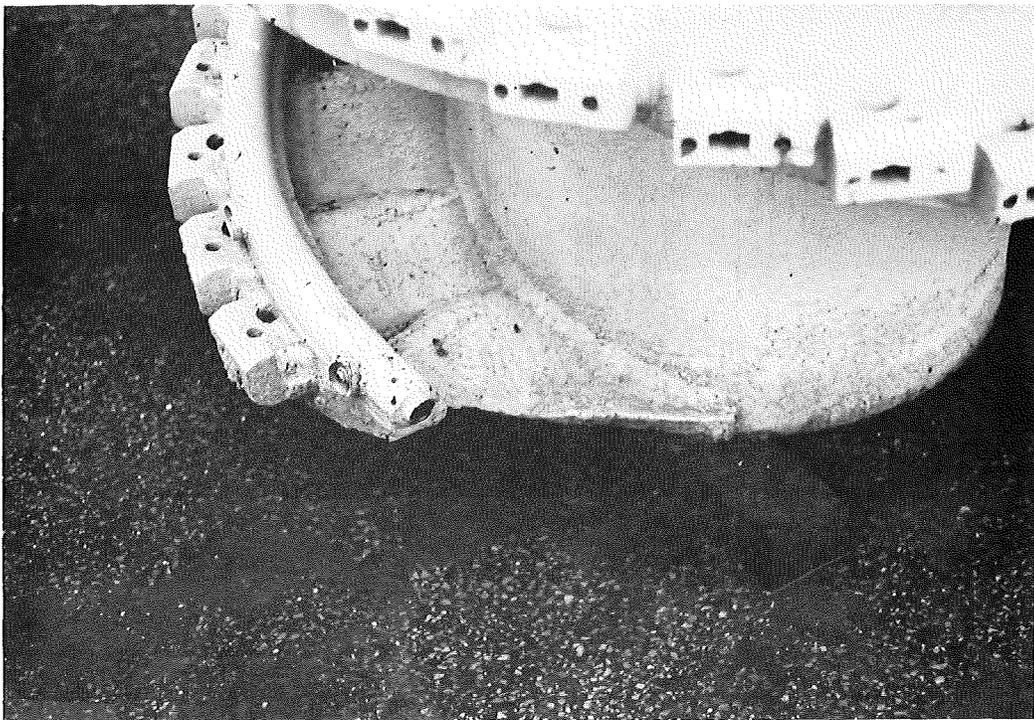


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**Figure 26. Blocks Mounted in End-ring Cutouts, 180° Apart**

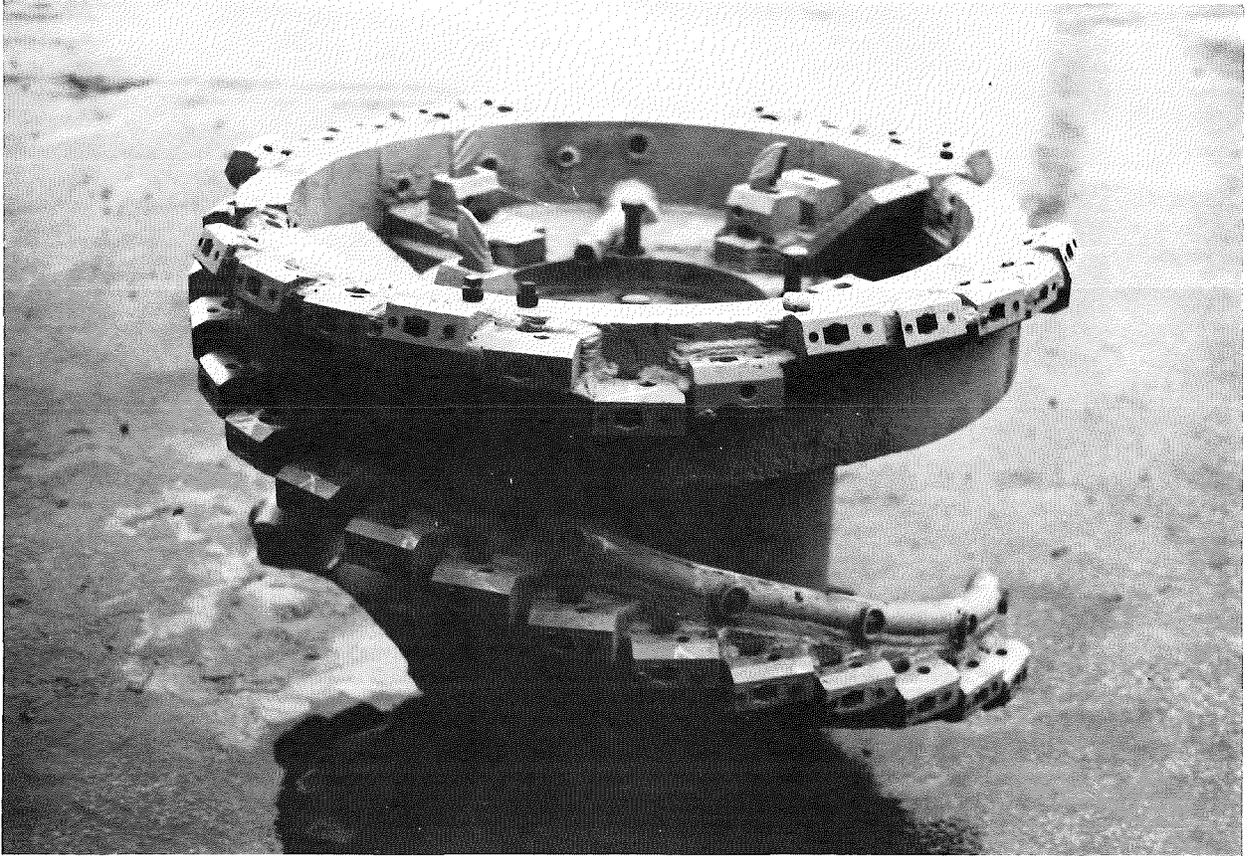


2208P127



2208P139

**Figure 27. Original Scroll Configuration (Top) and Modified (Bottom) to Shorten Scroll and Eliminate Interference With Panline**



2208P140

**Figure 28. Revised Standard Scroll Sprays**

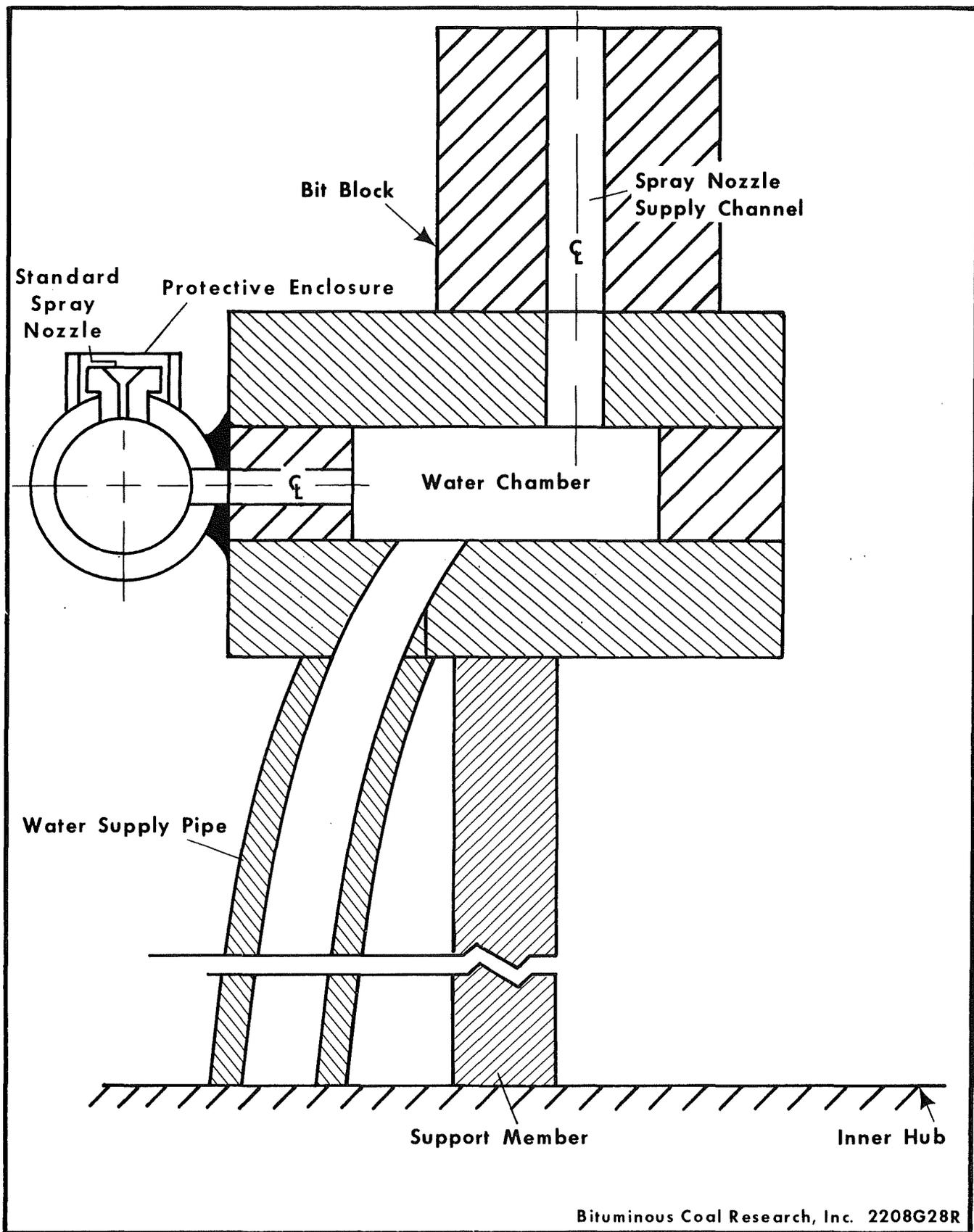


Figure 29. Standard Spray System Modification to Duplicate R&P Production Drum Configuration

Even though much of this work was carried out during Phase II and Phase III, it has been included in Phase I - Design, since it involved design or modification of the drum.

3. Fixed Nozzle Spray Header - Although no drum modifications were required, to satisfy the contract specifications for testing with a dry drum, a water header with five nozzles was designed for installation on the shearer housing behind the drum as shown in Figure 9. The configuration simulated the original shearer designs using only fixed sprays and provided a comparison between the "wet" drum and "dry" drum systems.

On September 29, 1975 the top of the shearer housing was cleaned off, the fixed spray header was installed on the shearer, and "dry" drum testing was initiated. Immediately after the first pass started, the foreman reported that coal had piled on top of the shearer, burying the header and blocking the water sprays. Figure 30 shows a comparison of the shearer with the top cleared of coal and coal piled on top of the machine after several passes. This pass was completed and the coal removed from the top of the housing. Immediately after the second pass started, coal again piled on top of the housing, blocking the sprays. Since it was apparent the fixed sprays would not be operational, testing was suspended for the shift. In addition to the blockage problem, the shearer operator also complained that (1) when the nozzles were not blocked, the mist generated by the nozzles impaired visibility, making guidance of the drum difficult, and (2) the sprays appeared to induce recirculation of the air, pulling the dust over the shearer operator's position.

During the third pass the top of a roof support canopy caught the header, bending the pipe and knocking it off the shearer. (Figure 31.)

The problem of coal covering the spray header during this shift was discussed with Mr. Kelly Strebis, Project TPO, and it was agreed to eliminate the "dry" drum tests.

#### D. Design of Spray Nozzles and Bit Blocks for the Bit Flushing Spray Systems

1. Design of Spray Nozzles - The original contract specifications required that each spray system be tested at two distinct operating pressures. The pressures selected were 150 psig and 250 psig. To establish a required water flow, therefore, tests were conducted at BCR using standard Eickhoff dust sprays and the standard cluster spray used to exhaust the oil-cooling water. The resultant flow data indicated a total standard spray system water flow of 21.59 gpm at 150 psig and 28.00 gpm at 250 psig (Table 4, Test Condition Z). The standard Eickhoff system uses 14 drum-mounted nozzles and one fixed cluster spray, located as shown in Figure 32. These data were then used as the basis for determining proper nozzle orifice size for the bit flushing sprays.

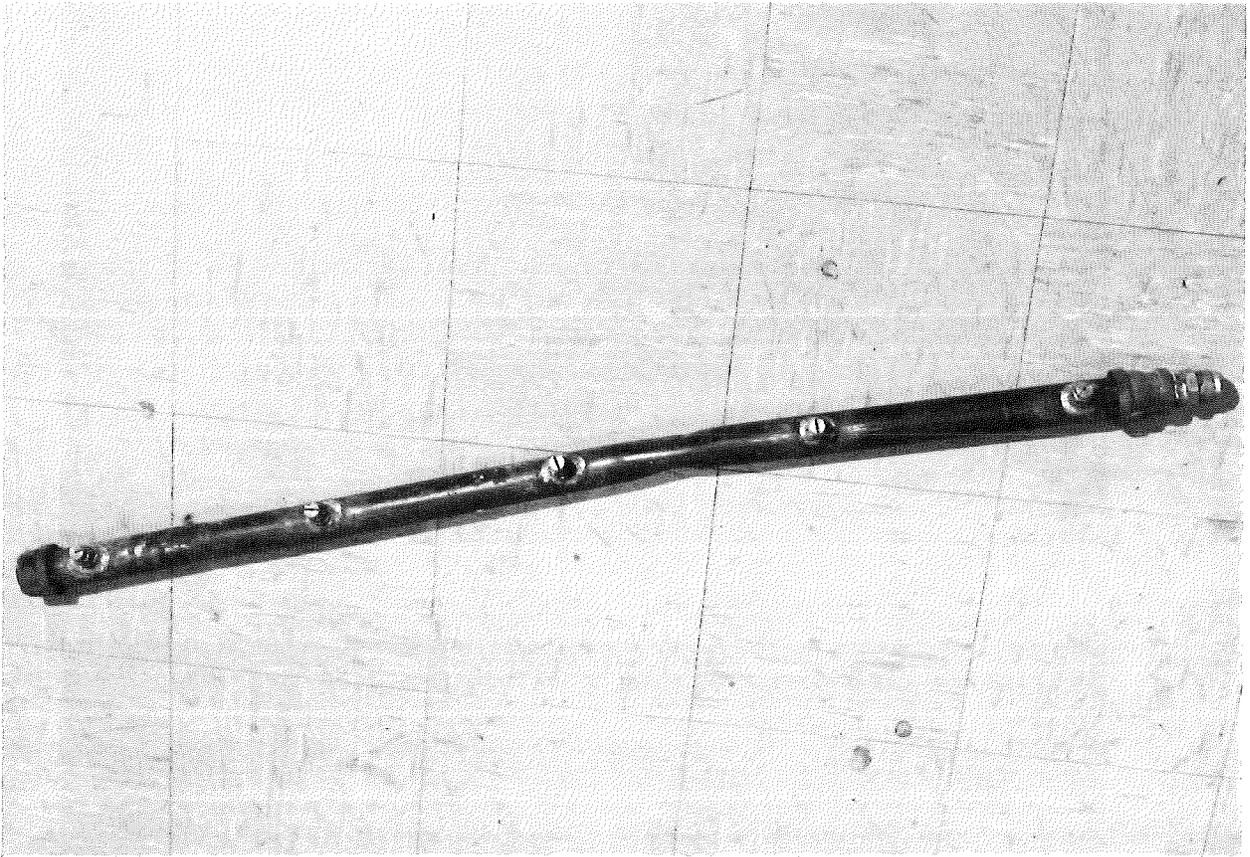


2208P147



2208P152

**Figure 30. Shearer Showing Upper Surface Cleared of Coal (Top) and After Several Passes (Bottom)**



2208P167

**Figure 31. Fixed Spray Header Showing Damage Incurred  
When Struck by Roof Support Chock**

TABLE 4. SPRAY SYSTEM SPECIFICATIONS FOR RECOMMENDED NOZZLE LOCATIONS

Location	No. of Nozzles	Test Conditions								
		X - Nozzles in Front of Bits			Y - Nozzles in Back of Bits			Z - Standard Spray Nozzles		
		Pressure (psi)	Flow/Jet (gpm)	Total Flow (gpm)	Pressure (psi)	Flow/Jet (gpm)	Total Flow (gpm)	Pressure (psi)	Flow/Jet (gpm)	Total Flow (gpm)
2, 7	48	250	.33	--	250	.33	15.84	250	.33	--
1, 6	48	250	.33	15.84	250	.33	--	250	.33	--
Drum End	4	250	1.6	6.40	250	1.6	6.40	250	1.6	6.40
Drum Scrolls	10	250	1.6	--	250	1.6	--	250	1.6	16.00
Fixed	1	250	5.6	<u>5.60</u>	250	5.6	<u>5.60</u>	250	5.6	<u>5.60</u>
				27.84			27.84			28.00
2, 7	48	150	.26	--	150	.26	12.48	150	.26	--
1, 6	48	150	.26	12.48	150	.26	--	150	.26	--
Drum End	4	150	1.24	4.96	150	1.24	4.96	150	1.24	4.96
Drum Scrolls	10	150	1.24	--	150	1.24	--	150	1.24	12.40
Fixed	1	150	4.23	<u>4.23</u>	150	4.23	<u>4.23</u>	150	4.23	<u>4.23</u>
				21.67			21.67			21.59

Note: Flows based on nozzle flow rate versus pressure tests conducted at BCR

43.

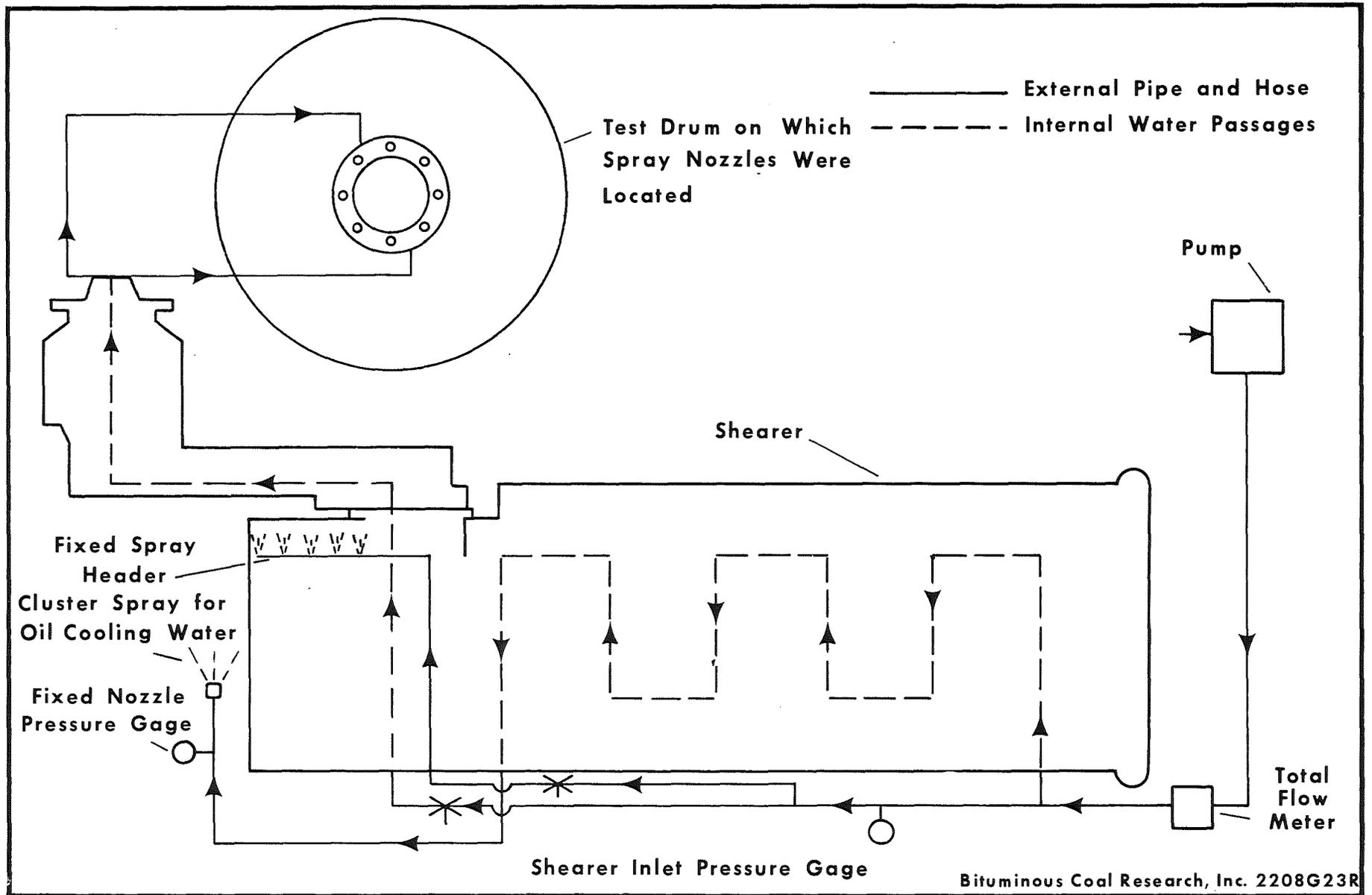


Figure 32. Schematic Arrangement of Eickhoff Shearer Water System

Initially, an effort was made to locate commercially-produced nozzles for the bit-flushing locations. However, the available nozzles were either too large or were not the right configuration for use in the proposed bit block design, and a special nozzle had to be developed by BCR. The final nozzle design, Figure 33, consisted of a section of externally threaded brass rod drilled through to provide a 0.049-inch diameter orifice. The rod was also drilled and tapped on one end to accept a 50 mesh screen. The orifice size was determined by conducting flow tests at 150 and 250 psig with various size orifices until the flow rate was obtained which gave calculated total spray system flows of approximately 28 gpm and 21 gpm. The final test results are summarized in Table 4 in the columns headed "X - Nozzles in front of bits" and "Y - Nozzles in back of bits".

2. Design of Bit Blocks - A primary consideration in the design of the bit blocks was that changes in the general configuration and dimensions of the test shearer drum had to be kept to a minimum. In particular, the features of prime importance were:

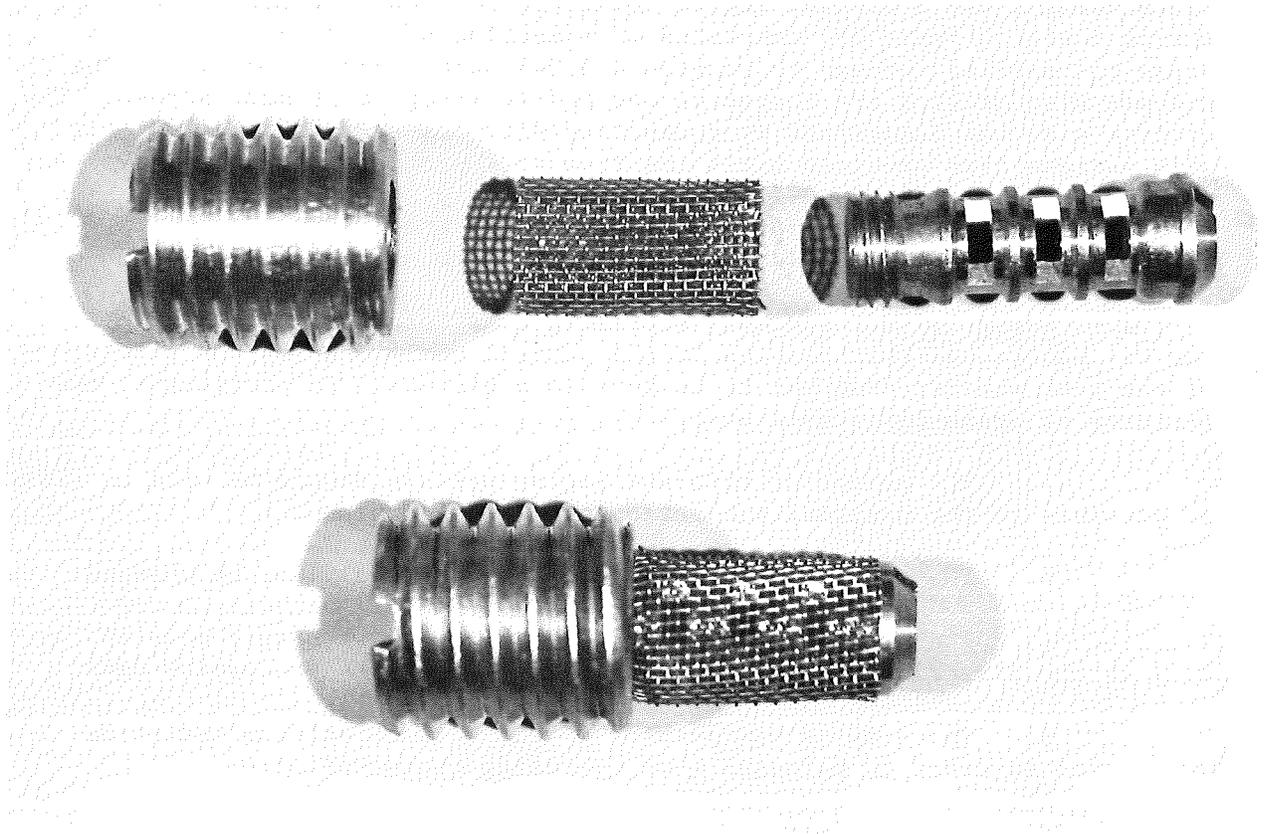
- a. The number of bits and lacing pattern should be held as close as possible to the original production drum configuration.
- b. The overall drum width and diameter could not be changed.
- c. The angle of the scrolls on which the bits were mounted, as well as the direction of rotation, had to duplicate the production drum.
- d. The sumping bit pattern of the production drum had to be duplicated in order to maintain good operating characteristics.

In addition, the block had to be practical to fabricate, require no special alignment or installation procedures for field replacement, and permit installation or replacement of the nozzles without requiring procedures for aligning the water jet with its point of impact on the bit.

The final block design, Figure 34, was almost an exact duplication of the standard block except it was one-half inch longer and had a hole on either end of the cutter bit hole to accept the bit-flushing nozzles and act as water supply channels to the nozzles. The block fulfilled all requirements for the test, and no problems with the block design were encountered during the field demonstration.

#### E. Longwall Water Supply System

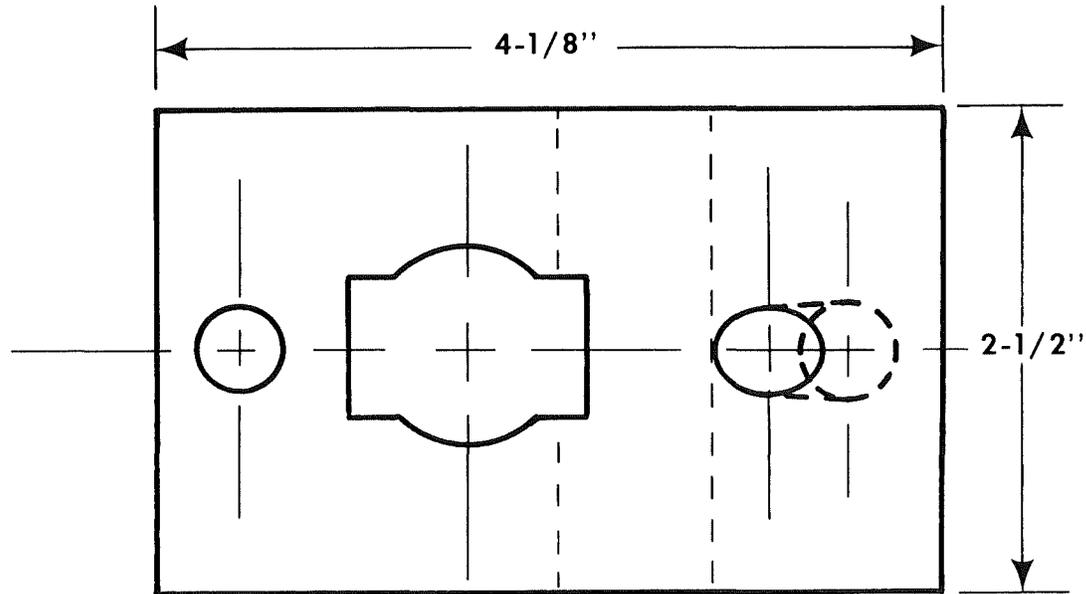
The water supply to the longwall section was through a 3-inch ID steel pipe at a static pressure of 120 psi. A wetting agent, Dowell Chemical Company F-65, was used throughout the sampling period. A schematic diagram of the water supply system is shown in Figure 35.



2208P74

**Figure 33. Jet Nozzle Assembly Used on Eickhoff Shearer**

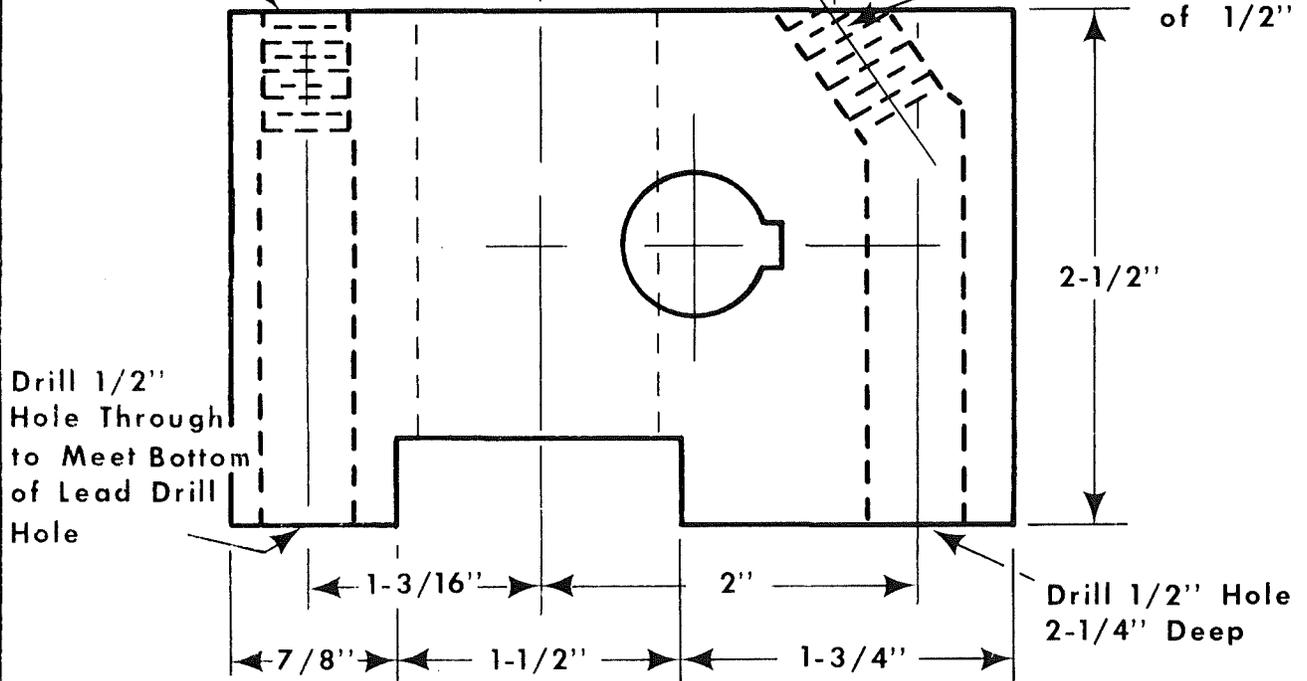
Revised 2/26/74



Note: Block is same as shown on Prox Dwg (No. MM-1059 Revised) except as shown.

Drill & Tap for 1/2-13 Thd. 1/2" Deep

7/16"  
28°  
Drill & Tap for 1/2-13 Thd. Hole to Intersect 1/2" Hole Drilled from Bottom. Tap to Depth of 1/2"



Drill 1/2" Hole Through to Meet Bottom of Lead Drill Hole

Drill 1/2" Hole 2-1/4" Deep

Bituminous Coal Research, Inc. 2208G17R

Figure 34. Final Design of Test Bit Block

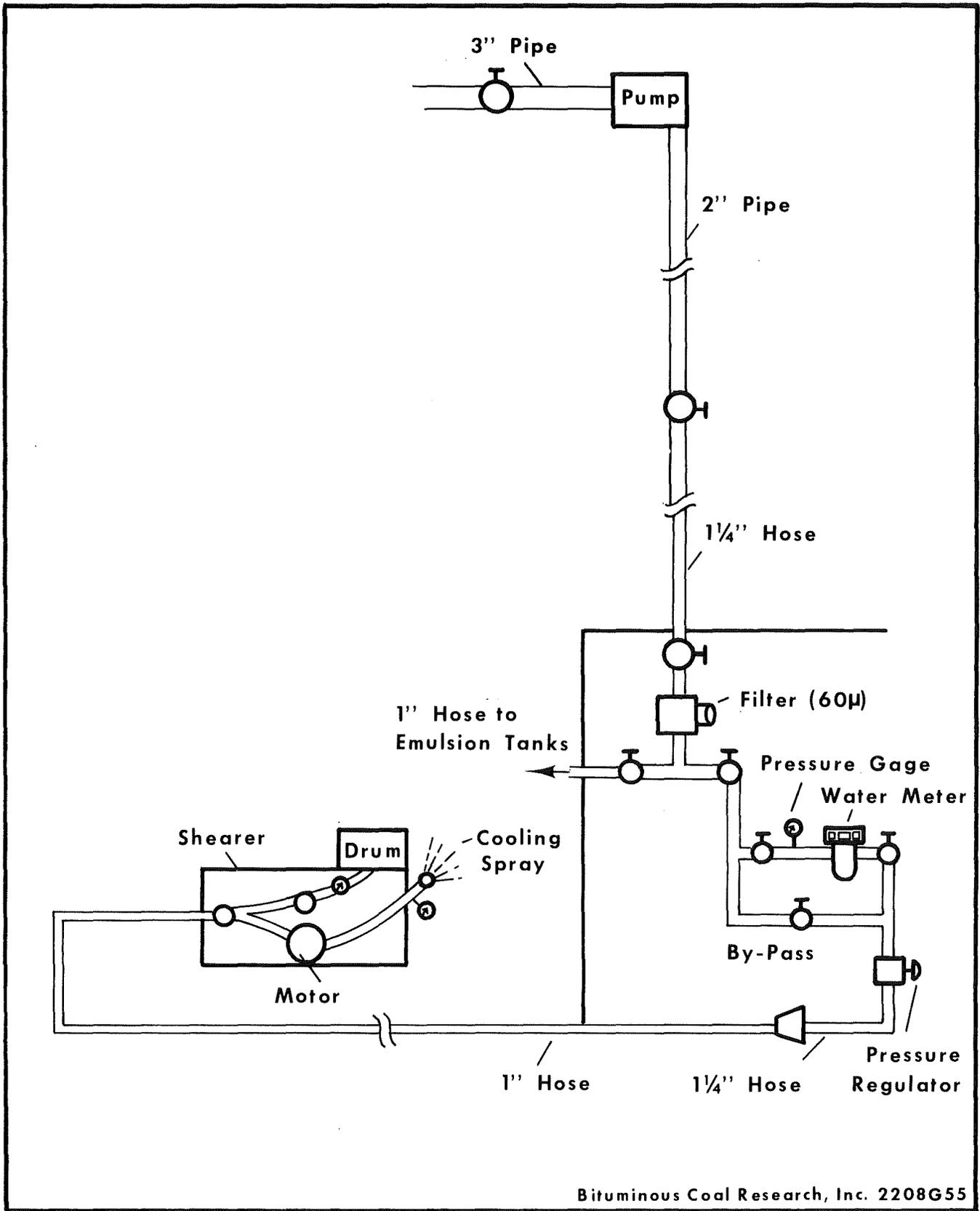


Figure 35. Schematic Diagram of Water Supply System for the Longwall Test Panel

The water pump for the section, Figure 36, was a Beam positive displacement pump, Model 470-11, located at the end of the panel adjacent to the main belt entry near and activated by a centrifugal switch controlled by the panel belt drive. Pump specifications are shown in Table 5. The Beam pump fed a 2-inch ID steel pipe which extended from the belt drive to within 100 feet of the face. The length of this section of pipe varied according to the face position.

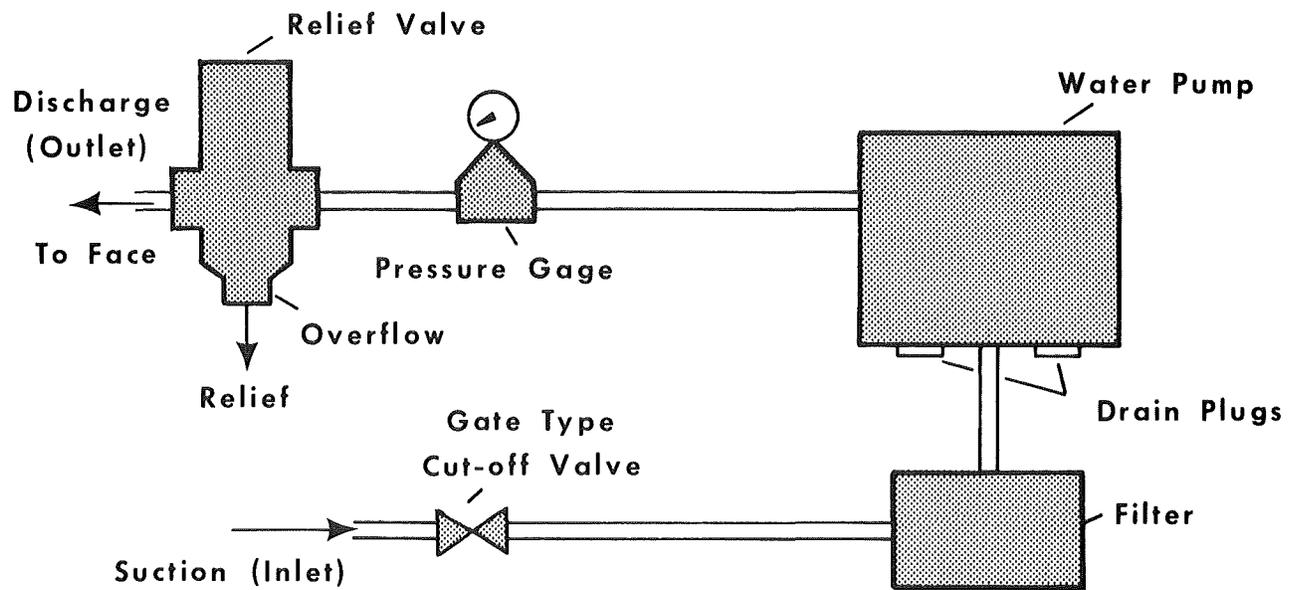
The 2-inch steel pipe was coupled to about 50 feet of 1-1/4-inch ID flexible high-pressure hose. This hose allowed for a face advance of approximately 100 feet before sections of the 2-inch steel pipe had to be removed.

A 60-micron water filter, water meter, pressure gage, pressure regulator, and water meter by-pass (Figure 37), were located on a shearer power supply skid which advanced with the face. This equipment was installed in the 1-1/4-inch ID flexible hose to the face.

The hydraulic system for the longwall roof support system utilized an oil-water emulsion for the working fluid. The water for this emulsion was supplied by a 1-inch hose connected to the main water supply line, just in by of the 60-micron filter. This water did not pass through the water meter; therefore, it did not affect the water flow measurements during the sampling shifts.

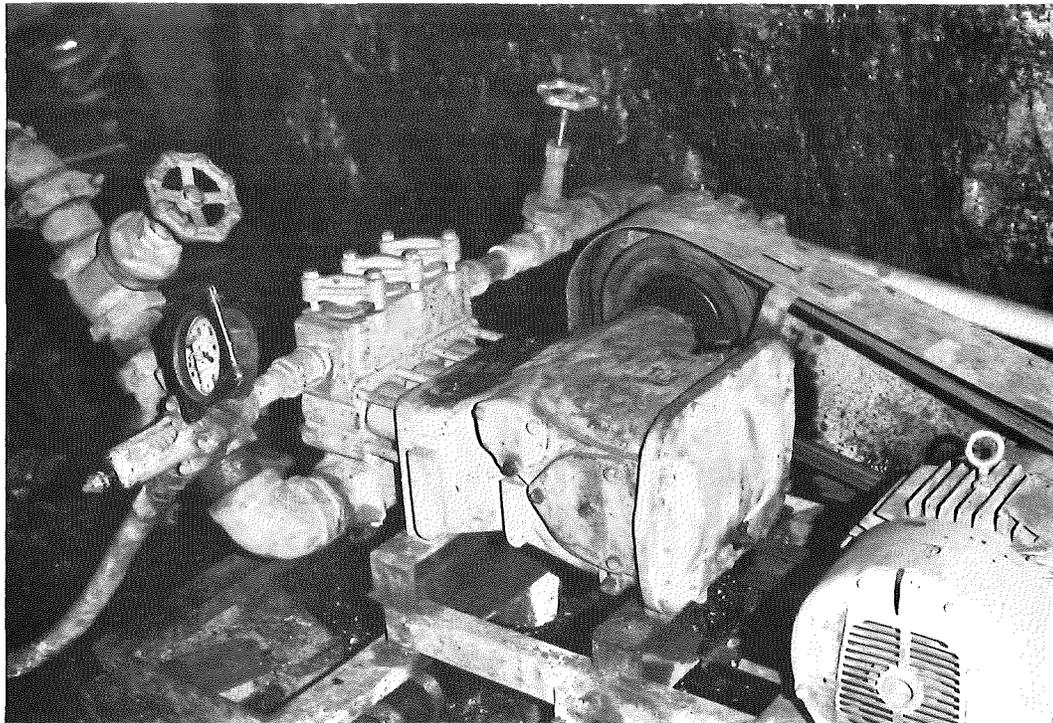
The final 300 to 400 feet of supply line to the shearer was 1-inch ID high-pressure hose. The hose, whose length depends on the length of the working face of the panel, is contained in and protected by the cable handler mounted on the gob side of the face panline conveyor.

Upon entering the shearer the water is divided, part becoming the shearer drum water supply and the remainder going through the motor cooling coils and exiting through a fixed, machine-mounted cluster spray. Pressure gages were mounted at the cluster spray and on the shearer drum supply line.



2208G57

a. Schematic Flow Diagram



2208P148

b. Pump Installed in Mine

Figure 36. Water Pump Installation

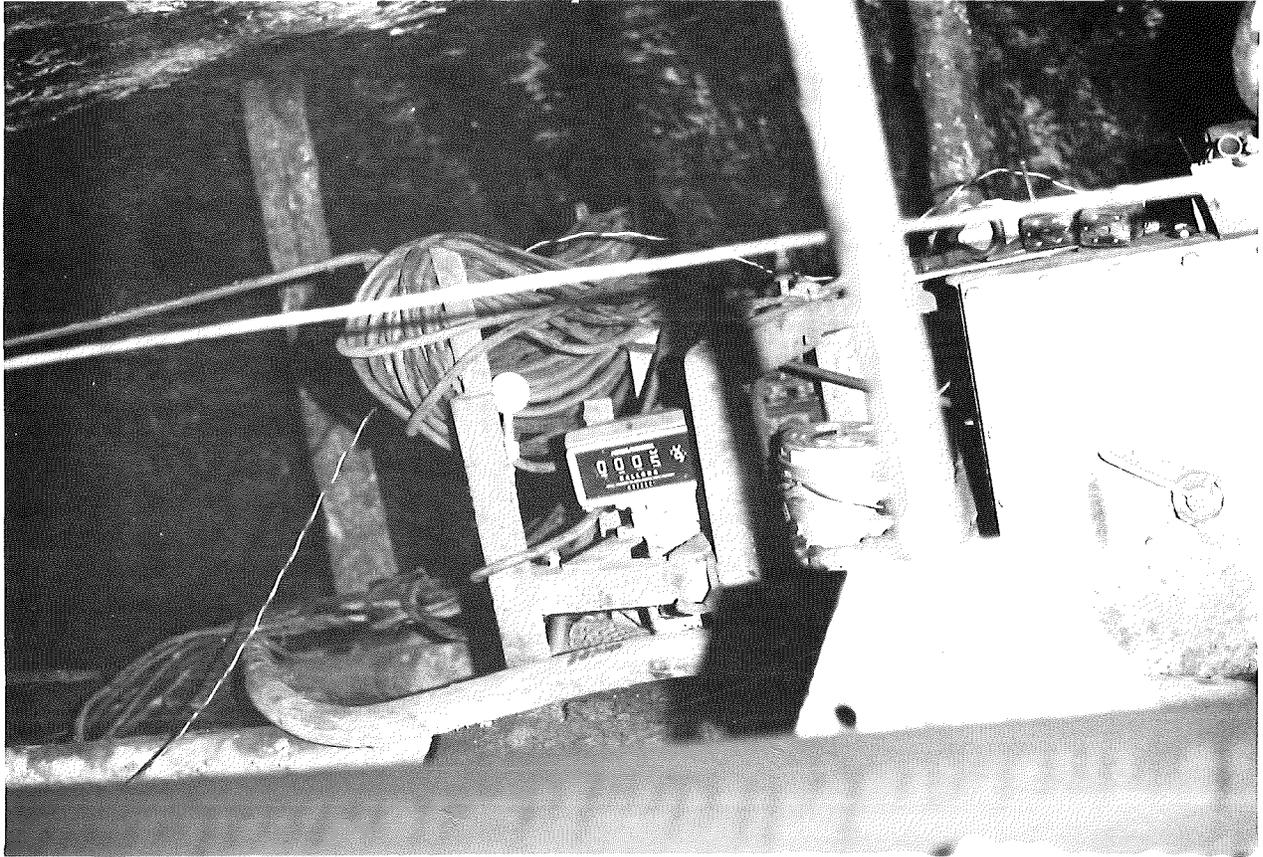
TABLE 5. SPECIFICATIONS FOR PUMP USED TO SUPPLY WATER TO THE LONGWALL

SPECIFICATIONS

<u>Pump</u>	<u>Gallons Per Revolution of Pinion</u>	<u>Countershaft</u>		<u>Valve Chamber</u>		<u>Lubr. Oil</u>	<u>Net Wt. In Lbs.</u>
		<u>Dia.</u>	<u>Keyway</u>	<u>Inlet</u>	<u>Outlet</u>		
470-11	.05892	1-1/2"	3/8" x 3/16"	2-1/2" NPT	1-1/2" NPT	5 Qts. SAE 30	431

MAXIMUM RATED PERFORMANCE

<u>Pump Model</u>	<u>Displacement GPM</u>	<u>PSI</u>		<u>Countershaft RPM</u>
		<u>Inter.</u>	<u>Cont.</u>	
470-11	70	800	600	1188



2208P155

**Figure 37. Location of Water Meter, Pressure Gage and  
Auxiliary Equipment**

#### IV. PHASE II - FABRICATION

The work accomplished during Phase II consisted of the following tasks:

1. Incorporate the design modifications developed during Phase I into the R&P drum or a new drum to permit testing the effect of bit-flushing sprays on dust levels.
2. Develop a test plan giving details of sampler locations, sampler package make-up, data to be collected, and schedule for testing each spray system, and operating parameters to be used during testing.
3. Submit a summary of the method to be used for analysis of the test data to show significant results.

