Information Circular 9404



# Modified Shearer Clearer System for Dust and Methane Control

By Andrew B. Cecala and Natesa I. Jayaraman

UNITED STATES DEPARTMENT OF THE INTERIOR
Bruce Babbitt, Secretary

BUREAU OF MINES

**Library of Congress Cataloging in Publication Data:**

**Cecala, Andrew B.**
Modified shearer clearer system for dust and methane control / by Andrew B. Cecala and Natesa I. Jayaraman.

p. cm. — (Information circular; 9404)

Includes bibliographical references (p. 12).

1. Coal-mining machinery. 2. Spray nozzles. 3. Coal mines and mining--Dust control. 4. Coalbed methane--Safety measures. I. Jayaraman, Natesa I. II. Title. III. Series: Information circular (United States. Bureau of Mines); 9404.

TN813.C66 1994 622'.82--dc20 94-14055 CIP

# REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188



PB95-104873

**2. REPORT DATE**

**3. REPORT TYPE AND DATED COVERED**
Information Circular (IC)

**4. TITLE AND SUBTITLE**
Modified Shearer Clearer System for Dust and Methane Control

**5. FUNDING NUMBERS**

**6. AUTHOR(S)**

Andrew B. Cecala and Natesa I. Jayaraman

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
U.S. Bureau of Mines
Pittsburgh Research Center
PO Box 18070
Pittsburgh, PA 15236

**8. PERFORMING ORGANIZATION REPORT NUMBER**
IC 9404

**9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)**

**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

**11. SUPPLEMENTARY NOTES**

**12a. DISTRIBUTION/AVAILABILITY STATEMENT**

**12b. DISTRIBUTION CODE**

**13. ABSTRACT (Maximum 200 words)**
This report provides a detailed description of the Bureau of Mines designed modified shearer clearer system. Engineering drawings are provided for all major components of this system. The modified shearer clearer system is a revised version of the original system intended to improve the ventilation around both cutting drums. The original shearer clearer technique was solely a dust control technique that has been effective in lowering shearer operator's dust exposures. The technique uses a series of water sprays that not only knock down a portion of the dust cloud but also act as small fans that move a substantial amount of air and keep the dust cloud from dispersing over the shearer body. The modified version is composed of two additional spray blocks for improved air movement around both cutting drums, thus lowering methane levels and the likelihood of an ignition. A laboratory study performed with the modified version in a full-scale longwall gallery resulted in a 73 pct reduction in methane concentrations at the shearer machine for both cut directions. The air moving capabilities of the system provides more turbulence at the cutting drums and reduces methane levels.

**14. SUBJECT TERMS** Longwall methane control, longwall dust control, water sprays, shearer dust and methane control

**15. NUMBER OF PAGES** 12

**16. PRICE CODE**

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| Unclassified | Unclassified | Unclassified | Unlimited |

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std 239-28
298-102

## GENERAL INSTRUCTIONS FOR COMPLETING SF 298

The Report Documentation Page (RDP) is used in announcing and cataloging reports. It is important that this information be consistent with the rest of the report, particularly the cover and title page. Instructions for filling in each block of the form follow. It is important to stay within the lines to meet optical scanning requirements

**Block 1.** Agency Use Only (Leave blank).

**Block 2.** Report Date. Full publication date including day, month, and year, if available (e.g. 1 Jan 88). Must cite at least the year.

**Block 3.** Type of Report and Dates Covered. State whether report is interim, final, etc. If applicable, enter inclusive report dates (e.g. 1 Jun 87 - 30 Jun 88).

**Block 4.** Title and Subtitle. A title is taken from the part of the report that provides the most meaningful and complete information. When a report is prepared in more than one volume, repeat the primary title, add volume number, and include subtitle for the specific volume. On classified documents enter the title classification in parentheses.

**Block 5.** Funding Numbers. To include contract and grant numbers; may include program element number(s), project number(s), task number(s), and work unit number(s). Use the following labels:

| | | | |
|---|---|---|---|
| C | - Contract | PR | - Project |
| G | - Grant | TA | - Task |
| PE | - Program Element | WU | - Work Unit Accession No. |

**Block 6.** Author(s). Name(s) of person(s) responsible for writing the report, performing the research, or credited with the content of the report. If editor or compiler, this should follow the name(s).

**Block 7.** Performing Organization Name(s) and Address(es). Self-explanatory.

**Block 8.** Performing Organization Report Number. Enter the unique alphanumeric report number(s) assigned by the organization performing the report.

**Block 9.** Sponsoring/Monitoring Agency Name(s) and Address(es). Self-explanatory.

**Block 10.** Sponsoring/Monitoring Agency Report Number. (If known).

**Block 11.** Supplementary Notes. Enter information not included elsewhere such as: Prepared in cooperation with...; Trans. of...; To be published in.... When a report is revised, include a statement whether the new report supersedes or supplements the older report.

**Block 12a.** Distribution/Availability Statement. Denotes public availability or limitations. Cite any availability to the public. Enger additional limitations or special markings in all capitals (e.g. NOFORN, REL.ITAR).

DOD - See DoDD 5230.24, "Distribution Statements on Technical Documents."

DOE - See authorities.

NASA - See Handbook NHB 2200.2.

NTIS - Leave blank.

**Block 12b.** Distribution Code.

DOD - Leave blank.

DOE - Enter DOE distribution categories from the Standard Distribution for Unclassified Scientific and Technical

NASA - Leave blank.

NTIS - Leave blank.

**Block 13.** Abstract. Include a brief (Maximum 200 words) factual summary of the most significant information contained in the report.

**Block 14.** Subject Terms. Keywords or phrases identifying major subjects in the report.

**Block 15.** Number of Pages. Enter the total number of pages.

**Block 16.** Price Code. Enter appropriate price codes (NTIS only).

**Blocks 17 - 19.** Security Classifications. Self-explanatory. Enter U.S. Security Classification in accordance with U.S. Security Regulations (i.e., UNCLASSIFIED). If form contains classified information, stamp classification on the top and bottom of the page.

**Block 20.** Limitation of Abstract. This block must be completed to assign a limitation to the abstract. Enter either UL (unlimited) or SAR (same as report). An entry in this block is necessary if the abstract is to be limited. If blank, the abstract is assumed to be unlimited.

# CONTENTS



## ILLUSTRATIONS

## UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

With Factors for Conversion to U.S. Customary Units

| Abbreviation | Unit of measure | To convert to— | Multiply by— |
|---|---|---|---|
| cm | centimeter | inch (in) | 0.39 |
| $kg/cm^2$ | kilogram per square centimeter | pound per square inch (psi) | 14.22 |
| m | meter | foot (ft) | 3.28 |
| $m^3/s$ | cubic meter per second | gallon per minute (gpm) | 4.41 |
| pct | percent | | |

# MODIFIED SHEARER CLEARER SYSTEM FOR DUST AND METHANE CONTROL

By Andrew B. Cecala[1] and Natesa I. Jayaraman[1]


## ABSTRACT

This U.S. Bureau of Mines report provides a detailed description of the Bureau-designed modified shearer clearer system. Engineering drawings are provided for all major components of this system. The modified shearer clearer system is a revised version of the original system and is intended to improve the ventilation around both cutting drums. The original shearer clearer technique was solely a dust control technique that has been effective in lowering shearer operators' dust exposures. The technique uses a series of water sprays that not only knock down a portion of the dust cloud but also act as small fans that move a substantial amount of air and keep the dust cloud from dispersing over the shearer body. The modified version is composed of two additional spray blocks for improved air movement around both cutting drums, thus lowering methane levels and the likelihood of an ignition. A laboratory study performed with the modified version in a full-scale longwall gallery resulted in a 73-pct reduction in methane concentrations at the shearer machine for both cut directions. The air-moving capabilities of the system provide more turbulence at the cutting drums and reduce methane levels.


[1]Mining engineer, Pittsburgh Research Center, U.S. Bureau of Mines, Pittsburgh, PA.

## INTRODUCTION

Dust and methane levels on longwall sections are two areas that must be constantly addressed by the U.S. mining industry and the U.S. Bureau of Mines in order to provide a healthy and safe work environment for underground miners. Over the past decade, there have been significant technological advances in both dust and methane control. An effective longwall dust control technique developed under a Bureau contract during this time has been the shearer clearer system. This system uses a series of water sprays and barriers to hold the dust cloud created during cutting against the face and away from the shearer operators (*1*).[2] Numerous installations of the shearer clearer system have been evaluated over the years, and the shearer operators' respirable dust exposures have been reduced by 50 to 60 pct.

In addition to the shearer clearer system, other dust control techniques have proved to be effective on longwall sections. Research to optimize face ventilation and shearer water usage has been effective at reducing longwall face dust levels (*2*). Using reverse drum rotation to reduce dust levels while increasing production has been successful in a number of mines (*3*). The limited application of foams to reduce longwall dust levels has also been successful in a few mines (*4*).

Controlling methane levels on longwalls is also a primary goal and is of concern to all longwall operators. Methane ignitions remain one of the most serious hazards facing longwall operators. There are three ways to control longwall face ignitions. The first way is to effectively monitor for methane so as to inform workers of potentially dangerous methane concentrations and to automatically deenergize equipment when such levels exist. The Bureau recently performed a study to determine optimal locations for face methane-monitoring equipment (*5*). Since most longwall ignitions are caused by the shearer, placing a methane monitor on the machine to detect when a potentially explosive concentration is present was investigated and holds promise.

The second way to reduce longwall ignitions is to control the ignition source. The most significant ignition source is the cutting bits on the shearer. One approach is to control this with the use of an anti-ignition drum design that uses a water spray behind each cutter bit to quench the hot streak created when cutting noncoal material (*6*). This technique has been shown to be effective at reducing shearer-generated frictional ignitions. Advances have also been made in bit design and bit lacing (*7*).

The last, but probably the most important, way to control longwall ignitions is to remove or dilute the methane to safe concentrations. Advances have been made in methane drainage in which the methane is extracted before or during mining (*8-9*). Increasing total ventilation air quantities and more effective use of existing air volumes have been successful at reducing methane levels. The ventilated-drum concept has been tested on a limited basis in this country and has shown reductions for both dust and methane levels at the longwall shearer (*10*). An additional approach that has shown potential is the use of a Bureau-designed modified shearer clearer system (*11*). This system is a modified version of the original system that provides more air movement around the cutting drums, thus lowering methane levels and the potential for frictional ignitions.

This publication provides mine operators with a basic understanding of the functioning of the modified shearer clearer system and with detailed engineering information to allow them to fabricate and install such systems at their operation.

## BACKGROUND

The shearer clearer system was originally developed under a Bureau contract in the early 1980's (*12*). This system consisted of strategically positioned water sprays and a number of passive barriers located on the shearer. The intent was to reduce dust concentrations at the operator's location by splitting the airflow and keeping the dust-laden air generated during cutting from contaminating the shearer operators. Feedback during testing of this original design indicated that a number of minor modifications could be implemented to improve its performance. The system was modified to use fewer water sprays, resulting in a reduction in the amount of water mist at the operator's location. Underground evaluations over the years by the Bureau of Mines, Foster-Miller Inc., the Mine Safety and Health Administration (MSHA), and coal producers have all confirmed the successful performance of the shearer clearer system from a dust control standpoint. The shearer clearer has accounted for a clean-air split in the walkway as far as 12.2 m (40 ft) downstream from the machine. MSHA is requiring some mine operators to include shearer clearer systems in their longwall dust control plans.

[2]Italic numbers in parentheses refer to items in the list of references at the end of this report.

While working on the development of the shearer clearer system, the Bureau was concurrently researching ways to effectively monitor and control methane levels on longwall sections. As previously noted, one way to control methane is to dilute it to safe concentrations. The shearer clearer system was considered as a possible method to reduce methane levels at the shearer, which is the primary ignition source. The system uses a number of water sprays that act as small fans, thus moving air and holding the dust cloud against the face. It was proposed that the system could be modified to increase the air-moving characteristics around both cutting drums, thus lowering methane levels in these ignition-prone areas. A study was initiated to investigate this.

Laboratory tests were conducted in a full-scale longwall gallery to define the size of the poorly ventilated areas around the shearer body (*12*). Tests were conducted over a wide range of conditions, including various levels of primary airflow and gob leakage in both cut directions. Methane gas was released at the cutting drums to simulate methane liberated during the cutting process. Methane was monitored from the floor to the roof, from the headside drum to 1.2 m (4 ft) downstream of the tailside drum, and from the face to past the shearer operator. Baseline tests showed that the face side area around both cutting drums and the entire area between the drums were not ventilated adequately. Increasing the primary airflow or changing the cutting direction had little impact on improving the ventilation in these areas. Of several different concepts investigated, one effective modification was to implement two additional spray blocks on the original shearer clearer design. One spray block was positioned near each cutting drum to increase the air-moving capabilities at the drums and to more effectively dilute the methane being liberated during cutting. This system with the two additional spray manifolds was named the "modified shearer clearer system" and was intended for both dust and methane control.

Methane concentrations were reduced by approximately 73 pct with the modified shearer clearer for both cut directions during laboratory testing. The additional sprays included in the modified shearer clearer system decreased methane concentrations behind the cutting drums by as much as 40 pct from concentrations recorded with the standard shearer clearer. The modified shearer clearer not only holds the dust cloud against the face, but also causes additional air to sweep the area on the face side of the shearer body, especially around the cutting drums, thus reducing methane levels at the machine and lessening the potential of a frictional ignition.

## SYSTEM DESIGN

The intent of this report is to provide operators with sufficient information about the modified shearer clearer system to allow them to fabricate and install such systems at their operations. A number of design drawings showing the various components of the system are presented.

Figure 1 shows the perspective used in all illustrations in this report. All illustrations are designed for a "left-handed" shearer clearer system. This is for longwall faces that are ventilated from right to left when looking at the face from the walkway area. If a face is ventilated from left to right, then a "right-handed" system is necessary and is just a mirror image of the drawings provided.

Nine different spray manifolds comprise the modified shearer clearer system. Figure 2 shows the location and mounting position of all nine of these spray manifolds.[3] Figures 3, 4, and 5 are design drawings of spray manifolds 1, 2, and 3, respectively, which are located on the headside splitter arm. It is recommended that all spray manifolds be fabricated using some type of carbon steel. Carbon steel is relatively inexpensive and is easier to machine and weld than many other metals. Stainless steel can be used if an operation is concerned with corrosion problems, but this will substantially increase the cost.