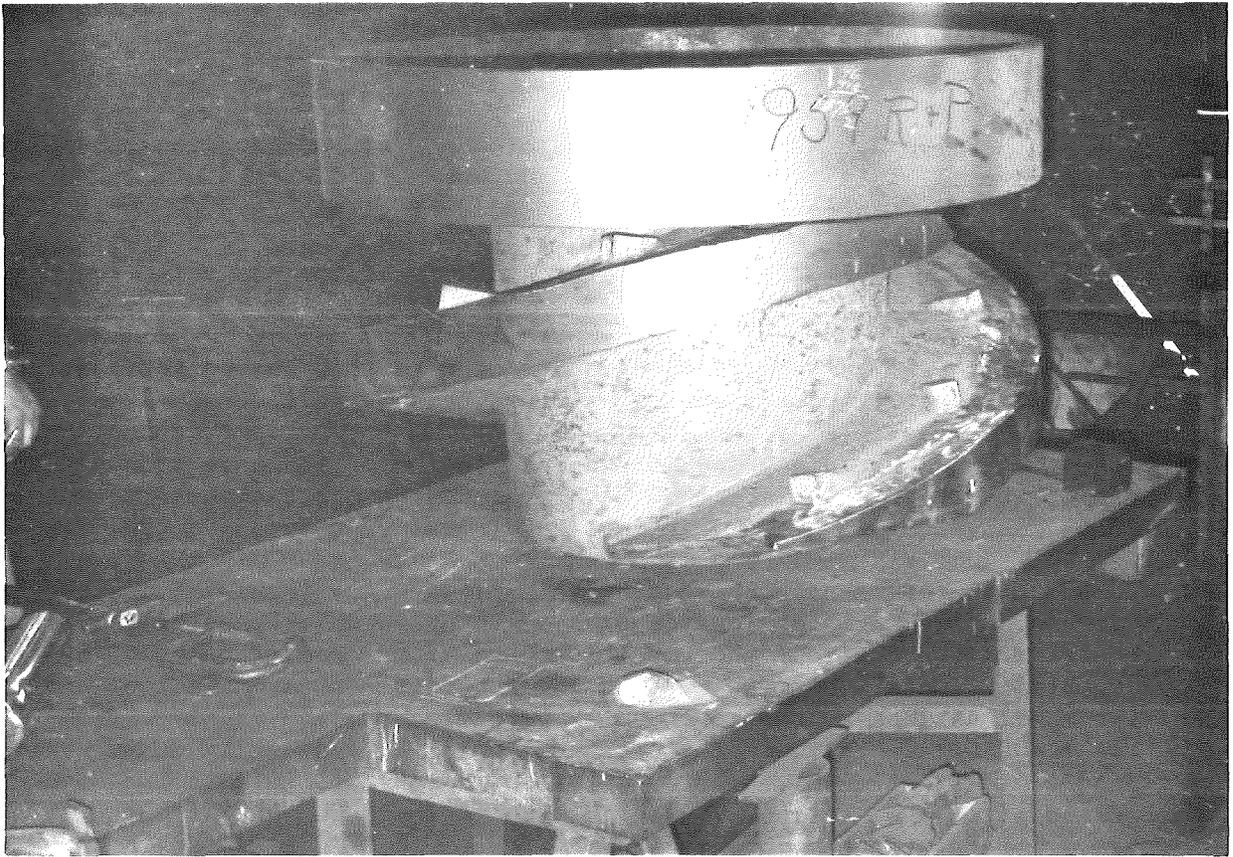
The test plan for the field demonstration and the method for test data analysis were submitted for review by the Bureau as part of the Phase II report (BCR Report L-614) and were approved. In the present report, details of the test plan are discussed in the description of the underground sampling phase of the project in Section V - Underground Demonstration. The method of data analysis is explained in Section VI - Data Analysis.

Due to unforeseen events during this project, two drums of distinctly different design were fabricated; and the second drum, although it performed satisfactorily, required minor modifications after completion of 43 shifts of sampling. Details of the reasons for the different drum designs and later modifications to the second drum were discussed in Section III, Phase I - Design. Following is a discussion of events during the fabrication and modification of the drums. Although some of the details covered occurred after the start of Phase III - Underground Demonstration, they are covered here since they involve fabrication or modification of the drum.

##### A. Fabrication of the First Test Drum

During the initial design phase of the project, BCR decided that the original Eickhoff drum design was more practical for use in the tests since the required water supply chamber for the bit-flushing sprays was already incorporated into the design (Figure 38). Since none of these drums was available in the United States, the drum in use at R&P could not be spared, and delivery time of a drum from Germany would be several months, a drum was fabricated, based on specifications supplied by the Pittsburgh office of Eickhoff America, Inc. Design details such as direction and angle of the drum spirals and the basic lacing pattern were decided on in conjunction with R&P Coal Company, based on the drum then in use.

The blank drum was fabricated at an independent machine shop in Portage, Pa. between June and September 1973, as part of Phase I. The modifications required, described in detail in Section III of this report, were made during Phase II and included:



2208P9

**Figure 38. Eickhoff Drum of Original Design Showing  
Sprays Mounted on Walls of Chamber Under Scroll**

1. Fabrication of a water supply chamber for the bit-flushing nozzles located on the end ring.
2. Installation of an additional water supply pipe from the main water supply pipe at the center of the drum to the end ring chamber.
3. Drilling through the scroll and end ring block mounting plates at the proper locations for supplying water to the nozzles.

These modifications were completed in May 1974, and successful water flow tests of the spray systems were conducted on May 15 and May 17, with results as shown in Tables 6 and 7.

#### B. Fabrication of the Second Test Drum

When the R&P Coal Company decided the drum rotation should be reversed, BCR also decided to redesign the test drum because:

1. The new standard Eickhoff drum no longer incorporated a water chamber in the scroll; therefore, as required in the research contract, the bit-flushing spray systems would have to be retrofitted to this new design.
2. Because of the large size of the scroll water chambers, approximately 1.0 to 1.5 minutes were required to fill them. This waiting time either resulted in decreased production or in mining without sprays. The latter alternative increased dust levels as well as the possibility of plugging the nozzles with coal.
3. The surface area of the scroll water chambers was large, creating greater opportunity for the formation of rust particles that could eventually plug the nozzles.
4. As a minor consideration the weight of the drum could be reduced slightly, because of less water in the system and less steel required to fabricate the scrolls.

Because of scheduling problems, the new drum was fabricated at a different machine shop, in Mannington, West Virginia. The first BCR drum was stripped down to the hub, Figure 39, and rebuilt, using the new BCR design discussed in Section III of this report. The new drum was fabricated between September and December 1974.

The required drum modifications included:

1. Reversing the scroll spiral direction and changing the scroll angle from 9 degrees to 18 degrees.
2. Fabricating new scrolls in accordance with BCR's new scroll and water channel design.

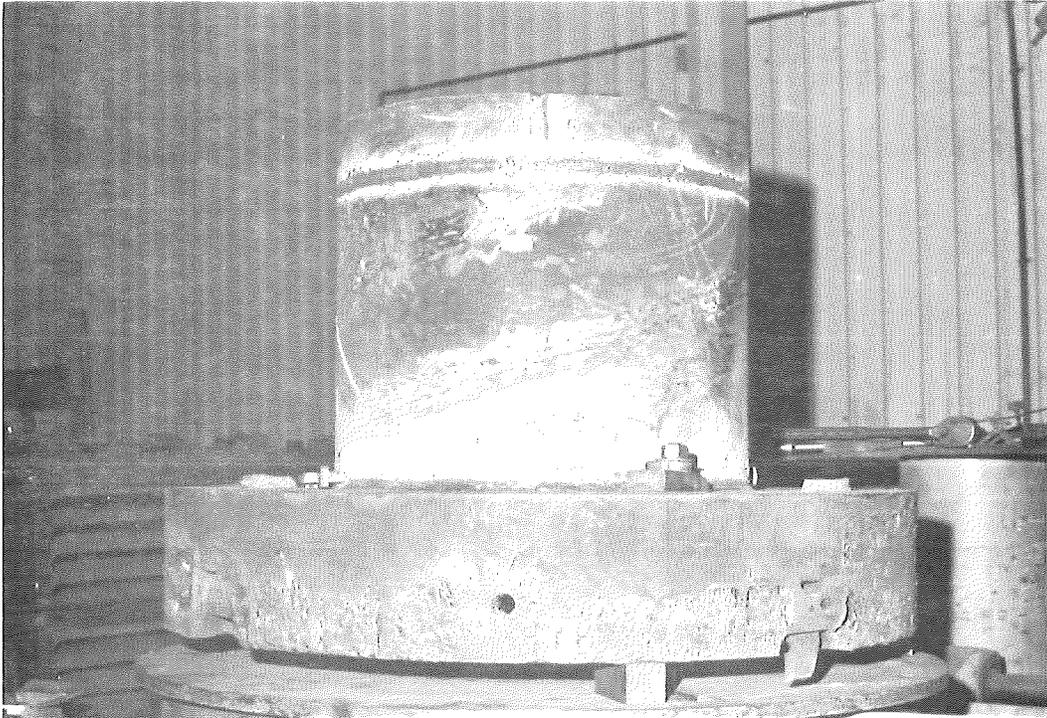
TABLE 6. FLOW TEST OF SHEARER, MAY 15, 1974

Pressure, Pound Per Square Inch (psi)				
<u>Pump</u>	<u>Drum Nozzles</u>	<u>Cluster Spray</u>	<u>GPM</u>	<u>Comments</u>
295	65	--	16.5	Bit nozzles only
450	95	--	21	Bit nozzles only
290	50	200	19.5	Bit nozzles and Cluster Spray
290	50	180	20.0	Bit nozzles and Cluster Spray
265	35	180	20.0	Bit nozzles, Cluster Spray, and Drum Face Sprays

TABLE 7. FLOW TEST ON MODIFIED DRUM, MAY 17, 1974

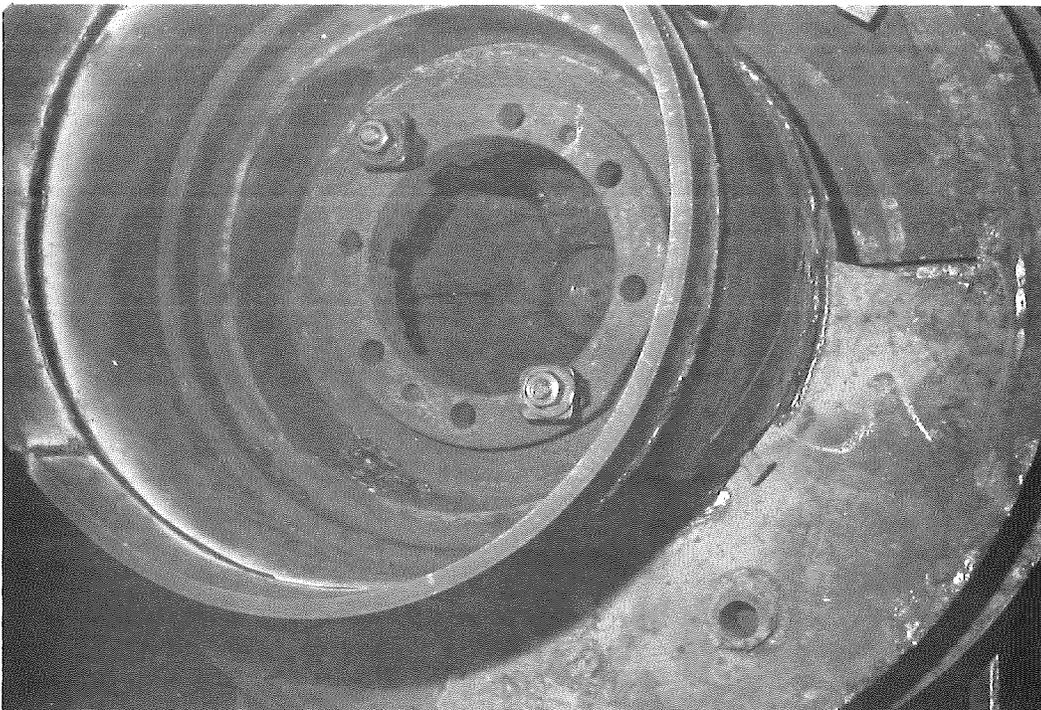
<u>Pressure, Pound Per Square Inch (psi)</u>				
<u>Inlet to Machine</u>	<u>Discharge of Machine</u>	<u>Drum</u>	<u>GPM</u>	<u>Comments</u>
150	80	75	26	Bit sprays, drum end sprays and cluster spray
200	140	135	27	Bit sprays and cluster spray
200	--	--	15	Dry drum

Note - With the spray system modifications, the pump used for the test did not have sufficient capacity to permit operation at higher pressures.



2208P111

**Figure 39. BCR Drum Stripped of the Original Scrolls  
With Addition of Extension to Hub to Correct Axial  
Positioning of Mounting Plate**



2208P109

**Figure 40. Repositioned Mounting Plate on BCR Drum**

3. Correcting the axial positioning of the mounting hub.
4. Mounting the bit blocks to insure uniform block spacing on the scrolls.

Figures 39 through 45 illustrate stages of the drum fabrication and the modifications made.

Because of the lack of a high water-pressure source, only low-pressure flow tests were made to check for leaks and to insure flow to all nozzles (Figure 45).

The new drum was delivered to Jane mine during the week ending December 28, 1974 and installed on January 4, 1975.

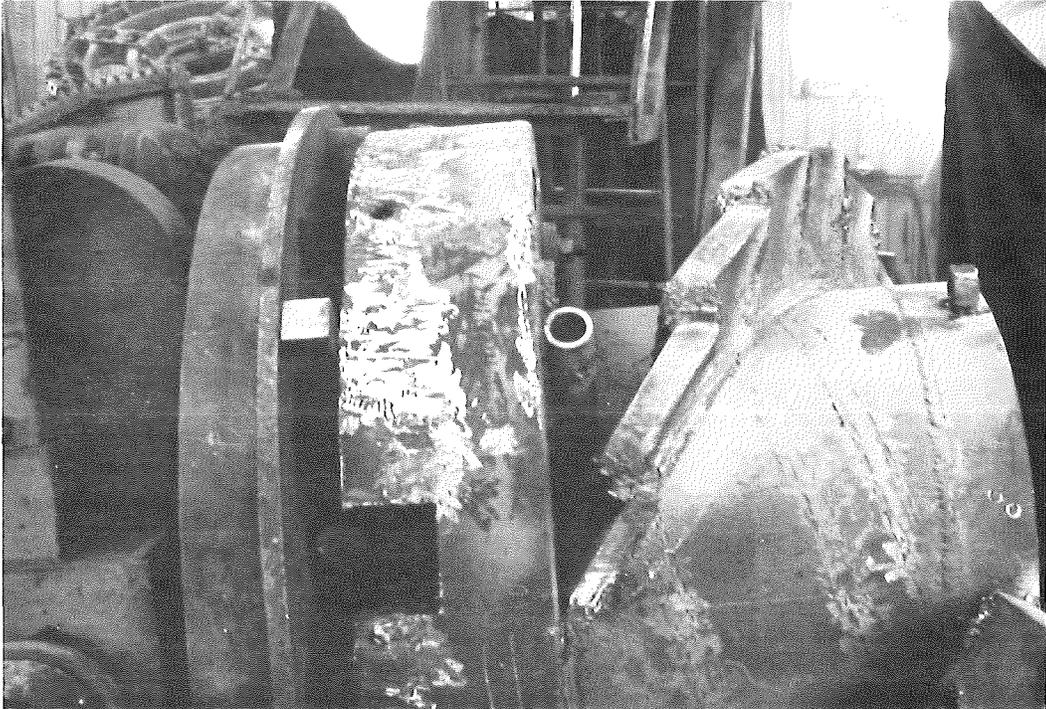
#### C. Modification of the Second Test Drum

This drum was used until January 23, 1975, when mining of the panel was completed. The drum was removed from the mine and again shipped to the fabricator for inspection, repair, and minor modifications, as discussed in Section III. The modifications and repairs included:

1. Welding of hairline cracks which had developed along welds in the end ring (Figure 46).
2. Shortening the scrolls to eliminate interference between the panline and the last bit block on each scroll (Figures 47 and 48).
3. Minor changes in the end ring lacing pattern to improve sumping characteristics (Figure 49).
4. Addition of scraper plates to the drum face to improve transport of coal from the end ring cavity to the panline (Figure 50).
5. Mounting of the standard scroll sprays in a pipe header welded along the side of the scrolls, to duplicate the Eickhoff design (Figure 51).

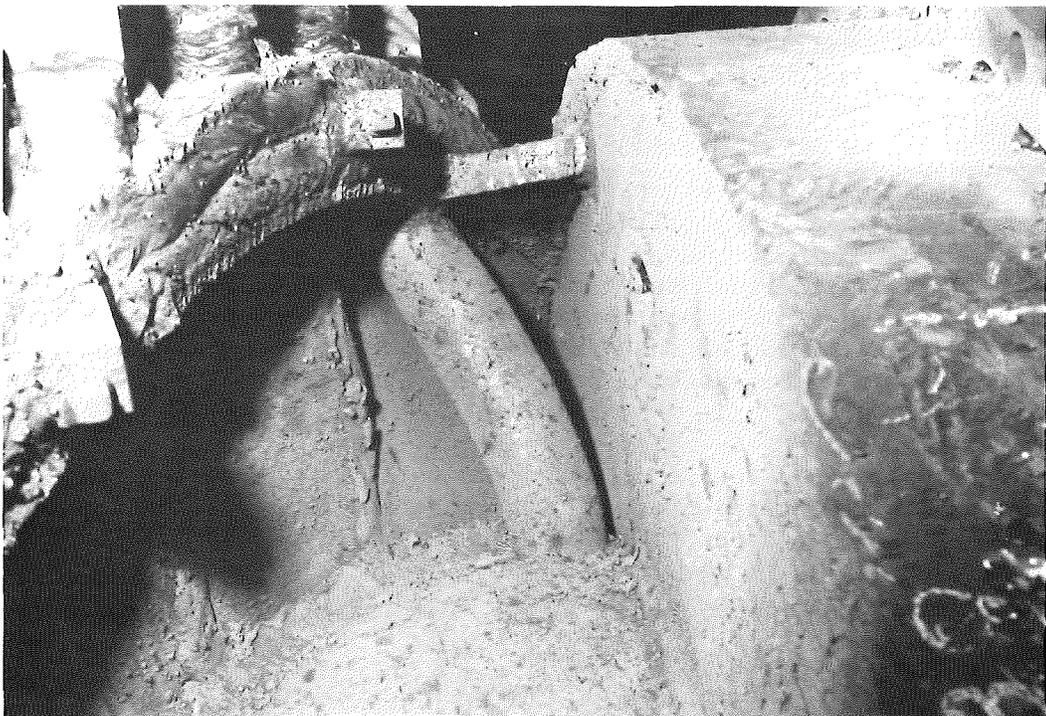
These modifications started in February 1975 and were completed in April 1975. The drum was shipped to Jane mine in May, but due to underground conditions, installation of the drum and sampling were delayed until August 25. Reasons for these delays will be discussed in Section V - Underground Demonstration.

The redesigned test drum performed well throughout the test period with no problem in maintaining production rates and no maintenance or safety problems reported. Evidence of the drum's capability to cut coal can be shown by the fact that a shift record of 1,400 tons and a 24-hour record of 3,500 tons were set during the test period (Test shift No. 57 and the two succeeding shifts).



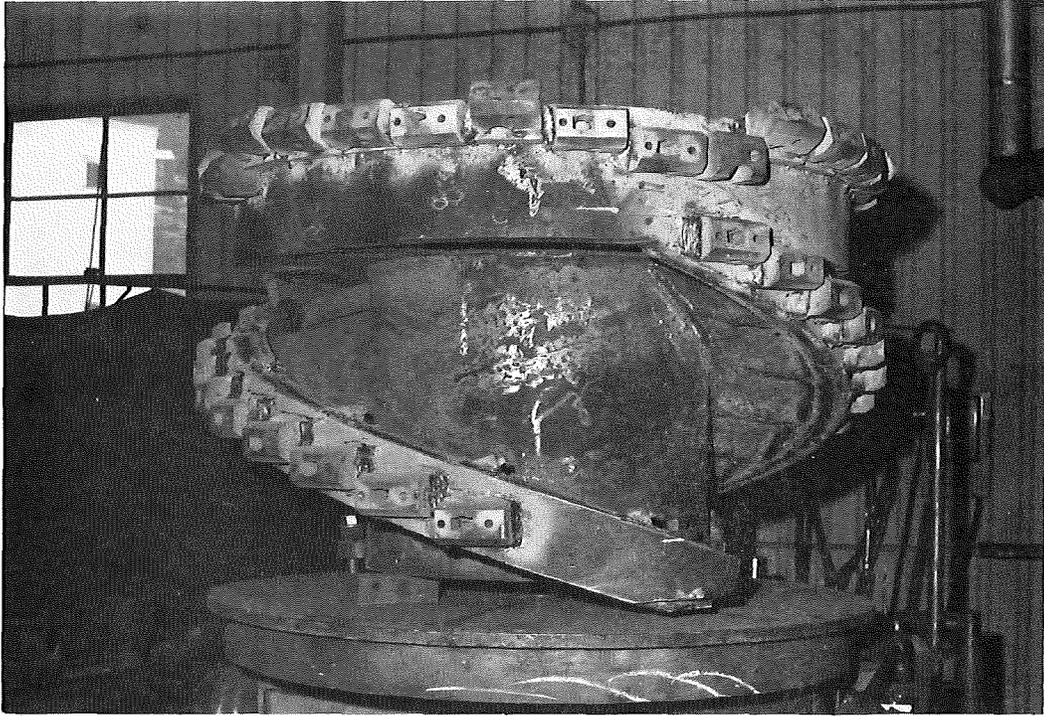
2208P110

**Figure 41. Redesigned Scroll Web and Water Supply Pipe of BCR Drum**



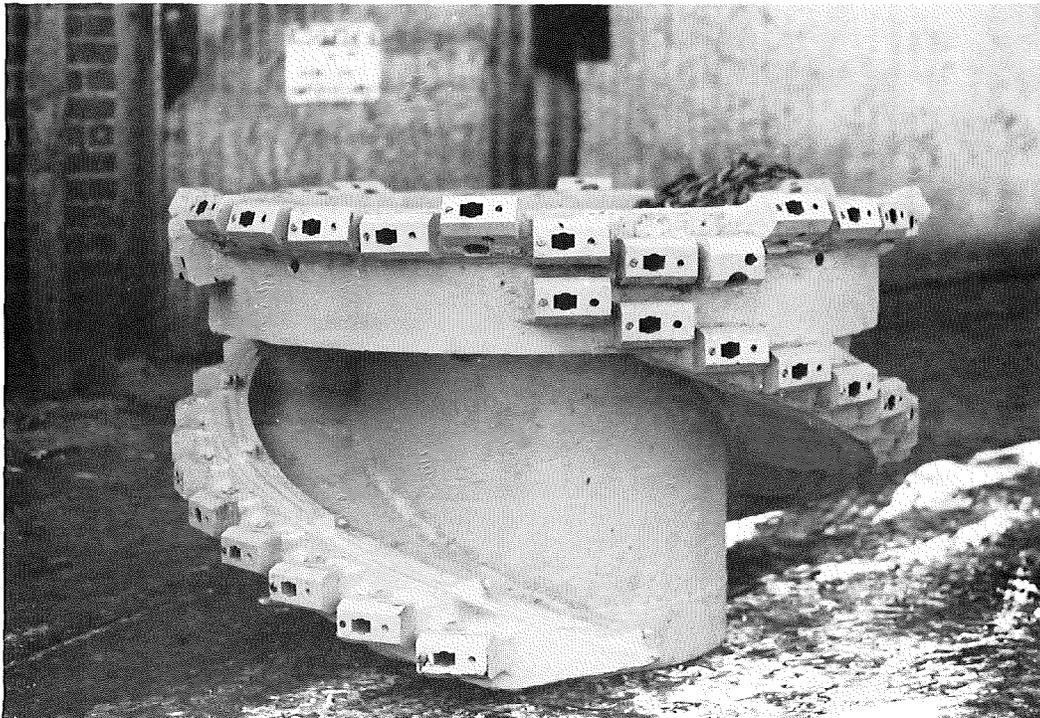
2208P114

**Figure 42. Water Supply Pipe to Scroll Water Chamber**



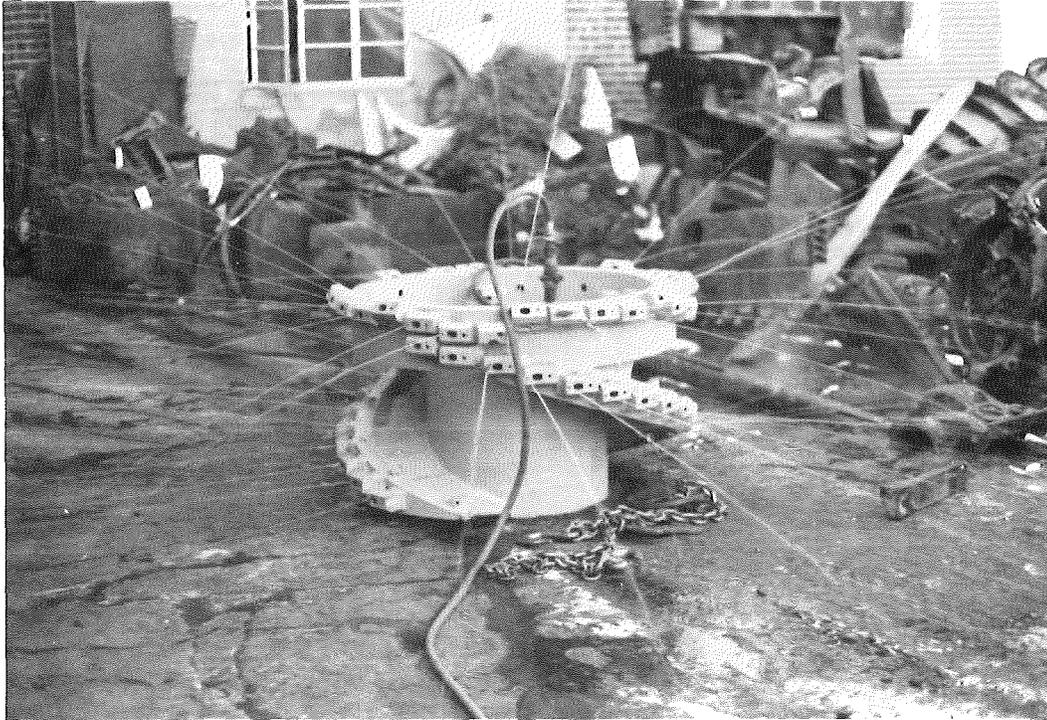
2208P115

**Figure 43. Blocks Installed on Scrolls of BCR Drum**



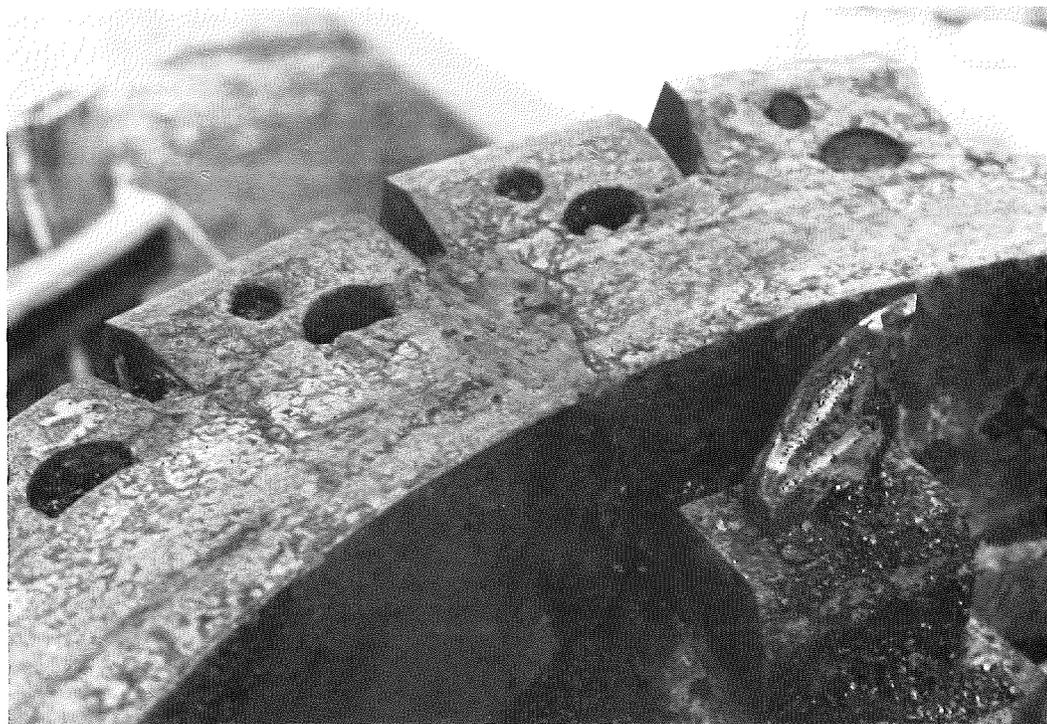
2208P117

**Figure 44. Completed Test Drum with Reversed Scroll Direction (Incorporates Modified Water System)**



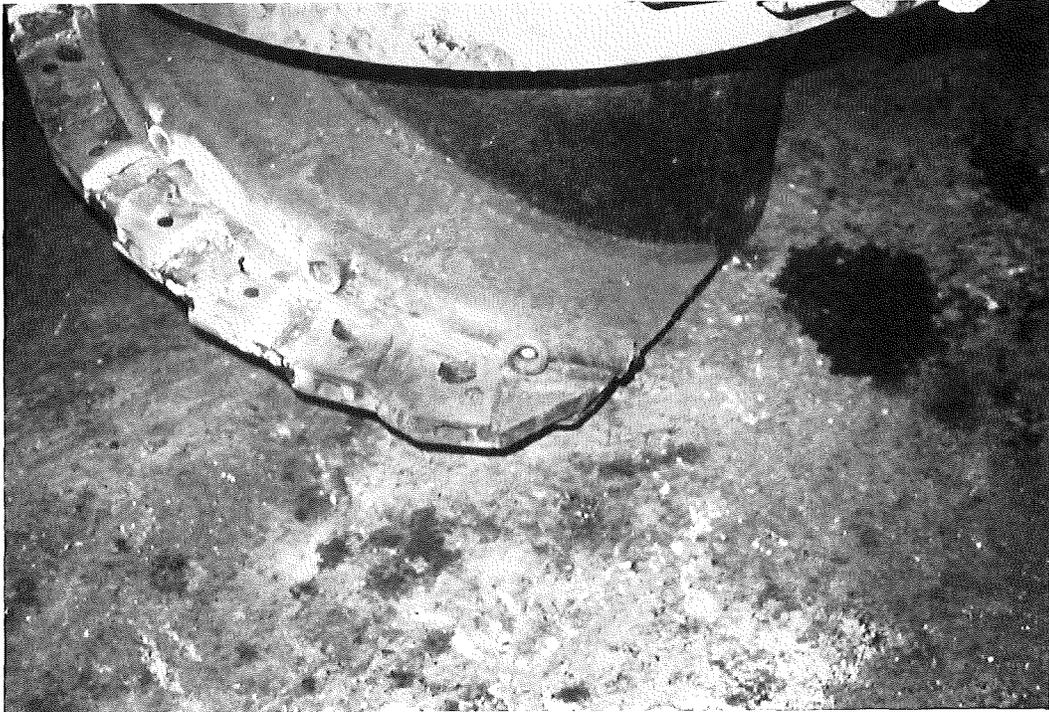
2208P118

**Figure 45. Flow Test of New BCR Drum**

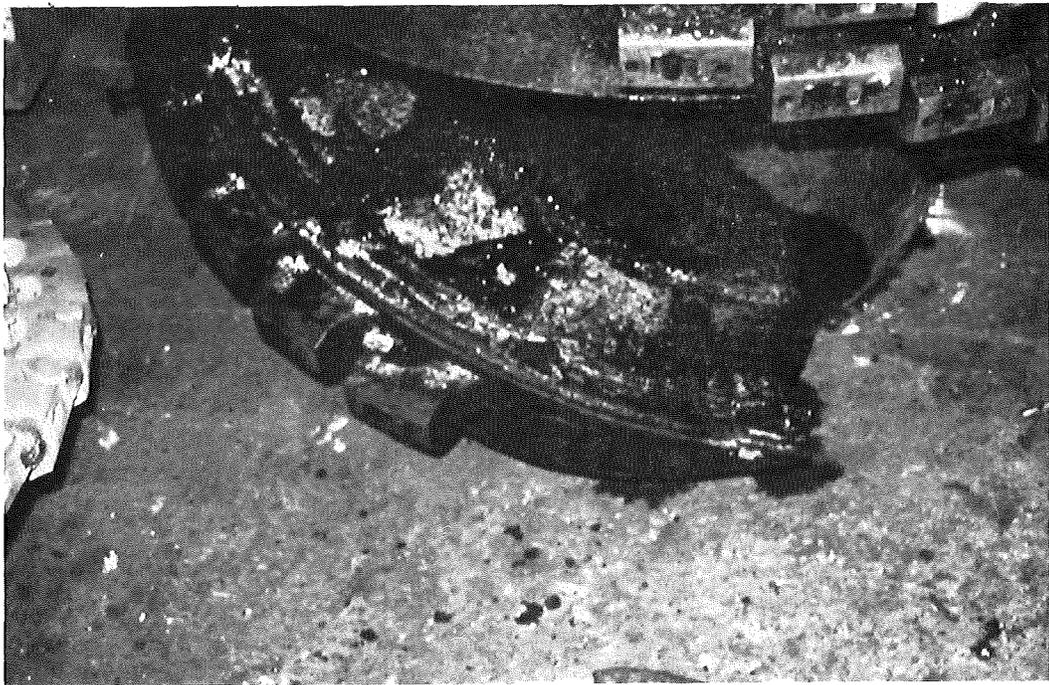


2208P126

**Figure 46. Hairline Fracture in the End of the Drum**

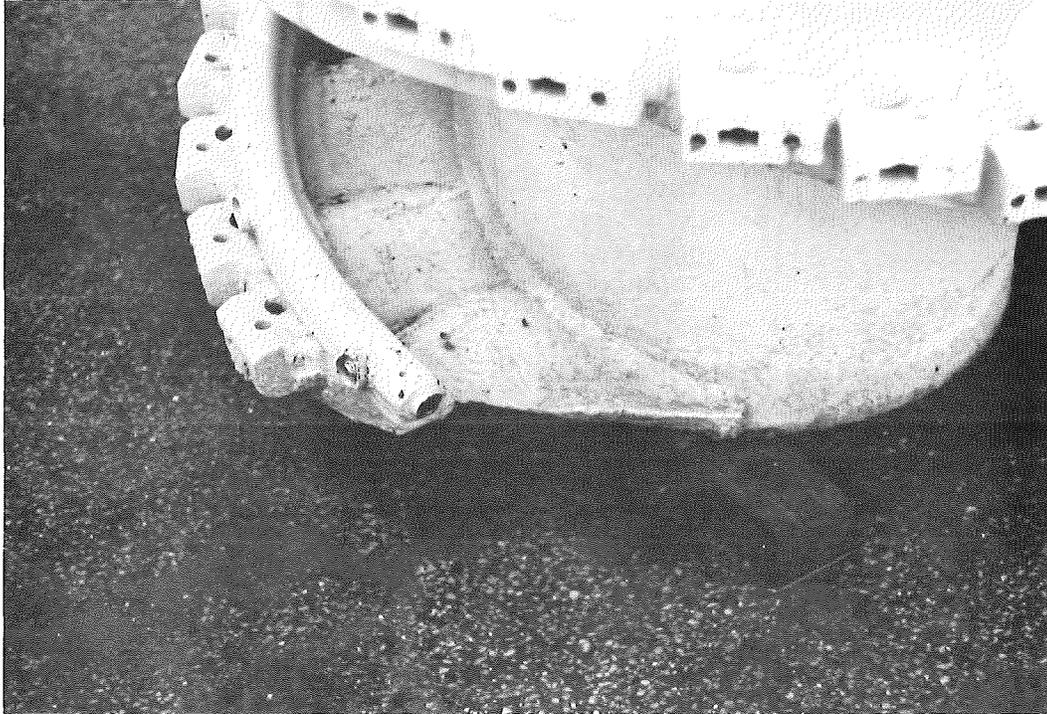


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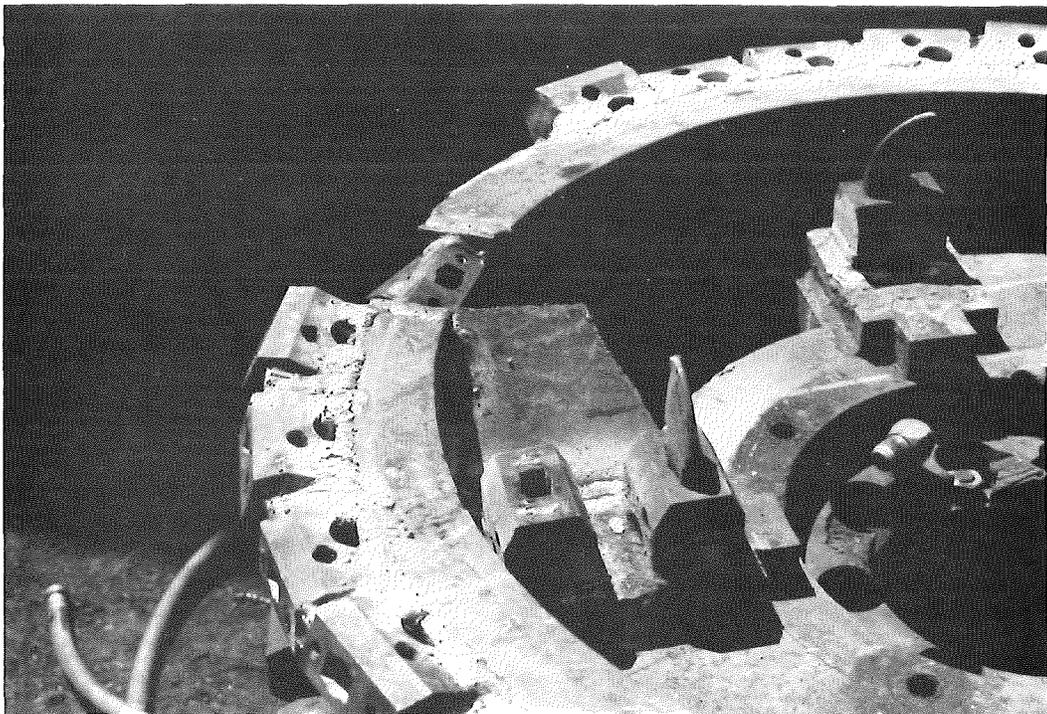
2208P132

**Figure 47. R&P Drum (Top) and BCR Test Drum (Bottom)  
Showing Excessive Length of Scrolls on BCR Test Drum**



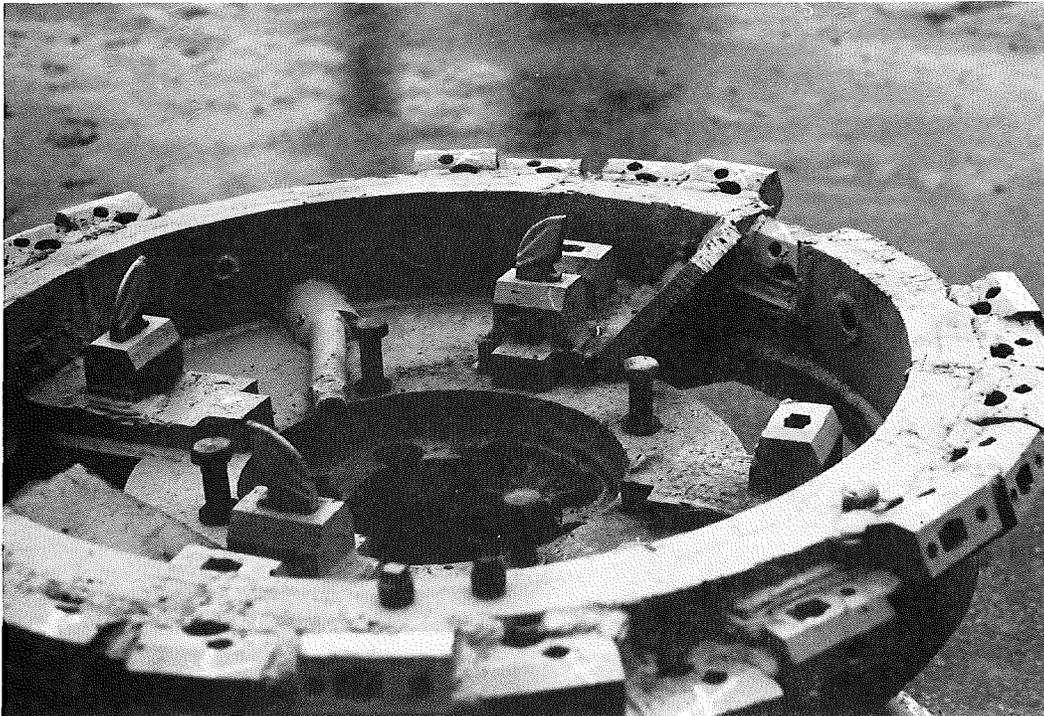
2208P139

**Figure 48. Scroll After Trimming**



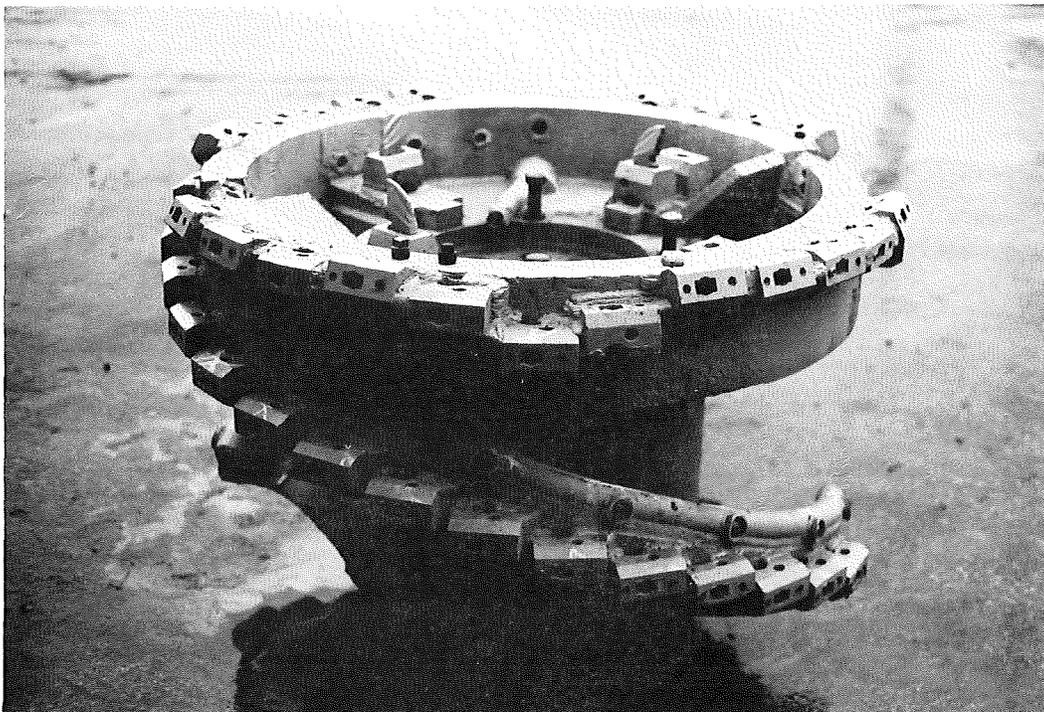
2208P135

**Figure 49. Sumping Blocks Mounted in End-ring  
Cutouts, 180° Apart**



2208P136

**Figure 50. Revised Drum Showing Addition of Scrapers**



2208P140

**Figure 51. Revised Standard Scroll Sprays**

## V. PHASE III - UNDERGROUND DEMONSTRATION

The underground sampling phase of the project was conducted in the Jane #1 mine of the Rochester & Pittsburgh Coal Company in Indiana County, Pa. The mine is located in the "D" slope of the Lower Freeport seam, which has an average seam thickness of 56 inches.