Figure 6 shows a design of a headside splitter arm used to mount the three spray manifolds. It is recommended that the splitter arm be hinged to the shearer to deflect when large pieces of coal or roof rock strike it. A spring-loading-type splitter arm has proved effective at a number

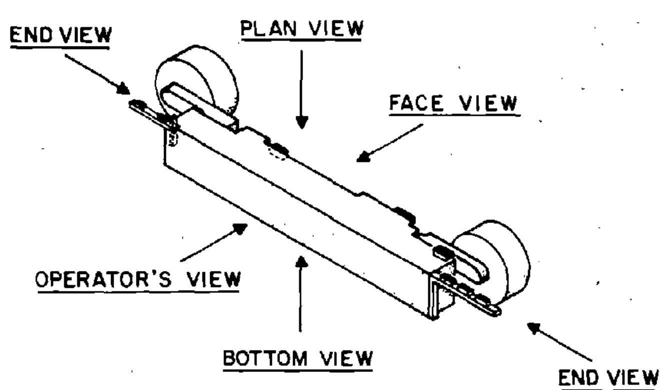


**Figure 1.—Perspective of all illustrations.**

[3]All figures are shown in customary units since it is the standard unit of measurement for U.S. coal mines.

of operations and should be used on the headside splitter arm. The splitter arm should extend approximately 20.5 to 30.8 cm (8 to 12 in) past the edge of the headside drum. This headside splitter arm is critical in that it starts the air split action and keeps the contaminated air close to the face. It is also recommended that all spray manifolds be bolted to the machine, not welded. This allows for easier replacement of worn or broken parts and hardware when needed.

Four spray manifolds are directly attached to the shearer body; figures 7, 8, 9, and 10 show these spray manifolds (4 through 7, respectively). Manifold 4 is mounted directly on the top, front edge of the shearer and is used to ventilate the area behind the headside cutting drum. Manifolds 5 and 6 should be located along the front, top edge of the shearer and are used to keep the air split maintained over the main body of the shearer. Figures 11 and 12 indicate the recommended mounting method for attaching spray manifolds 5 and 6, respectively, to the machine. A bracket assembly is used in which the spray manifold is mounted to the bracket; the assembly is then attached to the machine. Manifold 7 is mounted vertically at the tail end of the shearer and is used to improve the ventilation at the tailside drum. Since many shearer mining machines differ as to the design on the tail end of the machine body, manifold 7 can be attached by the operator at the most advantageous location. Two factors to be considered are (1) an uninterrupted spray pattern for the nozzle to be effective and (2) ability of the manifold to be durable and not to be ripped off or damaged during mining. Figure 13 shows spray manifolds 8 and 9, which are both mounted on the tailside splitter arm (figure 14). It is not necessary for the tailside splitter arm to use the spring-loading technique.

In this application, there are 9 spray manifolds encompassing 15 separate water sprays. In extensive testing by the Bureau, success was achieved using Spraying Systems Co.'s 3/8 BD20 whirljet spray nozzles.[4] Using the BD20 inserts provides dual inlets and thus reduces the possibility of clogging. The recommended operating pressure at the spray nozzles is between 8.4 kg/cm$^2$ (120 psi) and 10.5 kg/cm$^2$ (150 psi).

The spray nozzle tips to be used with the modified shearer clearer system are dependent on the volume of water available for use. The nozzle tips can vary between a No. 10 spray tip that will deliver approximately 1.13 m$^3$/s (5 gpm) per nozzle and a No. 3 spray tip that will deliver approximately 0.23 m$^3$/s (1 gpm). Operating volumes for the modified system will range from 17.0 m$^3$/s (75 gpm) with the No. 10 spray tips to 3.4 m$^3$/s (15 gpm) for No. 3 spray tips. The actual spray nozzle tip size needs to be evaluated along with other water usage parameters on the shearer; thus a wide range of spray nozzle sizes is presented. A No. 8 spray tip delivering approximately 0.8 m$^3$/s (3.5 gpm) per nozzle at a total system volume of 11.3 m$^3$/s (50 gpm) is recommended.

It is also advisable to use a good water filtration system because the water quality in most mines is poor. The modified shearer clearer system is composed of 15 different water sprays, and contaminated water will cause clogging problems and impair system efficiency. A filtration system successfully used in many field evaluations is a hydrocyclone system (*13*). These devices will remove product from 0.32 cm (1/8 in) in size all the way down to 60-mesh particulate. The particles are trapped on the bottom of the unit and are flushed out by simply opening a ball valve once per shift.

The effectiveness of the modified shearer clearer system will vary from face to face depending on a number of factors, including geological conditions, equipment layout and dimensions, ventilation rates, water pressure, and water flow rates, to name just a few. The system can be modified slightly to address these conditions on each face to optimize its performance.

Another consideration is turning off some of the water sprays on the system on bidirectional faces when cutting from headgate to tailgate or with ventilating airflow. At some operations, dust levels recorded at the headside drum operator's position were increased when cutting with the airflow (*1*). By eliminating spray manifolds 1, 2, 3, and 5, conditions at the headside drum operator's position were improved significantly. On bidirectional faces, the full system would be used when cutting from tailgate to headgate or when cutting against the airflow direction. Spray manifolds 4, 6, 7, 8, and 9 would be used when cutting from headgate to tailgate, or with the direction of the ventilating airflow. A determination of the best approach to use must be made for each individual longwall.

[4]Reference to specific manufacturers is for information only and does not imply endorsement by the U.S. Bureau of Mines.

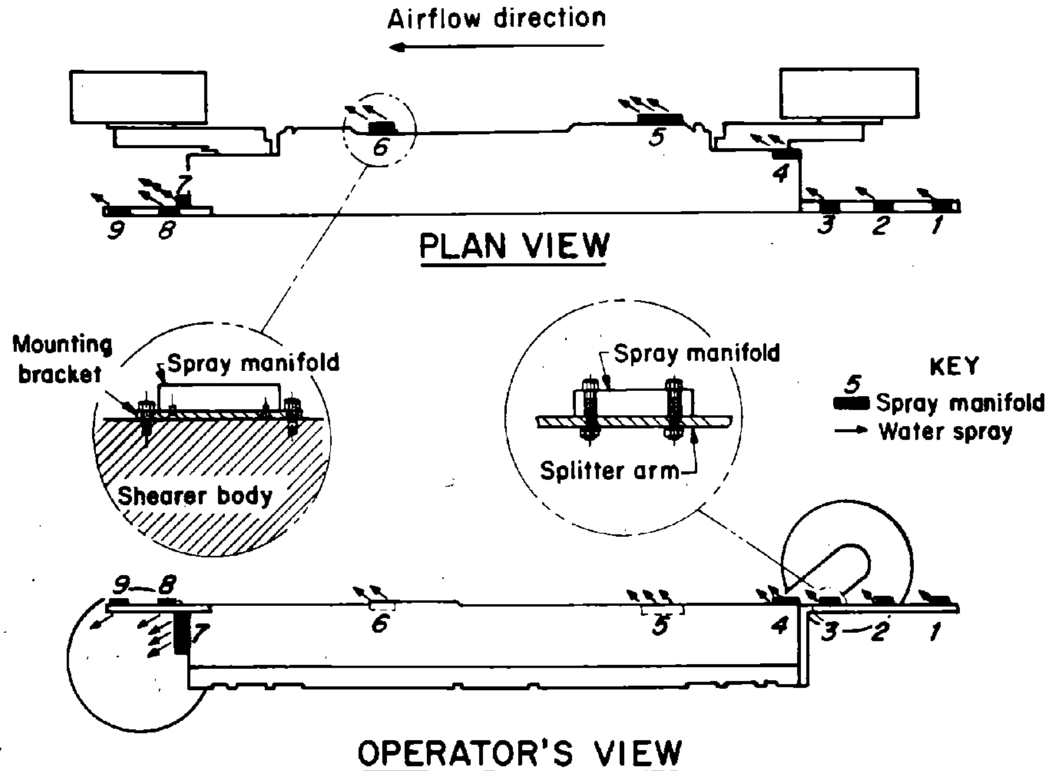


**Figure 2.—Location and mounting positions of spray manifolds on modified shearer clearer system. All dimensions are in inches.**

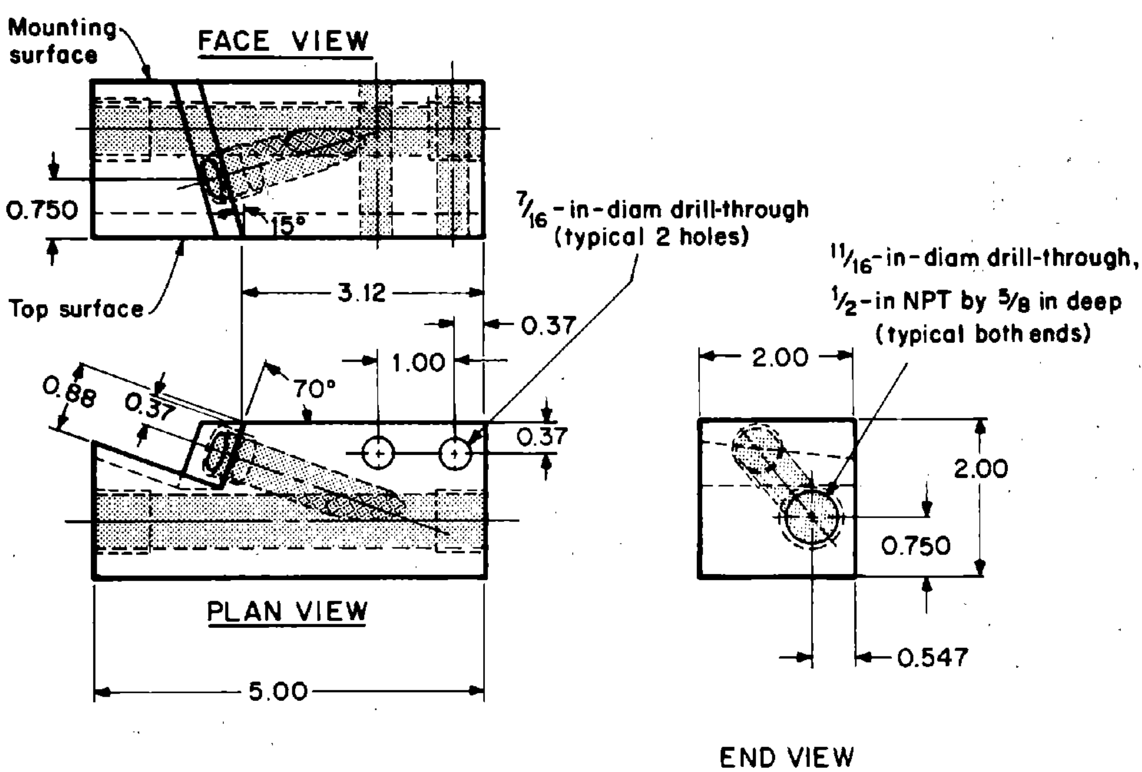


**Figure 3.—Water spray manifold 1. All dimensions are in inches.**

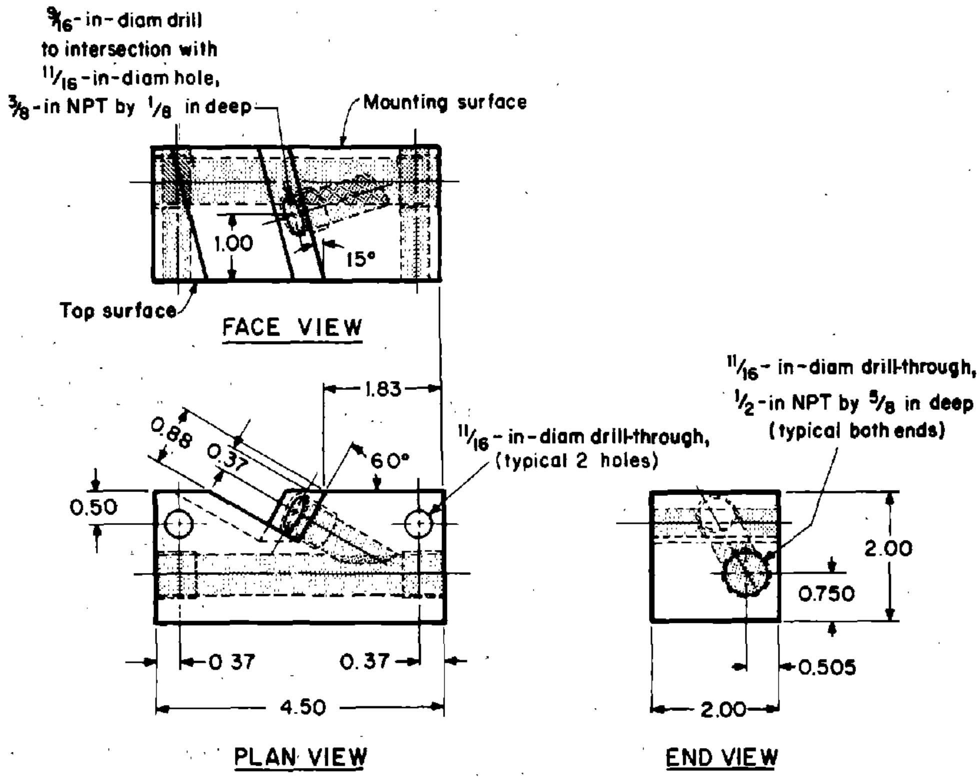


**Figure 4.—Water spray manifold 2. All dimensions are in inches.**

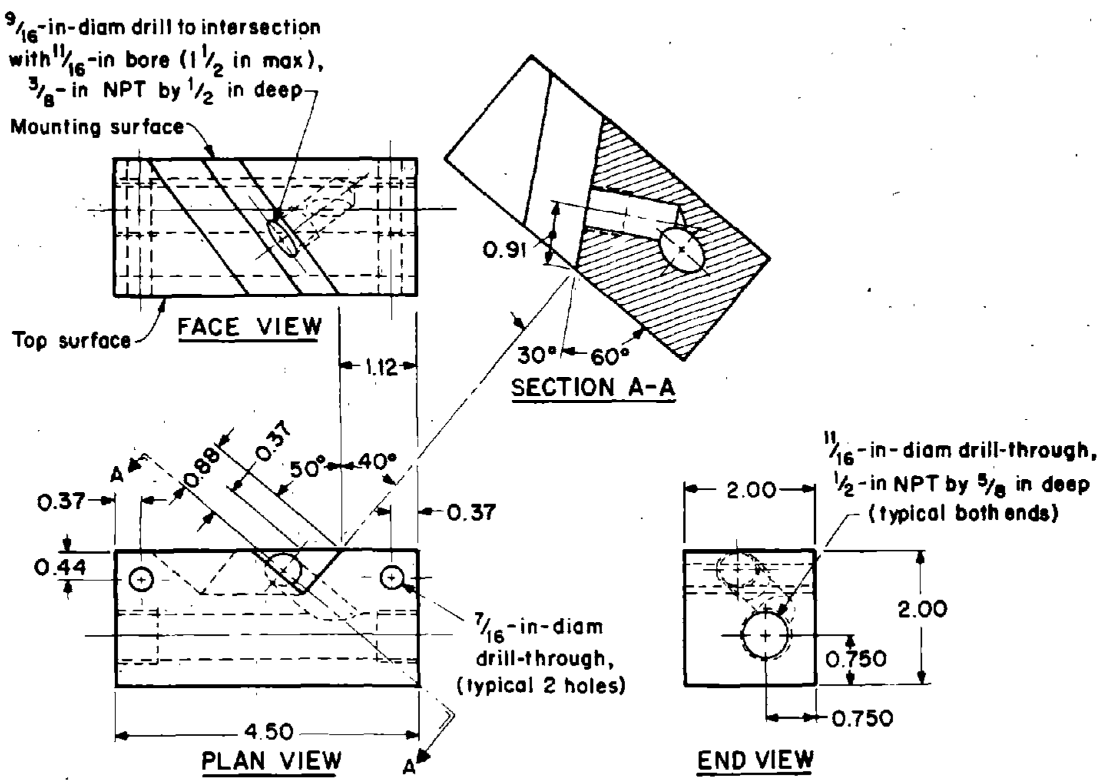