### A. Sampling Procedures and Equipment

#### 1. General Guidelines and Sampling Procedures

Phase III, Underground Demonstration, was conducted according to the following guidelines:

a. Sampling was conducted for 94 production shifts, 63 of which were valid. A valid shift was defined as one in which production was at least 50 percent of the average shift tonnage from the longwall section for the previous month as established by Rochester and Pittsburgh Coal Company.

b. Testing was normally conducted during two of the three daily production shifts.

c. BCR personnel were present during all sampling shifts, and any variations or problems were recorded.

d. Varied test conditions under which sampling was to be conducted were:

(1) No water through the drum but with 27 gpm through fixed sprays mounted on the miner behind the drum.

(2) With bit-flushing nozzles located in the bit block in front of the bit.

(3) With bit-flushing nozzles located in the block behind the bit.

(4) With the standard Eickhoff spray nozzles.

(5) Tests with the "wet" modes, as defined in Items (2), (3), and (4), at flow rates of approximately 21 gpm (150 psi) and 27 gpm, (250 psi) with the water pressure measured at the closest feasible point upstream of the drum.

The testing program was conducted in the sequence shown in Table 8, and reflects the seven test conditions specified in Items (1) through (5) above.

#### 2. Dust Sampling Equipment

Four types of samplers utilized for this project were specified

TABLE 8 - UNDERGROUND SAMPLING SEQUENCE AS A FUNCTION OF NOZZLE LOCATION AND WATER FLOW RATE

<u>Shift Numbers</u>	<u>Valid Shifts</u>	<u>Cumulative Valid Shifts</u>	<u>Nozzle Location</u>	<u>Avg. Water<sup>(1)</sup> Pressure, psi</u>	<u>Avg.<sup>(1)</sup> gpm</u>
1 - 3	0	0	Back of Bits	-	--
4 - 5	0	0	Front of Bits	-	--
*6 - 20	11	11	Standard System	95	20.4
21	0	11	Front of Bits	-	--
22 - 30	8	19	Front of Bits	136	21.7
31 - 37	5	24	Back of Bits	135	22.6
38	0	24	Back of Bits	-	--
39 - 43	2	26	Back of Bits	151	20.4
44 - 63	9	35	Standard System	214	20.0
64 - 66	2	37	Front of Bits	231	26.0
67	1	38	Front of Bits	223	23.0
68	1	39	Front of Bits	363	29.1
69	1	40	Front of Bits	204	21.6
70 - 71	2	42	Front of Bits	265	27.6
72	1	43	Front of Bits	183	22.2
73	1	44	Front of Bits	225	24.8
74 - 77	3	47	Back of Bits	267	26.1
78 - 79	2	49	Back of Bits	205	21.4
80 - 83	4	53	Back of Bits	302	26.7
84	0	53	Fixed Sprays	-	--
85 - 91	7	60	Standard System	311	26.3
92 - 94	3	63	Front of Bits	263	29.5

(1) Average values based on valid shifts only

\* Testing was done with R&P production drum

by the contract and included (1) dampened personal samplers with cyclones, (2) dampened personal samplers without cyclones (gross sample), (3) midget impinger samplers (driven by Unico pumps), and (4) MRE gravimetric samplers. The samplers were assembled in packages, illustrated in Figures 52 through 60, and located in the longwall section as shown in Figure 61.

The sampling locations, type, and number of samplers required per shift are summarized in Table 9 and the total number of samplers utilized is shown in Table 10. The main intake and return airway samplers remained stationary throughout the shift. All other samplers were attached to self-advancing equipment such as roof supports or the shearer itself.

The main intake airway sampler was hung approximately midway between the roof and bottom by using a "c" hook anchored between the roof and roof bolt plate. (Figure 52.) The shearer package was mounted on the shearer near the operator's controls (Figures 56 through 58). The two face packages (midpoint and head) were attached to the self-advancing roof supports approximately midway between the roof and bottom. (Figures 54 and 55.) The midget impinger sampler was mounted adjacent to the tail package for the duration of the pass(es) sampled. (Figure 60.)

All samplers except the midget impinger were scheduled to operate continuously for the entire production shift of 4-1/2 to 6 hours.

The general procedures for processing the filters are included as Appendix A to this report.

Procedures for the care, maintenance, and operation of the sampling equipment are included as Appendix B to this report.

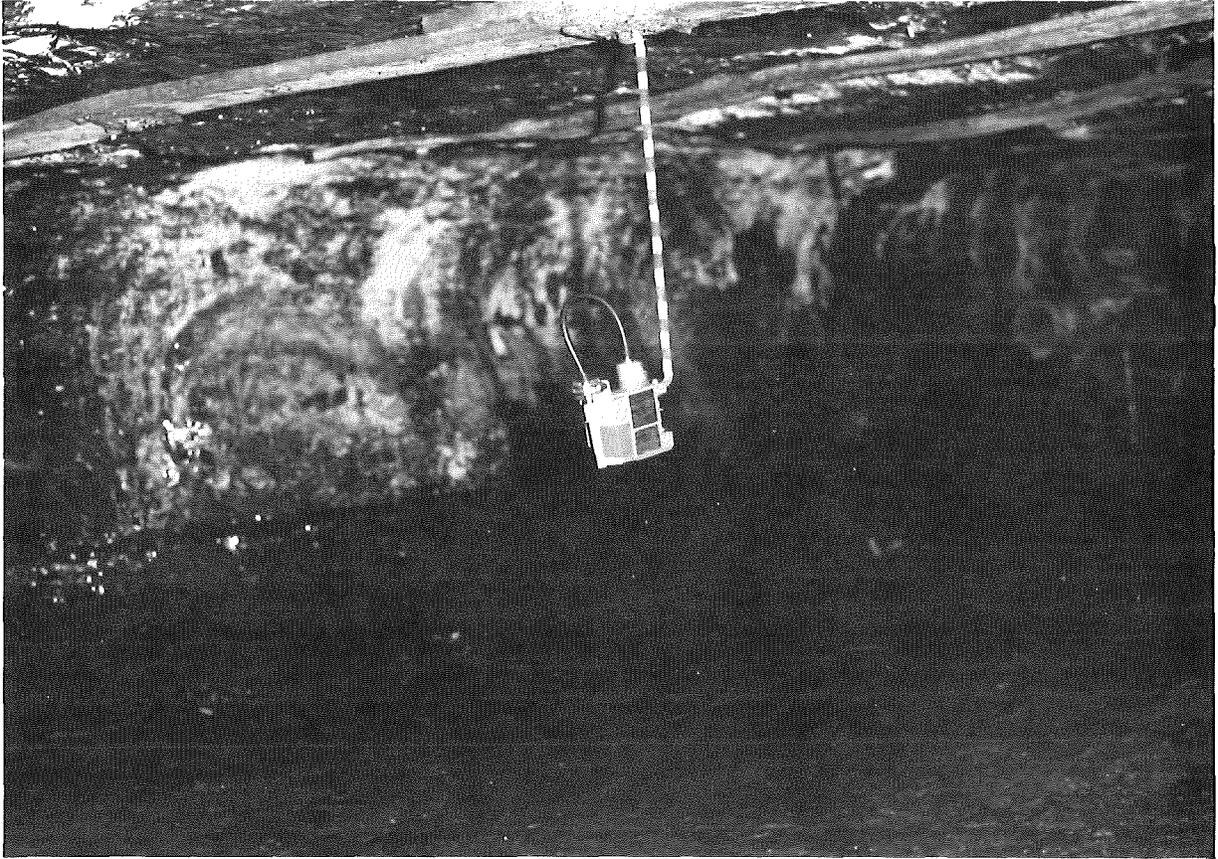
### 3. BCR Personnel Assignments

The sampling was conducted by teams of three men for each shift. Their normal locations and specific functions were as follows:

#### a. Location 1: Tail end of panel

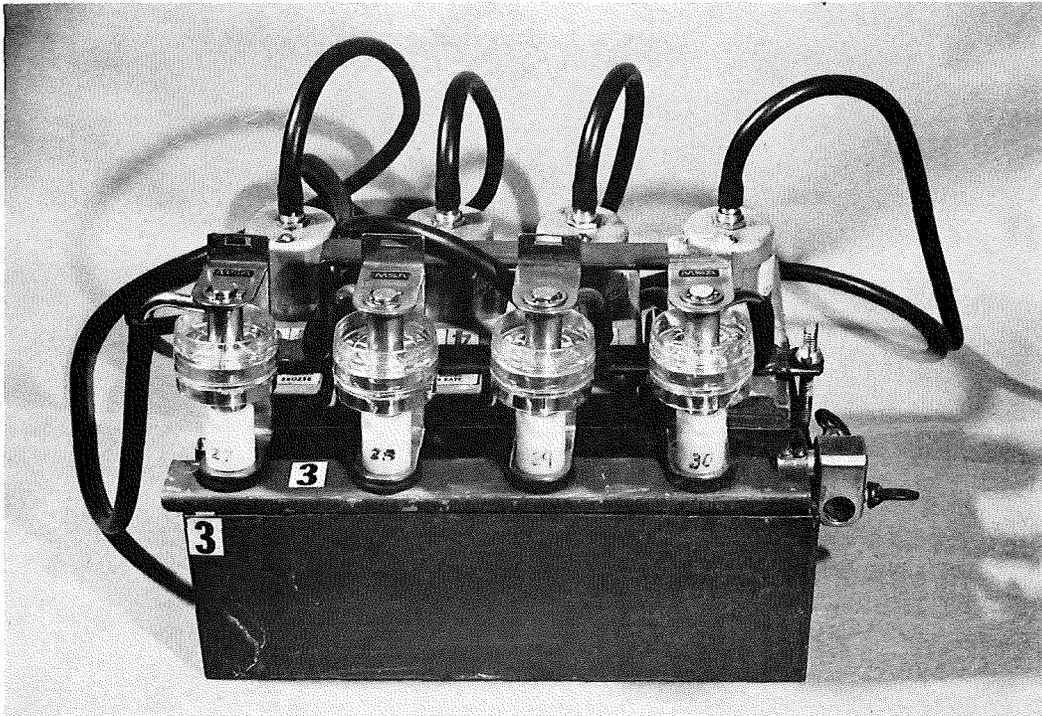
(1) Record the following data:

- (a) Intake heading dimensions at the cross section where air velocity measurements were taken
- (b) Intake heading air velocity using a vane anemometer
- (c) Beginning and ending times of individual shearer passes
- (d) Cross-sectional dimensions of the airway along the face

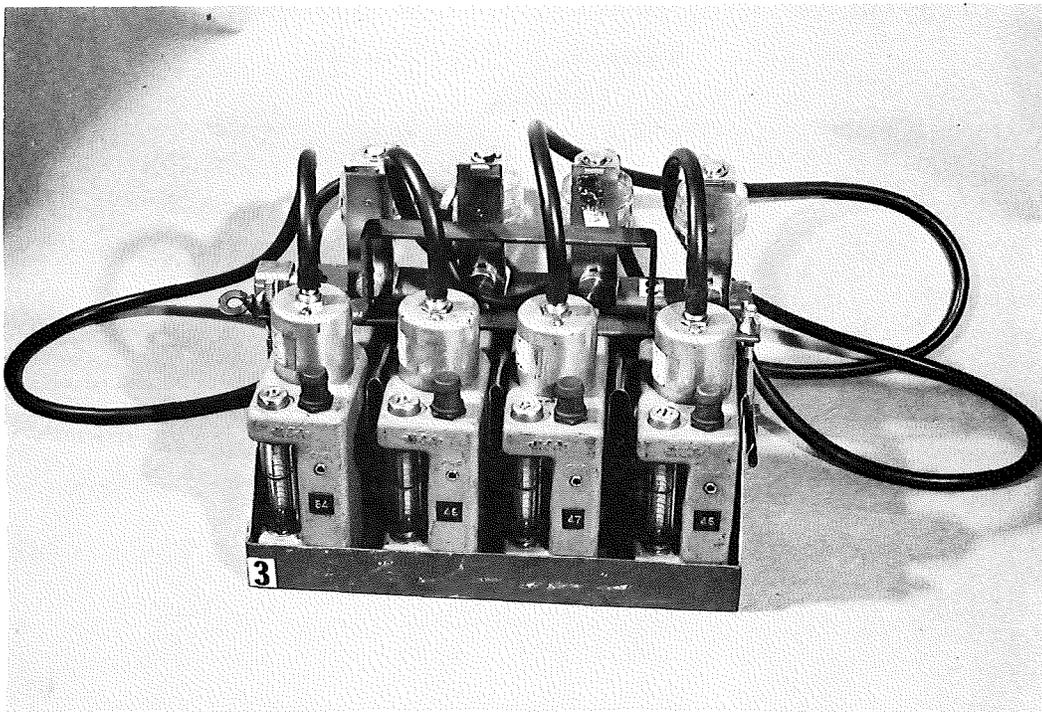


2208P145

**Figure 52. MSA Personal Sampler Suspended from Roof of Intake Heading, Used to Sample Dust Concentration of Intake Air**

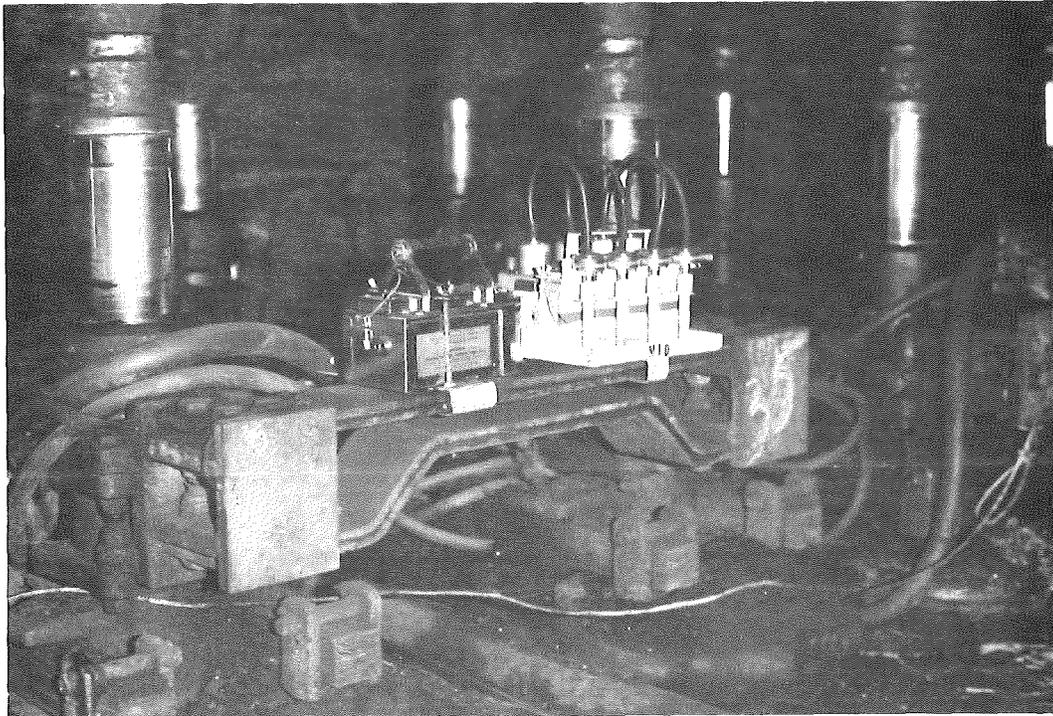


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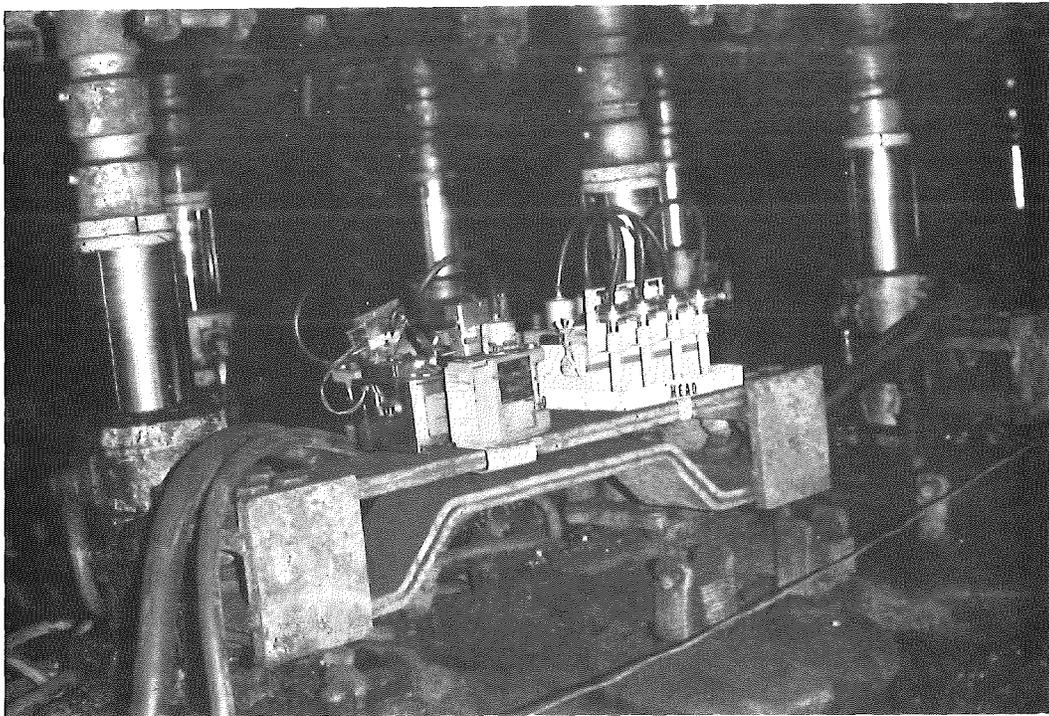
2208P83

**Figure 53. Front and Rear Views of the MSA Personal Sampler Package Used at the Midpoint and Head Locations**



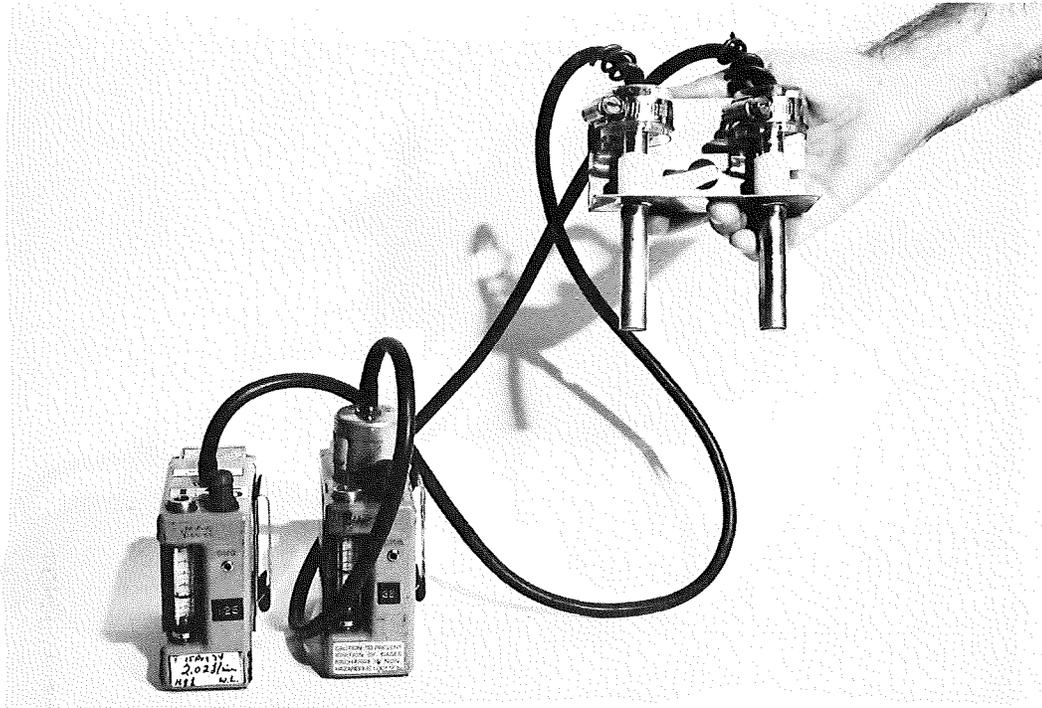
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**Figure 54. Midpoint Sampling Package Mounted on Roof Support Chocks**



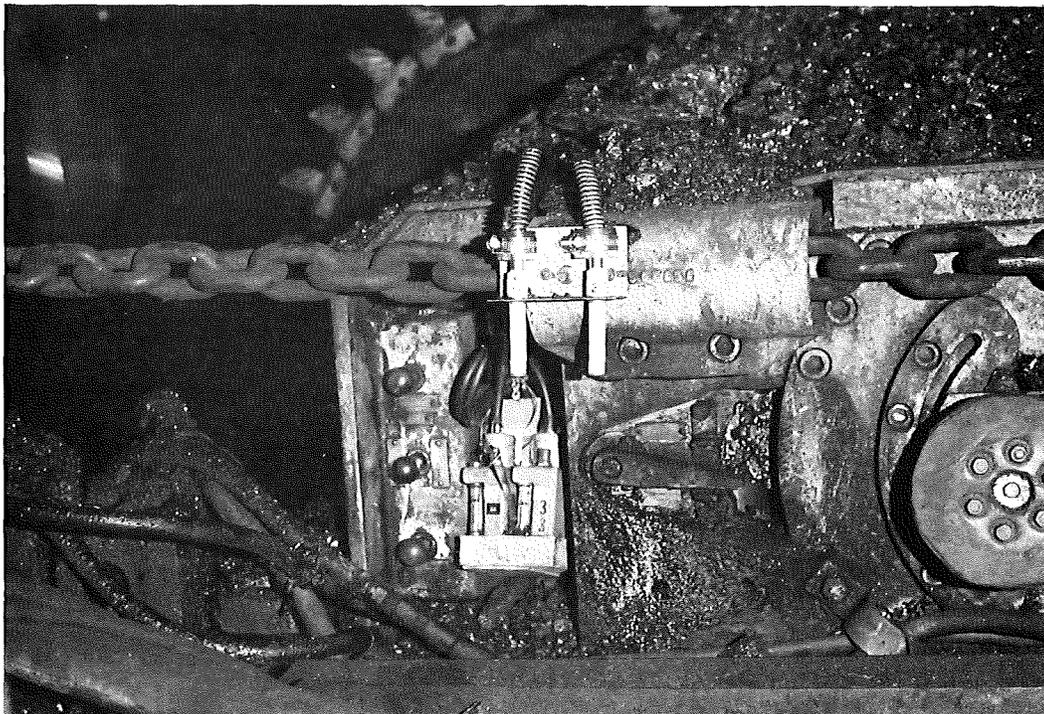
2208P149

**Figure 55. Head Sampling Package Mounted on Roof Support Chock**



2208P102

Figure 56. Sampling Package Used on the Shearer



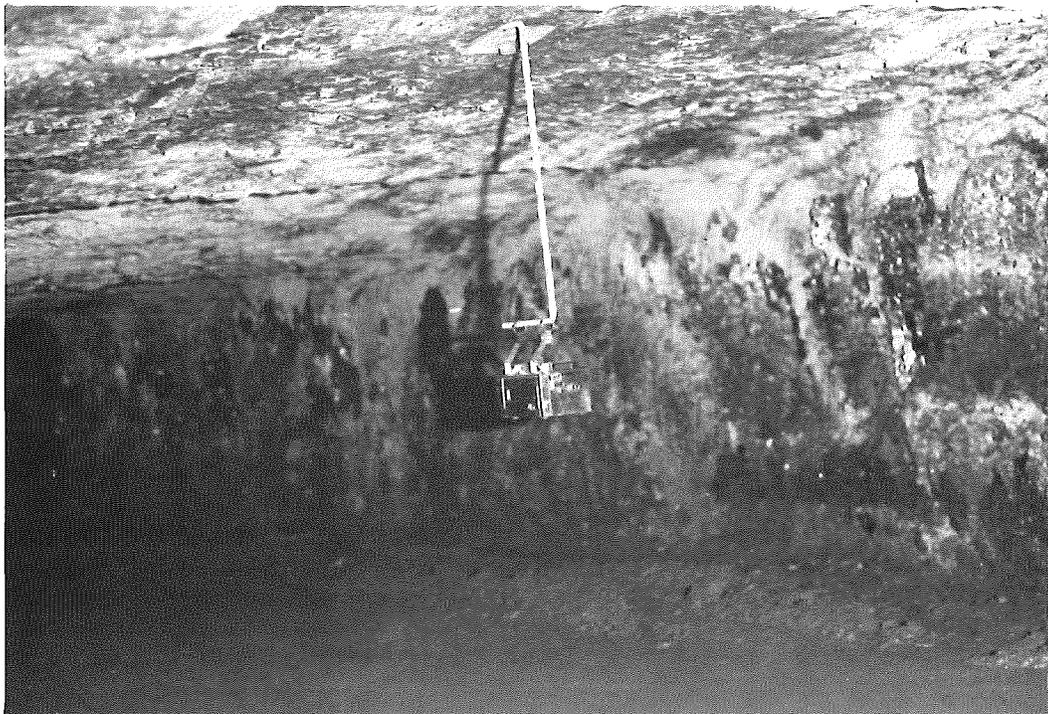
2208P146

Figure 57. Personal Samplers Mounted on Shearer



2208P162

**Figure 58. Position of Shearer Operator Relative to the Samplers During Normal Shearer Operation**



2208P153

**Figure 59. MRE Sampler Mounted in Return**



2208P121

**Figure 60. Midget Impinger Sampler Used to Sample Individual Passes of the Shearer**

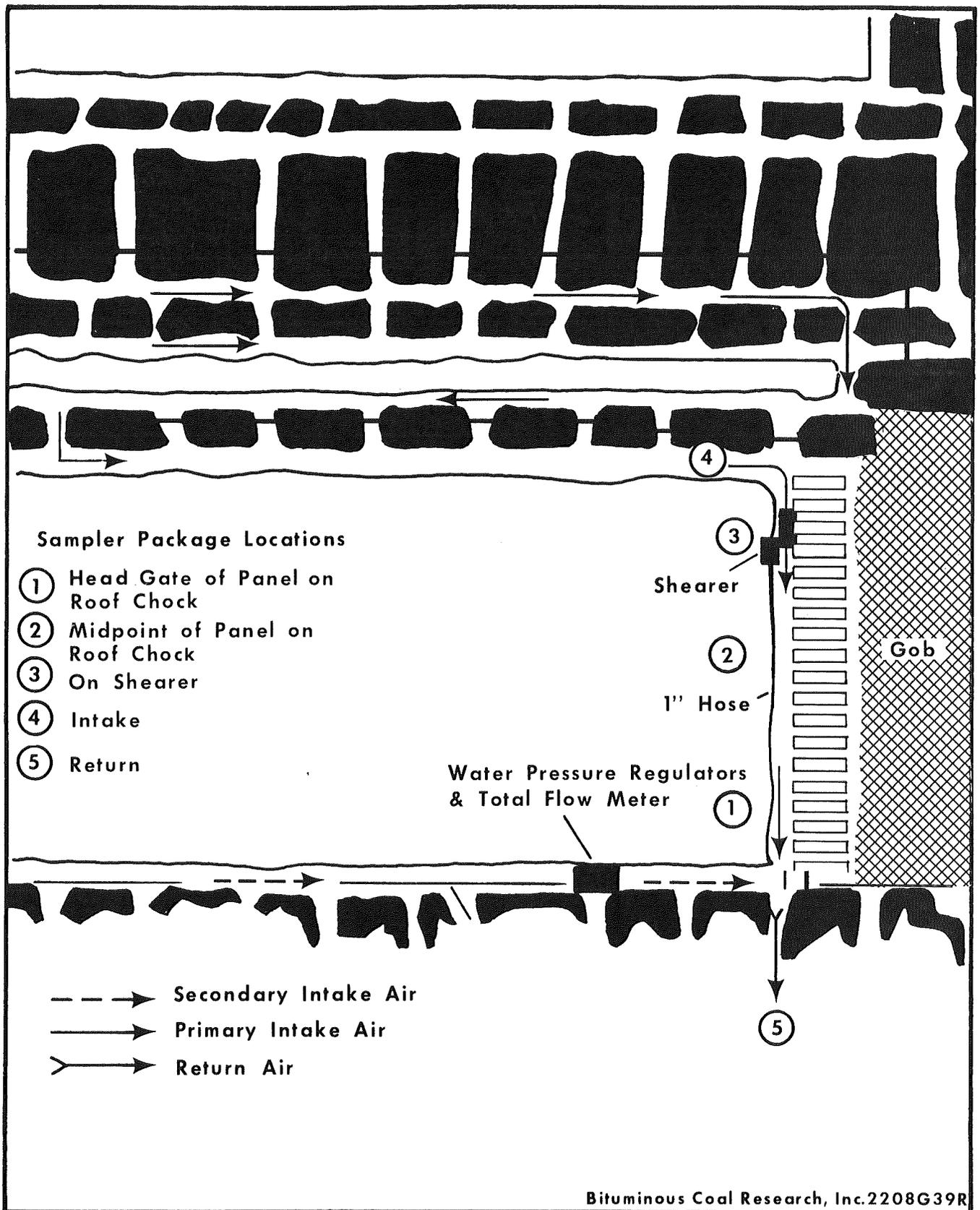


Figure 61. Typical Sampling Setup in Longwall Section

TABLE 9 - DISTRIBUTION AND NUMBER OF SAMPLERS  
 REQUIRED FOR SAMPLING PROGRAM ON LONGWALL SHEARER

	<u>Dampened*</u> <u>Personal</u> <u>w/Cyclone</u>	<u>Dampened</u> <u>Personal</u> <u>w/o Cyclone</u>	<u>MRE</u>	<u>Midget</u> <u>Impinger</u>
Main Intake Airway	1	--	--	--
Midpoint of Longwall Face	4	--	1	--
Shearing Machine	2	--	--	--
Tail of Longwall Face	4	2	1	1**
Return Airway 233' from Tail End of the Panel	--	--	1	--

\* Samplers will be equipped with SKC dampeners and SKC voltage regulators.

\*\* Although only one pump will be used, at least one pair of impinger samples will be collected each shift. One pair of samples will consist of a sample for each direction of shearer traverse of the panel.

TABLE 10 - TOTAL SAMPLER REQUIREMENTS FOR UNDERGROUND SAMPLING

<u>Type of Sampler</u>	<u>Per Shift</u>	<u>Total Needed for 1-shift Operation (including spares)</u>
Dampened Personal w/cyclone	11 )	26 + 5 = 31
Dampened Personal w/o cyclone	2 )	
Personal (for midget impinger)	1	2 + 1 = 3
MRE's	3	6 + 1 = 7

- (e) Air velocity measurements at the tail end of the panel, using a vane anemometer
- (f) Spray system water pressure at inlet to shearer
- (g) Reason for and duration of any shearer downtime

(2) Assist in setting up and taking down sampling packages; checking sampler operation at least four times during each shift and adjusting the flow rate, if necessary; and record pump ON and OFF times.

(3) Note and, if possible, correct any conditions such as plugged or missing sprays that might affect sampling results.

b. Location 2: Head of Panel

(1) Record the following data:

- (a) Cross-sectional dimensions of the airway along the face
- (b) Air velocity measurements at the head end of the face using a vane anemometer
- (c) Beginning and ending times for individual shearer passes
- (d) Spray system water pressure measurements at the inlet to the shearer
- (e) Reason for and duration of any shearer downtime

(2) Assist in setting up and taking down sampling packages; checking sampler operation at least four times during each shift and adjusting the flow rate, if necessary; and record pump ON and OFF times.

(3) Note and correct, if possible, any conditions which might affect sampling results.

(4) Take midget impinger samples of dust during individual shearer passes.

c. Location 3: At Water Flow Meter on Power Train in Conveyor  
Heading

(1) Record the following data:

- (a) Return heading dimensions at cross section where air velocity measurements were taken
- (b) Return air velocity measurements using a vane anemometer

- (c) Static and operating water pressure of the spray system at the flow meter
- (d) Total water flow per shift and per pass, and one-minute flow checks during each pass
- (e) Duration of and reason for any shearer downtime

(2) Assist in setting up and taking down sampling packages; checking sampler operation at least four times during each shift and adjusting the flow rate, if necessary; and record pump ON and OFF times.

Due to time limitations, most of the field demonstration was done on a two-shift per day basis, the 12 midnight to 8 a.m. and 4 p.m. to 12 midnight shifts. The personnel used on each crew were fixed, and each crew always worked the same shift.

#### 4. Data Collected

The data that were collected included, but were not limited to, the following:

- a. Water flow and pressure (total for both stationary and drum sprays)
- b. Number and condition of spray nozzles
- c. Airflow, with location of measurement
- d. Location of samplers
- e. Raw coal production (tons per shift) and shearer operating time
- f. Condition of bits
- g. Downtime (duration and reason)

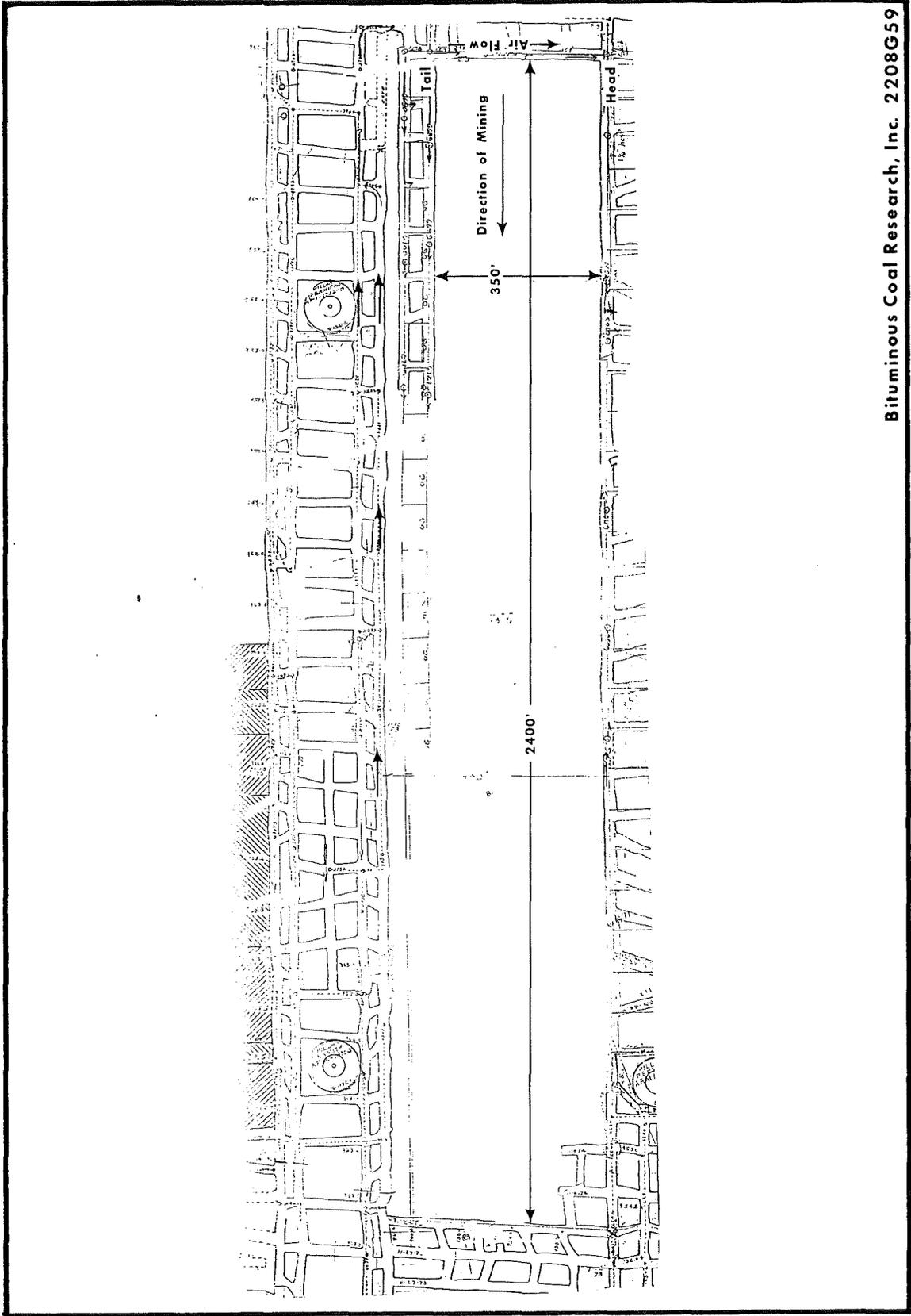
Sample copies of all data sheets used are included in Appendix C.

#### B. Underground Sampling

Underground sampling was initiated June 7, 1974 and was completed October 9, 1975. During this period, 94 shifts were sampled on two different panels. A plan of the initial panel is shown in Figure 62 and of the second panel in Figure 63. The major difference between the panels was their width and length, which did not affect sampling results.

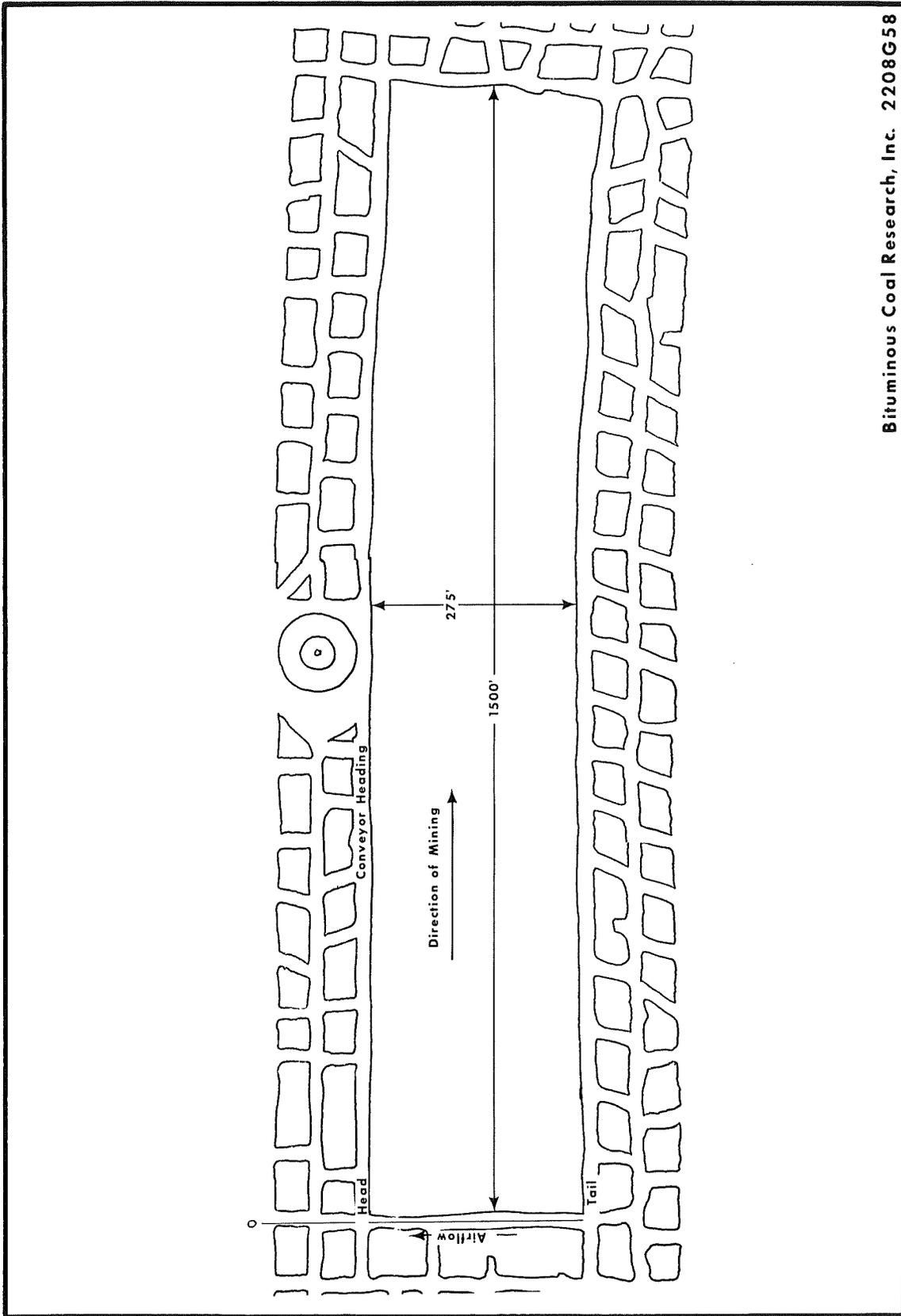
##### 1. Sampling with the First Test Drum

The field demonstration can be divided into three separate periods



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Figure 62. Plan of First Longwall Test Panel



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Figure 63. Plan of Second Longwall Test Panel

based on the shearer drum being used. The first sampling period was from June 6 through June 18, 1974. During this time, five shifts were sampled, none valid, using the original test drum design as shown in Figure 64 and described in Section III of this report. From the initial start-up the shearer operation was unstable, with the shearer underframe being lifted off the panline during traverses of the face. This condition did not exist during mining with the R&P production drum.

This instability was due to a change in the shearer configuration from that shown in Figure 65 (a) to that shown in Figure 65 (b). Analysis of the drum drive system shows that the reaction to the torque applied to the drum in the original configuration resulted in a downward force on the underframe. By changing the drum to the opposite end of the shearer but not changing direction of rotation, Figure 65 (b), the direction of this reaction force was changed to apply an upward lift to the underframe, thus creating the instability.

As a result of this instability, R&P decided to change the direction of drum rotation, Figure 65 (c) which resulted in the reaction force being applied in a downward direction on the underframe and eliminating the instability.

During the period that the drum rotation was being changed, the BCR test drum was redesigned and modified as described in Section III of this report.