**Figure 5.—Water spray manifold 3. All dimensions are in inches.**

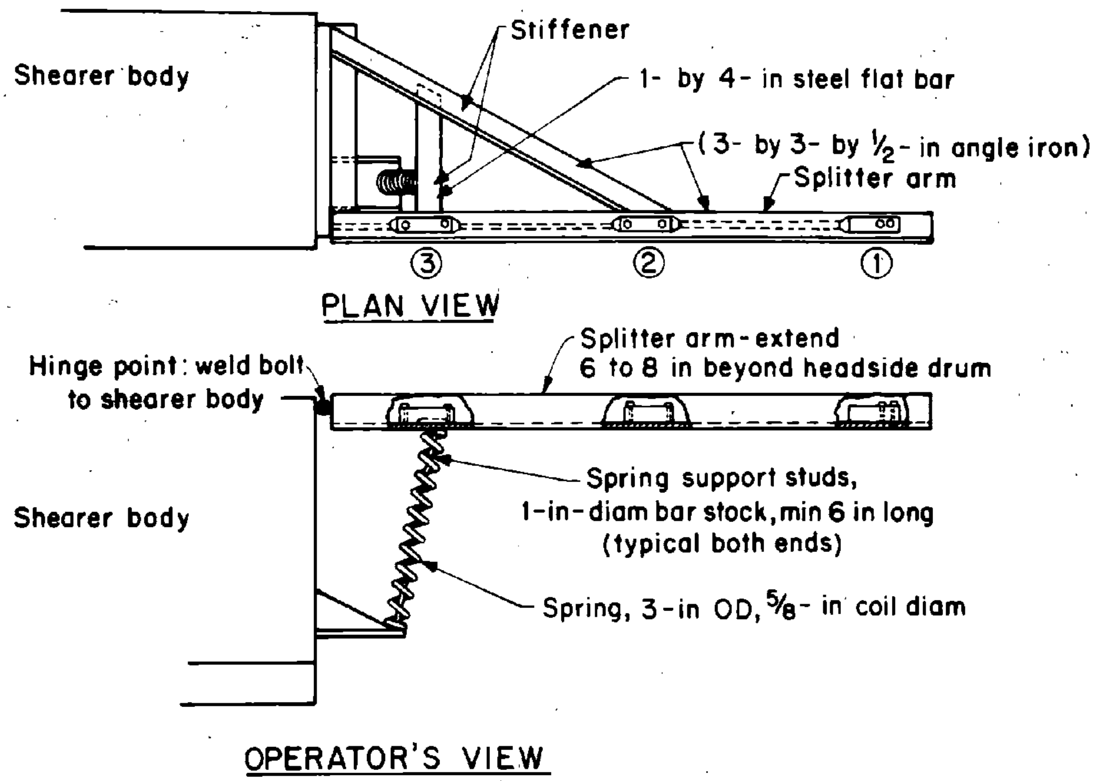


**Figure 6.—Design for headside splitter arm. All dimensions are in inches.**

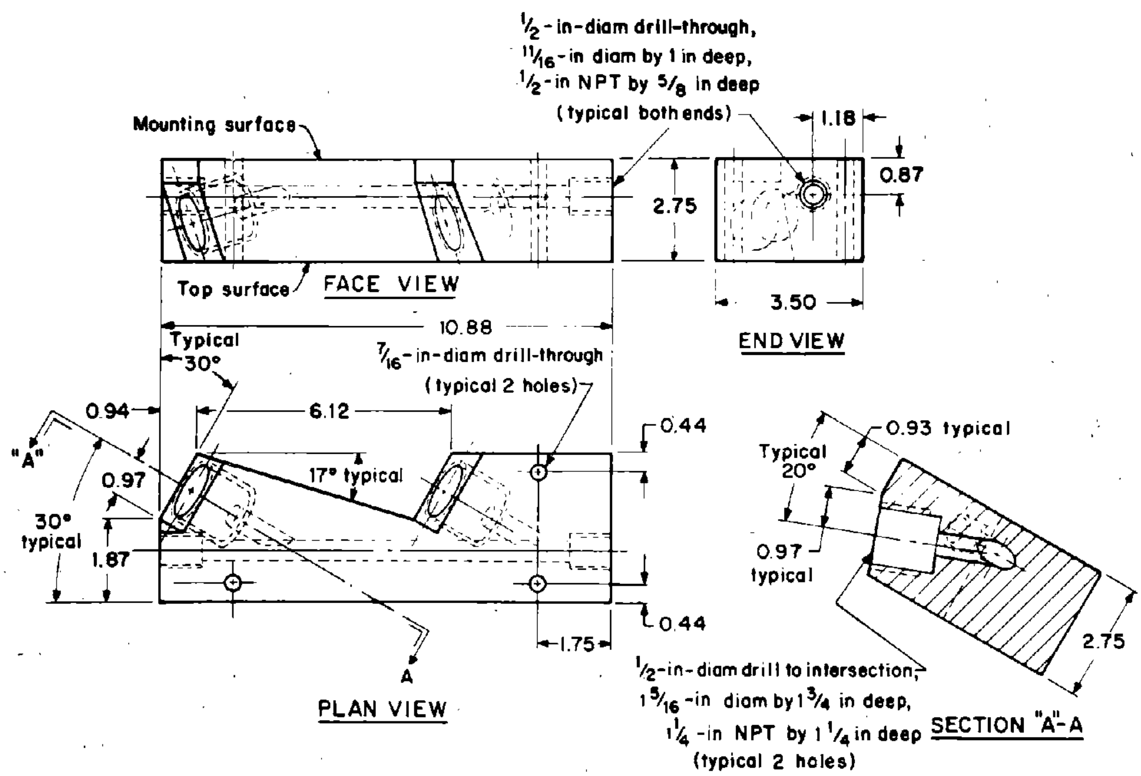


**Figure 7.—Water spray manifold 4. All dimensions are in inches.**

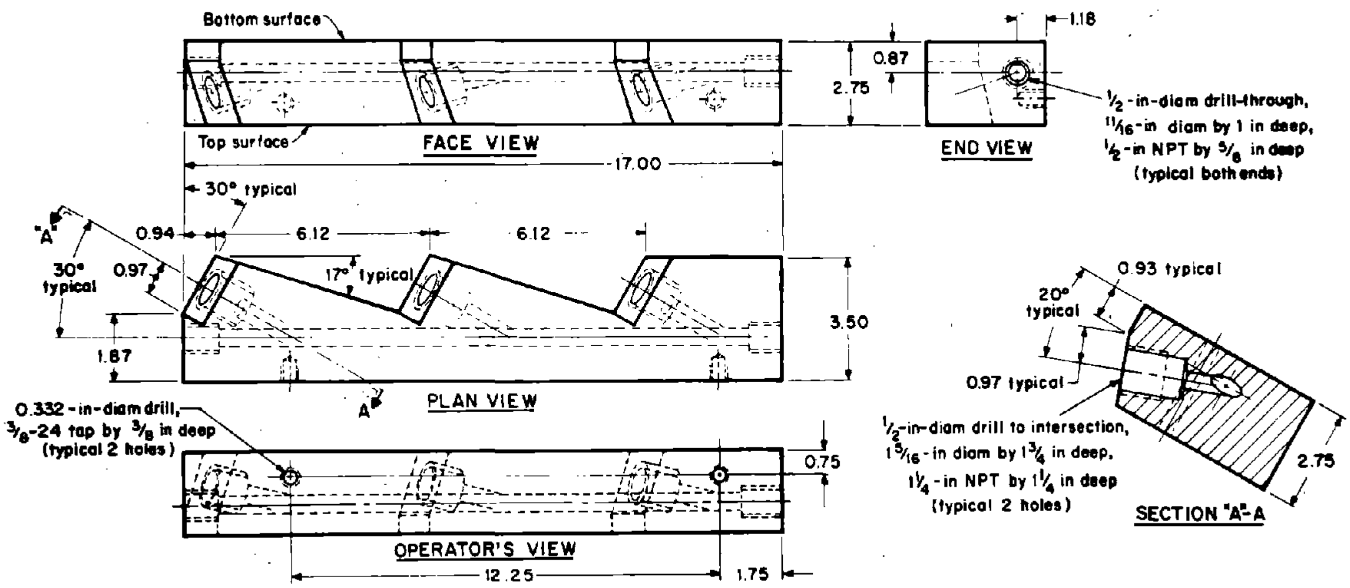


**Figure 8.—Water spray manifold 5. All dimensions are in inches.**

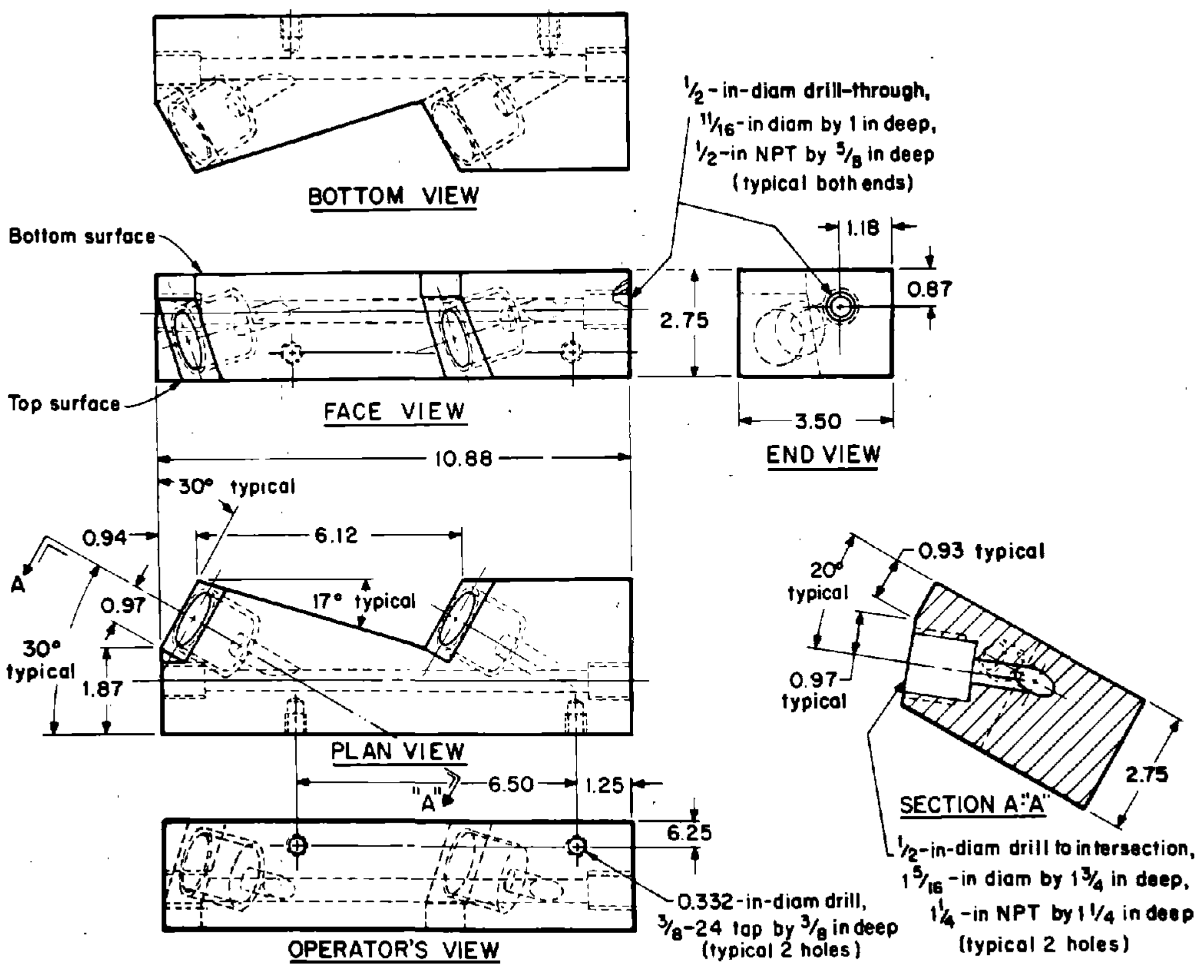


**Figure 9.—Water spray manifold 6. All dimensions are in inches.**

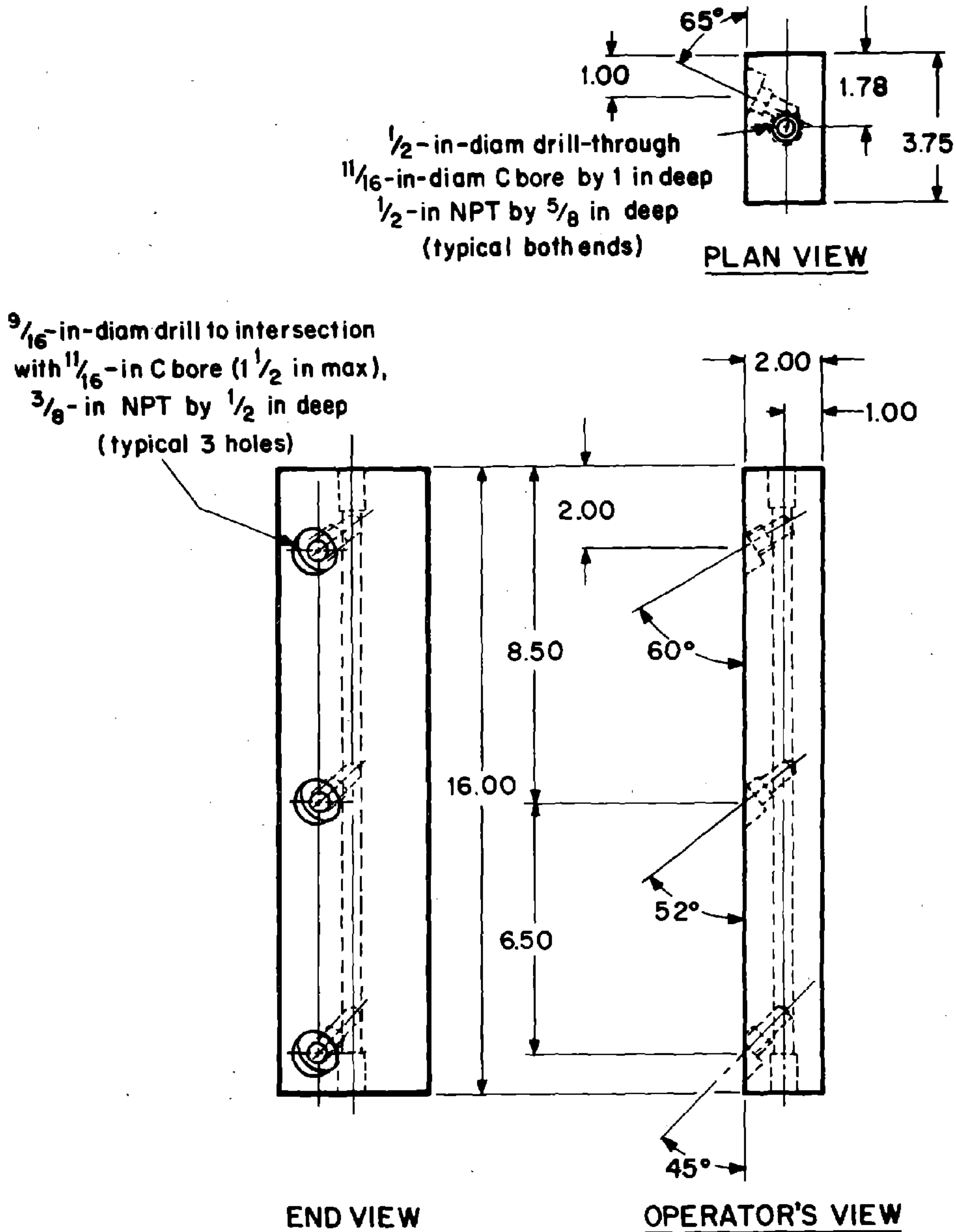


Figure 10.—Water spray manifold 7. All dimensions are in inches.