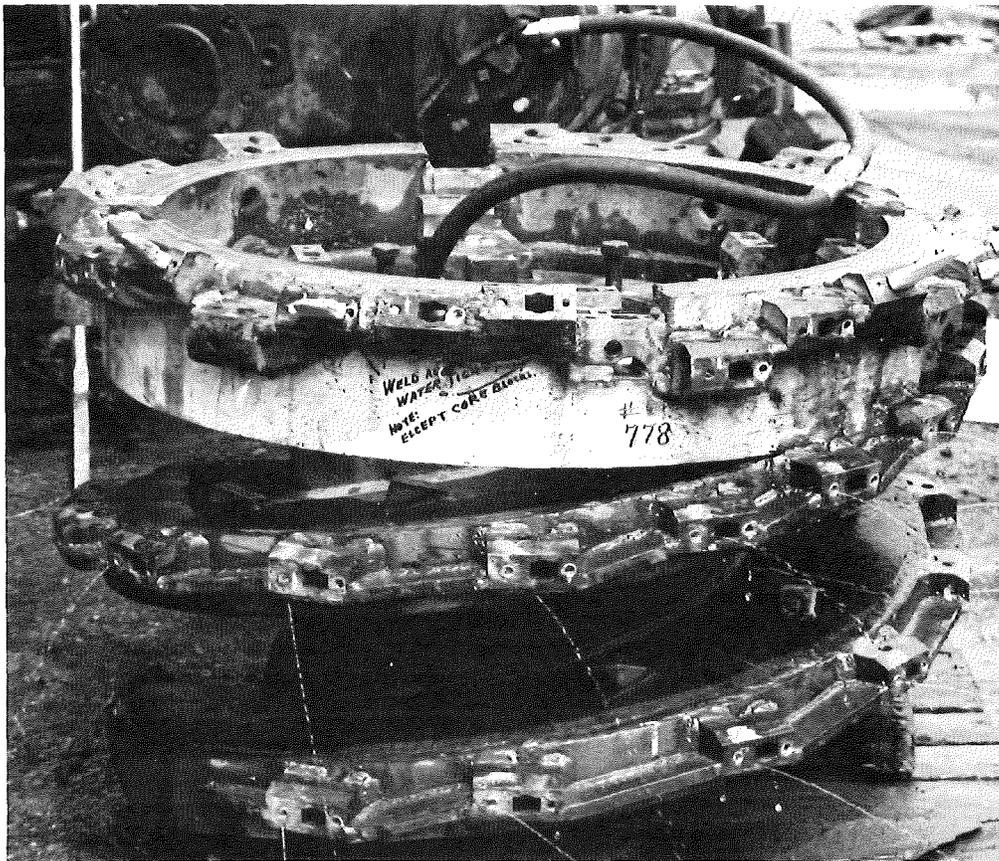
## 2. Sampling with the Second Test Drum

During the second test period, from January 6 to January 23, 1975, 23 shifts were sampled, of which 15 were valid. The spray systems tested were those with the nozzles located in front of and in back of the bits at low water flow, or 21 gpm. At this point the panel was mined out and the test drum was removed from the mine for inspection and required repairs.

A review of the drum performance with R&P personnel indicated generally satisfactory performance, with the following minor problems.

a. The last bits on the scrolls on the gob side of the drum were interfering with the panline. The bits were broken off and the block worn badly. An examination of the drum revealed that the scrolls were slightly longer than the scrolls on the production drum, resulting in the last bit blocks being located closer to the shearer and panline than design clearance would allow. As a result, the scrolls were shortened and the bit blocks relocated forward on the scrolls to provide the required clearance.

b. Even though the lacing pattern of the sumping bits was patterned after the R&P drum, the sumping characteristics were not entirely satisfactory. The problem was that there were no bits perpendicular to the coal face and extending beyond the edge of the drum end ring. During sumping operations the ring rubbed against the coal face, grinding the coal, and becoming hot to the touch. Although this did not appear to be a problem during the traverse of the face, R&P requested that modifications be made to improve sumping characteristics.



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**Figure 64. Completed Test Drum Showing Eickhoff  
Sprays on Side of Scrolls and Spray Nozzle  
Locations in Bit Block**

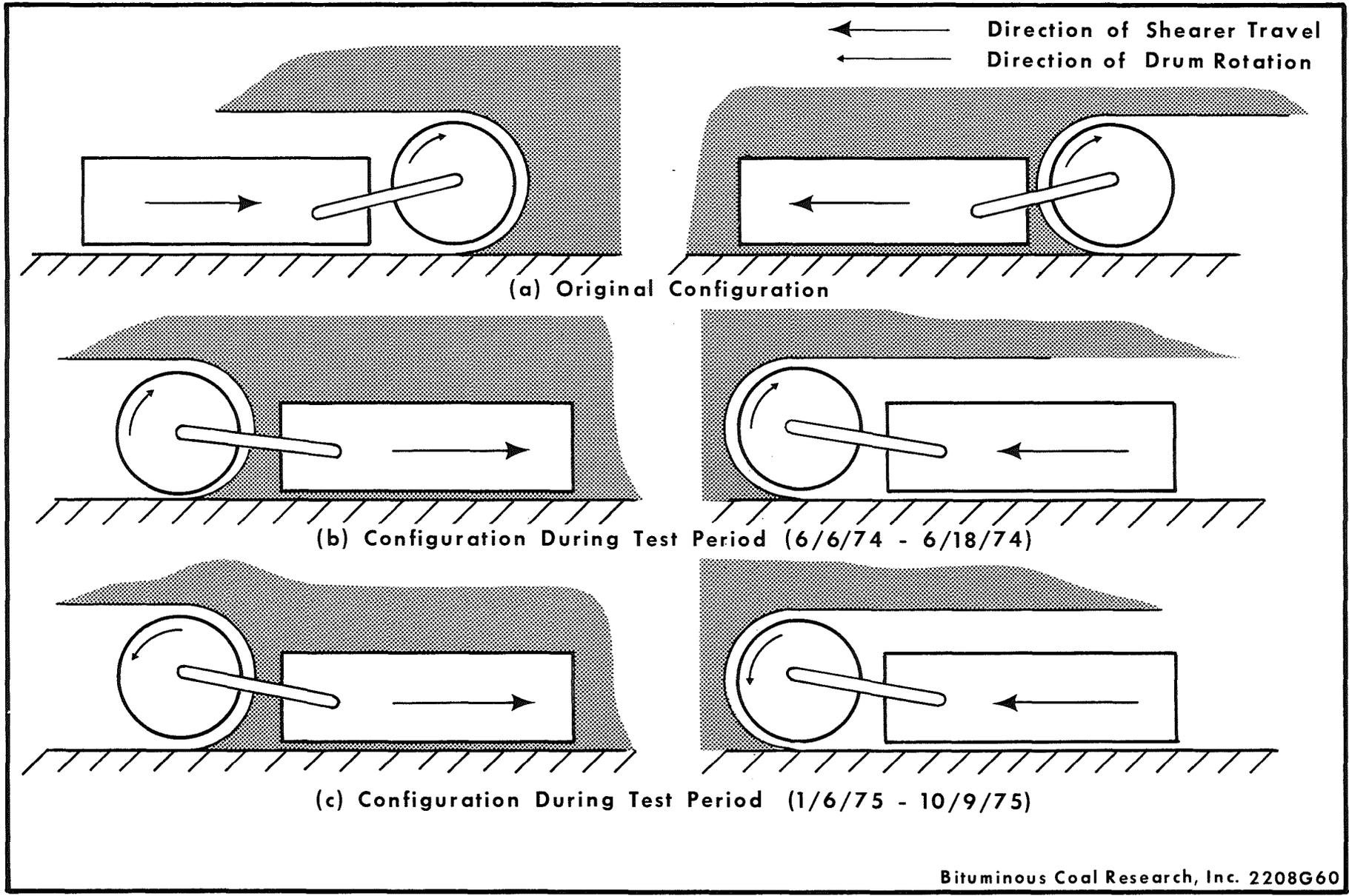


Figure 65. Comparison of Shearer Configurations Relating Drum Rotation, Direction of Travel, and Location of Drum on Shearer

This was accomplished by modifying the end ring lacing pattern to include the two bits, shown in Figure 49, which were nearly perpendicular to the coal face and extended beyond the edge of the end ring. During subsequent operation of the drum, there were no further complaints about its sumping characteristics.

### 3. Sampling with the Modified Second Test Drum

The modified drum was returned to the mine and installed on the shearer at the start of a new panel in August 1975. Sampling was not started until August 25, after the first major roof fall and the inflow of water from an unknown source had subsided. Sampling continued until October 9, 1975, and 51 shifts were sampled, 37 of which were valid shifts.

During this final test period, all spray systems were tested at both low, 21 gpm, and high, 27 gpm, water flows.

Performance of the drum during this period was entirely satisfactory, with no production time being lost for drum or spray system maintenance.

In general, the underground demonstration encountered few problems, as evidenced by the fact that 65 percent of all shifts using any of the BCR test drums were valid, and 70 percent of the shifts using the modified BCR test drum were valid. A summary of the reasons for the invalid shifts is given in Table 11.

### 4. Problems Encountered During Underground Sampling

The principal problems encountered during the sampling program, those of maintaining airflow and water pressure, are discussed below.

a. Airflow - The graphs in Figure 66 and in Appendix D show the following:

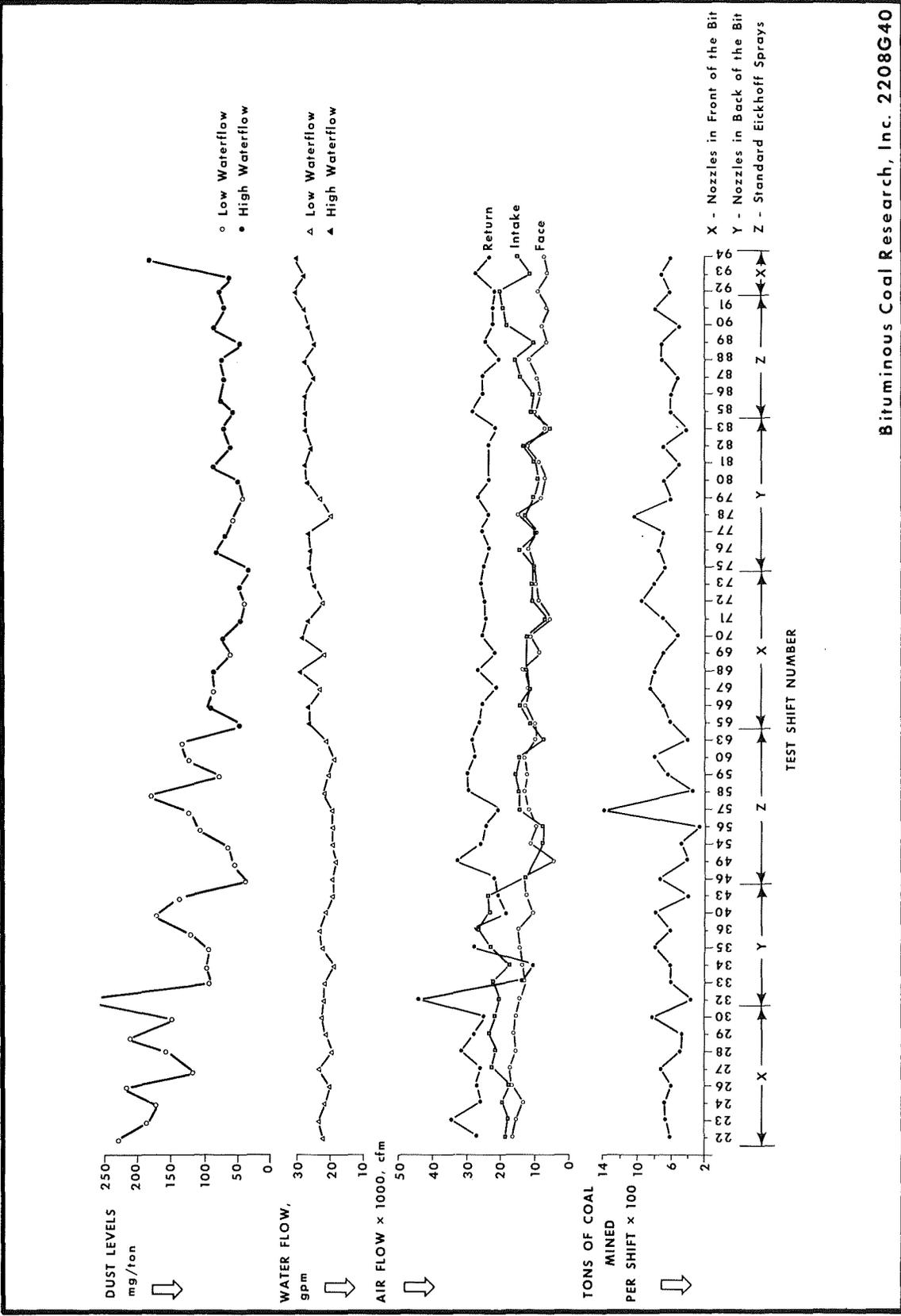
(1) During sampling of the first panel, shifts 22 through 43, the intake airflow averaged in excess of 20,000 cfm, compared to an average of approximately 13,000 cfm during sampling of the second panel. According to R&P personnel, this reduction in airflow to the second panel was due to an increase in the total number of sections being mined, with a resultant reduction in ventilation airflow to each section.

(2) There is a general downward trend in the face airflow, beginning with the first panel and continuing through the second panel. The overall decrease in face airflow was approximately 50 percent, from an initial flow of 16,000 to 17,000 cfm to a final flow of 7,000 to 8,000 cfm.

(3) The return air, in general, shows a fairly consistent airflow level around 25,000 cfm, the range being 20,000 to 30,000 cfm.

TABLE 11 - SUMMARY OF REASONS FOR INVALID SAMPLING SHIFTS

<u>Reason Shift Being Invalidated</u>	<u>No. of Shifts</u>
(1) Low water flow	11
(2) Low production due to maintenance on longwall equipment	7
(3) Strikes	4
(4) Low production-multiple delays (Main belts down)	3
(5) Water system too erratic-flow rate varied	3
(6) Low production-due to roof fall along face	2
(7) Spray system malfunction	1



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Figure 66. Test Data for Valid Shifts - Dust Levels in Mg/Ton of Respirable Dust Measured on the Shearer

The general downward trend in intake and face airflow was directly related to the ventilation plan illustrated in Figure 67. Specifically, the plan was designed to operate as follows:

Intake air was coursed through entries 1 in Figure 67 to the starting point of the panel, passed through crosscut 2, into parallel entries 3. This portion of the ventilation system remained constant throughout the life of the panel. Air for the longwall face traveled down entries 3 to an open crosscut 4 ahead of the face. One open crosscut was always maintained ahead of the face. Air for the bleeder system bled through by-passed open crosscuts 5, across the gob to open stoppings 6 on the return air side. Bleeding across the panel width, 250 to 350 feet, was considered more efficient and safer than trying to ventilate the gob by bleeding back through the gob from the face, which could reach distances in excess of 1,000 feet.

As a result of this ventilation plan, the number of gob bleed points increased as the panel was retreated and the volume of ventilation air available at the face correspondingly decreased.

Shift-to-shift variations in the face airflow can be attributed both to the variations in intake air and the constantly changing conditions of the gob immediately behind the roof supports. On many shifts, the gob would hang up for 10 to 15 feet behind the supports, fall in and become very tight, and then hang up again as the face advanced. This obviously affected the measured face airflow. An effort to account for this effect has been made in the data analysis.

b. Water Flow - Line pressure to the longwall section ranged from 100 to 120 psi. This could increase up to 550 to 600 psi by use of the piston pump located at the end of the longwall panel. In general, the system performed satisfactorily, but there were some problems, as discussed in the following sections.

(1) Pressure drop through the shearer and drum. During the test period from January 6 through January 23, 1975, the pressure required to attain 21 gpm through the bit-flushing nozzles averaged 140 psi. Attempts to operate at higher flows and pressure resulted in failure of the hoses along the face; therefore, no shifts at the high flow rate were sampled.

During the test period from August 25 through October 9, 1975, the pressure required to obtain 21 gpm through the bit-flushing nozzles increased to an average of 239 psi. Since there were no significant changes in the drum water system, the increased pressure drop must have been due to blockages in the water passages through the shearer.

Replacement of the water hoses along the face prior to the August-October sampling period allowed the pressure to be increased sufficiently to obtain the required high and low flows through the standard spray system, 239 psi at 21 gpm and 311 psi at 27 gpm.

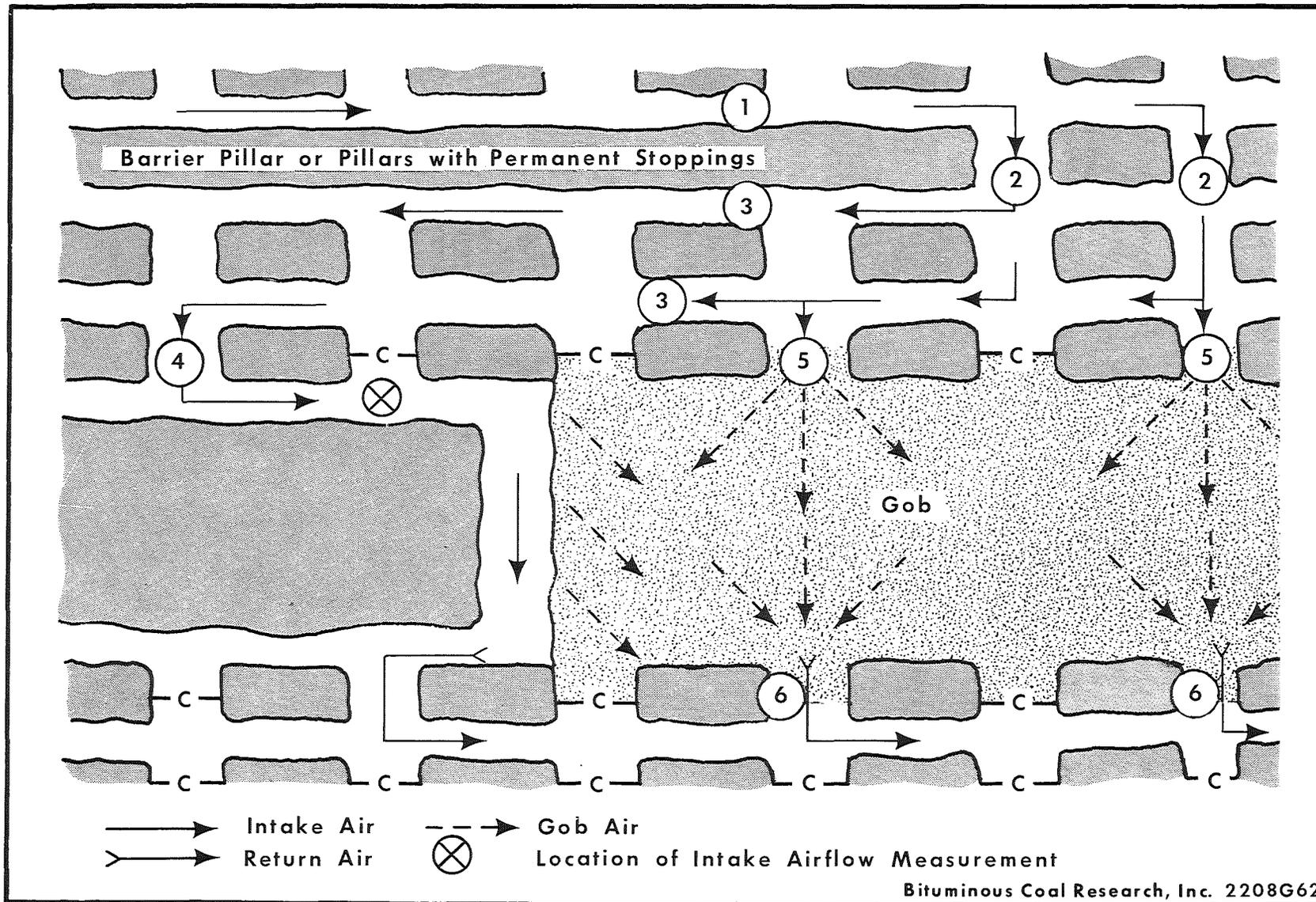


Figure 67. Schematic of Longwall Ventilation Plan Showing Bleeders for Ventilation of Gob

Operation at the high flow rates required that one of the sampling crew be stationed at the water pump to cut back on the output pressure as soon as the water flow was shut off. If this was not done, the resulting surges in the system, exceeding 600 psi, would either break a hose or separate two sections at a joint. Communications with the man at the pump were maintained with walkie talkies borrowed from the USBM Pittsburgh Mining and Safety Research Center.

It should be remembered that the pressures given in data tables, and used in discussions, were measured at the point where the supply hose enters the shearer. Therefore, any restrictions in the shearer or changes in these restrictions are reflected in the pressure data, and do not represent the pressure in the drum nozzle supply chambers. Again, there was no way to conveniently check changes in pressure drop through the machine. BCR, therefore, used the water flow rate as the controlling parameter rather than pressure at the shearer inlet.

## VI. PHASE IV - DATA ANALYSIS

The analysis of spray system performance was based on a comparison of operating characteristics of each system and a statistical analysis of respirable dust levels measured during operation with each spray system.

A comparison of the spray systems operating characteristics, shown in Tables 12, 13, and 14, indicates no major problems with any of the systems that would eliminate them for consideration as potential dust suppression systems on a shearer. A minor problem was experienced with the nozzles located in front of the bits in that they "backed out" of the bit blocks during cutting operations. This problem could be eliminated by use of a pipe thread on the nozzles instead of the bolt thread used on the test nozzles.

The statistical analysis of respirable dust levels was accomplished using the following steps:

1. Collect dust samples for a series of production shifts on a longwall panel during which each of the candidate spray systems was used at high and low water flow rates.
2. Use the procedure summarized in Appendix E to calculate the dust concentrations during these shifts and compare the dust levels for each spray system.
3. Compare the dust levels measured during periods of high water flow and low water flow.
4. Based on these comparisons, determine: (a) the ranking of the spray systems with respect to their effectiveness in reducing respirable dust levels, and (b) whether increased spray water flow has a significant effect on dust levels.

The data for the 52 valid shifts sampled while using the BCR test drum are presented in Table 15, and are the bases for the analysis of the performance of the spray systems.

In carrying out the analysis, several factors were taken into consideration, as follows:

1. The calculation of a dust concentration is normally done on the basis of the sampling time during a shift, which gives an average dust level for the sampling period. This calculation could distort the performance of a spray system, since a very high dust level generated during a short mining period could produce the same sampler dust weight as a low dust level generated during a longer coal-cutting period. The resultant concentrations, based on the same sampling time, would be equal. Therefore, to more closely reflect the dust levels generated during actual mining periods with each spray system, the shearer cutting time was recorded for each shift and used to calculate

TABLE 12. SUMMARY OF OPERATING CHARACTERISTICS AND ASSOCIATED  
DUST LEVELS OF NOZZLES LOCATED IN FRONT OF BITS

OPERATING CHARACTERISTICS	AVERAGE RESPIRABLE DUST LEVELS	
	High Water Flow	Low Water Flow
1. Nozzles tended to back out of block, resulting in the loss of several nozzles during operation. This condition was attributed to use of a bolt thread instead of pipe thread.	1. Average MRE Equivalent Concentration Based on Cutting Time	
	On Shearer	1.65
	Midpoint of Panel	4.59
	Head End of Panel	10.39
	Return	10.35
2. There was no major problem with plugging of the nozzles. Plugged nozzles resulted from internal plugging of individual screens rather than coal being forced into nozzles.	2. Average MRE Equivalent Concentration Based on Cutting Time Normalized for Panline Airflow	
	On Shearer	1.30
	Midpoint of Panel	3.59
	Head End of Panel	8.45
	Return	7.03
3. There was some damage to the nozzles by coal impinging on the exposed portion of the nozzle. This could be reduced by use of a harder nozzle material and better shielding.	3. Average mg/ton Concentration	
	On Shearer	74
	Midpoint of Panel	233
	Head End of Panel	550
	Return	493
		145
		386
		967
		806

TABLE 13. SUMMARY OF OPERATING CHARACTERISTICS AND ASSOCIATED  
DUST LEVELS OF NOZZLES LOCATED IN BACK OF THE BITS

OPERATING CHARACTERISTICS	AVERAGE RESPIRABLE DUST LEVELS	
	High Water Flow	Low Water Flow
1. No problems were encountered with the nozzles backing out of the block though some did become loose.	1. Average MRE Equivalent Concentration Based on Cutting Time	
	On Shearer	1.13
	Midpoint of Panel	3.87
	Head End of Panel	8.60
	Return	8.26
2. There was no major problem with plugging of the nozzles. Plugged nozzles resulted from internal plugging of individual screens rather than coal being forced into the nozzle.	2. Average MRE Equivalent Concentration Based on Cutting Time Normalized for Panline Airflow	
	On Shearer	.90
	Midpoint of Panel	3.11
	Head End of Panel	6.94
	Return	6.73
3. There was some damage to the nozzles from coal impingement but not to the degree experienced with the nozzles located in front of the bits.	3. Average mg/ton Concentration	
	On Shearer	59
	Midpoint of Panel	237
	Head End of Panel	537
	Return	554
4. Installation of the nozzles requires removal of the bits which creates a maintenance problem.		
		116
		457
		961
		804

TABLE 14. SUMMARY OF OPERATING CHARACTERISTICS AND ASSOCIATED DUST LEVELS OF STANDARD EICKHOFF NOZZLES

OPERATING CHARACTERISTICS	AVERAGE RESPIRABLE DUST LEVELS		
		High Water Flow	Low Water Flow
1. No problems encountered with nozzles backing out or plugging.	1. Average MRE Equivalent Concentration Based on Cutting Time		
	On Shearer	1.45	1.92
	Midpoint of Panel	4.99	4.15
	Head of Panel	9.64	10.42
	Return	8.64	10.45
2. Required slightly higher water pressure for same flow through bit flushing nozzles.	2. Average MRE Equivalent Concentration Based on Cutting Time Normalized for Panline Airflow		
	On Shearer	.99	1.60
	Midpoint of Panel	3.50	3.48
	Head End of Panel	6.77	8.81
	Return	6.32	9.72
3. Did not require removal of bits to change.	3. Average mg/ton Concentration		
	On Shearer	60	95
	Midpoint of Panel	252	241
	Head End of Panel	490	602
	Return	492	601
4. Due to smaller number and easy access, standard nozzles were easier to maintain.			

TABLE 15. DATA COLLECTED DURING UNDERGROUND DEMONSTRATION PHASE OF PROJECT

Shift No.		22	23	24	26	27
Date:		1-6-75	1-7-75	1-7-75	1-8-75	1-9-75
Spray System		front of bits				
<u>Respirable Dust Weight (mg)</u>						
Intake to Face - MSA						
#100 package		0.30	0.33	0.24	0.23	0.28
Shearer	MSA #1	0.59	0.59	0.58	1.06	0.62
#200 package	MSA #2	0.54	0.46	0.59	--	--
Midpoint of Face	MSA #1	0.70	0.64	0.67	0.53	0.66
#300 package	MSA #2	0.57	0.71	0.60	0.60	0.70
	MSA #3	--	0.71	0.56	0.63	0.69
	MSA #4	0.74	0.71	0.63	0.82	0.65
	MRE	0.14	1.44	1.35	3.02	1.70
Head End of Face	MSA #1	1.04	1.42	1.72	1.50	1.32
#400 package	MSA #2	1.14	1.50	1.80	1.34	1.48
	MSA #3	1.12	1.39	1.87	1.52	1.44
	MSA #4	1.12	2.34	1.86	1.52	1.46
	MRE	3.01	3.27	4.32	3.38	4.06
	Gross Sampler #1	11.19	13.12	14.13	12.77	12.92
	Gross Sampler #2	9.18	15.41	22.90	16.60	15.24
Return						
#500 package	MRE	3.05	4.03	5.05	2.38	3.90
<u>Airflow, cfm</u>						
Intake		18,123	17,751	19,856	17,693	22,900
Face		16,648	15,749	13,361	17,069	17,440
Return		26,703	34,067	25,154	26,923	25,337
<u>Waterflow</u>						
Gallons per shift		2,251	3,284	3,501	2,515	3,899
Average gpm for shift		21.0	23.25	21.97	20.28	23.21
Average pressure for shift		140	135	--	128	138
Tons Mined		605	665.5	674	605	726
Number of Passes		5	5-1/2	5-1/2	5	6
Cutting Time, min		107	135	157	124	168

TABLE 15. DATA COLLECTED DURING UNDERGROUND DEMONSTRATION  
PHASE OF PROJECT (Continued)

Shift No.		28	29	30	32	33
Date:		1-9-75	1-10-75	1-10-75	1-14-75	1-14-75
Spray System		front	front	front	back	back
		of bits	of bits	of bits	of bits	of bits
		Respirable Dust Weight (mg)				
Intake to Face - MSA						
#100 package		0.21	0.30	0.27	0.17	0.13
Shearer	MSA #1	0.34	0.45	0.53	0.50	0.30
#200 package	MSA #2	0.31	0.41	0.45	0.50	0.29
Midpoint of Face	MSA #1	0.93	0.45	0.82	0.75	0.71
#300 package	MSA #2	0.28	0.42	0.74	0.74	0.75
	MSA #3	0.37	0.45	0.85	0.99	0.71
	MSA #4	0.36	0.44	0.92	1.23	0.72
	MRE	0.70	1.13	1.90	--	1.55
Head End of Face	MSA #1	0.91	1.06	1.53	1.62	1.75
#400 package	MSA #2	0.93	1.08	1.52	0.98	1.80
	MSA #3	0.99	1.24	1.45	0.98	1.74
	MSA #4	0.91	1.15	1.47	1.25	1.76
	MRE	1.96	--	2.51	2.88	4.52
	Gross Sampler #1	7.91	10.82	14.09	8.14	17.22
	Gross Sampler #2	9.07	8.69	15.79	8.56	14.66
Return						
#500 package	MRE	2.03	2.73	4.47	5.83	--
		Airflow, cfm				
Intake		21,533	23,417	21,528	20,600	22,159
Face		15,829	16,065	15,804	14,124	12,419
Return		31,119	27,887	24,182	44,200	12,725
		Waterflow				
Callons per shift		1,694	2,440	3,564	2,155	2,891
Average gpm for shift		19.47	21.59	22.55	21.99	24.70
Average pressure for shift		141	139	134	133	139
Tons Mined		500	484	847	363	605
Number of Passes		4	4	7	3	5
Cutting Time, min		87	113	158	98	117

TABLE 15. DATA COLLECTED DURING UNDERGROUND DEMONSTRATION  
PHASE OF PROJECT (Continued)

Shift No.		34	35	36	38	40
Date:		1-15-75	1-15-75	1-17-75	1-21-75	1-22-75
Spray System		back of bits				
Respirable Dust Weight (mg)						
Intake to Face - MSA						
#100 package		0.13	0.33	0.26	0.42	0.23
Shearer	MSA #1	0.28	0.37	0.30	0.88	0.83
#200 package	MSA #2	0.32	0.32	0.34	1.06	0.98
Midpoint of Face	MSA #1	0.46	1.11	0.67	1.69	1.34
#300 package	MSA #2	0.17	0.88	0.51	1.54	1.44
	MSA #3	0.54	0.98	0.55	1.67	1.65
	MSA #4	0.60	0.98	1.08	1.73	1.49
	MRE	0.91	2.14	1.14	3.77	3.30
Head End of Face	MSA #1	1.04	2.03	1.10	4.75	2.62
#400 package	MSA #2	1.11	1.98	1.01	2.88	2.67
	MSA #3	1.10	2.04	0.98	2.74	2.65
	MSA #4	2.00	2.14	1.07	3.59	2.75
	MRE	2.61	6.12	2.47	6.90	3.61
	Gross Sampler #1	7.17	17.78	6.94	19.41	23.62
	Gross Sampler #2	8.11	16.04	8.29	25.86	24.85
Return						
#500 package	MRE	1.61	0.42	2.44	3.77	6.45
Airflow, cfm						
Intake		17,200	23,111	26,833	23,880	23,400
Face		13,548	14,437	14,937	13,538	10,354
Return		10,389	27,979	27,071	17,433	18,169
Waterflow						
Gallons per shift		2,856	4,084	3,125	4,733	3,597
Average gpm for shift		19.04	22.82	24.61	31.14	21.67
Average pressure for shift		131	137	134	196	142
Tons Mined		605	794	605	975	794
Number of Passes		5	6-1/2	5	8	6-1/2
Cutting Time, min		145	179	127	152	166

TABLE 15. DATA COLLECTED DURING UNDERGROUND DEMONSTRATION PHASE OF PROJECT (Continued)

Shift No.		43	46	49	54	56
Date:		1-23-75	8-27-75	8-28-75	9-5-75	9-8-75
Spray System		back of bits	stan- dard	stan- dard	stan- dard	stan- dard
		Respirable Dust Weight (mg)				
Intake to Face - MSA						
#100 package		0.12	0.20	0.14	0.07	0.10
Shearer	MSA #1	0.32	0.13	0.38	0.17	0.20
#200 package	MSA #2	0.24	0.10	0.33	0.20	0.20
Midpoint of Face	MSA #1	0.89	0.24	0.49	3.27	0.16
#300 package	MSA #2	0.72	0.31	0.57	0.80	0.16
	MSA #3	0.71	0.30	0.57	1.37	0.16
	MSA #4	0.69	0.30	0.54	4.07	0.16
	MRE	1.85	0.55	1.25	0.68	0.34
Head End of Face	MSA #1	1.50	1.08	1.19	0.53	0.57
#400 package	MSA #2	1.33	1.05	1.28	0.60	0.51
	MSA #3	1.28	1.09	1.11	0.61	0.51
	MSA #4	1.19	1.06	0.86	0.53	0.51
	MRE	3.18	2.20	2.65	1.08	1.18
	Gross Sampler #1	9.28	10.08	13.97	16.99	18.84
	Gross Sampler #2	10.25	21.01	17.09	18.87	19.97
Return						
#500 package	MRE	3.37	3.20	1.52	2.65	1.26
		Airflow, cfm				
Intake		23,924	12,968	--	7,029	7,693
Face		12,893	13,879	4,207	11,944	9,443
Return		20,944	21,198	32,740	25,369	24,019
		Waterflow				
Gallons per shift		1,972	2,606	1,366	2,133	854
Average gpm for shift		19.15	19.45	18.50	19.6	19.8
Average pressure for shift		161	169	230	273	143
Tons Mined		392	740	400	498	254
Number of Passes		3-1/4	6	4	5	2-1/2
Cutting Time, min		103	134	74	109	43

TABLE 15. DATA COLLECTED DURING UNDERGROUND DEMONSTRATION  
PHASE OF PROJECT (Continued)

Shift No.		57	58	59	60	63
Date:		9-9-75	9-9-75	9-10-75	9-11-75	9-13-75
Spray System		stan- dard	stan- dard	stan- dard	stan- dard	stan- dard
<u>Respirable Dust Weight (mg)</u>						
Intake to Face - MSA						
#100 package		0.18	0.12	0.19	0.18	0.10
Shearer	MSA #1	0.99	0.30	0.24	0.52	0.39
#200 package	MSA #2	0.95	0.33	0.23	0.51	0.37
Midpoint of Face	MSA #1	0.69	0.24	0.33	0.48	0.55
#300 package	MSA #2	0.74	0.29	0.34	0.51	0.49
	MSA #3	0.67	0.25	0.32	0.60	0.44
	MSA #4	0.74	0.26	0.30	0.51	0.41
	MRE	1.77	0.13	0.73	1.20	0.53
Head End of Face	MSA #1	1.88	0.61	0.77	1.21	1.00
#400 package	MSA #2	1.81	0.70	0.82	1.21	0.92
	MSA #3	1.79	0.67	0.75	1.32	0.96
	MSA #4	1.76	0.62	0.72	1.25	0.96
	MRE	4.52	0.62	1.75	3.06	2.40
	Gross Sampler #1	41.70	20.02	23.14	29.81	13.23
	Gross Sampler #2	51.95	20.20	20.44	30.15	10.43
Return						
#500 package	MRE	4.25	2.69	2.31	3.11	1.40
<u>Airflow, cfm</u>						
Intake		14,749	14,870	15,891	14,673	7,747
Face		12,159	13,604	12,627	13,192	9,755
Return		20,314	29,142	29,475	27,737	28,199
<u>Waterflow</u>						
Gallons per shift		3,964	1,286	2,187	2,228	1,438
Average gpm for shift		19.7	22.2	20.8	18.9	21.1
Average pressure for shift		219	206	223	--	253
Tons Mined		1400	350	650	800	400
Number of Passes		14	3.5	6.5	8	4
Cutting Time, min		213	58	105	118	62

TABLE 15. DATA COLLECTED DURING UNDERGROUND DEMONSTRATION  
PHASE OF PROJECT (Continued)

Shift No.		65	66	67	68	69
Date:		9-15-75	9-16-75	9-16-75	9-17-75	9-17-75
Spray System		front of bits	front of bits	front of bits	front of bits	front of bits
		<u>Respirable Dust Weight (mg)</u>				
Intake to Face - MSA						
#100 package		0.16	0.12	0.10	0.11	0.13
Shearer	MSA #1	0.17	0.40	0.45	0.35	0.33
#200 package	MSA #2	0.16	0.30	0.36	0.33	0.29
Midpoint of Face	MSA #1	0.25	0.30	0.37	0.75	0.49
#300 package	MSA #2	0.27	0.46	0.40	0.68	0.55
	MSA #3	0.25	0.43	0.39	0.65	0.50
	MSA #4	0.39	0.41	0.37	0.72	0.41
	MRE	0.72	1.01	0.80	1.62	1.25
Head End of Face	MSA #1	0.54	1.30	1.50	1.81	1.27
#400 package	MSA #2	0.61	1.42	1.52	1.79	1.28
	MSA #3	0.61	1.24	1.61	1.84	1.37
	MSA #4	0.63	1.28	1.50	1.81	1.34
	MRE	1.40	2.99	3.73	4.71	3.28
	Gross Sampler #1	5.38	11.60	16.03	14.62	13.08
	Gross Sampler #2	5.50	10.36	12.24	14.77	14.02
Return						
#500 package	MRE	1.48	2.83	2.69	2.40	1.68
		<u>Airflow, cfm</u>				
Intake		11,621	14,884	11,690	12,868	--
Face		10,583	13,031	11,494	13,047	8,883
Return		26,006	25,460	21,518	26,362	21,924
		<u>Waterflow</u>				
Gallons per shift		2,364	3,330	2,948	4,228	2,352
Average gpm for shift		26.0	26.0	23.0	29.1	21.6
Average pressure for shift		199	263	223	363	204
Tons Mined		600	700	840	800	700
Number of Passes		6	7	8.4	8	7
Cutting Time, min		91	128	128	135	104

TABLE 15. DATA COLLECTED DURING UNDERGROUND DEMONSTRATION  
PHASE OF PROJECT (Continued)

Shift No.		70	71	72	73	75
Date:		9-18-75	9-18-75	9-19-75	9-19-75	9-22-75
Spray System		front of bits	front of bits	front of bits	front of bits	back of bits
		Respirable Dust Weight (mg)				
Intake to Face - MSA #100 package		0.13	0.15	0.09	0.07	0.14
Shearer	MSA #1	0.22	0.43	0.29	0.27	0.24
	#200 package MSA #2	0.21	0.39	0.28	0.26	0.04
Midpoint of Face #300 package	MSA #1	0.57	0.58	0.92	0.58	0.50
	MSA #2	0.53	0.51	0.91	0.59	0.48
	MSA #3	0.44	0.61	0.96	0.57	0.44
	MSA #4	0.42	0.58	0.85	0.58	0.43
	MRE	1.00	2.46	2.61	1.34	1.19
Head End of Face #400 package	MSA #1	0.92	1.35	2.11	1.01	0.90
	MSA #2	0.95	1.29	2.06	0.93	0.88
	MSA #3	0.98	1.21	2.24	0.89	0.86
	MSA #4	0.96	1.35	2.19	0.85	0.90
	MRE	2.17	3.33	5.46	3.27	2.37
	Gross Sampler #1	8.62	10.82	24.83	8.66	6.81
	Gross Sampler #2	8.97	12.56	25.75	9.23	6.86
Return #500 package		2.07	2.02	1.97	2.42	2.79
		Airflow, cfm				
Intake		12,967	6,773	11,050	11,165	10,239
Face		11,223	5,820	9,333	10,097	10,632
Return		25,460	24,195	24,035	25,658	24,552
		Waterflow				
Gallons per shift		2,436	2,717	3,481	2,856	3,017
Average gpm for shift		28.3	26.9	22.2	24.8	26.0
Average pressure for shift		290	240	183	225	273
Tons Mined		513	700	959	800	675
Number of Passes		5	7	9.5	8	6.75
Cutting Time, min		86	101	157	116	116

TABLE 15. DATA COLLECTED DURING UNDERGROUND DEMONSTRATION  
PHASE OF PROJECT (Continued)

Shift No.		76	77	78	79	80
Date:		9-23-75	9-23-75	9-24-75	9-24-75	9-25-75
Spray System		back of bits	back of bits	back of bits	back of bits	back of bits
		Respirable Dust Weight (mg)				
Intake to Face - MSA						
	#100 package	0.17	0.16	0.11	0.14	0.09
Shearer	MSA #1	0.35	0.32	0.30	0.22	0.29
	#200 package MSA #2	0.28	0.30	0.20	0.17	0.32
Midpoint of Face	MSA #1	0.55	0.59	0.84	0.48	0.53
	#300 package MSA #2	0.52	0.58	0.80	0.46	0.58
	MSA #3	0.55	0.62	0.79	0.47	0.60
	MSA #4	0.55	0.59	0.63	0.48	0.59
	MRE	0.91	1.35	1.76	1.06	1.11
Head End of Face	MSA #1	0.93	1.12	1.56	1.01	1.16
	#400 package MSA #2	1.01	1.23	1.56	1.10	1.16
	MSA #3	1.01	0.84	1.49	1.03	1.21
	MSA #4	1.04	1.10	1.72	1.14	1.18
	MRE	2.18	2.97	4.00	2.54	--
	Gross Sampler #1	6.06	8.40	11.70	7.62	8.31
	Gross Sampler #2	6.60	8.39	18.83	9.75	10.18
Return						
	#500 package MRE	2.35	2.59	4.49	1.88	2.68
		Airflow, cfm				
Intake		14,852	9,898	13,702	10,367	9,438
Face		12,787	9,553	15,499	8,663	7,576
Return		23,172	25,836	23,380	26,779	23,402
		Waterflow				
Gallons per shift		3,206	3,427	3,622	2,629	3,233
Average gpm for shift		25.6	26.6	19.8	22.9	26.8
Average pressure for shift		307	220	174	235	309
Tons Mined		750	700	1,080	600	685
Number of Passes		7.5	7	10.8	6	6.8
Cutting Time, min		125	129	183	109	122

TABLE 15. DATA COLLECTED DURING UNDERGROUND DEMONSTRATION  
PHASE OF PROJECT (Continued)

Shift No.		81	82	83	85	86
Date:		9-25-75	9-26-75	9-26-75	10-2-75	10-3-75
Spray System		back of bits	back of bits	back of bits	stan- dard	stan- dard
Respirable Dust Weight (mg)						
Intake to Face - MSA						
	#100 package	0.21	0.09	0.08	0.05	0.10
Shearer	MSA #1	0.34	0.27	0.27	0.21	0.38
	#200 package MSA #2	0.27	0.20	0.30	0.20	0.27
Midpoint of Face	MSA #1	0.50	0.54	0.43	0.53	0.61
	#300 package MSA #2	0.52	0.56	0.47	0.51	0.60
	MSA #3	0.51	0.51	0.54	0.54	0.61
	MSA #4	0.53	0.50	0.49	0.53	0.63
	MRE	0.83	1.11	0.97	1.23	1.29
Head End of Face	MSA #1	1.08	1.30	0.83	0.91	1.08
	#400 package MSA #2	1.14	1.37	0.87	0.80	1.14
	MSA #3	1.22	1.26	0.88	0.98	1.17
	MSA #4	1.09	1.27	0.89	1.00	1.18
	MRE	2.58	3.19	1.98	2.50	2.92
	Gross Sampler #1	6.02	10.16	5.55	9.44	13.27
	Gross Sampler #2	8.66	11.78	6.87	11.79	14.46
Return						
#500 package	MRE	2.51	2.92	1.73	2.43	1.68
Airflow, cfm						
Intake		10,077	13,482	5,635	11,236	10,513
Face		9,197	12,313	6,556	10,229	8,998
Return		--	23,217	21,587	28,142	25,175
Waterflow						
Gallons per shift		2,715	4,455	2,500	2,149	2,529
Average gpm for shift		27.2	25.9	27		27.2
Average pressure for shift		312	315	270	337	318
Tons Mined		500	700	409	600	600
Number of Passes		5	7	4	6	6
Cutting Time, min		100	169	100	108	93

TABLE 15. DATA COLLECTED DURING UNDERGROUND DEMONSTRATION PHASE OF PROJECT (Continued)

Shift No.		87	88	89	90	91
Date:		10-3-75	10-6-75	10-6-75	10-7-75	10-7-75
Spray System		stan- dard	stan- dard	stan- dard	stan- dard	stan- dard
		Respirable Dust Weight (mg)				
Intake to Face - MSA						
#100 package		0.06	0.13	0.07	0.18	0.28
Shearer	MSA #1	0.25	0.29	0.29	0.35	0.50
#200 package	MSA #2	0.19	0.23	0.33	0.31	0.54
Midpoint of Face	MSA #1	0.69	0.57	0.41	0.52	0.75
#300 package	MSA #2	0.73	0.85	0.44	0.50	0.81
	MSA #3	0.71	0.43	0.43	0.59	0.83
	MSA #4	0.75	0.52	0.50	0.48	0.83
	MRE	1.78	--	0.93	2.32	1.34
Head End of Face	MSA #1	0.96	0.97	0.92	0.96	1.67
#400 package	MSA #2	0.98	1.02	0.92	0.95	1.44
	MSA #3	1.01	1.07	0.93	0.95	1.38
	MSA #4	0.98	1.00	0.92	0.96	1.33
	MRE	2.30	2.22	2.31	2.16	2.90
	Gross Sampler #1	7.43	9.13	9.18	10.69	14.56
	Gross Sampler #2	10.13	9.64	11.35	11.28	17.97
Return						
#500 package	MRE	2.33	3.21	1.75	2.07	2.87
		Airflow, cfm				
Intake		14,964	16,417	10,147	18,495	19,580
Face		9,923	12,337	6,821	8,206	6,985
Return		25,290	20,523	24,618	22,749	22,294
		Waterflow				
Gallons per shift		2,465	3,573	2,743.5	2,318	3,339
Average gpm for shift		24.9	27.5	24.3	26.0	27.6
Average pressure for shift		304	320	309	308	281
Tons Mined		523	700	700	500	800
Number of Passes		5-1/4	7	7	5	8
Cutting Time, min		99	130	113	89	121

TABLE 15. DATA COLLECTED DURING UNDERGROUND DEMONSTRATION  
PHASE OF PROJECT (Concluded)

Shift No.		92	93	94
Date:		10-8-75	10-8-75	10-9-75
Spray System		front of bits	front of bits	front of bits
<u>Respirable Dust Weight (mg)</u>				
Intake to Face - MSA				
#100 package		0.16	0.16	0.14
Shearer	MSA #1	0.30	0.36	0.92
#200 package	MSA #2	0.30	0.34	0.91
Midpoint of Face	MSA #1	0.52	1.39	0.33
#300 package	MSA #2	0.55	1.48	0.68
	MSA #3	0.64	1.53	0.77
	MSA #4	0.58	1.60	0.69
	MRE	1.15	2.28	1.69
Head End of Face	MSA #1	0.86	1.02	1.28
#400 package	MSA #2	0.90	1.04	1.23
	MSA #3	0.92	1.05	1.25
	MSA #4	0.87	1.04	1.33
	MRE	2.14	3.80	2.72
	Gross Sampler #1	8.25	14.62	11.71
	Gross Sampler #2	8.81	13.89	13.63
Return				
#500 package	MRE	2.48	2.20	2.95
<u>Airflow, cfm</u>				
Intake		20,481	11,935	15,221
Face		9,791	6,901	7,892
Return		21,150	27,860	23,121
<u>Waterflow</u>				
Gallons per shift		3,192	3,180	3,450
Average gpm for shift		30.9	27.4	30.3
Average pressure for shift		267	256	267
Tons Mined		600	700	600
Number of Passes		6	7	6
Cutting Time, min		103	116	114

a "cutting time concentration." This quantity was then used as one means of comparing spray system performance.