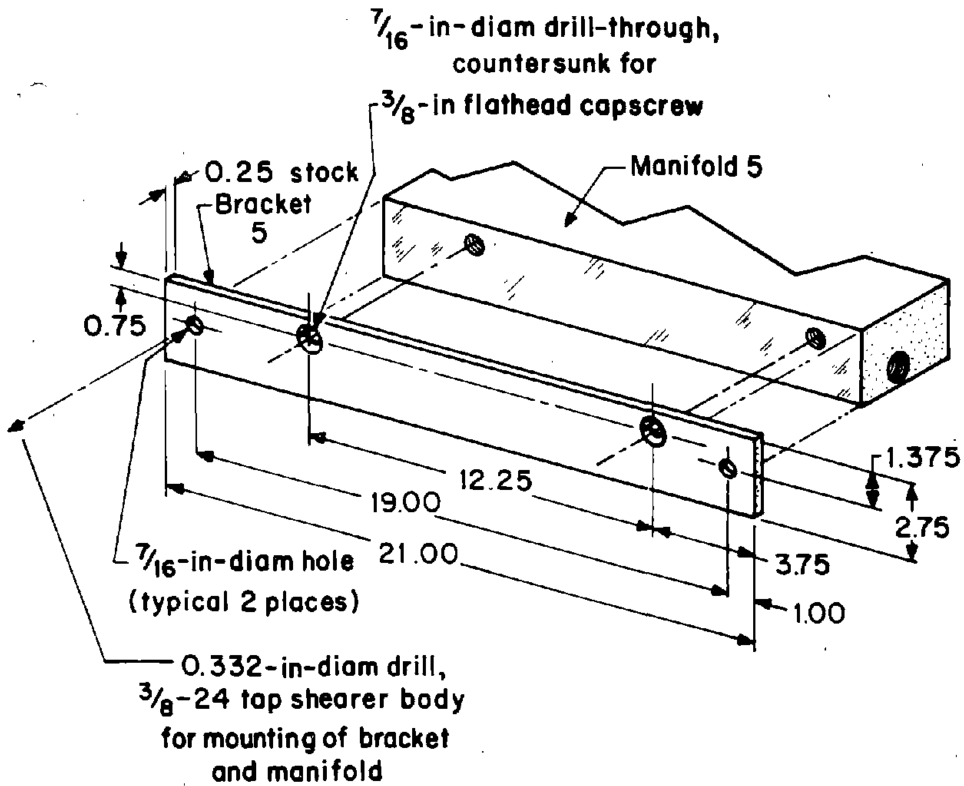


Figure 11.—Mounting bracket for water spray manifold 5. All dimensions are in inches.

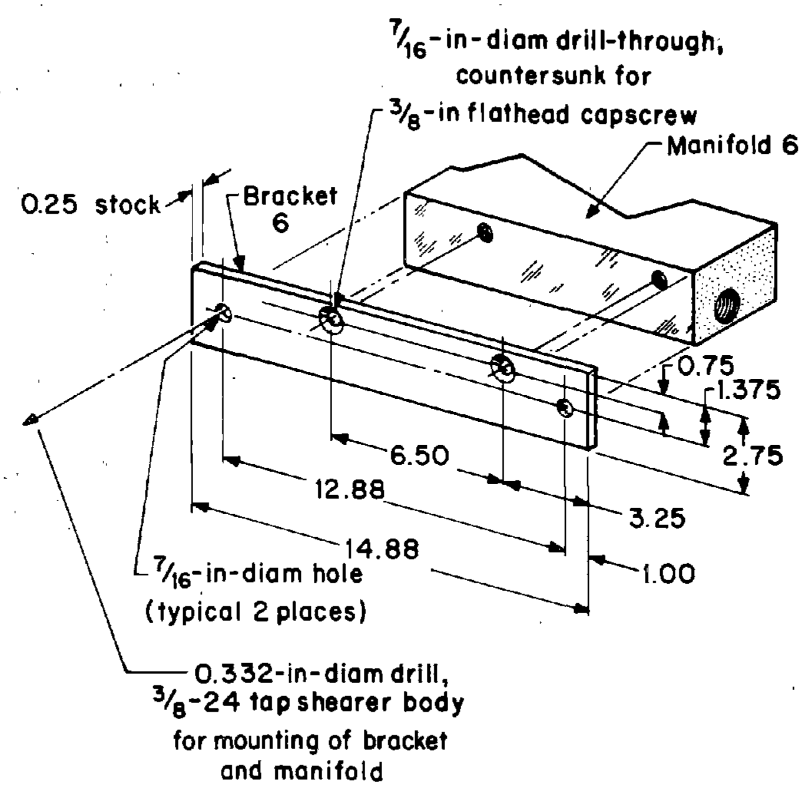


Figure 12.—Mounting bracket for water spray manifold 6. All dimensions are in inches.