2. It is accepted that respirable dust concentration levels are directly related to the volume of ventilation air flowing during the cutting process; that is, with a given amount of dust being liberated, if the ventilation air is doubled, the dust concentration in  $\text{mg}/\text{m}^3$  should decrease by 50 percent. Since, as previously noted, there were variations in airflow from shift to shift and a downward trend throughout the tests, the cutting concentrations were adjusted to a base airflow using the relationship

$$\text{Normalized concentration} = (\text{calculated concentration}) \times \left( \frac{\text{measured airflow}}{\text{base airflow}} \right)$$

where the base airflow was the average of the measured airflows for the valid shifts.

This normalized value, which minimizes the effect of changing airflow, was used as a second basis for comparison of spray system performance.

3. Three distinct airflow measurements: intake air, face air, and return air, were used in calculating dust concentrations in the intake heading, along the face, and in the return.

The face airflow measurements, were the sum of four separate measurements taken (1) directly over the panline, (2) in the walkway between the panline and the front hydraulic cylinders of the roof chocks, (3) between the front and back hydraulic cylinders of the roof chocks, and (4) behind the chocks (see Figure 81). Accurate measurements could be taken in the first three sections; the flow behind the chocks was difficult to determine, however, because the cross-sectional area was constantly changing and had to be estimated, and velocity measurements could only be taken immediately behind the rear hydraulic rams under the support canopy. Therefore, the cutting concentration was normalized on the basis of the sum of the airflow over the panline and in the walkway for the following reasons:

a. These airflows could be more accurately measured than total face airflow.

b. Since the dust measurements along the face were taken in air flowing through the walkway, the concentration level would be more closely related to or affected by changes in this airflow.

c. The airflow between the chock cylinders and behind the chocks, visibly cleaner than the pan and walkway air, was not representative of the dust levels actually being generated and was not considered in the normalizing procedure.

4. Another factor related to dust levels is the number of tons of coal mined and the amount of dust liberated by each ton or the  $\text{mg}$  of respirable dust/ton of coal mined. The formula used to calculate this quantity is:

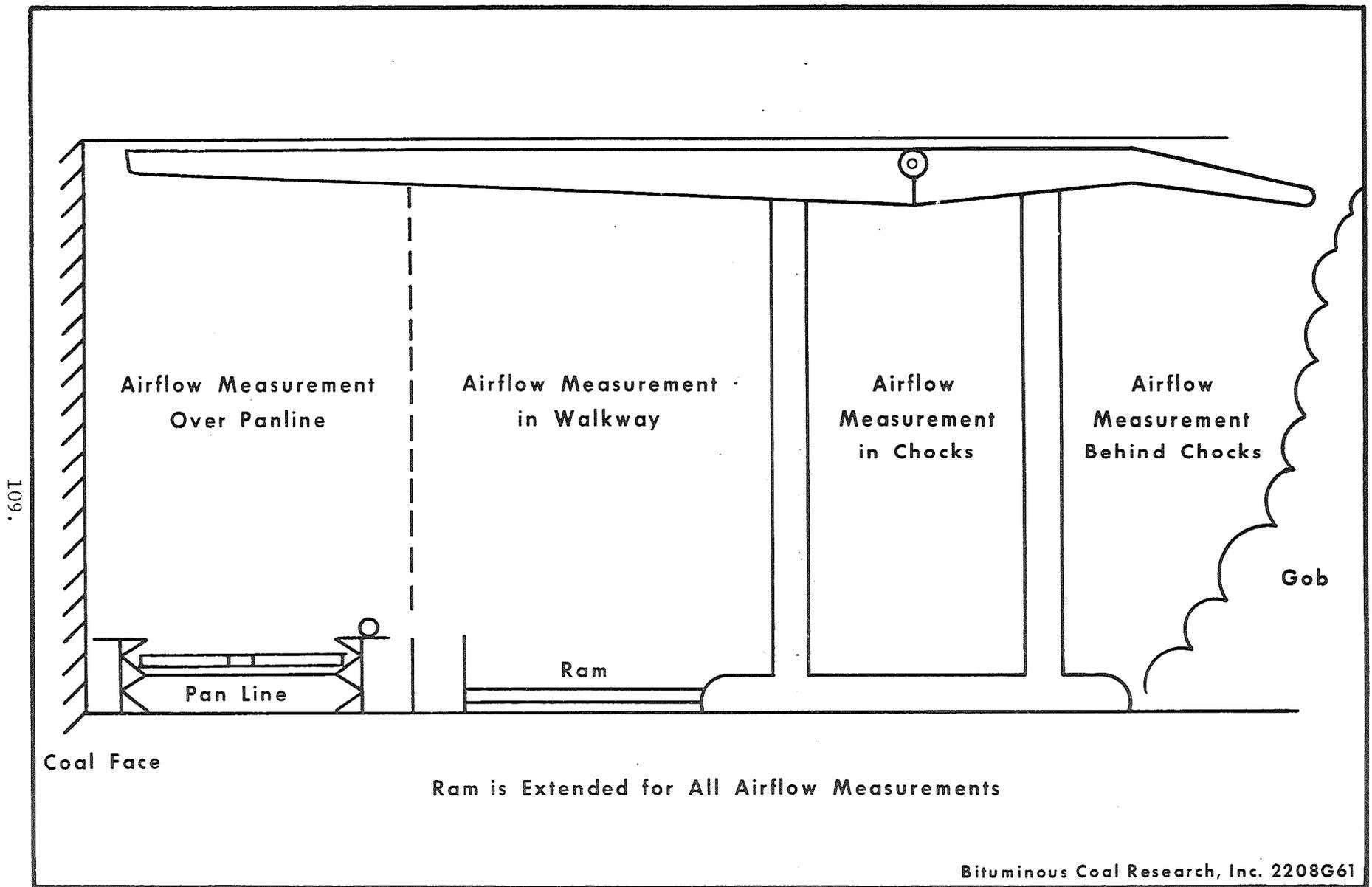


Figure 68. Diagram of Four Areas Used to Determine Face Airflow

$$\text{Mg/ton} = \frac{(\text{dust concentration, mg/m}^3)(\text{cfm of ventilation air})(\text{sampling time, min})}{\text{Tons of coal mined}}$$

This quantity, which takes into account both the amount of coal mined and the airflow quantities, was the third basis for comparison of spray system performance.

The use of these three measures of performance, instead of one, should reinforce the conclusions drawn from the data analysis.

The results of calculation of these dust concentration quantities are presented in Table 16 and in Figure 66, page 88, and in Appendix D. The results of the data analyses, by spray system and water flow level, are given in the following sections.

#### A. Comparison of Spray System Performance

One method used to evaluate the performance of the spray systems was to compare measured dust concentrations and determine the number of times each system ranked number one (lowest concentration), number two (second lowest), or number three (highest concentration) for the various test conditions at each sampling location, and for the different bases of comparison.

In the following analysis, data were considered from four sampling positions (shearer, midpoint, tail, and return positions) and compared on three bases (cutting concentration, cutting concentration normalized for panline air flow, and dust weight per ton). This provided 12 comparisons of system performance in reducing respirable dust at both low and high water flows. Only three comparisons were possible for gross dust since it was measured only at the "head" sampling position.

Table 17 presents the average values of the three different dust concentration values calculated for the valid test shifts by spray system and sampling location. An examination of these data show the following results:

1. The ranking of the systems with respect to reducing respirable dust levels, summarized in Table 18, shows that spray system performance is definitely affected by the waterflow rate. For the low flow rate, 21 gpm, the ranking is:

Number One, Lowest concentration - Standard Eickhoff system  
 Number Two, Second lowest concentration - Sprays behind the bits  
 Number Three, Highest concentration - Sprays in front of the bits

For the high flow rate, 27 gpm, the ranking is:

Number One, Lowest concentration - Nozzles behind the bits

TABLE 16. CALCULATED MRE EQUIVALENT DUST CONCENTRATION LEVELS FOR  
VALID TEST SHIFTS AT VARIOUS SAMPLING LOCATIONS

Shift No.	22	23	24	26	27
Date:	1-6-75	1-7-75	1-7-75	1-8-75	1-9-75
<u>Spray System and Water Flow Rate (gpm)</u>					
Front of Bits	21	21	21	21	21
Back of Bits					
Standard					
<u>Shearer Package</u>					
Uncorrected (mg/m <sup>3</sup> )	2.64	1.94	1.86	2.13	1.26
Normalized for panline airflow (mg/m <sup>3</sup> )	3.75	2.74	2.14	2.97	1.84
Normalized for airflow & tonnage (mg/ton)	221	176	165	211	106
<u>Midpoint Package</u>					
Uncorrected (mg/m <sup>3</sup> )	5.61	4.50	3.49	4.42	3.67
Normalized for airflow (mg/m <sup>3</sup> )	7.98	6.36	4.02	6.16	5.37
Normalized for airflow & tonnage (mg/ton)	513	452	340	505	463
<u>Head Package</u>					
Uncorrected (mg/m <sup>3</sup> )	10.31	10.23	11.24	11.46	8.56
Normalized for airflow (mg/m <sup>3</sup> )	14.67	14.43	12.95	15.96	12.52
Normalized for airflow & tonnage (mg/ton)	953	1084	1091	1256	1086
<u>Return Package</u>					
Uncorrected (mg/m <sup>3</sup> )	11.40	11.94	12.86	7.67	9.28
Normalized for airflow (mg/m <sup>3</sup> )	16.19	16.84	14.83	10.69	13.57
Normalized for airflow & tonnage (mg/ton)	819	1071	1128	755	1039
<u>Gross Dust at Head</u>					
Uncorrected (mg/m <sup>3</sup> )	38.07	42.26	47.17	47.37	33.52
Normalized for airflow (mg/m <sup>3</sup> )	54.09	59.61	54.38	65.95	49.01
Normalized for airflow & tonnage (mg/ton)	3959	4812	5187	5904	4778

TABLE 16. CALCULATED MRE EQUIVALENT DUST CONCENTRATION LEVELS FOR  
VALID TEST SHIFTS AT VARIOUS SAMPLING LOCATIONS (Continued)

Shift No.	28	29	30	32	33
Date:	1-9-75	1-10-75	1-10-75	1-14-75	1-14-75
<u>Spray System and Water Flow Rate (gpm)</u>					
Front of Bits	21	21	21		
Back of Bits				21	21
Standard					
<u>Shearer Package</u>					
Uncorrected (mg/m <sup>3</sup> )	1.86	1.90	1.55	2.55	1.26
Normalized for panline airflow (mg/m <sup>3</sup> )	2.39	2.81	2.18	3.37	1.37
Normalized for airflow & tonnage (mg/ton)	146	203	128	274	86
<u>Midpoint Package</u>					
Uncorrected (mg/m <sup>3</sup> )	3.44	3.60	4.70	6.87	5.46
Normalized for airflow (mg/m <sup>3</sup> )	4.41	5.31	6.61	9.09	5.93
Normalized for airflow & tonnage (mg/ton)	311	436	429	839	401
<u>Head Package</u>					
Uncorrected (mg/m <sup>3</sup> )	10.48	9.79	9.24	10.91	14.88
Normalized for airflow (mg/m <sup>3</sup> )	13.43	14.46	12.99	14.29	16.17
Normalized for airflow & tonnage (mg/ton)	946	1201	879	1289	1107
<u>Return Package</u>					
Uncorrected (mg/m <sup>3</sup> )	9.33	9.66	11.31	23.79	0.51
Normalized for airflow (mg/m <sup>3</sup> )	11.95	14.27	15.91	31.47	0.55
Normalized for airflow & tonnage (mg/ton)	718	1021	934	2539	34
<u>Gross Dust at Head</u>					
Uncorrected (mg/m <sup>3</sup> )	39.03	34.53	37.82	34.08	54.49
Normalized for airflow (mg/m <sup>3</sup> )	50.01	51.01	53.18	45.07	59.22
Normalized for airflow & tonnage (mg/ton)	3828	4574	4387	4625	4581

TABLE 16. CALCULATED MRE EQUIVALENT DUST CONCENTRATION LEVELS FOR  
VALID TEST SHIFTS AT VARIOUS SAMPLING LOCATIONS (Continued)

Shift No.	34	35	36	40	43
Date:	1-15-75	1-15-75	1-17-75	1-22-75	1-23-75
<u>Spray System and Water Flow Rate (gpm)</u>					
Front of Bits					
Back of Bits	21	21	21	21	21
Standard					
<u>Shearer Package</u>					
Uncorrected (mg/m <sup>3</sup> )	1.03	.96	1.25	2.72	1.35
Normalized for panline airflow (mg/m <sup>3</sup> )	1.15	1.16	1.65	2.59	1.52
Normalized for airflow & tonnage (mg/ton)	94	90	111	166	132
<u>Midpoint Package</u>					
Uncorrected (mg/m <sup>3</sup> )	3.06	4.69	3.95	7.87	6.37
Normalized for airflow (mg/m <sup>3</sup> )	3.42	5.69	5.19	7.49	7.12
Normalized for airflow & tonnage (mg/ton)	324	458	388	513	652
<u>Head Package</u>					
Uncorrected (mg/m <sup>3</sup> )	7.28	11.20	7.95	15.77	12.05
Normalized for airflow (mg/m <sup>3</sup> )	8.13	13.60	10.45	15.00	13.48
Normalized for airflow & tonnage (mg/ton)	740	1152	795	1075	1257
<u>Return Package</u>					
Uncorrected (mg/m <sup>3</sup> )	4.44	0.93	7.68	15.54	13.08
Normalized for airflow (mg/m <sup>3</sup> )	4.96	1.13	10.09	14.78	14.63
Normalized for airflow & tonnage (mg/ton)	405	86	676	941	1260
<u>Gross Dust at Head</u>					
Uncorrected (mg/m <sup>3</sup> )	21.07	37.78	23.98	58.39	37.92
Normalized for airflow (mg/m <sup>3</sup> )	23.55	45.86	31.51	55.54	42.42
Normalized for airflow & tonnage (mg/ton)	2436	4342	2677	4499	4536

TABLE 16. CALCULATED MRE EQUIVALENT DUST CONCENTRATION LEVELS FOR  
VALID TEST SHIFTS AT VARIOUS SAMPLING LOCATIONS (Continued)

Shift No.	46	49	54	56	57
Date:	8-27-75	8-28-75	9-5-75	9-8-75	9-9-75
<u>Spray System and Water Flow Rate (gpm)</u>					
Front of Bits					
Back of Bits					
Standard	21	21	21	21	21
<u>Shearer Package</u>					
Uncorrected (mg/m <sup>3</sup> )	0.42	2.39	.84	2.32	2.27
Normalized for panline airflow (mg/m <sup>3</sup> )	0.55	0.95	.95	1.24	2.37
Normalized for airflow & tonnage (mg/ton)	30	52	62	104	119
<u>Midpoint Package</u>					
Uncorrected (mg/m <sup>3</sup> )	1.88	6.59	4.65	3.42	3.04
Normalized for airflow (mg/m <sup>3</sup> )	2.45	2.63	5.21	1.83	3.17
Normalized for airflow & tonnage (mg/ton)	170	162	387	198	175
<u>Head Package</u>					
Uncorrected (mg/m <sup>3</sup> )	7.80	15.41	7.11	11.69	8.35
Normalized for airflow (mg/m <sup>3</sup> )	10.15	6.16	7.96	6.27	8.70
Normalized for airflow & tonnage (mg/ton)	639	375	603	625	481
<u>Return Package</u>					
Uncorrected (mg/m <sup>3</sup> )	9.55	8.21	9.72	11.72	7.98
Normalized for airflow (mg/m <sup>3</sup> )	12.42	3.28	10.89	6.28	8.31
Normalized for airflow & tonnage (mg/ton)	682	182	707	537	430
<u>Gross Dust at Head</u>					
Uncorrected (mg/m <sup>3</sup> )	46.40	83.94	65.79	179.67	87.93
Normalized for airflow (mg/m <sup>3</sup> )	60.37	33.54	73.72	96.41	91.61
Normalized for airflow & tonnage (mg/ton)	4128	2312	6089	10178	5758

TABLE 16. CALCULATED MRE EQUIVALENT DUST CONCENTRATION LEVELS FOR  
VALID TEST SHIFTS AT VARIOUS SAMPLING LOCATIONS (Continued)

Shift No.	58	59	60	63	65
Date:	9-9-75	9-10-75	9-11-75	9-13-75	9-15-75
<u>Spray System and Water Flow Rate (gpm)</u>					
Front of Bits					27
Back of Bits					
Standard	21	21	21	21	
<u>Shearer Package</u>					
Uncorrected (mg/m <sup>3</sup> )	2.71	1.11	2.18	3.06	0.90
Normalized for panline airflow (mg/m <sup>3</sup> )	2.66	1.26	2.68	1.75	0.84
Normalized for airflow & tonnage (mg/ton)	173	64	120	131	41
<u>Midpoint Package</u>					
Uncorrected (mg/m <sup>3</sup> )	4.10	2.78	3.99	6.86	2.73
Normalized for airflow (mg/m <sup>3</sup> )	4.02	3.15	4.90	3.93	2.54
Normalized for airflow & tonnage (mg/ton)	307	181	255	338	143
<u>Head Package</u>					
Uncorrected (mg/m <sup>3</sup> )	10.89	7.01	10.34	15.2	6.33
Normalized for airflow (mg/m <sup>3</sup> )	10.69	7.93	12.70	8.72	5.89
Normalized for airflow & tonnage (mg/ton)	812	455	659	765	333
<u>Return Package</u>					
Uncorrected (mg/m <sup>3</sup> )	18.55	8.80	10.54	9.03	6.50
Normalized for airflow (mg/m <sup>3</sup> )	18.21	9.96	12.94	5.18	6.05
Normalized for airflow & tonnage (mg/ton)	1167	492	726	483	369
<u>Gross Dust at Head</u>					
Uncorrected (mg/m <sup>3</sup> )	138.68	83.00	101.62	76.32	23.91
Normalized for airflow (mg/m <sup>3</sup> )	136.16	93.96	124.80	43.80	22.24
Normalized for airflow & tonnage (mg/ton)	11068	5993	7000	4085	1358

TABLE 16. CALCULATED MRE EQUIVALENT DUST CONCENTRATION LEVELS FOR  
VALID TEST SHIFTS AT VARIOUS SAMPLING LOCATIONS (Continued)

Shift No.	66	67	68	69	70
Date:	9-16-75	9-16-75	9-17-75	9-17-75	9-18-75
<u>Spray System and Water Flow Rate (gpm)</u>					
Front of Bits	27	27	27	21	27
Back of Bits					
Standard					
<u>Shearer Package</u>					
Uncorrected (mg/m <sup>3</sup> )	1.36	1.58	1.25	1.49	1.25
Normalized for panline airflow (mg/m <sup>3</sup> )	1.46	1.55	1.15	.91	1.27
Normalized for airflow & tonnage (mg/ton)	92	78	78	55	66
<u>Midpoint Package</u>					
Uncorrected (mg/m <sup>3</sup> )	2.88	2.65	4.66	4.00	5.03
Normalized for airflow (mg/m <sup>3</sup> )	3.09	2.60	4.28	2.46	5.12
Normalized for airflow & tonnage (mg/ton)	231	154	331	164	299
<u>Head Package</u>					
Uncorrected (mg/m <sup>3</sup> )	9.87	11.70	13.14	12.41	10.66
Normalized for airflow (mg/m <sup>3</sup> )	10.59	11.49	12.07	7.64	10.85
Normalized for airflow & tonnage (mg/ton)	764	665	911	514	649
<u>Return Package</u>					
Uncorrected (mg/m <sup>3</sup> )	8.84	8.40	7.11	6.46	9.62
Normalized for airflow (mg/m <sup>3</sup> )	9.48	8.25	6.52	3.97	9.80
Normalized for airflow & tonnage (mg/ton)	746	521	554	301	641
<u>Gross Dust at Head</u>					
Uncorrected (mg/m <sup>3</sup> )	34.31	44.17	43.54	52.11	40.90
Normalized for airflow (mg/m <sup>3</sup> )	36.81	43.38	39.98	32.09	41.64
Normalized for airflow & tonnage (mg/ton)	2894	2738	3393	2434	2724

TABLE 16. CALCULATED MRE EQUIVALENT DUST CONCENTRATION LEVELS FOR  
VALID TEST SHIFTS AT VARIOUS SAMPLING LOCATIONS (Continued)

Shift No.	71	72	73	75	76
Date:	9-18-75	9-19-75	9-19-75	9-22-75	9-23-75
<u>Spray System and Water Flow Rate (gpm)</u>					
Front of Bits	27	21	27		
Back of Bits				27	27
Standard					
<u>Shearer Package</u>					
Uncorrected (mg/m <sup>3</sup> )	2.02	0.90	1.14	0.60	1.26
Normalized for panline airflow (mg/m <sup>3</sup> )	.99	0.78	1.01	0.50	1.47
Normalized for airflow & tonnage (mg/ton)	48	39	47	31	76
<u>Midpoint Package</u>					
Uncorrected (mg/m <sup>3</sup> )	5.03	5.14	4.50	3.69	3.88
Normalized for airflow (mg/m <sup>3</sup> )	2.46	4.42	4.04	3.06	4.55
Normalized for airflow & tonnage (mg/ton)	134	245	214	223	267
<u>Head Package</u>					
Uncorrected (mg/m <sup>3</sup> )	12.71	13.68	7.74	7.58	7.62
Normalized for airflow (mg/m <sup>3</sup> )	6.21	11.76	6.91	6.28	8.94
Normalized for airflow & tonnage (mg/ton)	348	658	365	459	537
<u>Return Package</u>					
Uncorrected (mg/m <sup>3</sup> )	8.00	5.01	8.34	9.62	7.52
Normalized for airflow (mg/m <sup>3</sup> )	3.91	4.31	7.44	7.97	8.81
Normalized for airflow & tonnage (mg/ton)	237	271	432	622	567
<u>Gross Dust at Head</u>					
Uncorrected (mg/m <sup>3</sup> )	46.29	64.43	30.84	23.56	20.25
Normalized for airflow (mg/m <sup>3</sup> )	22.65	55.41	27.51	19.52	23.74
Normalized for airflow & tonnage (mg/ton)	1376	3485	1598	1524	1528

TABLE 16. CALCULATED MRE EQUIVALENT DUST CONCENTRATION LEVELS FOR VALID TEST SHIFTS AT VARIOUS SAMPLING LOCATIONS (Continued)

Shift No.	77	78	79	80	81
Date:	9-23-75	9-24-75	9-24-75	9-25-75	9-25-75
<u>Spray System and Water Flow Rate (gpm)</u>					
Front of Bits					
Back of Bits	27	21	21	27	27
Standard					
<u>Shearer Package</u>					
Uncorrected (mg/m <sup>3</sup> )	1.20	0.68	0.89	1.25	1.52
Normalized for panline airflow (mg/m <sup>3</sup> )	0.86	0.65	0.36	0.84	1.15
Normalized for airflow & tonnage (mg/ton)	59	50	39	47	79
<u>Midpoint Package</u>					
Uncorrected (mg/m <sup>3</sup> )	4.13	3.92	3.89	4.09	4.35
Normalized for airflow (mg/m <sup>3</sup> )	2.98	3.74	1.59	2.75	3.30
Normalized for airflow & tonnage (mg/ton)	239	335	202	177	262
<u>Head Package</u>					
Uncorrected (mg/m <sup>3</sup> )	8.82	8.59	9.53	9.43	10.91
Normalized for airflow (mg/m <sup>3</sup> )	6.37	8.21	3.91	6.34	8.28
Normalized for airflow & tonnage (mg/ton)	515	740	494	406	662
<u>Return Package</u>					
Uncorrected (mg/m <sup>3</sup> )	8.03	9.81	6.89	8.78	10.04
Normalized for airflow (mg/m <sup>3</sup> )	5.80	9.37	2.83	5.90	7.61
Normalized for airflow & tonnage (mg/ton)	500	912	384	419	653
<u>Gross Dust at Head</u>					
Uncorrected (mg/m <sup>3</sup> )	26.03	33.36	31.87	30.31	29.36
Normalized for airflow (mg/m <sup>3</sup> )	18.80	31.87	13.08	20.38	22.28
Normalized for airflow & tonnage (mg/ton)	1622	3101	1775	1447	1911

TABLE 16. CALCULATED MRE EQUIVALENT DUST CONCENTRATION LEVELS FOR  
VALID TEST SHIFTS AT VARIOUS SAMPLING LOCATIONS (Continued)

Shift No.	82	83	85	86	87
Date:	9-26-75	9-26-75	10-2-75	10-3-75	10-3-75
<u>Spray System and Water Flow Rate (gpm)</u>					
Front of Bits					
Back of Bits	27	27			
Standard			27	27	27
<u>Shearer Package</u>					
Uncorrected (mg/m <sup>3</sup> )	0.69	1.42	0.94	1.74	1.11
Normalized for panline airflow (mg/m <sup>3</sup> )	0.74	0.74	0.68	1.19	0.77
Normalized for airflow & tonnage (mg/ton)	58	64	49	68	59
<u>Midpoint Package</u>					
Uncorrected (mg/m <sup>3</sup> )	2.76	4.22	4.41	5.81	6.62
Normalized for airflow (mg/m <sup>3</sup> )	2.95	2.20	3.20	3.96	4.59
Normalized for airflow & tonnage (mg/ton)	269	221	267	262	403
<u>Head Package</u>					
Uncorrected (mg/m <sup>3</sup> )	7.52	8.35	8.86	12.11	9.60
Normalized for airflow (mg/m <sup>3</sup> )	8.04	4.35	6.43	8.25	6.66
Normalized for airflow & tonnage (mg/ton)	733	444	546	553	599
<u>Return Package</u>					
Uncorrected (mg/m <sup>3</sup> )	6.91	6.92	9.00	7.22	9.41
Normalized for airflow (mg/m <sup>3</sup> )	7.38	3.61	6.53	4.92	6.52
Normalized for airflow & tonnage (mg/ton)	727	392	586	356	626
<u>Gross Dust at Head</u>					
Uncorrected (mg/m <sup>3</sup> )	25.96	24.84	39.31	59.63	35.47
Normalized for airflow (mg/m <sup>3</sup> )	27.75	12.96	28.53	40.62	24.59
Normalized for airflow & tonnage (mg/ton)	2732	1409	2562	2944	2358

TABLE 16. CALCULATED MRE EQUIVALENT DUST CONCENTRATION LEVELS FOR  
VALID TEST SHIFTS AT VARIOUS SAMPLING LOCATIONS (Continued)

Shift No.	88	89	90	91	92
Date:	10-6-75	10-6-75	10-7-75	10-7-75	10-8-75
<u>Spray System and Water Flow Rate (gpm)</u>					
Front of Bits					27
Back of Bits					
Standard	27	27	27	27	
<u>Shearer Package</u>					
Uncorrected (mg/m <sup>3</sup> )	1.00	1.37	1.85	2.14	1.45
Normalized for panline airflow (mg/m <sup>3</sup> )	1.13	0.67	1.36	1.16	1.21
Normalized for airflow & tonnage (mg/ton)	64	42	76	64	69
<u>Midpoint Package</u>					
Uncorrected (mg/m <sup>3</sup> )	3.49	3.49	5.24	5.91	4.85
Normalized for airflow (mg/m <sup>3</sup> )	3.98	1.72	3.85	3.20	4.04
Normalized for airflow & tonnage (mg/ton)	260	125	249	195	263
<u>Head Package</u>					
Uncorrected (mg/m <sup>3</sup> )	7.46	8.01	10.32	11.11	8.38
Normalized for airflow (mg/m <sup>3</sup> )	8.50	3.95	7.57	6.01	6.97
Normalized for airflow & tonnage (mg/ton)	567	289	501	373	465
<u>Return Package</u>					
Uncorrected (mg/m <sup>3</sup> )	9.87	6.19	9.30	9.48	9.63
Normalized for airflow (mg/m <sup>3</sup> )	11.25	3.05	6.82	5.13	8.01
Normalized for airflow & tonnage (mg/ton)	801	241	481	354	572
<u>Gross Dust at Head</u>					
Uncorrected (mg/m <sup>3</sup> )	28.87	36.33	49.37	53.76	33.12
Normalized for airflow (mg/m <sup>3</sup> )	32.89	17.92	36.22	29.09	27.55
Normalized for airflow & tonnage (mg/ton)	2342	1416	2552	2010	1971

TABLE 16. CALCULATED MRE EQUIVALENT DUST CONCENTRATION LEVELS FOR VALID TEST SHIFTS AT VARIOUS SAMPLING LOCATIONS (Concluded)

Shift No.	93	94
Date:	10-8-75	10-9-75
<u>Spray System and Water Flow Rate (gpm)</u>		
Front of Bits	27	27
Back of Bits		
Standard		
<u>Shearer Package</u>		
Uncorrected (mg/m <sup>3</sup> )	1.50	4.01
Normalized for panline airflow (mg/m <sup>3</sup> )	0.73	2.76
Normalized for airflow & tonnage (mg/ton)	48	170
<u>Midpoint Package</u>		
Uncorrected (mg/m <sup>3</sup> )	7.92	5.64
Normalized for airflow (mg/m <sup>3</sup> )	3.85	3.88
Normalized for airflow & tonnage (mg/ton)	289	278
<u>Head Package</u>		
Uncorrected (mg/m <sup>3</sup> )	12.73	10.64
Normalized for airflow (mg/m <sup>3</sup> )	6.19	7.32
Normalized for airflow & tonnage (mg/ton)	474	524
<u>Return Package</u>		
Uncorrected (mg/m <sup>3</sup> )	7.58	10.35
Normalized for airflow (mg/m <sup>3</sup> )	3.68	7.12
Normalized for airflow & tonnage (mg/ton)	307	549
<u>Gross Dust at Head</u>		
Uncorrected (mg/m <sup>3</sup> )	49.15	44.45
Normalized for airflow (mg/m <sup>3</sup> )	23.89	30.61
Normalized for airflow & tonnage (mg/ton)	1989	2359

TABLE 17. COMPARISON OF SPRAY SYSTEM PERFORMANCE

Nozzle Location	Respirable Dust Concentration (mg/m <sup>3</sup> ) at Sampling Locations								Gross Dust Concentration mg/m <sup>3</sup>	
	Shearer		Midpoint		Head		Return		Dust Level	Rank
	Dust Level	Rank	Dust Level	Rank	Dust Level	Rank	Dust Level	Rank		
A - Based on "Cutting Concentration"										
<u>Low Water Flow</u>										
Front of Bits	1.75	2	4.26	2	10.74	2	9.49	2	43.63	2
Back of Bits	1.41	1	5.12	3	10.91	3	9.19	1	36.99	1
Standard Sprays	1.92	3	4.15	1	10.42	1	10.45	3	95.93	3
<u>High Water Flow</u>										
Front of Bits	1.65	3	4.59	2	10.39	3	8.44	2	39.07	2
Back of Bits	1.13	1	3.87	1	8.60	1	8.26	1	25.76	1
Standard Sprays	1.45	2	4.99	3	9.64	2	8.64	3	43.25	3
B - Based on "Normalized Cutting Concentration"										
<u>Low Water Flow</u>										
Front of Bits	2.25	3	5.31	2	13.08	3	12.25	3	52.47	2
Back of Bits	1.53	1	5.48	3	11.49	2	9.98	2	38.68	1
Standard Sprays	1.60	2	3.48	1	8.81	1	9.72	1	83.82	3
<u>High Water Flow</u>										
Front of Bits	1.03	3	3.59	3	8.45	3	7.03	3	31.63	3
Back of Bits	.90	1	3.11	1	6.94	2	6.73	2	20.78	1
Standard Sprays	.99	2	3.50	2	6.77	1	6.32	1	29.98	2
C - Based on "Mg/Ton"										
<u>Low Water Flow</u>										
Front of Bits	145	3	386	2	967	3	806	3	4335	2
Back of Bits	116	2	457	3	961	2	804	2	3619	1
Standard Sprays	95	1	241	1	602	1	601	1	6290	3
<u>High Water Flow</u>										
Front of Bits	74	3	233	2	550	3	493	2	2240	2
Back of Bits	59	1	237	1	537	2	554	3	1739	1
Standard Sprays	60	2	252	3	490	1	492	1	2312	3

TABLE 18. COMPARISON OF SPRAY SYSTEM RANKING BASED ON CUTTING CONCENTRATION,  
NORMALIZED CUTTING CONCENTRATION, AND MG/TON

<u>Nozzle Location</u>	<u>Frequency of Ranking</u>					
	<u>Respirable Dust</u>			<u>Gross Dust</u>		
	<u>No. 1</u> <u>Most</u> <u>Effective</u>	<u>No. 2</u> <u>Second Most</u> <u>Effective</u>	<u>No. 3</u> <u>Least</u> <u>Effective</u>	<u>No. 1</u> <u>Most</u> <u>Effective</u>	<u>No. 2</u> <u>Second Most</u> <u>Effective</u>	<u>No. 3</u> <u>Least</u> <u>Effective</u>
<u>Low Water Flow</u>						
Front of Bits	0	6	6	0	3	0
Back of Bits	3	5	4	3	0	0
Standard Sprays	9	1	2	0	0	3
<u>High Water Flow</u>						
Front of Bits	0	4	8	0	2	1
Back of Bits	8	3	1	3	0	0
Standard Sprays	4	5	3	0	1	2

Number Two, Second lowest concentration - Standard Eickhoff system  
Number Three, Highest concentration - Nozzles in front of the bits

2. The performance of each spray system, regardless of comparative ranking, is definitely improved by higher water flow rates. This is shown in Table 19 which shows the percent increase (+) or decrease (-) in dust concentration with high water flow compared to that with low water flow. The values shown were calculated with the data in Table 17 using the relationship:

$$\% \text{ change} = \frac{(\text{concentration at high water flow}) - (\text{concentration at low water flow})}{(\text{concentration at low water flow})}$$

The specific results shown by the data of Table 19 are:

a. All systems show an improvement in performance with increased water flow.

b. The nozzles behind the bits show the greatest reduction in respirable dust, while the standard sprays show the least reduction.

c. The standard sprays show the lowest level in gross dust, and the nozzles in front of the bits show the least reduction in gross dust.

3. An indication of the validity of the data is the consistency of the results with respect to the various sampling location. Specifically, all locations appear to show similar rankings with respect to spray system performance in controlling dust levels and similar results between high and low spray water flows. Table 20 shows a comparison of the performance ranking by sampling location in terms of how many times a system received a particular ranking based on all three quantities used for comparison. Considering the variation in environmental conditions, such as airflow and water flow, and lack of controls over the test conditions, these results represent a high degree of consistency in comparison between the sampling locations and a high degree of reliability in conclusions made, based on the test data.

The high degree of consistency of the data showing the effect of water can be seen in Table 19, where 41 of 45 comparisons between high and low water flow data, including all sampler locations, show a reduction in dust levels when using the high water flows.

In addition to the data taken with personal and MRE samplers, dust samples were collected with midget impingers during individual passes of the shearer across the panel. The objective of these tests was to determine whether the direction of mining with the shearer made a difference in dust levels generated. The data collected with the midget impinger are given in Table 21. The values given in the table are dust weight (mg) collected

TABLE 19. COMPARISON OF THE EFFECT OF WATER FLOW  
ON SPRAY SYSTEM PERFORMANCE

Percent Increase or Decrease of Dust Level at Sampler Locations

<u>Nozzle Location</u>	<u>Shearer</u>	<u>Midpoint</u>	<u>Head</u>	<u>Return</u>	<u>Gross</u>
A - "Cutting Concentration"					
Front of Bits	- 5	+ 7	- 3	-11	-10
Back of Bits	-19	-24	-21	-10	-30
Standard Sprays	-24	+20	- 7	-19	-54
B - "Normalized Cutting Concentration"					
Front of Bits	-54	-32	-35	-42	-39
Back of Bits	-41	-43	-39	-32	-46
Standard Sprays	-38	+1.0	-23	-34	-65
C - "Mg/Ton"					
Front of Bits	-48	-39	-43	-38	-48
Back of Bits	-49	-48	-44	-31	-51
Standard Sprays	-36	+ 4	-18	-18	-63

Note: The above figures represent the percent reduction (-) or percent increase (+) in the average dust concentration when using each spray system with high water flow as compared to the corresponding test with low water flow. The percentages were calculated using the equation given on Page 154.

TABLE 20. COMPARISON OF SPRAY SYSTEM RANKING DATA TO SHOW  
CONSISTENCY OF RESULTS

<u>Nozzle Location</u>	<u>Sampling Location, Rank, and Frequency of Each Rank</u>														
	<u>Shearer</u>			<u>Midpoint</u>			<u>Head</u>			<u>Return</u>			<u>Gross</u>		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
<u>Low Water Flow</u>															
Front of Bits	0	0	3	0	3	0	0	1	2	0	1	2	0	3	0
Back of Bits	2	1	0	0	0	3	0	2	1	2	1	0	3	0	0
Standard System	1	2	0	3	0	0	3	0	0	1	1	1	0	0	3
<u>High Water Flow</u>															
Front of Bits	0	0	3	0	3	0	0	1	2	0	2	1	0	2	1
Back of Bits	3	0	0	3	0	0	2	1	0	1	1	1	3	0	0
Standard System	0	3	0	0	0	3	1	2	0	2	0	1	0	1	2

TABLE 21. MIDGET IMPINGER DUST WEIGHT DATA FOR SAMPLING OF  
INDIVIDUAL PASSES OF THE SHEARER

Shift No:	2*	3†	6	7	8	11	14†	22	24
Date:	6-11-74	6-13-74	9-16-74	9-17-74	9-18-74	9-24-74	10-1-74	1-6-75	1-7-75
<u>Spray System and Water Flow Rate (gpm)</u>									
Front of Bits								21	21
Back of Bits	21	21							
Standard System			21	21	21	21	21		
<u>Weight (mg) of Samples Collected During Head to Tail Passes</u>									
	0.6	8.0	3.9	1.6	4.1	4.1	2.4	1.5	
				2.2	1.1	4.5	1.6	.6	
				4.7					
<u>Weight (mg) of Samples Collected During Tail to Head Passes</u>									
	2.8	1.9	0.6	0.7	0.4	0.6	0.6	.6	.4
			0.6	0.6	0.3		0.5	1.4	2.6
			0.9					2.3	2.2
								1.9	1.6

\* Shearer using first BCR Test Drum (Shifts 2 and 3)

† Shearer using R&P Production Drum (Shifts 6 - 14)

† Shearer using BCR Test Drum (Shifts 22 - 94)

TABLE 21. MIDGET IMPINGER DUST WEIGHT DATA FOR SAMPLING OF  
INDIVIDUAL PASSES OF THE SHEARER (Continued)

Shift No:	26	28	30	31	33	36	39	45	49
Date:	1-8-75	1-9-75	1-10-75	1-13-75	1-14-75	1-17-75	1-21-75	8-25-75	8-28-75
<u>Spray System and Water Flow Rate (gpm)</u>									
Front of Bits	21	21	21						
Back of Bits				21	21	21	21		
Standard System								21	21
<u>Weight (mg) of Samples Collected During Head to Tail Passes</u>									
	3.9	1.5	4.9	9.9	8.4			7.3	2.2
	2.4	5.2	1.6	2.4	6.8				
		1.1			7.7				
					4.8				
<u>Weight (mg) of Samples Collected During Tail to Head Passes</u>									
	3.6		2.4		2.1	1.5	1.1	4.0	1.9
	1.0		1.7		1.8	1.0			
	2.3					1.9			
	3.0					1.0			
	2.4								
	1.1								

TABLE 21. MIDGET IMPINGER DUST WEIGHT DATA FOR SAMPLING OF  
INDIVIDUAL PASSES OF THE SHEARER (Continued)

Shift No:	51	53	54	56	58	61	66	68	70
Date:	9-2-75	9-4-75	9-5-75	9-8-75	9-9-75	9-11-75	9-16-75	9-17-75	9-18-75
<u>Spray System and Water Flow Rate (gpm)</u>									
Front of Bits							27	27	27
Back of Bits									
Standard System	21	21	21	21	21	21			
<u>Weight (mg) of Samples Collected During Head to Tail Passes</u>									
		2.8	1.0	2.2	4.8	3.4	.8	4.2	4.7
						6.0	.2	4.9	4.1
<u>Weight (mg) of Samples Collected During Tail to Head Passes</u>									
	1.0			2.0		1.3	.2	2.0	1.2
						1.2	1.0	1.6	1.7

TABLE 21. MIDGET IMPINGER DUST WEIGHT DATA FOR SAMPLING OF  
INDIVIDUAL PASSES OF THE SHEARER (Concluded)

Shift No:	72	76
Date:	9-19-75	9-23-75

Spray System and Water Flow Rate (gpm)

Front of Bits	21	
Back of Bits		27
Standard System		

Weight (mg) of Samples Collected During Head to Tail Passes

	7.2	1.2
	9.0	2.0

Weight (mg) of Samples Collected During Tail to Head Passes

	1.9	.8
	2.7	.8

during each pass. The sampler airflow used to collect the data was set by adjusting the pump setting to give a 12-inch vacuum differential across the impinger tube. Therefore, a definite flow was not known and concentrations corresponding to the dust weights could not be calculated. However, the results of the tests were conclusive and indicated the following:

a. The data in Table 22 indicate that the amount of total airborne dust liberated into the ventilating current during a single pass is a function of the shearer drum rotation, as shown in Figure 69.

Maximum dust levels were measured when the R&P drum, rotating clockwise, was cutting from tail to head and when the BCR drum, rotating counterclockwise, was cutting head to tail. In both cases the bits were cutting while moving up into the coal and the cuttings were thrown over the top of the drum into the ventilating current.

Minimum dust levels were measured when the R&P drum, rotating clockwise, was cutting from head to tail and when the BCR drum, rotating counterclockwise, was cutting tail to head. In both cases, the bits were cutting while moving down into the coal and throwing the cuttings into the confined area between the plow or gate and the drum, where a fixed spray was directed into the dust cloud. Therefore, the maximum total airborne dust was entrained in the ventilating current when the drum rotation was such that the coal cuttings are thrown upward.

b. Based on the limited data with high water flow, the impinger results appear to confirm that higher water flow does reduce dust levels.

c. The impinger data also corroborate the ranking of the spray systems, as determined by personal sampler data, with respect to reducing dust levels.

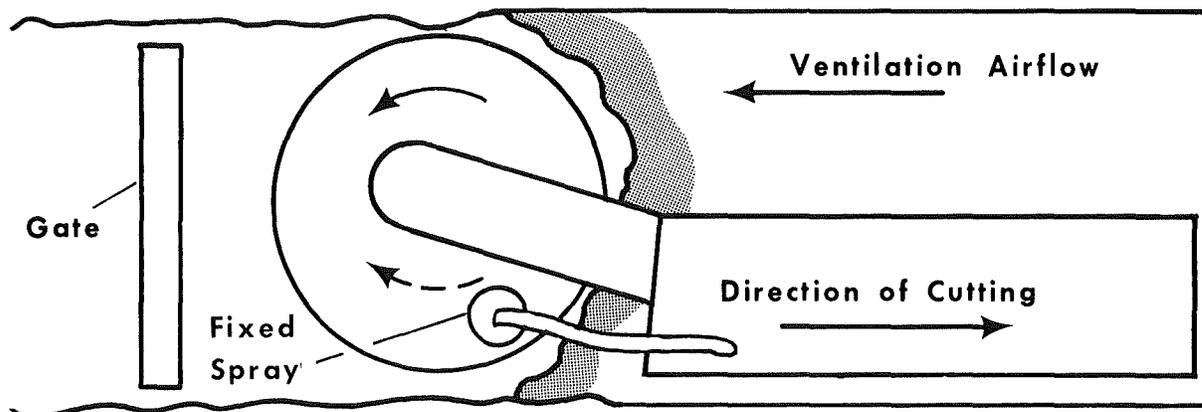
The test data are plotted in Figure 66 and in Appendix D as a function of the shift number for the shearer, midpoint, head, return, and gross sampler positions, using each of the three dust level comparisons; i.e., mg/ton, cutting concentration, and cutting concentration normalized for panline airflow.

Of particular interest in these graphs is (1) a comparison of the dust levels during the initial period of low water flow and the final period of high water flow, and (2) a comparison of the dust levels during periods when different spray systems were in use. To aid in these comparisons, different symbols were used in the dust level and waterflow curves to differentiate between the shifts using high and low water flows. In addition, the periods during which each spray system was used are indicated on the horizontal axis.

These graphs and the average dust levels, Table 23, for the period of operation with each spray system corroborate previous comparisons and show the following:

TABLE 22. SUMMARY OF AVERAGE SAMPLE DUST WEIGHT TAKEN  
WITH MIDGET IMPINGER FOR INDIVIDUAL PASSES OF THE SHEARER

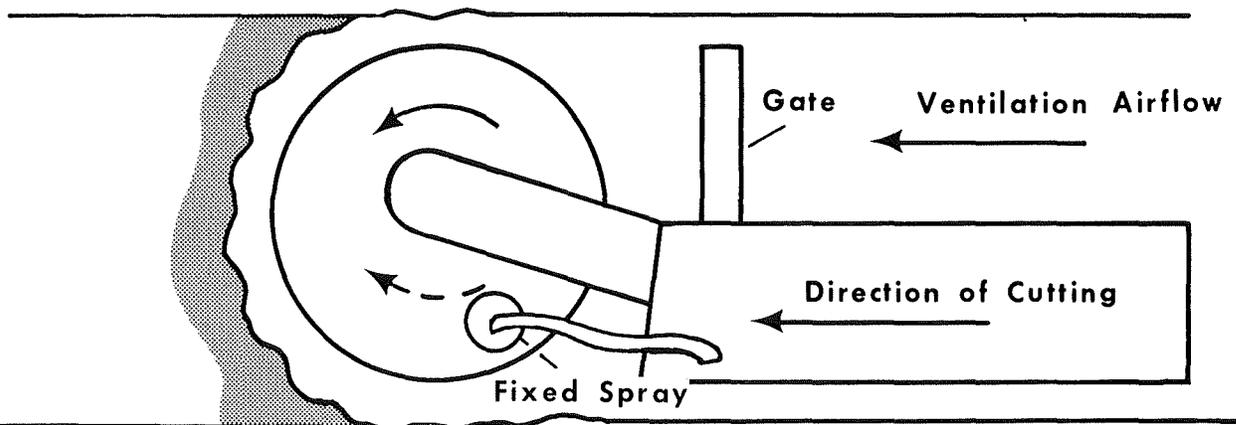
<u>Nozzle Location</u>	<u>BCR Test Drum</u>		<u>R&amp;P Production Drum</u>	
	<u>Direction of Shearer Pass</u>		<u>Direction of Shearer Pass</u>	
	Head to Tail, mg	Tail to Head, mg	Head to Tail, mg	Tail to Head, mg
<u>Low Water Flow</u>				
Front of Bits	3.8	2.1	---	---
Back of Bits	6.7	1.5	---	---
Standard System	3.7	1.9	0.7	2.3
<u>High Water Flow</u>				
Front of Bits	3.7	1.5	---	---
Back of Bits	1.6	0.8	---	---
Standard System	---	---	---	---



**(1) Head to Tail Pass**

**BCR Test Drum (Solid Arrow) - Gives Maximum Dust Weight with Cuttings Tending to be Thrown Over Top of Drum**

**R&P Production Drum (Dashed Arrow) - Gave Minimum Dust Weight with Cuttings Tending to be Deposited in Confined Area Covered by Spray**



**(2) Tail to Head Pass**

**BCR Test Drum (Solid Arrow) - Gives Minimum Dust Weight with Cuttings Tending to be Deposited in Confined Area Covered by Spray**

**R&P Production Drum (Dashed Arrow) - Gave Maximum Dust Weight with Cuttings Tending to be Thrown Over Top of Drum**

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**Figure 69. Relationship Between Drum Rotation and Weight of Dust Liberated into Ventilation Air**

TABLE 23. AVERAGE DUST LEVELS FOR TEST PERIODS USING DIFFERENT SPRAY SYSTEMS

Shift No.	22-30	32-43	46-63	65-73	75-83	85-91	92-94
Spray System	<u>Front of Bits</u>	<u>Back of Bits</u>	<u>Standard</u>	<u>Front of Bits</u>	<u>Back of Bits</u>	<u>Standard</u>	<u>Front of Bits</u>

A. Dust Levels, mg/ton

Sampling Location

Shearer	169	136	95	60	56	60	95
Midpoint	431	453	241	212	243	251	276
Head	1062	1059	602	578	554	490	487
Return	935	844	601	452	575	492	476
Gross	4678	3956	6290	2444	1894	2312	2106

B. Cutting Concentration (mg/m<sup>3</sup>)

Shearer	1.89	1.58	1.92	1.32	1.05	1.45	2.32
Midpoint	4.17	5.46	4.15	4.06	3.43	4.99	6.13
Head	10.16	11.44	10.42	10.91	8.70	9.64	10.58
Return	10.43	9.42	10.45	7.58	8.82	8.64	9.18
Gross	39.97	27.66	95.93	42.27	27.28	43.25	42.24

C. Cutting Concentration Normalized for Panline Airflow (mg/m<sup>3</sup>)

Shearer	2.60	1.83	1.60	1.10	.81	.99	1.56
Midpoint	5.77	6.27	3.48	3.44	3.01	3.50	3.92
Head	13.92	13.03	8.81	9.26	6.31	6.76	6.82
Return	14.28	11.08	9.72	6.63	7.14	6.32	6.27
Gross	54.65	43.31	83.82	35.74	21.15	29.98	27.35

Note - Shifts 22-63 were at low water flow (21 gpm)  
 Shifts 65-94 were at high water flow (27 gpm) with the exception of 5 shifts at low flow

(1) Dust levels are significantly reduced with higher water-flow rates.

(2) The standard spray system (noted as "Z" on the graph) is more effective than either bit-flushing system at low water flow and essentially equivalent to the nozzles located behind the bits (noted as "Y" on the graphs) at high water flow.

(3) The nozzles located in front of the bits (noted as "X" on the graphs) are least effective at both high and low water flows.

#### B. Effect of Spray Systems on Gross Airborne Dust

A comparison between the gross airborne and respirable dust concentrations shows that changes in gross airborne dust levels generally follow the same pattern as the respirable dust levels, (Figures 70, 71, and 72). Table 24 shows that, with the exception of the standard spray system at low water flow, the ratio of the gross dust concentration to the respirable dust concentration remained relatively constant on a shift-to-shift basis for all modes of operation.

The use of higher water pressures improved the knockdown efficiency on gross airborne dust with all modes of operation.

The jets located behind the bits were most effective in knocking down total airborne dust, while the standard Eickhoff spray system was the least effective.

#### C. Sampling with the R&P Production Drum

During the period from September 16, 1975 to November 17, 1975, a series of production shifts was sampled while a standard Eickhoff production drum was being used on the shearer. The drum was equipped with the standard spray system only, and the tests were conducted to provide a comparison with the BCR drum test drum using the standard system. The results of the tests, summarized in Table 25, show fair agreement between the test results using the standard spray systems on both drums. There is some variation in the measured concentration values of the production drum and test drum, but the comparison between the production drum spray system and the bit-flushing systems generally gives the same relative results as with the standard spray system on the test drum. This again confirms the previous conclusion that at low water flow the standard spray system is the most effective in suppressing respirable dust.

No sampling was done with high flow rates using the production drum because the water hoses in use would not withstand the higher pressure required.

#### D. Sampler Performance

To evaluate the accuracy and reliability of the MSA samplers, an analysis was made of the dust weights obtained from the midpoint and head sampling

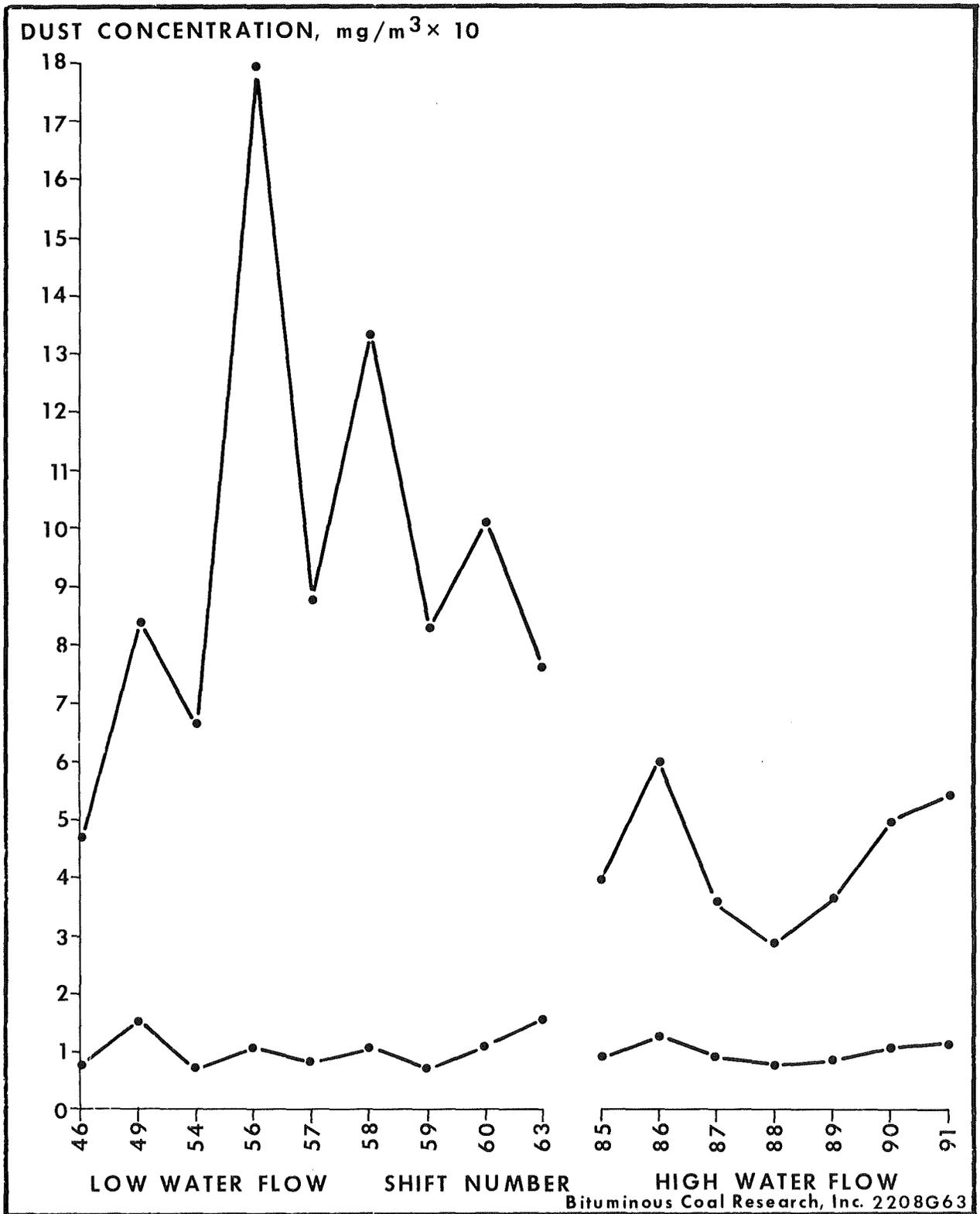
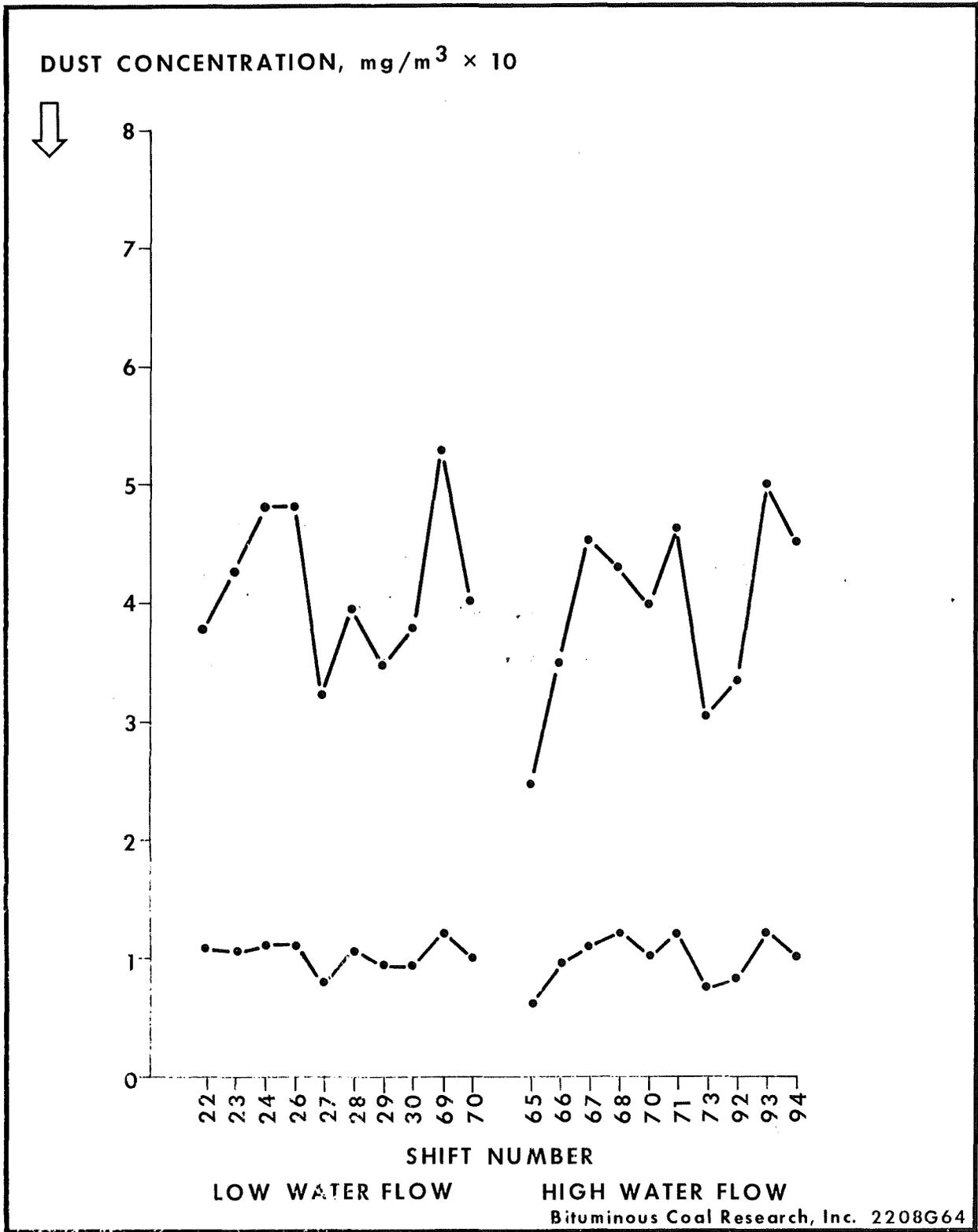


Figure 70. Comparison of Respirable and Gross Dust Concentrations at High and Low Water Flows Using Standard Sprays



**Figure 71. Comparison of Respirable and Gross Dust Concentrations at High and Low Water Flows Using Nozzles in Front of Bits**

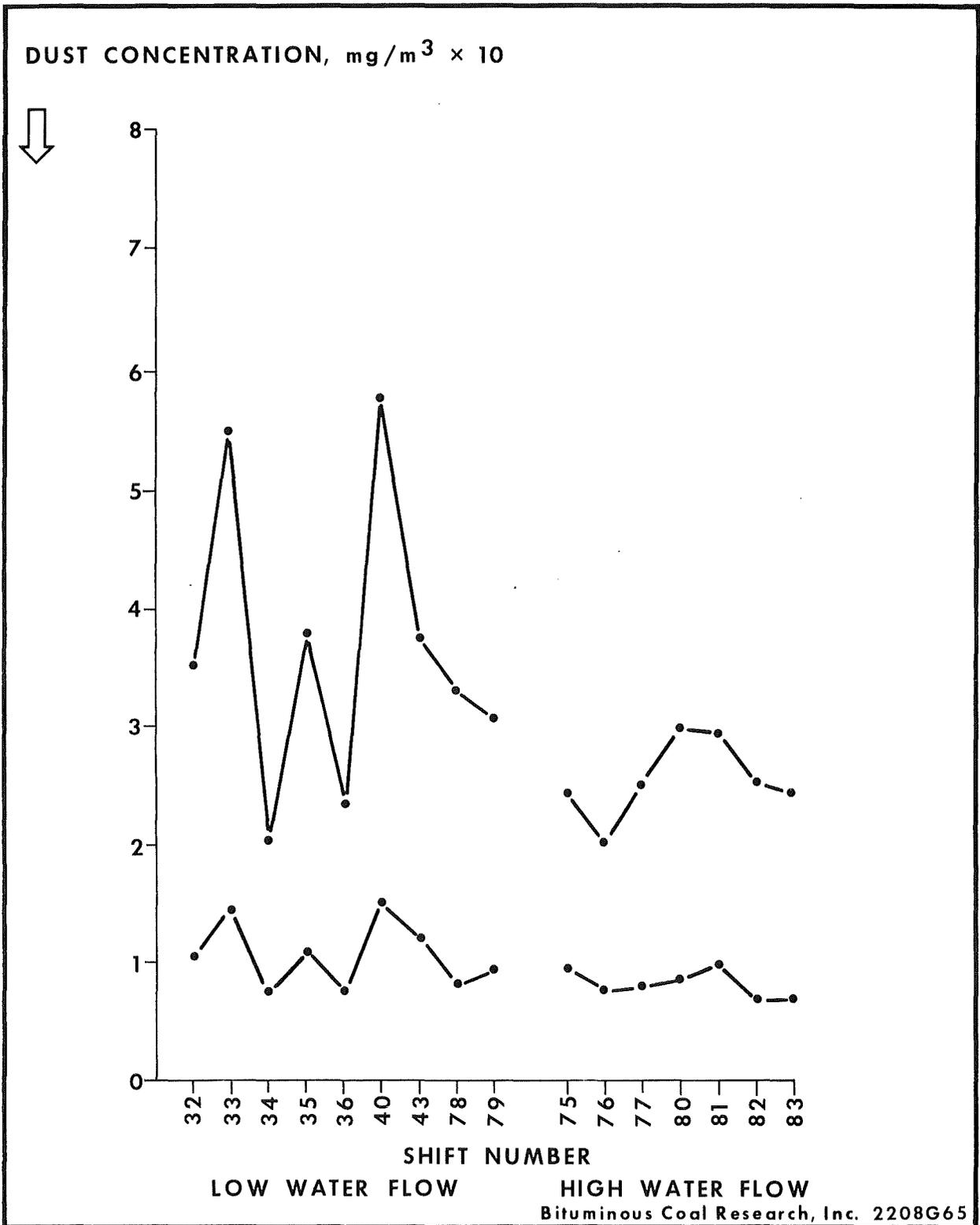


Figure 72. Comparison of Respirable and Gross Dust Concentrations at High and Low Water Flows Using Nozzles Back of Bits

TABLE 24. COMPARISON OF GROSS TO RESPIRABLE DUST  
CONCENTRATION RATIOS

<u>Standard System</u>		<u>Nozzles in Front of Bits</u>		<u>Nozzles Back of Bits</u>	
<u>Shift No.</u>	<u>Ratio</u>	<u>Shift No.</u>	<u>Ratio</u>	<u>Shift No.</u>	<u>Ratio</u>
<u>Low Water Flow</u>		<u>Low Water Flow</u>		<u>Low Water Flow</u>	
46	5.9	22	3.7	32	3.1
49	5.4	23	4.1	33	3.7
54	9.2	24	4.2	34	2.9
56	15.3	26	4.1	35	3.4
57	10.3	27	3.9	36	3.0
58	12.7	28	3.7	40	3.7
59	11.8	29	3.5	43	3.1
60	9.8	30	4.1	78	3.9
63	5.0	69	4.1	79	3.3
--	--	72	4.7	--	--
Average	9.5	Average	4.0	Average	3.3
<u>High Water Flow</u>		<u>High Water Flow</u>		<u>High Water Flow</u>	
85	4.4	65	3.8	75	3.1
86	4.9	66	3.5	76	2.6
87	3.7	67	3.8	77	2.9
88	3.9	68	3.3	80	3.2
89	4.5	70	3.8	81	2.7
90	4.8	71	3.6	82	3.4
91	4.8	73	4.0	83	3.0
--	--	92	3.8	--	--
--	--	93	3.8	--	--
--	--	94	4.2	--	--
Average	4.4	Average	3.7	Average	3.0

TABLE 25. COMPARISON OF R&P PRODUCTION DRUM AND BCR TEST DRUM SPRAY SYSTEM PERFORMANCES

<u>Nozzle Location</u>	<u>Sampling Locations-Respirable Dust</u>				<u>Gross Sampler</u>
	<u>Shearer</u>	<u>Midpoint</u>	<u>Head</u>	<u>Return</u>	<u>Head</u>
A. <u>Cutting Concentration, mg/m<sup>3</sup></u>					
Front of Bits	1.75	4.26	10.74	9.49	43.63
Back of Bits	1.41	5.12	10.91	9.19	36.99
Standard Sprays	1.92	4.15	10.42	10.45	95.93
Production Drum	1.53	2.97	8.09	9.00	45.83
B. <u>Cutting Concentration Normalized for Panline Airflow, mg/m<sup>3</sup></u>					
Front of Bits	2.25	5.31	13.08	12.25	52.47
Back of Bits	1.53	5.48	11.49	9.98	38.68
Standard Sprays	1.60	3.48	8.81	9.72	83.82
Production Drum	1.63	3.67	10.02	11.21	57.82
C. <u>Dust Level, mg/ton</u>					
Front of Bits	145	386	967	806	4335
Back of Bits	116	457	961	804	3619
Standard Sprays	95	241	602	601	6290
Production Drum	122	278	777	734	4845

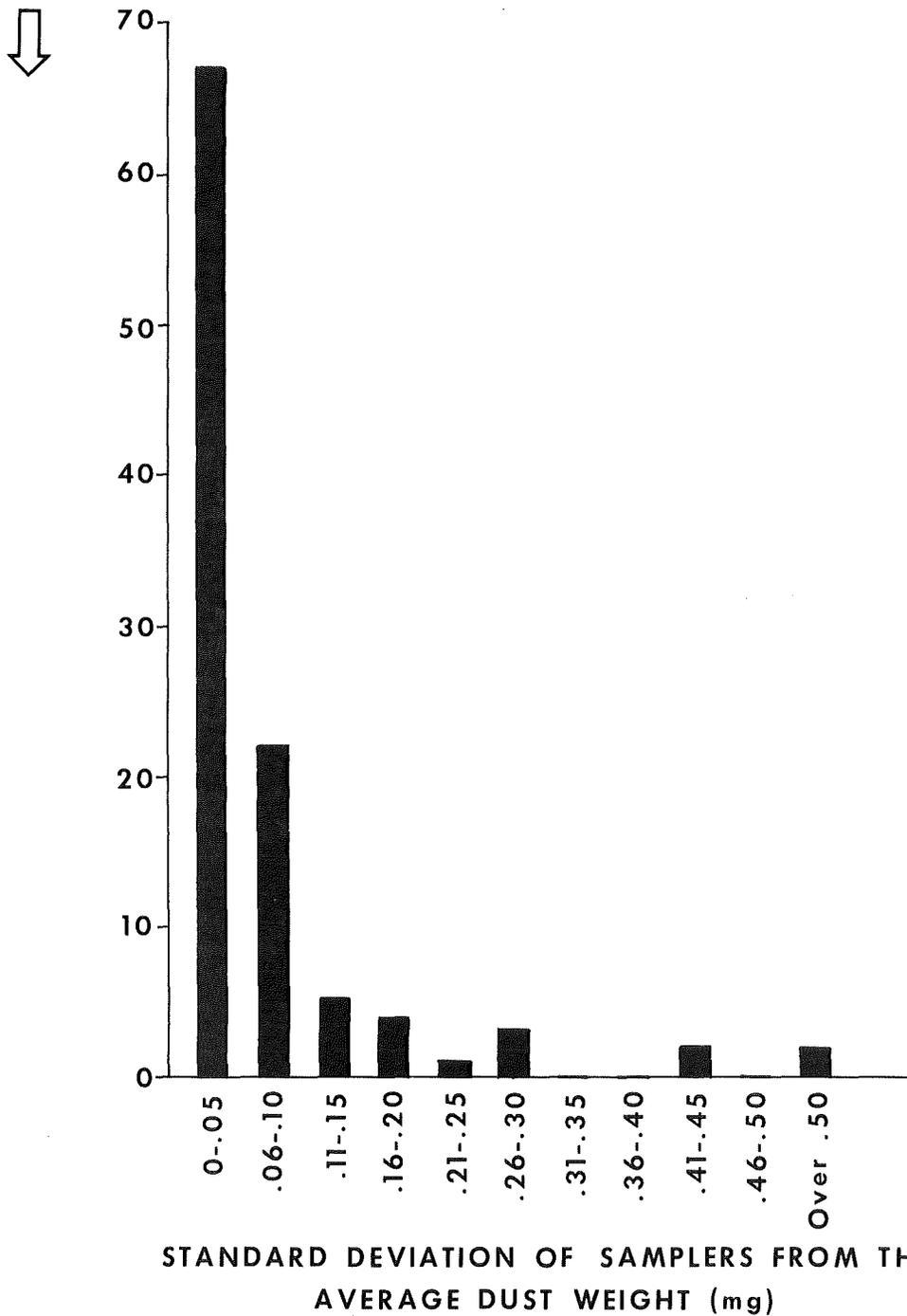
Note - All data taken at low water flow (21 GPM) through nozzles.

packages. Each package contained four MSA samplers. The average dust weight of the four samples from each package was determined. The standard deviation for each set of four samples was then calculated, as was the average percent deviation from the average weight.

The results of this analysis showed the average standard deviation of the samplers was  $\pm 0.09$  mg and the average percent deviation from the average weight was  $\pm 8.5$  percent. The distribution of the data is shown in Figures 73 and 74.

Both the low average deviation and the distribution pattern indicate a high degree of sampler accuracy and reliability. This is attributed to close monitoring of the samplers during underground operation and a high level of sampler maintenance, including frequent calibration checks of the sampler airflow.

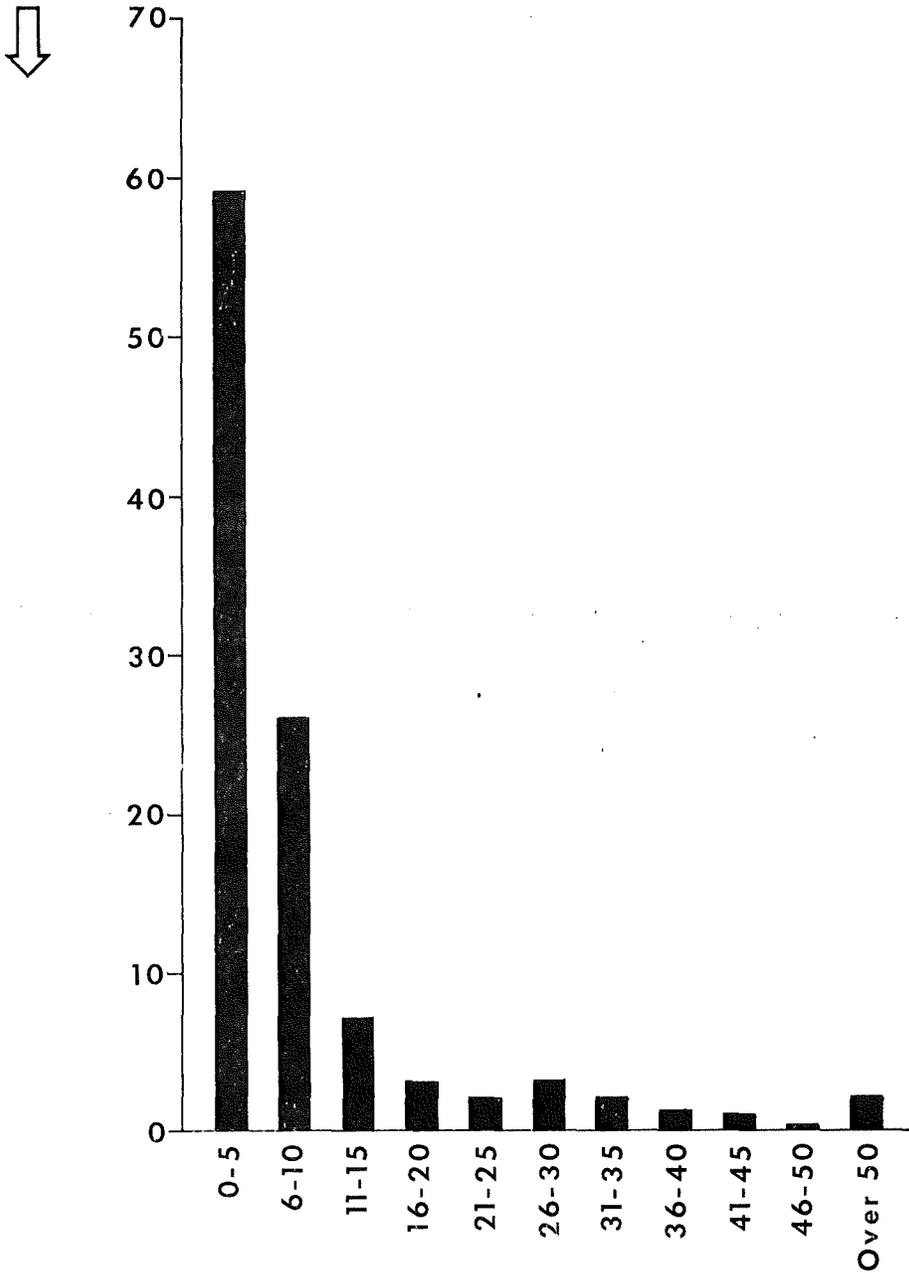
NUMBER OF SAMPLER PACKAGE MEASUREMENTS WITH STANDARD DEVIATION WITHIN RANGES INDICATED



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Figure 73. Distribution of Sampler Standard Deviation Data

NUMBER OF SAMPLER PACKAGE MEASUREMENTS HAVING PERCENT DEVIATION WITHIN RANGES INDICATED



PERCENT DEVIATION OF INDIVIDUAL SAMPLERS FROM AVERAGE DUST WEIGHT

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Figure 74. Distribution of Sampler Data for Standard Deviation as Percent of Average Dust Weights

## VII. DISCUSSION OF CONCLUSIONS

### A. Selection of a Spray System

The fact that statistical analysis of test results indicates that one spray system shows a lower dust level than another does not warrant that the system showing the lowest dust level be selected for use. Other questions that must be considered are:

1. Is the difference in dust levels significant; i.e., 10, 50, or 100 percent better?
2. How many sprays does each system require?
3. Are the sprays used in one system more prone to plugging than those in the other system, thus increasing maintenance problems?
4. Are the water delivery systems simple in design and maintenance-free?
5. Are the systems comparable in terms of water flow and pressure requirements?
6. Do the systems create any safety problems such as impairment of the operator's vision?
7. Do the systems restrict production?

If the candidate systems used during this project are analyzed on the basis of these factors, the selection of the best spray system is simplified.

Experience during the underground tests showed that none of the three systems created any safety problems or restricted production. The water flow rates and associated pressures used for each system were essentially the same. Since the same water delivery system was used for all three spray systems, maintenance would not vary regardless of the nozzle location used. Therefore, the selection resolves down to the number and type of sprays used and relative performance.

Examination of the spray system designs indicates a definite preference in favor of the standard system since:

1. The standard system has 10 sprays compared to 52 for each of the bit-flushing systems.
2. The orifice diameter of the standard spray is 0.098 in. compared to 0.040 in. for the bit-flushing sprays.

Both the greater number of sprays and their smaller diameter present a high potential maintenance problem if the bit-flushing systems are used, and a very significant decrease in dust level would be required to make these systems attractive.

The data in Table 26 which compares the relative performance of the bit-flushing systems to the standard system, immediately eliminates the bit-flushing system using nozzles located in front of the bits. Based on the average values, this system resulted in higher respirable dust levels under all conditions.

The performance of the bit-flushing system using nozzles behind the bits was much better than the system using nozzles in front of the bits, and at high water flow reduced dust levels below those attained with the standard spray system. However, the average improvement indicated is 14 percent, with a maximum of 22 percent indicated at the shearer and midpoint packages. Considering the increased cost of the nozzles and blocks to install these flushing nozzles, and the potential plugging and maintenance problems, this improvement in respirable dust levels is not significant enough to recommend that the bit-flushing system replace the standard system except in a mine where the dust levels exceed the 2.0 mg/m<sup>3</sup> limit but could be brought into compliance by the 14 percent reduction. In this case the increased cost of the bit-flushing spray system and some additional maintenance may be preferable to the alternative of cutting production.

The gross dust data in Table 26 indicate a significant reduction in non-respirable dust when using either bit-flushing system. This could have many benefits, including the reduction of rock dusting costs; therefore, the bit-flushing systems should be seriously considered where rock dusting is a problem. The reduction of non-respirable dust levels was not an objective of this project; therefore, the reduction in gross dust would not be a basis for recommending the use of either bit-flushing system.

#### B. Establishment of Water Flow Rates

The water flow rate used with a spray system is controlled by:

1. The amount of moisture that can be tolerated on the coal,
2. The effect of the moisture on the roof and floor,
3. The effect on working conditions such as reduced operator visibility,
4. Relative improvement in dust levels at the higher flows.

Items 1, 2, and 3 must be determined by the conditions at each mine, and no conclusions can be made on these items from the test results. The test data as shown in Table 17, however, show a significant reduction in both respirable and gross dust levels with all three spray systems at higher water flow rates. Therefore, the use of as high a flow rate as practical for mine conditions would be recommended to minimize dust concentration levels regardless of the spray system used.

TABLE 26. PERCENT CHANGE IN DUST LEVELS, BIT FLUSHING SYSTEMS  
 COMPARED TO STANDARD SYSTEMS

Percent Increase or Decrease in Dust Levels For Sampling Locations

<u>Nozzle Location</u>	<u>Shearer</u>	<u>Midpoint</u>	<u>Head</u>	<u>Return</u>	<u>Gross</u>
A - "Cutting Concentration"					
<u>Low Water Flow</u>					
Front of Bits	- 8	+ 2	+ 3	- 9	-54
Back of Bits	-26	+23	+ 4	-12	-61
<u>High Water Flow</u>					
Front of Bits	+13	- 8	+ 7	- 2	- 9
Back of Bits	-22	-22	-10	- 4	-40
B - "Normalized Cutting Concentration"					
<u>Low Water Flow</u>					
Front of Bits	+40	+52	+48	+26	-37
Back of Bits	- 4	+57	+30	+ 2	-53
<u>High Water Flow</u>					
Front of Bits	+ 4	+ 2	+24	+11	+ 5
Back of Bits	- 9	-11	+ 2	+ 6	-30
C - "Mg/Ton"					
<u>Low Water Flow</u>					
Front of Bits	+52	+60	+60	+34	-31
Back of Bits	+22	+89	+59	+33	-42
<u>High Water Flow</u>					
Front of Bits	+23	- 7	+12	0	- 3
Back of Bits	- 1	- 5	+ 9	+12	-24

### C. Mining Procedure

In mines that have very high dust levels due to the coal properties, some measures in addition to the use of sprays may be required to attain compliance with the Coal Mine Health and Safety Act. One possible recommendation for longwall installations is mining in one direction only. The test results shown in Table 20 indicate that this could result in 50 percent or higher reductions in dust levels. This mining procedure obviously could result in lower production unless provisions, such as high-speed traverse of the machine in the non-cutting direction, were used to minimize the losses. However, based on test results, it would be recommended that in extreme cases modified mining procedures be investigated as a possible means of lowering high dust concentrations.

### D. Spray Nozzle Design

A major concern in designing any spray system is to minimize plugging of the nozzles. Two possible causes of plugging are, internally, from particles in the water and, externally, from coal's being forced into the orifice. Experience during this project leads to the conclusion that as long as good flow is maintained through the nozzle, plugging externally is rare and should create no maintenance or production problems. Conversely, emphasis must be placed on providing clean water to the sprays and protecting internal surfaces of the water system from corrosion, a major cause of nozzle plugging.

### E. Comparison of Bit Flushing and Cavity Filling Systems Performance

Since the operating parameters such as water flow, water pressure, and mining procedures were comparable for all three systems tested, the difference in performance must be due to the physical characteristics of the spray in relation to the coal-cutting process.

Based on the test data and observations made during the underground sampling, it appeared that the poorer performance of the bit-flushing systems was due to ineffective dispersion of the water jets into a fine mist. The bit-flushing nozzles directed a solid jet at the bit and depended on its impact with the bit or the coal to produce a fine mist. The standard nozzles developed a spray pattern immediately that effectively filled the cavity around the bits.

If, instead of a jet, a nozzle generating a fine mist had been used at the bit-flushing locations, the system would probably have been more effective in controlling respirable dust.

## VIII. RECOMMENDATIONS

The specific recommendations resulting from this project are as follows:

1. Additional testing should be conducted to determine, if possible, the relationship between water flow and dust concentration levels. This is undoubtedly not a direct or straight line relationship, and determination of the point where increased water flow does not provide corresponding reductions in dust levels would be valuable information for machine designers as well as for mine personnel in laying out water systems and developing specifications for equipment.

2. Further testing of bit-flushing nozzles located in front of the bits should be stopped on shearers of the Eickhoff or similar design. The coal particles cut by the bit apparently interrupt or block the water jet, preventing extensive wetting of the coal surface and limiting the sprays' efficiency in reducing respirable dust levels.

3. Additional testing should be conducted to determine the effect of mining procedures on dust levels. Any procedures that show promise in reducing dust levels should be considered in the design of new mining equipment.

4. At the present time, longwall shearers should continue to use spray systems of the same basic design as the Eickhoff shearer.

5. Further testing of bit-flushing nozzles located behind the bits should be considered, particularly where higher water flows are feasible. This configuration apparently has wetting characteristics similar to the standard system. With some modification to spray pattern, water flow rate, and nozzle angle, this system could possibly prove to be even more efficient than the standard system than is shown by these test results.

6. Information should be developed and made readily available on methods of minimizing plugging of spray nozzles, including:

a. Use of filtering systems in the supply lines to remove particles capable of plugging nozzles internally.

b. Protecting water passages to prevent corrosion, with coatings or linings that will not fleck off and create additional problems.

c. Use and availability of pumps, hoses, and auxiliary equipment that can provide high pressure to the nozzles without creating additional maintenance problems.

## IX. ADDENDUM ON NOISE LEVELS ASSOCIATED WITH THE SHEARER

Although noise-level reduction was not a specific objective of this project, information collected by Mr. George Bugay, USBM inspector from the Kittanning Office, indicates that the test drum design (Figure 36) resulted in a reduction in noise levels during shearer operation. Specifically, spot checks made on February 28, 1973 during operation of the original production drum showed sound levels of 99 to 102 dbA with an average of 101 dbA. On December 30, 1974, another spot check was made during operation of the test drum; and results showed sound levels of 93 to 99 dbA with an average of 97 dbA. This would indicate that the water chamber under the bits absorbs some of the impact of the bits' cutting the coal and thereby reduces the noise generated during the cutting operation. It should be noted that these data were collected during spot checks and not on an 8-hour survey; therefore, this information would have to be confirmed if this drum design were to be investigated as a potential method to reduce noise levels.

X. INVENTIONS

There are no patentable results or inventions from the work performed under this contract.

APPENDIX A

PROCEDURES FOR PROCESSING AND WEIGHING FILTER MATERIALS

## PROCEDURES FOR PROCESSING AND WEIGHING FILTER MATERIALS

### Apparatus:

Analytical balance: Mettler M5 Micro Gram-atic

### Filter Material:

#### MSA Personal Samplers

Gelman Instrument Co. Vinyl Metrical, a polyvinylchloride membrane filter (VM-1), 5.0 $\mu$  pore size, 37 mm diameter

#### MRE Sampler

Gelman Instrument Co. Vinyl Metrical, a polyvinylchloride membrane filter (VM-1), 5.0 $\mu$  pore size, 55 mm diameter

### Weighing Procedure:

1. Weighing Before Use: Both types of filters are processed in the same manner before being taken to the mine and used for dust sampling. Filters are dried in a vacuum desiccator for one-half hour at room temperature and in a vacuum of approximately 28 inches of mercury. Air is then admitted slowly to the desiccator through a gas drying column packed with Drierite. The desiccator is opened and the filters are preweighed with the weights being recorded on the corresponding shift data sheet. The filter weights are recorded to the nearest 0.001 milligram.

Filters for use in the personal samplers are placed in a cassette. The MRE filters are placed in a disposable Petri dish and transferred to the sampler just prior to being used underground.

2. Weighing After Use: After the dust samples have been taken, the filters are brought back to the laboratory for postweighing.

The transport containers are carefully opened and the filters are subjected to vacuum desiccation in the same manner as described above for the preweighing process. Care is taken to bring the contents of the desiccator to equilibrium slowly, so as not to disturb the dust on the filters.

The filter preweight (tare weight) is subtracted from the postweight value to determine the weight of dust retained, to the nearest 0.001 mg.

After all filters are weighed, they are stored for future reference.

### Procedure for Checking Accuracy of Balance:

Small variations in room temperature and humidity will cause the zero-alignment and sensitivity of the microbalance to fall out of adjustment. These two adjustments must be made manually.

The zero point alignment is accomplished with an adjusting knob on the balance. During a series of filter weighings, the zero point is checked and adjusted if necessary after every three or four weighings.

The sensitivity of the microbalance is checked as follows:

- a. Load the pan with 10 mg ( $\pm 0.3$  mg) and dial on 0.01 g with the weight setting knob.
- b. Release the balance fully and set zero point accurately.
- c. With the balance released, carefully dial off the 0.01 g weight.
- d. The resulting deflection should be exactly 100 graduations on the optical scale. If it is not, an adjusting screw on the balance beam is turned and the sequence of operations is repeated. (It is necessary to wait about 15 minutes for temperature equilibration after touching the balance beam or adjusting screw.)

The sensitivity has been checked at least twice a day when the balance was in use, and a written record has been kept of deviations. It has been arbitrarily specified that any deviation within the range  $\pm 0.050$  mg, over the 10 mg range, would not necessitate a sensitivity readjustment. A deviation of 0.050 mg on a 2 mg weight would result in a 0.010 mg error.

When the microbalance is in use, at least one door of the balance room is kept closed to avoid problems caused by air currents through the room.

APPENDIX B

PROCEDURES FOR CARE, MAINTENANCE, AND OPERATION  
OF THE SAMPLING EQUIPMENT

PROCEDURES FOR CARE, MAINTENANCE, AND OPERATION  
OF THE SAMPLING EQUIPMENT

I. HANDLING OF FILTERS, SAMPLERS, AND SAMPLING PACKAGES  
BEFORE AND AFTER EACH TESTING SHIFT

A. Assembly of Samplers Prior to Working Shift

1. MSA personal sampler (respirable plus gross)
  - a. Inspect cyclone for scoring. (respirable sampler only)
  - b. Assemble dry cyclone and install in sampling package. (respirable sampler only)
  - c. Remove plugs from filter holder and install filter holder.
  - d. Record pump and cyclone numbers on pump schedule sheet.
  
2. Impinger
  - a. Fill clean flask with 10 ml of filtered alcohol.
  - b. Insert impinger tube through green rubber stopper and install splash guard/centering device on tube approximately 3 inches from tip. Insert stopper in flask and position impinger tube tip 5 mm from bottom of flask. (Location is marked on side of flask.)
  - c. Install air-setting shrink tape around stopper and impinger flask.
  - d. Number flask with wax pencil and place in carrying package.
  - e. Record impinger tube and pump numbers on pump schedule sheet.
  - f. Prepare 500 ml bottle of filtered alcohol for refills during shift.
  
3. MRE sampler
  - a. Line up samplers with corresponding filters.
  - b. Remove blanking plates and install filters.
  - c. Re-check counter and zero if necessary.
  - d. Close each sampler.

## II. PROCEDURE FOR CALIBRATION OF DUST SAMPLERS

The procedures outlined in Bureau of Mines Information Circular 8503, February 1971, by staff, Pittsburgh Field Health Group, Chapter VIII, pp. 27 through 30, are used for the calibration of the sampling equipment. The only modifications to the IC 8503 guidelines are as follows:

### 1. MRE Gravimetric Sampler

- a. To adapt MRE to test stand, a rubber hose configuration was set up to duplicate filter and elutriator resistance. This system was supplied by the Pittsburgh Field Health Group.
- b. Motor speed is checked at three voltage levels: 6.5, 6.0, and 5.7 volts; and instrument is run at 6.0 volts for approximately one hour.
- c. Elutriator and filter holder are checked for leakage as explained in instruction leaflet 3104/AT for Gravimetric Dust Sampler Type 113A.

### 2. MSA Personal Sampler with SKC Pulsation Damper and Voltage Regulator

- a. The test rig was changed to cut down on length of rubber hose from cyclone to pump, in order to match conditions under which the sampler is used in the sampling package.
- b. Instrument is run for approximately 1 hour at 6.4 volts.

### 3. UNICO C-110 Pump

- a. The pump is not calibrated as such, but is connected to a previously calibrated impinger tube in a 30 ml impinger flask filled with 10 ml of alcohol. It should be able to maintain a maximum of 14-inch water vacuum for the duration of the sampling period.
- b. The flow meter in the pump is disconnected to reduce flow resistance and decrease battery discharge.
- c. A 15-inch calibrated vacuum gauge is attached so that 12-inch water vacuum can be monitored and maintained during sampling period.

### 4. Impinger Tubes

- a. The impinger tubes are calibrated using standard method A-15, "Calibration of Midget Impinger Nozzles," as supplied by the Dust Group, Pittsburgh Tech. Support Center, MESA.

### III. OPERATIONAL PROCEDURE FOR MIDGET IMPINGERS

Three basic criteria must be met and maintained for the efficient operation of midget impingers.

1. The distance between the tip of the impinger tube and the bottom of the flask must be maintained at 5 mm.
2. The sampling pump (Unico C-110 or C-115) must pull a vacuum of 12-inch water gage.
3. The diameter of the impinger tube orifice must be  $1 \text{ mm} \pm 5 \text{ percent}$ . The impinger tubes are calibrated, using standard method A-15, "Calibration of Midget Impinger Nozzles," as supplied by the Dust Group, Pittsburgh Technical Support Center, MESA.

The volume of air drawn through the impinger, a 12-inch H<sub>2</sub>O vacuum and a 1 mm orifice should be 0.1 cubic foot per minute. The  $\pm 5 \text{ percent}$  on the orifice diameter gives a range of 0.095 to 0.105 cfm. Any impinger tubes outside of this range should not be used.

The volume of alcohol in the flask should be maintained at 10 ml for the midget impingers.

#### PREPARATION PROCEDURE FOR MIDGET IMPINGERS

All samplers should be prepared and checked before being taken underground, which includes:

1. Check battery voltage of sampling pump - 7.5 volts
2. Fill impinger tubes with alcohol - 10 ml
3. Insert impinger tube and stopper in flask, making sure nozzle orifice is 5 mm from bottom of flask. Place a shrink band around the flask and stopper union. This helps prevent the sample from being contaminated when the stopper is removed.
4. Connect pump to flask, turn on, and adjust to 12-inch H<sub>2</sub>O vacuum.
5. Disconnect pump and cap flask inlet and outlet with rubber policemen to prevent contamination before use.

#### IV. IMPINGER SAMPLE PROCESSING PROCEDURES

##### A. Determination of Weight of Dust Collected and Preparation for Size Analysis

1. Place a pre-weighed filter on a standard millipore filtration set up.
2. Clean the outside of the impinger flask to make sure that it is free of any dust particles, and remove the shrink tape.
3. Remove the stopper and impinger tube from the flask and, using filtered isopropanol, rinse any particles that may be adhering to any part of the impinger tube and stopper into the funnel of the filtering equipment. Empty the flask into the funnel and rinse the inside of the flask into the funnel. Rinse any dust particles from the sides of the funnel onto the filter.
4. Remove the filter and place it in a vacuum desiccator. Evacuate the desiccator for one hour to evaporate all the isopropanol from the filter. When bringing the desiccator back to equilibrium, release the vacuum slowly so as not to disturb the dust on the filter. Weigh the filter and record the weight on a data sheet. Subtract the tare weight of the filter to obtain the weight of the dust retained.
5. The sample can now be handled in the same manner as an MSA or MRE filter to obtain size analysis with the Coulter counter.

##### B. Preparation for Size Analysis When Weight Determination is Not Necessary

1. Clean the outside of the impinger flask to make sure it is free of dust particles, and remove the shrink tape.
2. Remove the stopper from the flask and, using filtered isopropanol, rinse any particles that may be adhering to any part of the impinger tube and stopper into the flask. Rinse the sides and sidearm of the flask back into the sample.
3. Place a clean magnetic stirring bar in the sample and place it on a magnetic stirrer to disperse the dust particles in the isopropanol. With a 5-ml clean disposable pipet alternately transfer aliquots of the stirring sample to two plastic vials until duplicate samples of about 12 ml are obtained for Coulter counter analysis. (One of these vials will be stored for future reference.)

e. Reassemble.

6. Clean sampling packages, C-110, and MSA pumps with brush or blow with air; wipe off all connecting rubber tubing.

## II. PROCEDURE FOR CALIBRATION OF DUST SAMPLERS

The procedures outlined in Bureau of Mines Information Circular 8503, February 1971, by staff, Pittsburgh Field Health Group, Chapter VIII, pp. 27 through 30, are used for the calibration of the sampling equipment. The only modifications to the IC 8503 guidelines are as follows:

### 1. MRE Gravimetric Sampler

- a. To adapt MRE to test stand, a rubber hose configuration was set up to duplicate filter and elutriator resistance. This system was supplied by the Pittsburgh Field Health Group.
- b. Motor speed is checked at three voltage levels: 6.5, 6.0, and 5.7 volts; and instrument is run at 6.0 volts for approximately one hour.
- c. Elutriator and filter holder are checked for leakage as explained in instruction leaflet 3104/AT for Gravimetric Dust Sampler Type 113A.

### 2. MSA Personal Sampler with SKC Pulsation Damper and Voltage Regulator

- a. The test rig was changed to cut down on length of rubber hose from cyclone to pump, in order to match conditions under which the sampler is used in the sampling package.
- b. Instrument is run for approximately 1 hour at 6.4 volts.

### 3. UNICO C-110 Pump

- a. The pump is not calibrated as such, but is connected to a previously calibrated impinger tube in a 30 ml impinger flask filled with 10 ml of alcohol. It should be able to maintain a maximum of 14-inch water vacuum for the duration of the sampling period.
- b. The flow meter in the pump is disconnected to reduce flow resistance and decrease battery discharge.
- c. A 15-inch calibrated vacuum gauge is attached so that 12-inch water vacuum can be monitored and maintained during sampling period.

### 4. Impinger Tubes

- a. The impinger tubes are calibrated using standard method A-15, "Calibration of Midget Impinger Nozzles," as supplied by the Dust Group, Pittsburgh Tech. Support Center, MESA.

### III. OPERATIONAL PROCEDURE FOR MIDGET IMPINGERS

Three basic criteria must be met and maintained for the efficient operation of midget impingers.

1. The distance between the tip of the impinger tube and the bottom of the flask must be maintained at 5 mm.
2. The sampling pump (Unico C-110 or C-115) must pull a vacuum of 12-inch water gage.
3. The diameter of the impinger tube orifice must be  $1 \text{ mm} \pm 5 \text{ percent}$ . The impinger tubes are calibrated, using standard method A-15, "Calibration of Midget Impinger Nozzles," as supplied by the Dust Group, Pittsburgh Technical Support Center, MESA.

The volume of air drawn through the impinger, a 12-inch  $\text{H}_2\text{O}$  vacuum and a 1 mm orifice should be 0.1 cubic foot per minute. The  $\pm 5 \text{ percent}$  on the orifice diameter gives a range of 0.095 to 0.105 cfm. Any impinger tubes outside of this range should not be used.

The volume of alcohol in the flask should be maintained at 10 ml for the midget impingers.

### PREPARATION PROCEDURE FOR MIDGET IMPINGERS

All samplers should be prepared and checked before being taken underground, which includes:

1. Check battery voltage of sampling pump - 7.5 volts
2. Fill impinger tubes with alcohol - 10 ml
3. Insert impinger tube and stopper in flask, making sure nozzle orifice is 5 mm from bottom of flask. Place a shrink band around the flask and stopper union. This helps prevent the sample from being contaminated when the stopper is removed.
4. Connect pump to flask, turn on, and adjust to 12-inch  $\text{H}_2\text{O}$  vacuum.
5. Disconnect pump and cap flask inlet and outlet with rubber policemen to prevent contamination before use.

#### IV. IMPINGER SAMPLE PROCESSING PROCEDURES

##### A. Determination of Weight of Dust Collected and Preparation for Size Analysis

1. Place a pre-weighed filter on a standard millipore filtration set up.
2. Clean the outside of the impinger flask to make sure that it is free of any dust particles, and remove the shrink tape.
3. Remove the stopper and impinger tube from the flask and, using filtered isopropanol, rinse any particles that may be adhering to any part of the impinger tube and stopper into the funnel of the filtering equipment. Empty the flask into the funnel and rinse the inside of the flask into the funnel. Rinse any dust particles from the sides of the funnel onto the filter.
4. Remove the filter and place it in a vacuum desiccator. Evacuate the desiccator for one hour to evaporate all the isopropanol from the filter. When bringing the desiccator back to equilibrium, release the vacuum slowly so as not to disturb the dust on the filter. Weigh the filter and record the weight on a data sheet. Subtract the tare weight of the filter to obtain the weight of the dust retained.
5. The sample can now be handled in the same manner as an MSA or MRE filter to obtain size analysis with the Coulter counter.

##### B. Preparation for Size Analysis When Weight Determination is Not Necessary

1. Clean the outside of the impinger flask to make sure it is free of dust particles, and remove the shrink tape.
2. Remove the stopper from the flask and, using filtered isopropanol, rinse any particles that may be adhering to any part of the impinger tube and stopper into the flask. Rinse the sides and sidearm of the flask back into the sample.
3. Place a clean magnetic stirring bar in the sample and place it on a magnetic stirrer to disperse the dust particles in the isopropanol. With a 5-ml clean disposable pipet alternately transfer aliquots of the stirring sample to two plastic vials until duplicate samples of about 12 ml are obtained for Coulter counter analysis. (One of these vials will be stored for future reference.)

## V. SIZE ANALYSIS PROCEDURES: REMOVAL OF DUST FROM FILTERS AND PREPARATION FOR SIZE ANALYSIS, COULTER COUNTER OPERATION

### A. Personal and MRE-Type Filters, Cleaning Procedure

1. Rinse a clean 250-ml beaker with filtered isopropanol to ensure that it is free from dust particles. The isopropanol is filtered by pressure filtration through a Pall Ultipor filter cartridge, 0.35 micron absolute pore size.

2. Add 5 drops of dispersing agent (Isoterge) to the beaker and add about 25 ml of filtered isopropanol. Using clean forceps, remove the filter from the cassette and place, dust-laden side down, in the filtered alcohol.

3. Wash any dust adhering to that Petri dish into the beaker with filtered isopropanol from a squeeze bottle. Bring the amount of filtered isopropanol in the beaker up to about 50 ml.

4. Place the beaker in the tank of the ultrasonic cleaner (Branson Instruments Co., Inc., Model 520, 40 KHz). Turn on the ultrasonic cleaner for 60 seconds at a powerstat setting of 90 to 95. It may be necessary to gently agitate the filters in the alcohol with a pair of forceps during ultrasonic cleaning to help ensure removal of the dust particles.

5. Remove the sample suspension from the ultrasonic cleaner, place a small magnetic stirring bar in the beaker, and place the beaker on a magnetic stirrer to help keep the dust particles in suspension. Using a clean disposable Pasteur pipet, alternately transfer 2 ml aliquots of the stirred suspension to two clean plastic sample vials until about 12 ml of sample is obtained in each vial. These samples are used for subsequent Coulter counter analysis.

Samples from the personal and MRE filters are ordinarily analyzed using the 50-micron aperture tube.

### B. Gross Sample Filters, Cleaning Procedure

In some cases it is necessary to scalp the gross samples at 20 microns in order to use the 50-micron aperture tube when analyzing the sample on the Coulter counter. When this is necessary, the following procedure is followed.

1. Rinse a clean 250-ml beaker with filtered isopropanol to ensure that it is free from dust particles.

2. Add 5 drops of dispersing agent (Isoterge) to the beaker and add about 25 ml of filtered isopropanol. Using clean forceps, remove the filter from the cassette and place, dust-laden side down, in the filtered alcohol.

3. Wash any dust adhering to the Unico cassette into the beaker with filtered isopropanol from a squeeze bottle. Bring the amount of filtered isopropanol in the beaker up to about 50 ml.

4. Place the beaker in the tank of the ultrasonic cleaner (Branson Instruments Co., Inc., Model 520, 40 KHz). Turn on the ultrasonic cleaner for 60 seconds at a powerstat setting of 90 to 95. It may be necessary to gently agitate the filters in the alcohol with a pair of forceps during ultrasonic cleaning to help ensure removal of the dust particles.

5. Rinse a clean 3-inch, 20-micron sieve with filtered isopropanol to ensure that it is free from dust particles, then place the sieve on top of a 400-ml beaker.

6. Remove the sample suspension from the ultrasonic cleaner and remove the filter from the suspension. Wash any remaining dust particles from the filter using filtered isopropanol.

7. Carefully pour the contents on to the 20-micron sieve. Using the filtered alcohol, wash any dust remaining in the beaker onto the sieve.

8. Gently brush and wash particles through the sieve until all minus 20-micron particles have passed through the sieve.

9. Remove the sieve from the beaker and place it on a clean watch glass in a drying oven at 105 C for about 20 minutes. Allow the sieve to cool to room temperature, then transfer the contents to a tared weighing paper by brushing, and weigh the plus 20-micron material. Subsequent Coulter counter data are corrected for the weight percentage of plus 20-micron material in the sample.

10. Samples from the gross filters are ordinarily analyzed using the 50-micron aperture tube.

#### C. Procedure for Model T Coulter Counter Analysis

1. Attach the appropriate aperture tube to the Coulter counter and calibrate with the appropriate monosized suspension.

2. Rinse a clean 150-ml round-bottom sample beaker and fill with approximately 100 ml of filtered electrolyte (a 4 percent weight-to-weight solution of ammonium thiocyanate in isopropanol is ordinarily used). The electrolyte is filtered by suction filtration through a 0.35-micron Pall Ultipor filter cartridge and stored in a one-gallon bottle.

3. Check for excessive electrolyte background counts.

4. Set the arithmetic control knob to the cumulative volume mode.

5. Set the channel selector knob to Channel 14.

6. Set the preset number to 100.
7. Shake the sample vial to get the particles into suspension.
8. Initiate aperture current and, using a clean Pasteur pipet, transfer 2-ml aliquots of the sample suspension to the sample beaker. If possible, the amount added should be sufficient to attain a reading between 0.10 and 0.15 on the concentration index meter. To avoid an excessive background level, however, no more than 8 ml of the sample suspension should be added.
9. After the particles are sufficiently dispersed in the electrolyte, press the start button and allow the instrument to count to the preset number (100). At least three determinations are made to check the repeatability of the analysis.

Throughout the procedures for filter cleaning and Coulter counter analysis, particular care is taken to avoid contaminating the samples during handling.

10. The cumulative volume counts are then plotted against the corresponding particle sizes and the curve is extrapolated through the lower range of the system to obtain a value for total counts. This value is then employed in calculating the cumulative weight percentages in the size range of interest.

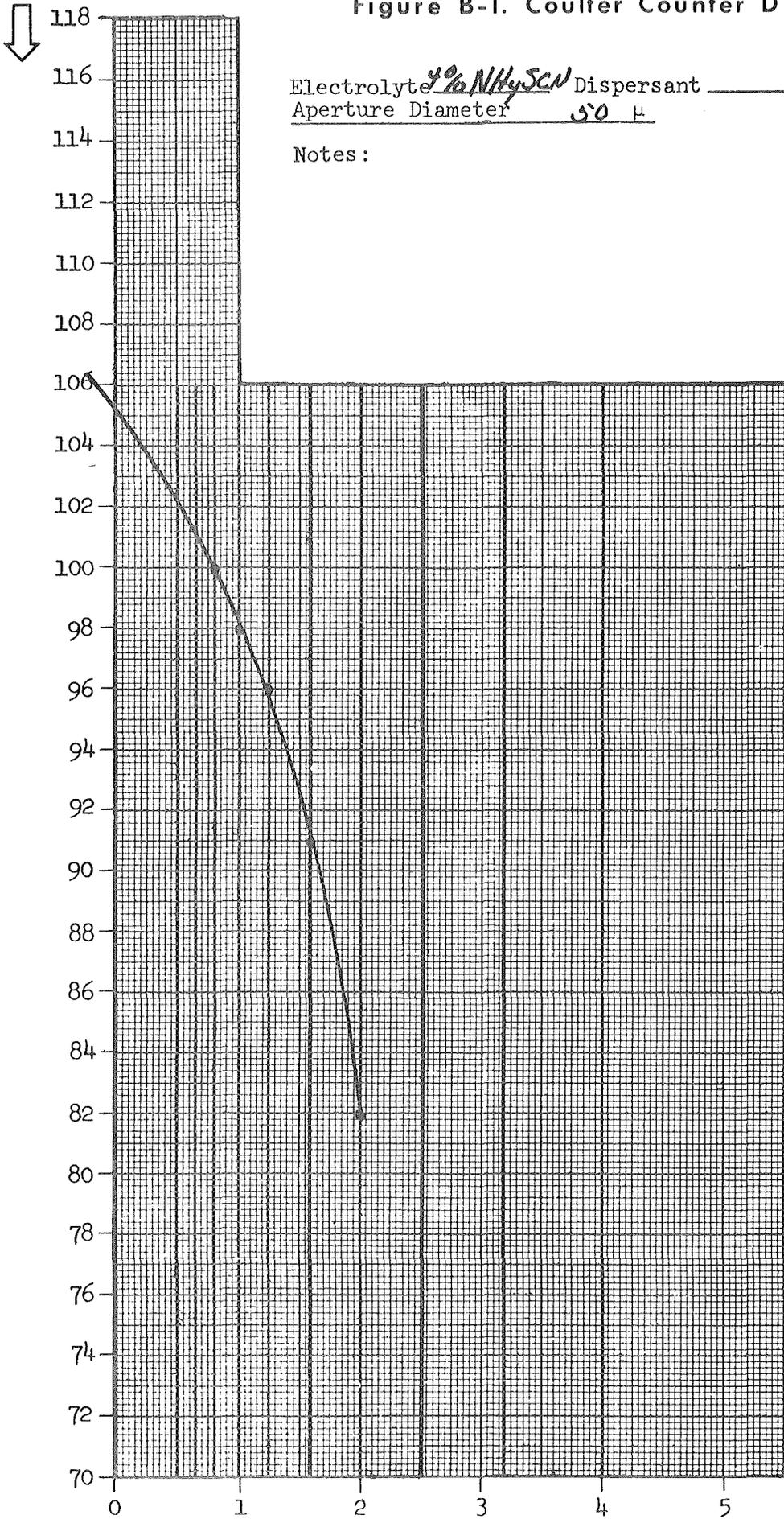
Our experience with the Model T Coulter Counter has shown that, under the conditions normally employed for the particle size analysis of respirable dust samples (50-micron aperture tube, using an organic electrolyte consisting of 4 percent ammonium thiocyanate in isopropanol), results are only reliable down to a lower limit of  $0.794\mu\text{m}$ . Below this level, background noise becomes significant. Consequently, it is necessary to estimate the amount of material below  $0.794\mu\text{m}$  so that the raw data can be normalized to cumulative weight percentage values.

Although several techniques for extrapolating the particle size distribution curve have been advanced, we have adopted a simplified graphical method which involves plotting the cumulative volume data for the smallest particle diameters (usually four or five points) vs. particle size on a linear scale, and extrapolating the smooth curve through these points to a particle diameter of zero. The resulting value for cumulative volume at zero particle diameter is rounded to the nearest whole number and is then used as the divisor to normalize the raw data to cumulative weight percentages. This graphical extrapolation is illustrated in Figure B-1, which is a reproduction of the data sheet actually employed for a typical respirable dust sample.

For a given group of dust samples collected under similar conditions, it is not uncommon for the last three or four cumulative volume values

CUMULATIVE VOLUME

Figure B-1. Coulter Counter Data Sheet



Electrolyte 4% NH<sub>4</sub>SCN Dispersant \_\_\_\_\_  
 Aperture Diameter 50 μ

Sample No. 23-3736  
 Operator BEDNAR  
 Date 4/28/73

Notes:

Extrapolated Results

Total 105

Chan. No.	Dia. μ	Cum. Vol.	Cum. Wt. %
	.500		
	.630		
13	.794	100	95.2
12	1.00	98	93.3
11	1.26	96	91.4
10	1.59	91	86.7
9	2.00	82	78.1
8	2.52	66	62.9
7	3.17	47	44.8
6	4.00	27	25.7
5	5.04	11	10.5
4	6.35	4	3.8
3	8.00	2	1.9
2	10.08	1	1.0
1	12.7	0	0.0
0	16.0	0	
	20.2		
	25.4		
	32.0		
	40.3		

BCR Form 226R

(i.e., those at the smallest particle diameters) to be identical for several samples. This can be explained by the following reasons:

1. The instrument is always preset to register a cumulative volume of 100 at the lowest particle size (0.794 $\mu$ m).

2. Since the particle diameters follow a cube root of 2 geometrical progression, the "spread" among particle sizes becomes less when going from the coarser to the finer particle sizes. Thus, as shown in Figure B-1, the ranges 1.00 to 2.00, 2.00 to 4.00, 4.00 to 8.00, and 8.00 to 16.0 $\mu$ m are each covered by four channels on the instrument. The resultant effect is a tendency to smooth out differences among the accumulating values at the lower particle diameters.

Finally, although the raw data and extrapolated values for cumulative volume are obtained as whole numbers, the normalized results are calculated and reported to the nearest tenth of a percent. This may not be warranted by the precision of the method in some cases, but in any event it should be understood that when the weight percentage values at the smallest particle sizes are identical among several samples, this is not necessarily as significant as might be implied by the number of figures employed in the results as reported.

APPENDIX C

SAMPLE DATA SHEET FORMS

UNDERGROUND DUST SAMPLING DATA SHEET

Project 2208

Date \_\_\_\_\_ Shearer Operator \_\_\_\_\_

Shift \_\_\_\_\_ Shift No. \_\_\_\_\_ Test Condition \_\_\_\_\_

Personnel \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_

Shearer

Total Water Meter

Final \_\_\_\_\_

Initial \_\_\_\_\_

\_\_\_\_\_ gallons this shift

Samplers	Time On	Time Off	Sampling Time (min)
Main Intake (100)	_____	_____	_____
Shearing Machine (200)	_____	_____	_____
* Mid-point of Longwall face (300)	_____	_____	_____
Tail of Longwall face (400)	_____	_____	_____
Main Return (500)	_____	_____	_____
Midget Impinger (600)			
Pass # _____	_____	_____	_____
Pass # _____	_____	_____	_____
Pass # _____	_____	_____	_____
Pass # _____	_____	_____	_____

Number of passes (     ) x tons/pass (     ) = (     ) tps (raw coal)

Condition of bits: \_\_\_\_\_ Good \_\_\_\_\_ Poor

Condition of sprays: \_\_\_\_\_ Good \_\_\_\_\_ Poor

Sprays Plugged \_\_\_\_\_ Sprays Cleaned This Shift \_\_\_\_\_

Cutting Rock \_\_\_\_\_

Comments: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_





UNDERGROUND DUST SAMPLING DATA SHEET, PAGE 4

Total Gallons Per Pass

Date \_\_\_\_\_ Shift \_\_\_\_\_ Shift No. \_\_\_\_\_

Shearer Operator \_\_\_\_\_ Test Condition \_\_\_\_\_

Time of Reading	Gallons	Running Time Per Pass (min)	Average gpm/Pass	Static Water Pressure	Pass No.
Final _____					
Initial 00000					
Gallons _____					
Final _____					
Initial 00000					
Gallons _____					
Final _____					
Initial 00000					
Gallons _____					
Final _____					
Initial 00000					
Gallons _____					
Final _____					
Initial 00000					
Gallons _____					

UNDERGROUND DUST SAMPLING DATA SHEET, PAGE 5

gpm Flow Check

Date \_\_\_\_\_ Shift \_\_\_\_\_ Shift No. \_\_\_\_\_

Shearer Operator \_\_\_\_\_ Test Condition \_\_\_\_\_

Time of Reading	Gallons	Time (min)	gpm	Operating Water Pressure	Pass No.
Final _____					
Initial _____		1.0			
Gallons _____					
Final _____					
Initial _____		1.0			
Gallons _____					
Final _____					
Initial _____		1.0			
Gallons _____					
Final _____					
Initial _____		1.0			
Gallons _____					
Final _____					
Initial _____		1.0			
Gallons _____					



UNDERGROUND DUST SAMPLING HOURLY LOG

Project 2208

Date \_\_\_\_\_ Test Conditions \_\_\_\_\_

Shift \_\_\_\_\_ Shift No. \_\_\_\_\_

Observer \_\_\_\_\_

Start of Shift - 10:00 a.m.	12:00 noon - 1:00 p.m.
10:00 a.m. - 11:00 a.m.	1:00 p.m. - 2:00 p.m.
11:00 a.m. - 12:00 noon	2:00 p.m. - End of Shift

UNDERGROUND DUST SAMPLING TESTS, LONGWALL SHEARER

Pump Schedule

Shift \_\_\_\_\_ Date \_\_\_\_\_ Project \_\_\_\_\_

Test Condition \_\_\_\_\_

Main Intake (100)

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_  
Cyclone No. \_\_\_\_\_

Tail of Longwall Face (400)

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_  
Cyclone No. \_\_\_\_\_

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_

Cyclone No. \_\_\_\_\_

Shearing Machine (200)

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_  
Cyclone No. \_\_\_\_\_

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_

Cyclone No. \_\_\_\_\_

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_  
Cyclone No. \_\_\_\_\_

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_

Cyclone No. \_\_\_\_\_

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_  
Cyclone No. \_\_\_\_\_

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_

Cyclone No. \_\_\_\_\_

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_  
Cyclone No. \_\_\_\_\_

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_

Cyclone No. \_\_\_\_\_

Mid-point of Longwall Face (300)

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_  
Cyclone No. \_\_\_\_\_

MRE No. \_\_\_\_\_ Filter No. \_\_\_\_\_  
Counter \_\_\_\_\_ L

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_  
Cyclone No. \_\_\_\_\_

Main Return (500)

MRE No. \_\_\_\_\_ Filter No. \_\_\_\_\_  
Counter \_\_\_\_\_ L

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_  
Cyclone No. \_\_\_\_\_

Midget Impinger (600)

MSA No. \_\_\_\_\_ Filter No. \_\_\_\_\_  
Cyclone No. \_\_\_\_\_

Unico No. \_\_\_\_\_

MRE No. \_\_\_\_\_ Filter No. \_\_\_\_\_  
Counter \_\_\_\_\_ L

A. Flask No. \_\_\_\_\_ Sample No. \_\_\_\_\_

B. Flask No. \_\_\_\_\_ Sample No. \_\_\_\_\_

C. Flask No. \_\_\_\_\_ Sample No. \_\_\_\_\_

D. Flask No. \_\_\_\_\_ Sample No. \_\_\_\_\_

LONGWALL SHEARER TEST CONDITION LOG

Shift No. \_\_\_\_\_ Shearer \_\_\_\_\_ Test Conditions \_\_\_\_\_ Date \_\_\_\_\_ Observer \_\_\_\_\_

Operator \_\_\_\_\_

Pass No.	Direction	Time		Section Intake CFM	Airflow Face Intake CFM	Main Return CFM	Water Flow, gal/pass Total	Impinger Sample Flask No.
		Start	Finish					

183.

Down Time		
Pass No.	Duration	Reason

Code of Test Conditions

- X-1 Jets ahead of bits - 100 PSI
- X-2 Jets ahead of bits - 250 PSI
- Y-1 Jets behind bits - 100 PSI
- Y-2 Jets behind bits - 250 PSI
- Z-1 Sprays in Scroll - 100 PSI
- Z-2 Sprays in Scroll - 250 PSI
- C-1 Fixed sprays only - 100 PSI
- C-2 Fixed sprays only - 250 PSI

APPENDIX D

GRAPHS OF TEST DATA FOR VALID SHIFTS

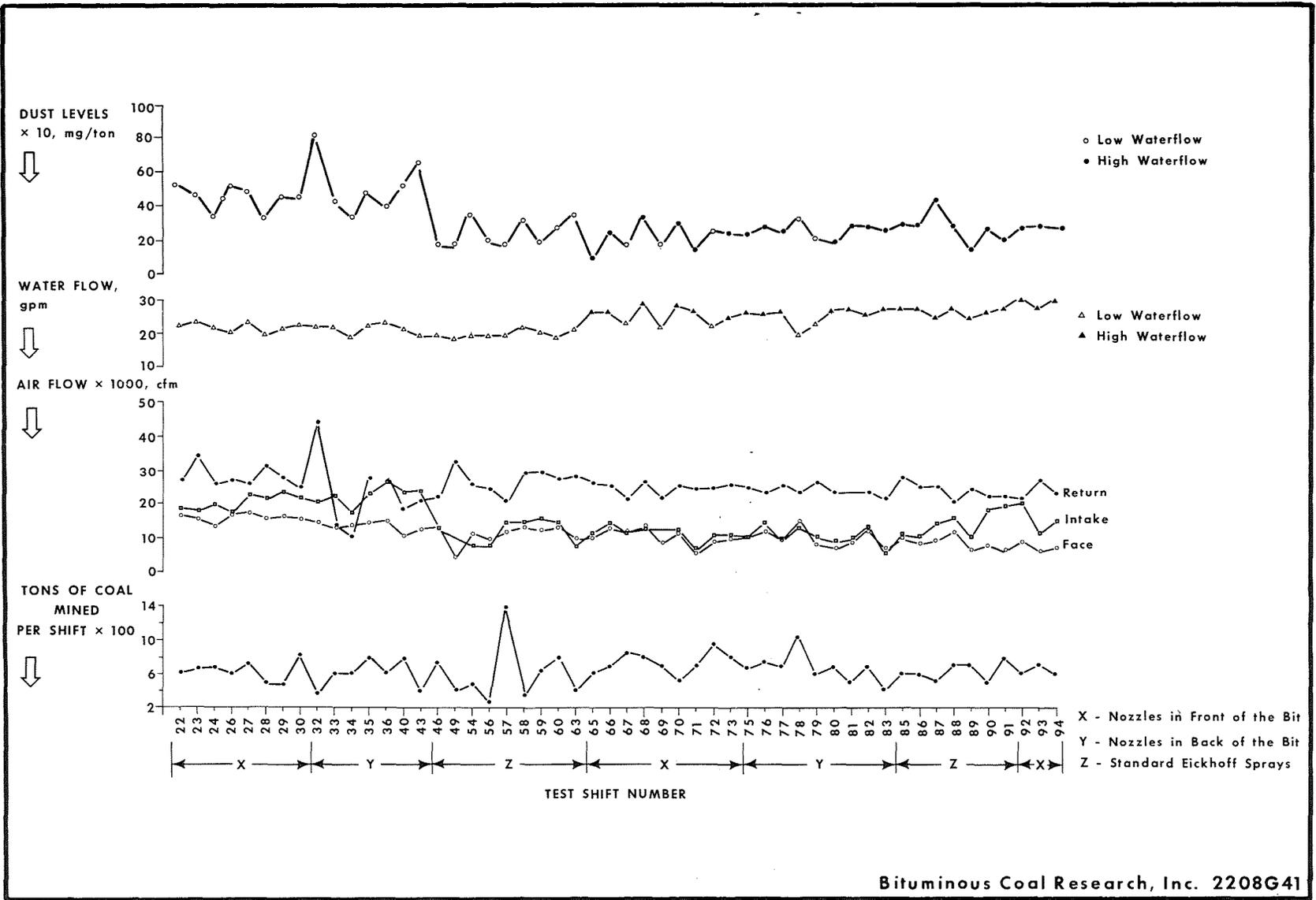
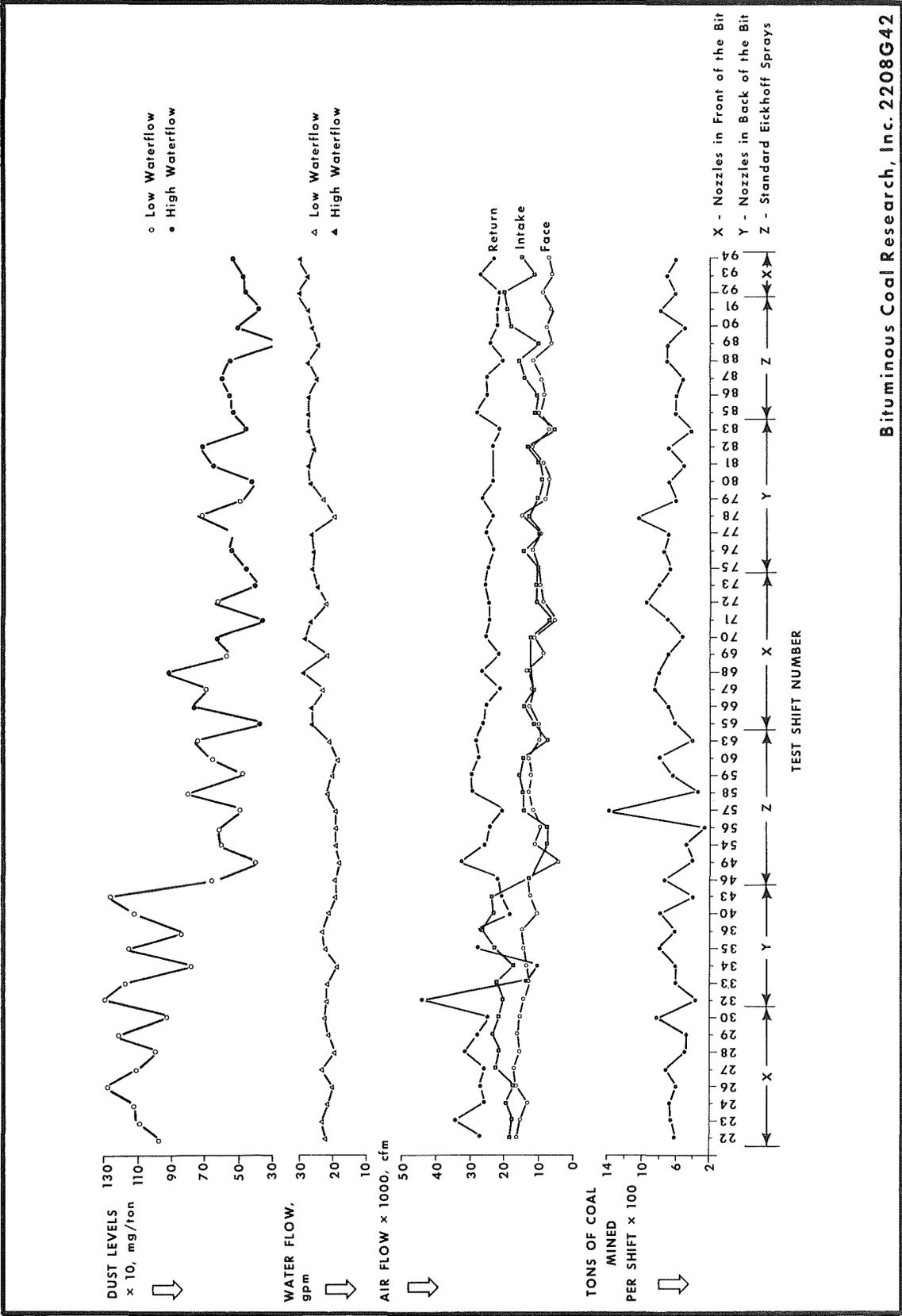


Figure D-1. Test Data for Valid Shifts - Dust Levels in Mg/Ton of Respirable Dust Measured at Midpoint of Face



Bituminous Coal Research, Inc. 2208G42

Figure D-2. Test Data for Valid Shifts - Dust Levels in Mg/Ton of Respirable Dust Measured at Head of Face

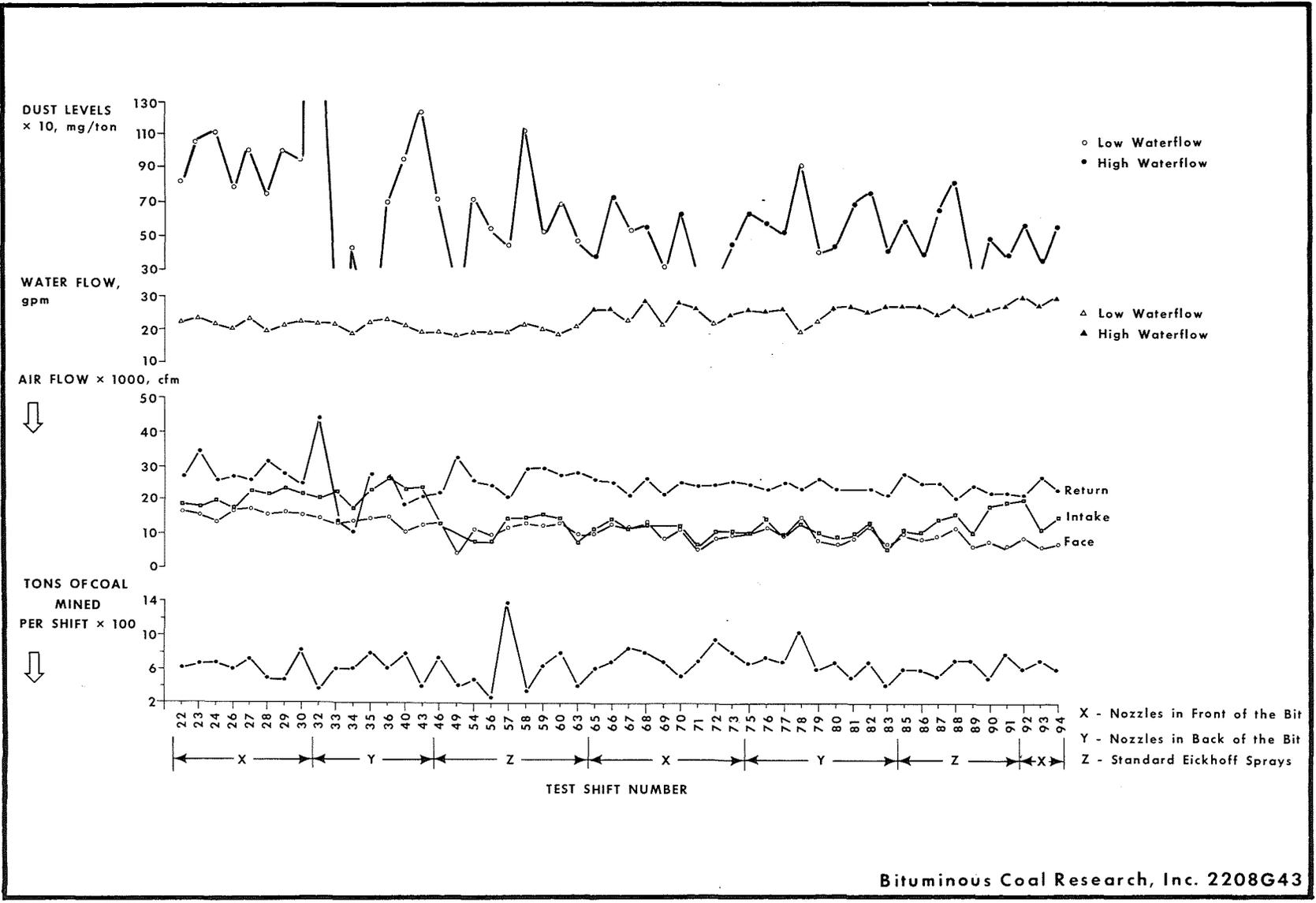
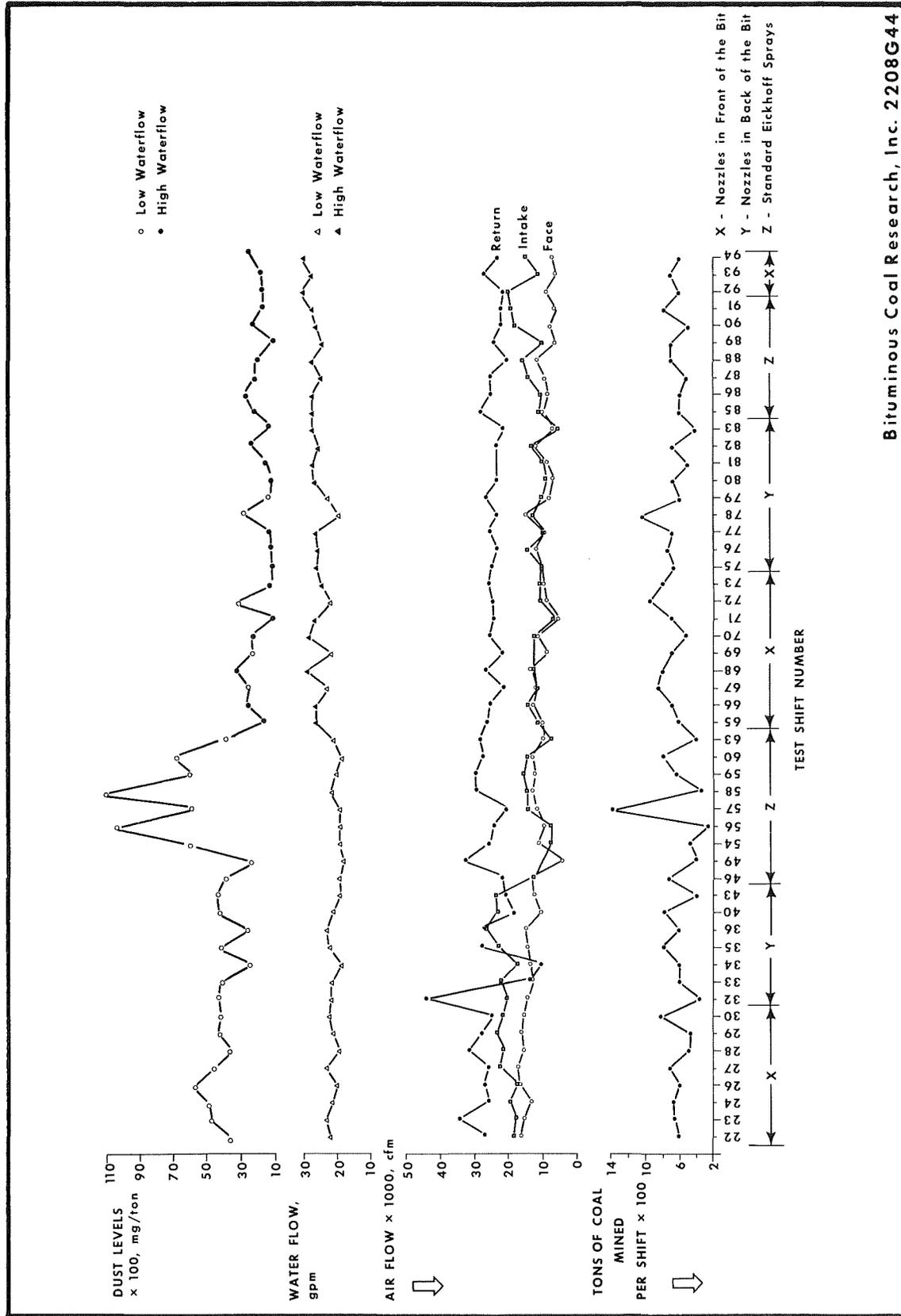
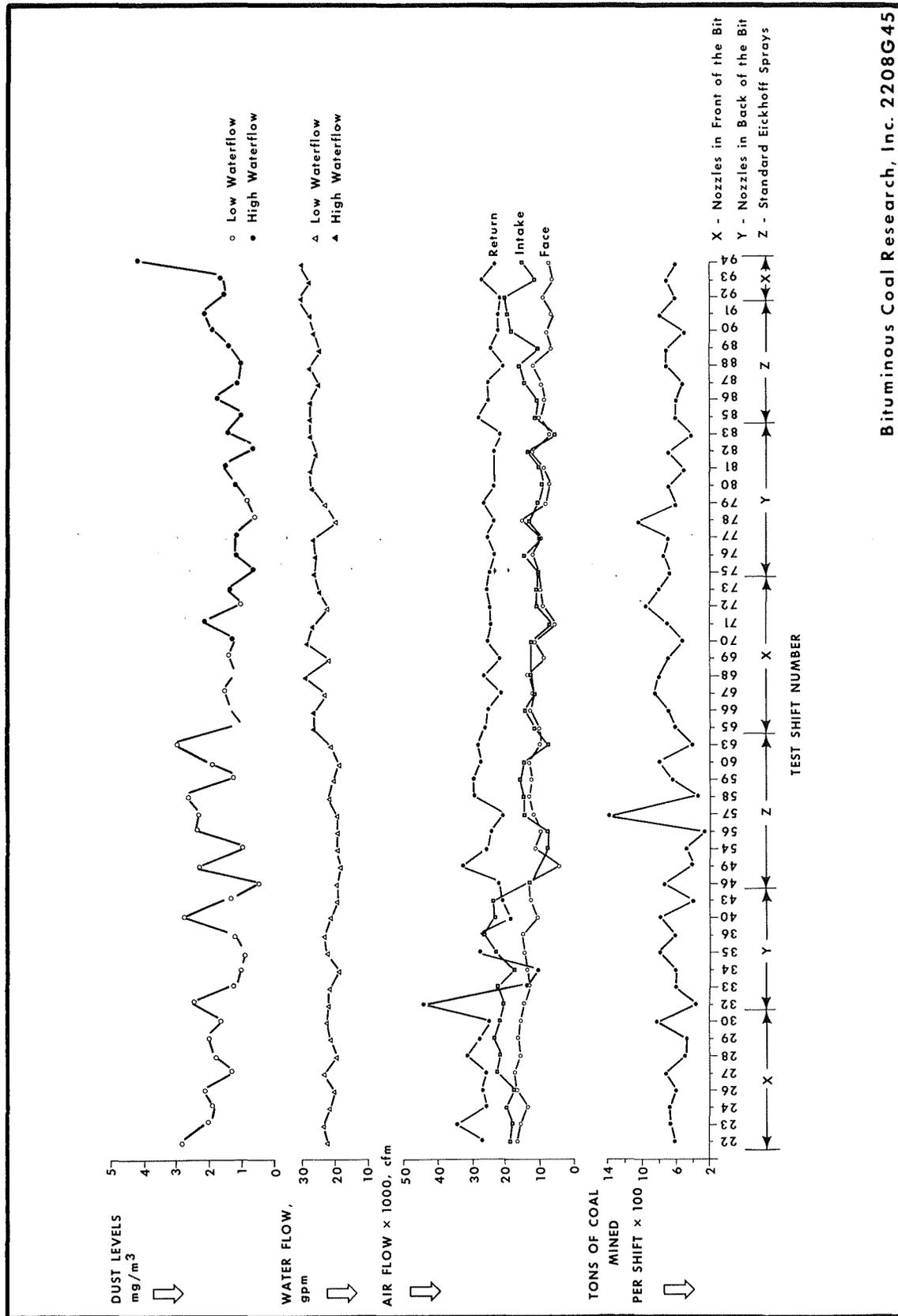


Figure D-3. Test Data for Valid Shifts - Dust Levels in Mg/Ton of Respirable Dust Measured in the Return



Bituminous Coal Research, Inc. 2208G44

Figure D-4. Test Data for Valid Shifts - Dust Levels in Mg/Ton of Gross Dust Measured at Head of Face



Bituminous Coal Research, Inc. 2208G45

Figure D-5. Test Data for Valid Shifts - Dust Levels in Cutting Concentration of Respirable Dust Measured on the Shearer

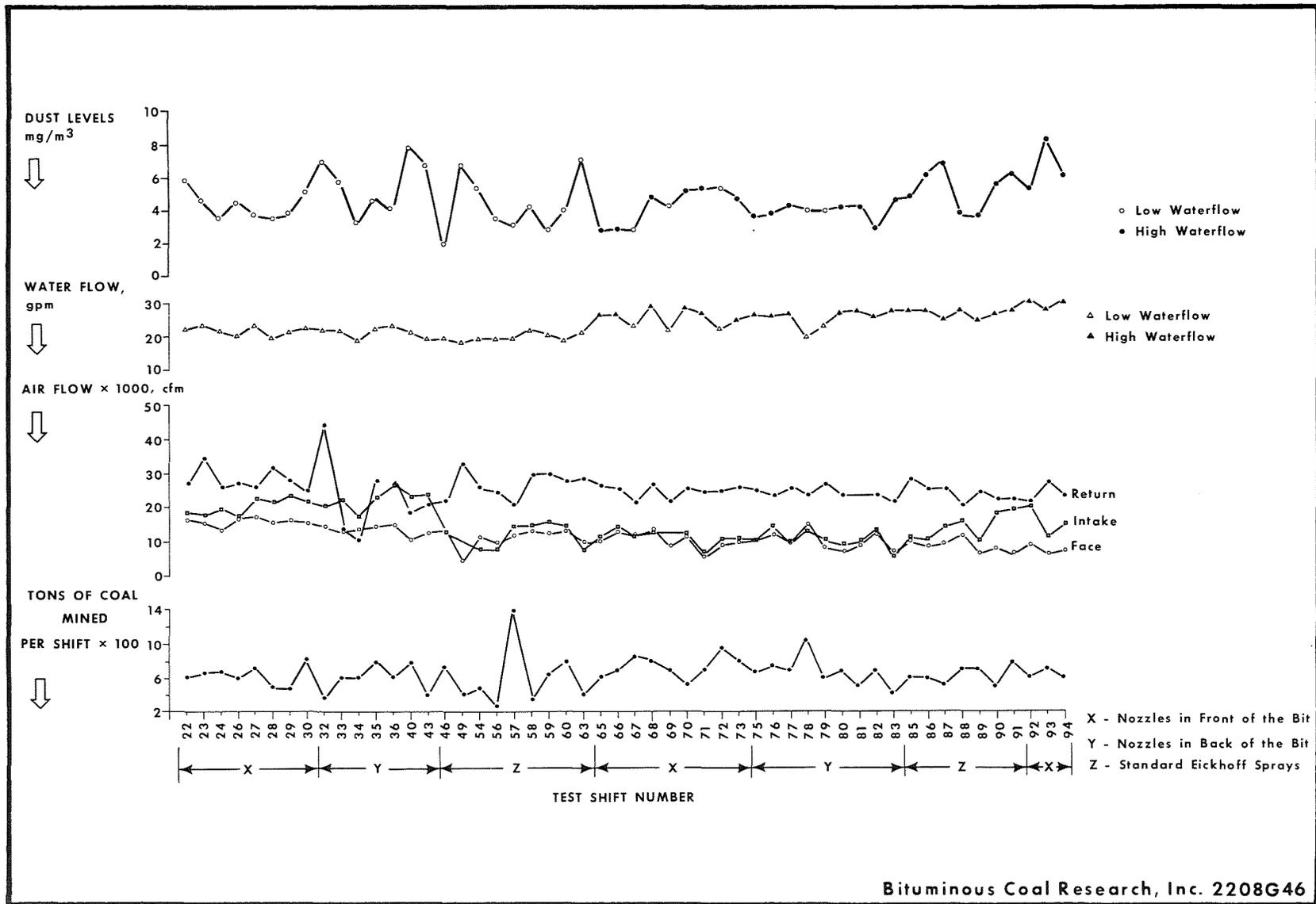


Figure D-6. Test Data for Valid Shifts - Dust Levels in Cutting Concentration of Respirable Dust Measured at Midpoint of Face

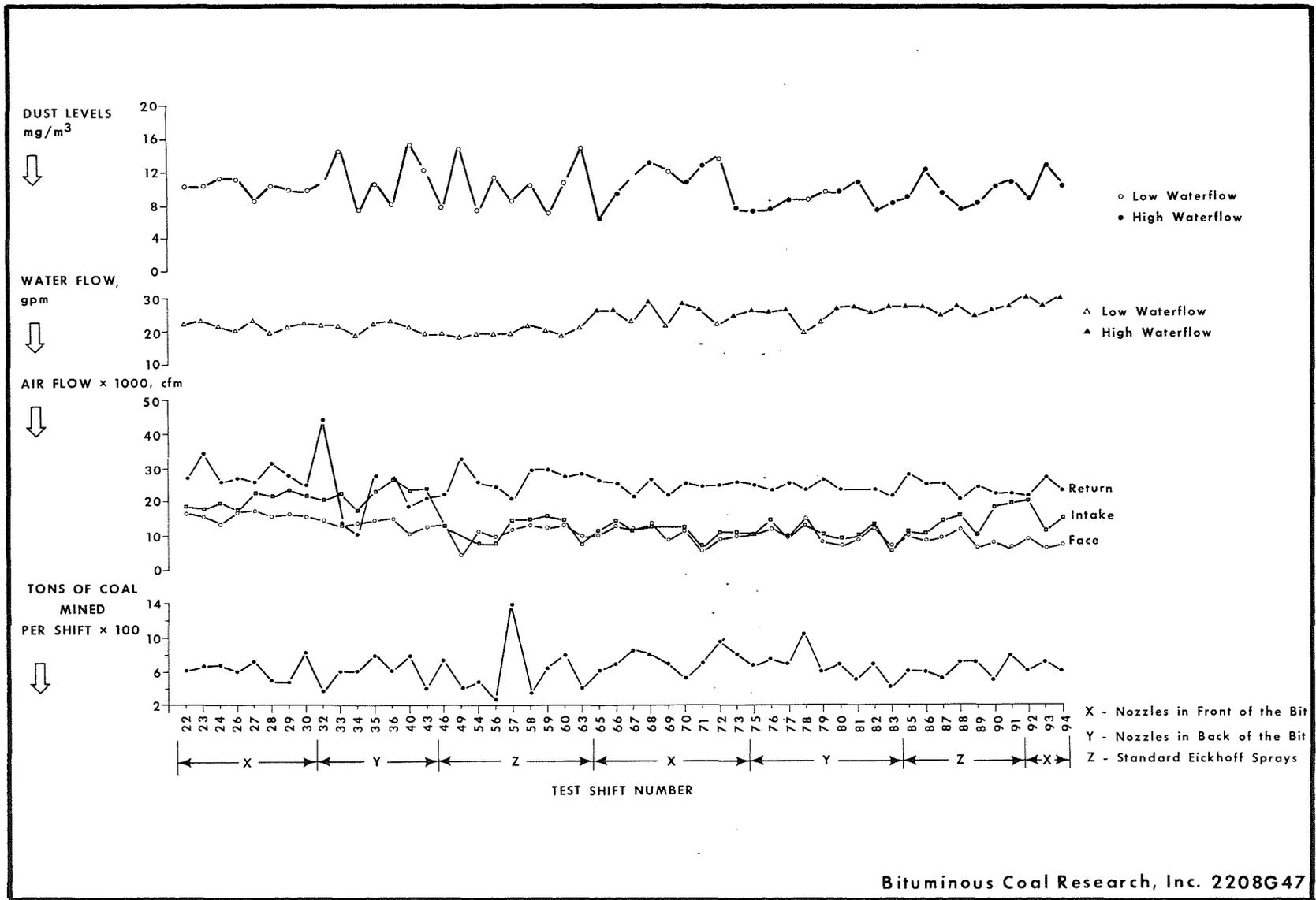


Figure D-7. Test Data for Valid Shifts - Dust Levels in Cutting Concentration of Respirable Dust Measured at Head of Face

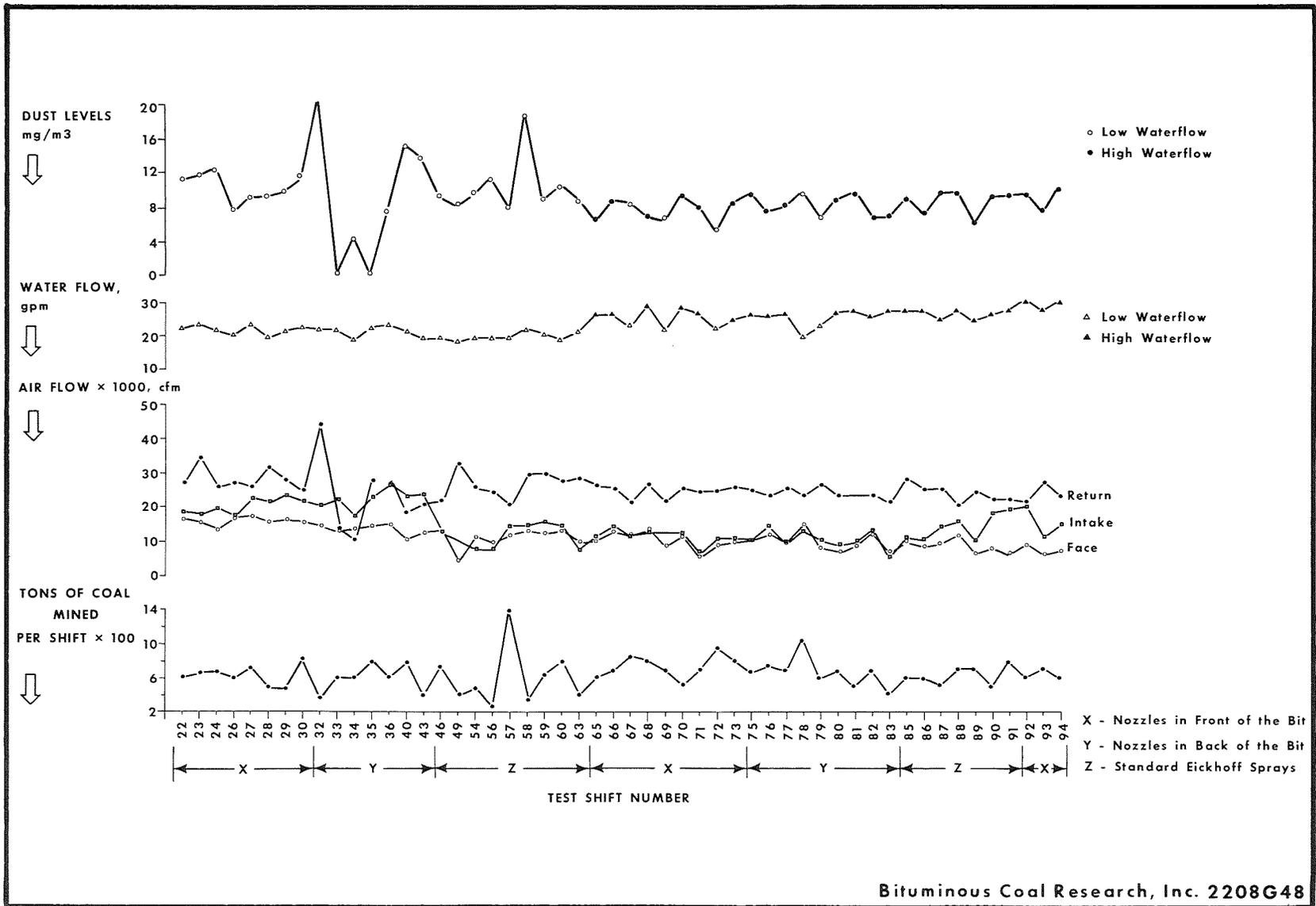
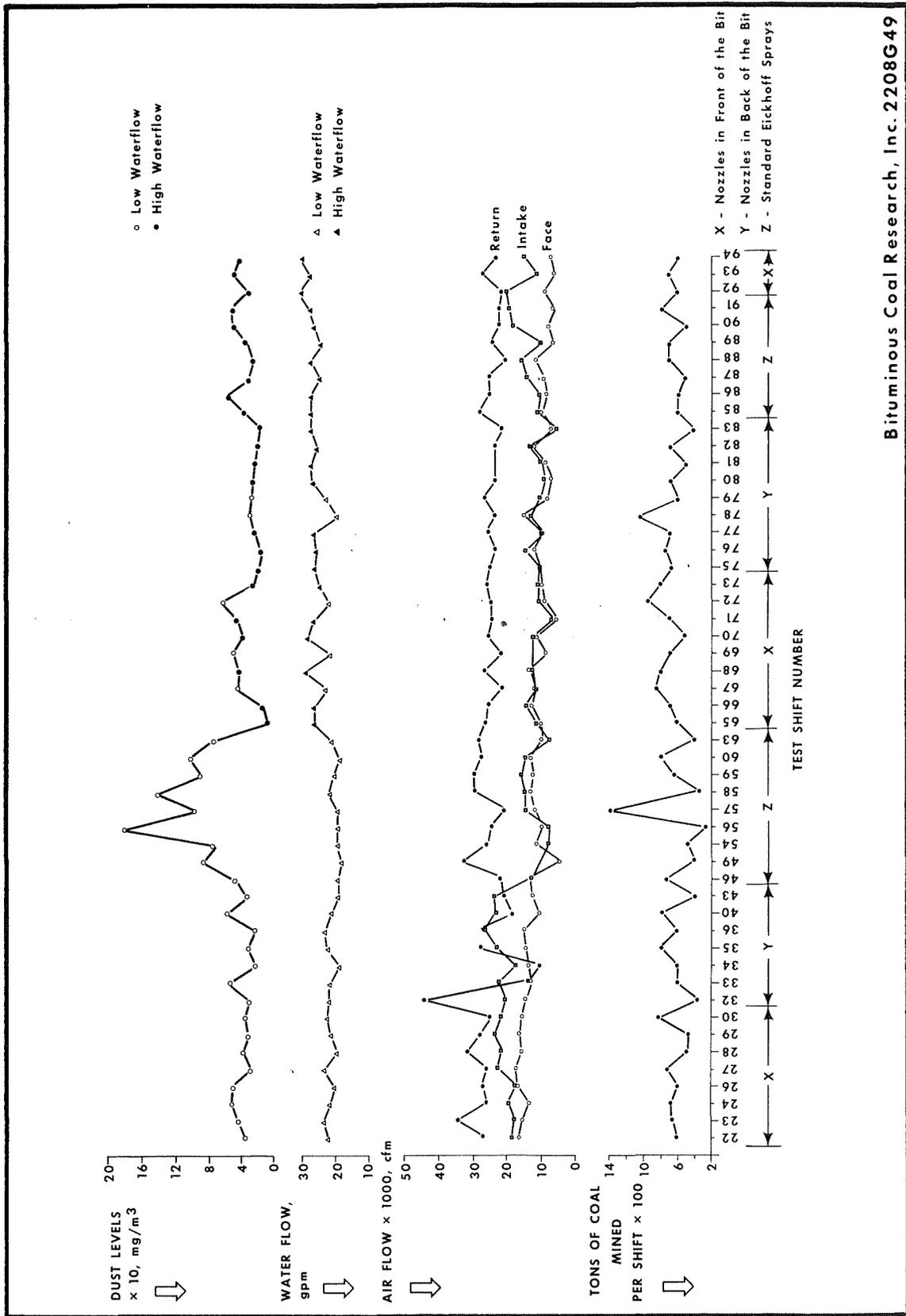
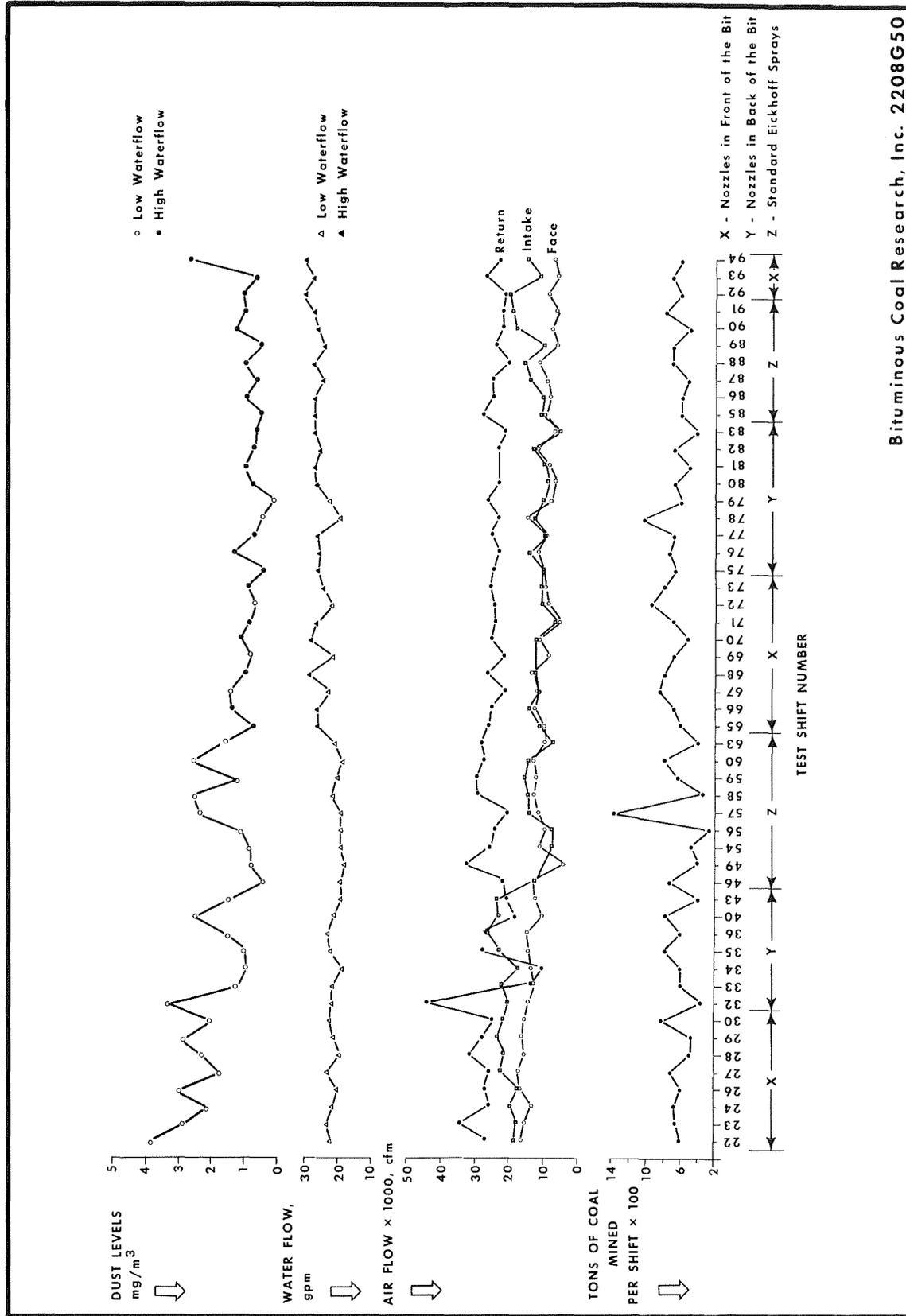


Figure D-8. Test Data for Valid Shifts - Dust Levels in Cutting Concentration of Respirable Dust Measured in Return



Bituminous Coal Research, Inc. 2208G49

Figure D-9. Test Data for Valid Shifts - Dust Levels in Cutting Concentration of Gross Dust Measured at Head of Face



Bituminous Coal Research, Inc. 2208G50

Figure D-10. Test Data for Valid Shifts - Dust Levels in Cutting Concentration of Respirable Dust, Normalized for Panline Airflow, Measured on the Shearer

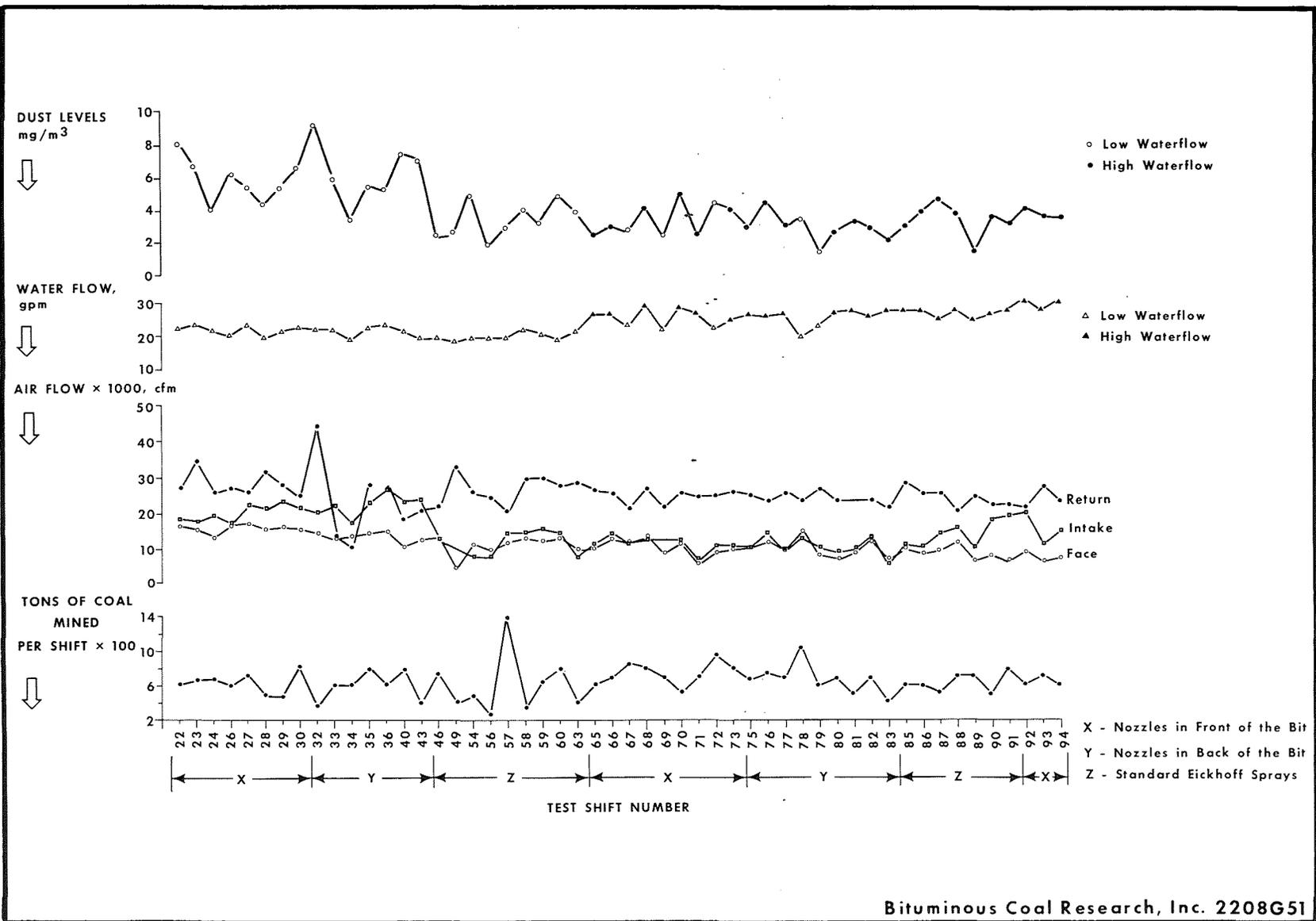
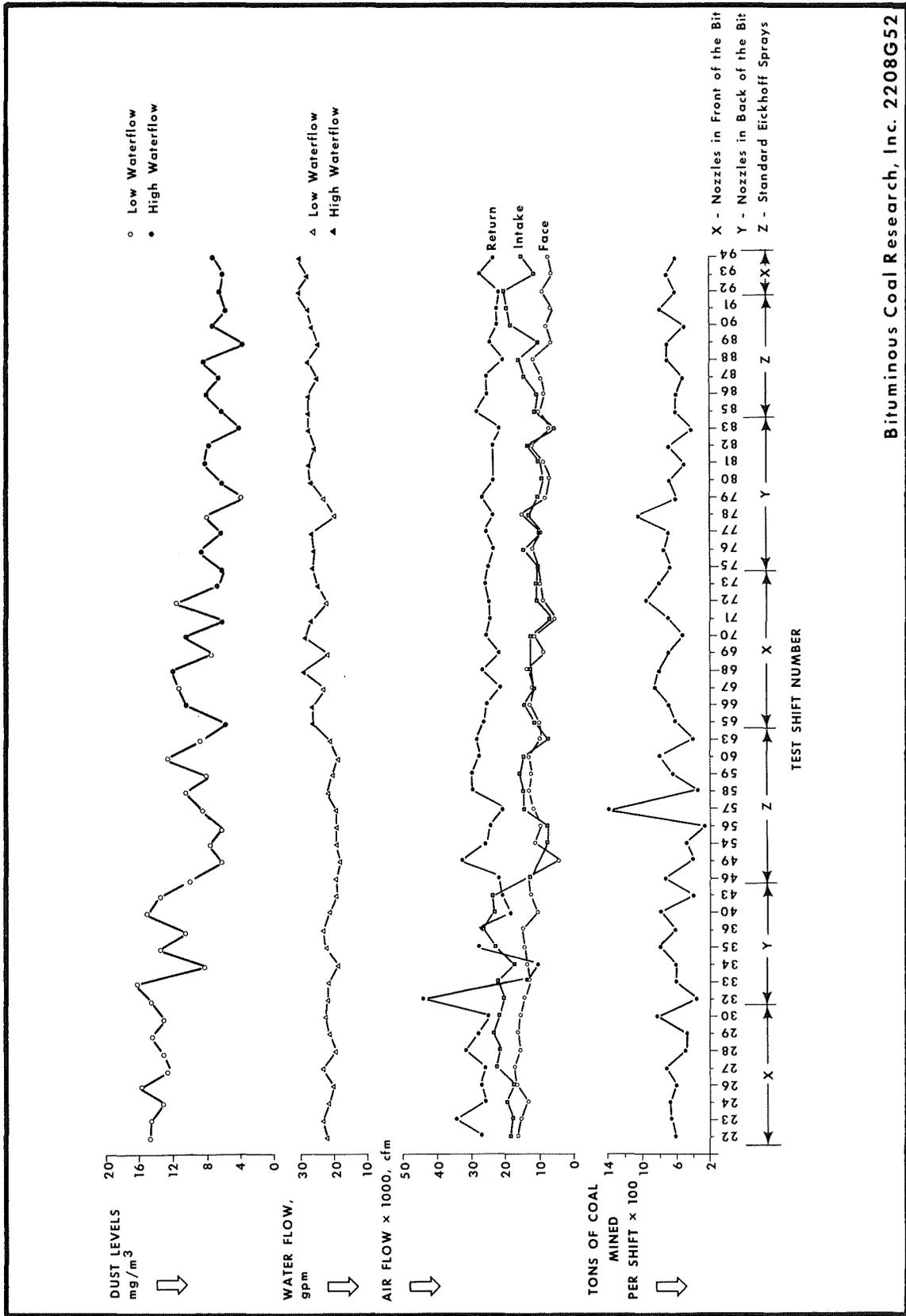


Figure D-11. Test Data for Valid Shifts - Dust Levels in Cutting Concentration of Respirable Dust, Normalized for Panline Airflow, Measured at Midpoint of Face



Bituminous Coal Research, Inc. 2208G52

Figure D-12. Test Data for Valid Shifts - Dust Levels in Cutting Concentration of Respirable Dust, Normalized for Panline Airflow, Measured at Head of Face

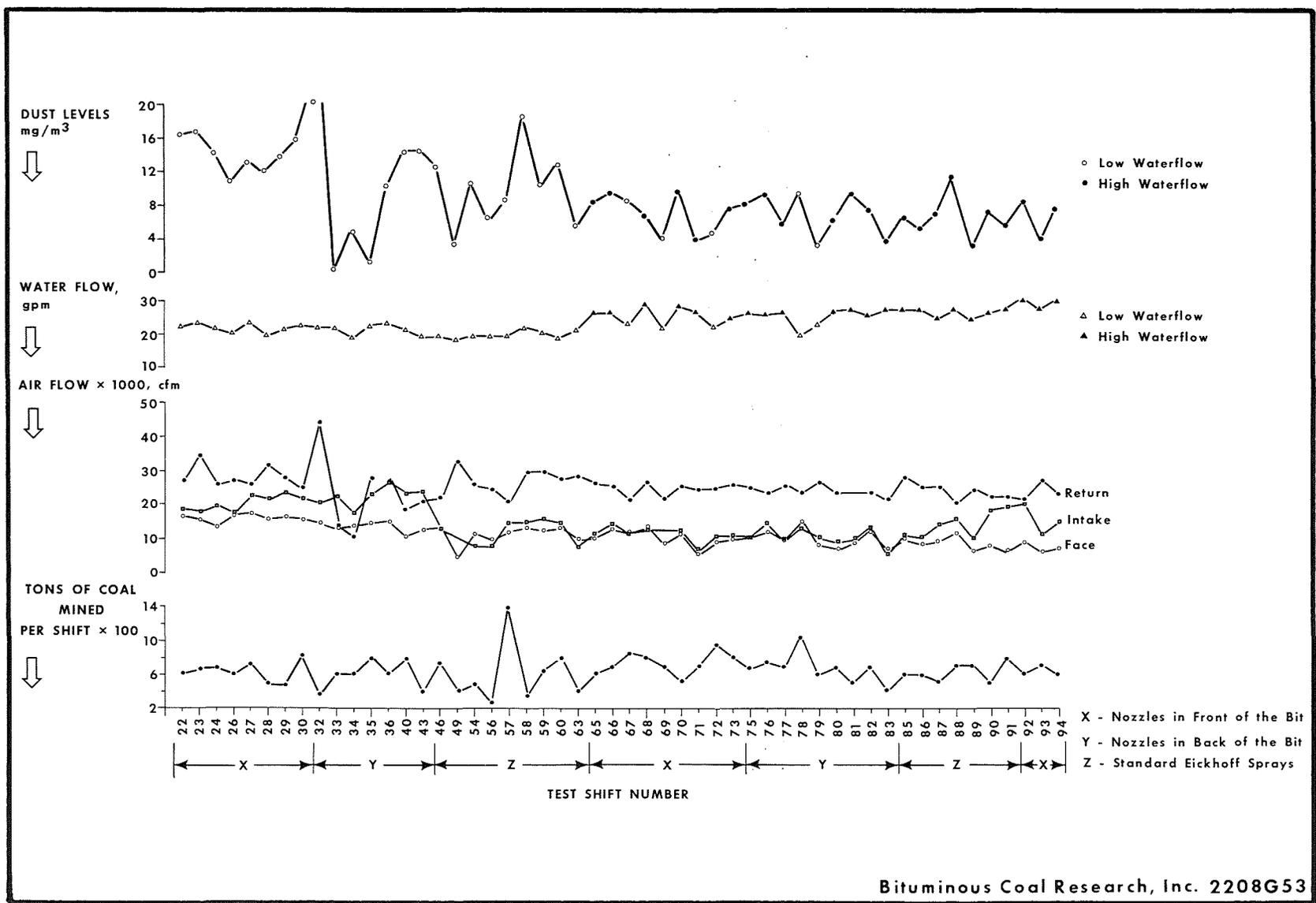
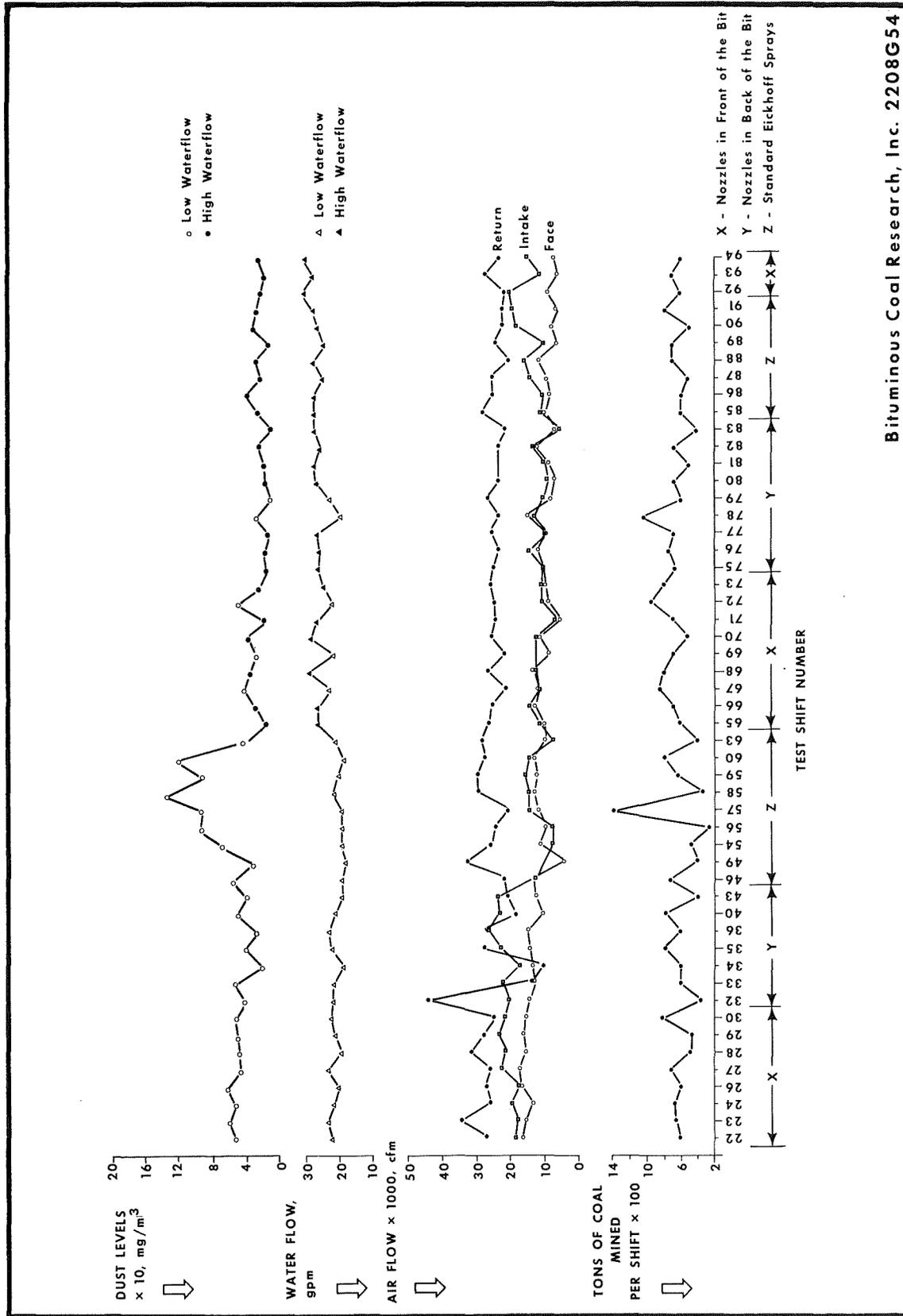


Figure D-13. Test Data for Valid Shifts - Dust Levels in Cutting Concentration of Respirable Dust, Normalized for Panline Airflow, Measured in Return



Bituminous Coal Research, Inc. 2208G54

Figure D-14. Test Data for Valid Shifts - Dust Levels in Cutting Concentration of Gross Dust, Normalized for Panline Airflow, Measured at Head of Face

APPENDIX E

SUMMARY OF CALCULATIONS AND STATISTICAL PROCEDURE FOR  
ANALYSIS OF FIELD TEST DATA

SUMMARY OF CALCULATIONS AND STATISTICAL PROCEDURE FOR  
ANALYSIS OF FIELD TEST DATA

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The following is a description of the statistical procedure which BCR used for the analysis of data obtained during the underground testing phase of this project. All calculations were made using a Digital PDP8 computer.

Since the main objective of this analysis was to quantify the effectiveness of the water spray systems in reducing respirable dust levels, the analysis included steps for the correction of dust measurements for the effects of other inherent variables (e.g., tonnage, airflow, cutting time). An underlying problem in any statistical analysis of respirable dust data seems to be that of the accuracy of the individual pieces of dust weight and concentration data. The basic approach used to remove these inaccuracies was twofold:

1. Personal sampler dust measurements were first made commensurable with, or made to be of the same relative magnitude as, the MRE measurements.

2. Each set of dust measurements from each position was then replaced by an average dust value, hereafter referred to as an adjusted dust value or  $\bar{Y}$ .

In addition to a general improvement in the accuracy of computations based on these dust weight and concentration averages, the amount of dust data was reduced so as to allow a more thorough, efficient analysis.

A. The Computation of Adjusted Dust Weights and Concentrations (MRE Equivalent) for Each Package Position

The method used to combine individual pieces of data from midpoint and head sampling positions is outlined in the following steps:

1. For each package position the best least squares linear equation

$$Y = AX + B \quad (1)$$

was determined for the relationship between the personal sampler dust weights (X) and MRE sampler dust weight (Y).

2. For each of the valid shifts equation (1) was then used to convert each personal sampler dust weight  $X_i$  to an adjusted personal weight  $Y_i$ .

3. For each shift, an arithmetic average  $\bar{Y}$  and deviation  $d$  was computed using the adjusted personal weights  $Y_1, Y_2, \dots, Y_K$  and the MRE sampler dust weight  $Y_M$  for that shift.

$$\bar{Y} = (Y_M + Y_1 + Y_2 + \cdots + Y_k) / (k + 1) \quad (2)$$

$$d = \sqrt{\frac{(Y_M - \bar{Y})^2 + (Y_1 - \bar{Y})^2 + (Y_2 - \bar{Y})^2 + \cdots + (Y_k - \bar{Y})^2}{(k + 1)}} \quad (3)$$

Still considering a particular position, if the deviation  $d$  for a given shift was small, all the samples from that position were used to calculate the average dust weight  $Y$  for that position during that shift. On the other hand, if the deviation was large, the individual samples were examined, the "offending" one eliminated, and the average  $\bar{Y}$  calculated from the remaining samples.

The elimination was carried out in steps, by coding the doubtful samples from 1 to 5, code 1 corresponding to the suspected "worst" samples. The code 1 samples were chosen and eliminated first. After elimination, the coefficients of equation (1) were recalculated for each position and the average  $\bar{Y}$  deviation  $d$  recalculated for each shift of each position. After examination of the deviation, the code 2 samples were chosen and eliminated and the calculating process repeated; and so on for codes 3, 4 and 5. The criteria used to code the samples was as follows:

1. For each shift having  $d \geq 1.00$  mg, the individual dust sample, which is the primary cause of this large deviation, was coded with a "1". However, if more than three shifts of a given package position satisfied  $d > 1.00$ , then a code "1" was used in coding data from the shifts with the three largest deviations, and a code "2" used in coding data from each of the remaining shifts satisfying  $d > 1.00$ .

2. For any other shift with a deviation which exceeded those of all other uncoded shifts by more than a reasonable amount (typically 0.50 mg) the sample which was the main cause of this larger deviation was also coded with a "2".

(1) Codes "3" and "4" were assigned in the same manner as codes "1" and "2", but using smaller  $d$  values, such as, 0.50 and 0.25 mg.

(2) Finally, code 5 was used where either elimination or inclusion was of questionable or minimal value in the analysis.

After the eliminations were completed, the following conditions were satisfied approximately:

(3) The standard error of the estimate (SEE) for most of the conversion equations was less than 0.5 mg.

(4) Further dust sample data elimination would likely cause little, if any, additional change in the magnitude of the average dust weights.

B. Adjusted Dust Concentrations for Each Package Position

The process described above in "1" was repeated, using dust concentrations in lieu of dust weights.

C. Calculation of a "Normalized" Dust Emission

"Normalized" dust emission figures were calculated for every shift, using (1) the adjusted dust weight and (2) the adjusted dust concentration at the shearer, head, midpoint, tail, and return positions. The defining equations for "normalized" dust emissions are

$$\text{mg/ton} = \frac{C \times S \times H \times Q}{T} \quad (4)$$

when calculations are based on dust concentration and

$$\text{mg/ton} = \frac{W \times H}{\bar{H} \times T} \quad (5)$$

when calculations are based on dust weight, where

W = adjusted dust weight in mg

C = adjusted dust concentration in mg/m<sup>3</sup>

S = sampling time in minutes

T = shift production in tons

H = airflow in cfm

Q = constant (.02832) to convert ft<sup>3</sup> to m<sup>3</sup>

$\bar{H}$  = average value of airflow for the shift

The effectiveness of the various water spray systems was evaluated by making comparisons of the average "normalized" dust emissions for the shearer operating modes.

In addition to the dust emissions normalized for airflow and tonnage, a similar evaluation was made based on the adjusted dust concentration (MRE equivalent) normalized to a base airflow along the panline. The equation used for this calculation was

$$Y' \text{ (mg/m}^3\text{)} = Y \frac{\text{Panline airflow}}{\text{Base airflow}}$$

where

$Y'$  = Normalized MRE equivalent concentration for a given shift and sampler location

$Y$  = Original MRE equivalent concentration for a given shift and sampler location

Panline airflow = Average airflow over the panline during associated shifts

Base airflow = Average panline airflow for all valid shifts sampled