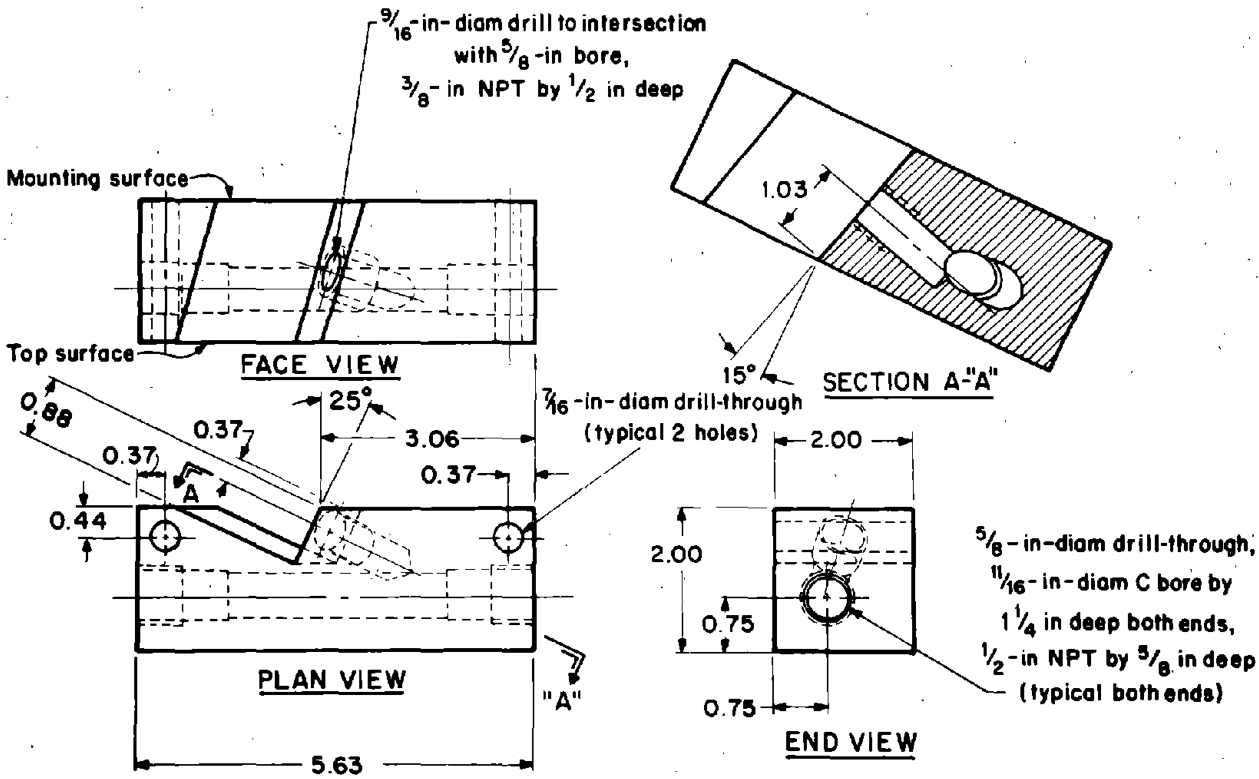


Figure 13.—Water spray manifolds 8 and 9. All dimensions are in inches.

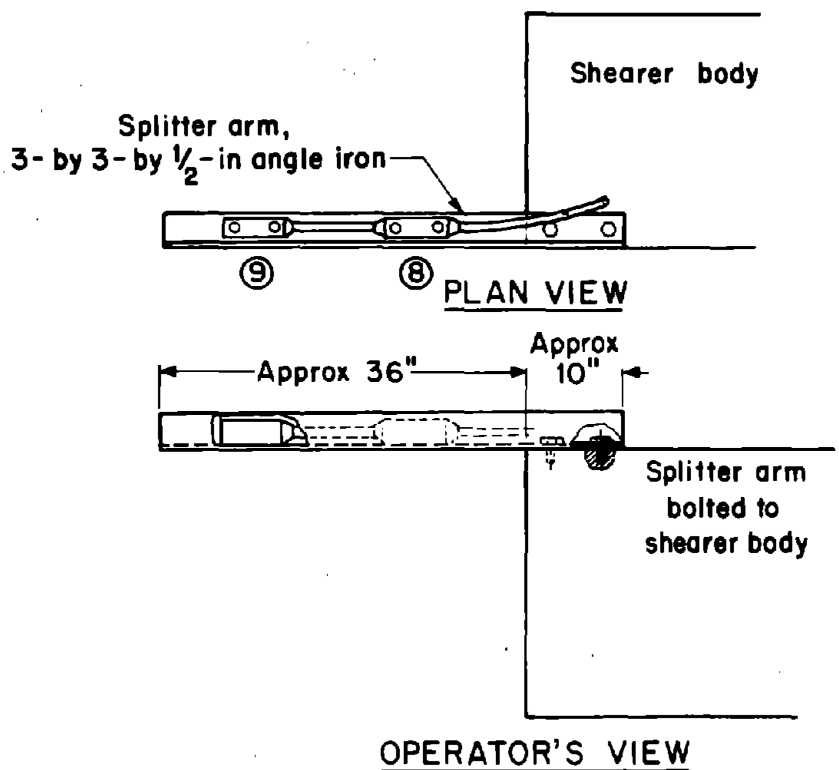


Figure 14.—Design for tailside splitter arm.

## CONCLUSIONS

The modified shearer clearer system is designed to provide both dust and methane control for longwall shearers. The system is composed of strategically located water sprays that act as small fans to hold the dust cloud generated during cutting against the face and away from the shearer operators. Two additional spray manifolds (4 and 7) have been added to the original system, providing more ventilation in and around the cutting drums, thus lowering methane concentrations and reducing the possibility of shearer-generated frictional ignitions. From a dust control standpoint, this system has proved itself over the past decade to be a mechanically dependable system that is effective for lowering shearer operators' respirable dust exposures. Regarding methane control, laboratory tests have shown increases in ventilation volumes and decreases in methane levels behind the cutting drums by as much as 40 pct. The modified shearer clearer system is a supplemental system that works with other dust and methane control systems on longwall sections in an effort to improve the health and safety of all longwall workers.

## ACKNOWLEDGMENT

The authors would like to thank Marion B. Molchen, design draftsman for SSI, for his efforts in preparing the art work for this report.

## REFERENCES

1. Jayaraman, N. I., R. A. Jankowski, and F. N. Kissell. Improved Shearer-Clearer System for Double-Drum Shearers on Longwall Faces. USBM RI 8963, 1985, 11 pp.

2. McClelland, J. J., C. Babbitt, and R. A. Jankowski. Optimizing Face Ventilation and Shearer Water Consumption To Reduce Longwall Dust Levels. Paper in Proceedings of the Third Mine Ventilation Symposium (Pennsylvania State University, Oct. 12-14, 1987). Min. Eng. AIME, 1987, pp. 553-557.

3. U.S. Bureau of Mines. Reversing Drum Rotation Reduces Longwall Dust and Increase Coal Production. Technol. News 284, 1987, 2 pp.

4. ___. Novel Foam Application Lowers Longwall Dust. Technol. News 326, 1989, 2 pp.

5. Cecala, A. B., J. A. Zimmer, and E. D. Thimons. Determination of Optimal Longwall Face Methane Monitoring Locations. Paper in Proceedings of Sixth U.S. Mine Ventilation Symposium. SME, 1993, pp. 301-306.

6. Courtney, W. G. Frictional Ignition With Coal Mining Bits. USBM IC 9251, 1990, 25 pp.

7. Wirch, S. D., and J. S. Kelly. A Longwall Drum Design Expert System. Paper in Proceedings of Longwall USA (Pittsburgh, PA, Sept. 13-15, 1988). Industrial Presentations, Inc., Aurora, CO, 1988, pp. 257-264.

8. McCall, F. E., A. A. Campoli, J. Cervik, F. Burns, and P. Thakur. Cross-Measure Borehole Technology For Gob Gas Control. Min. Eng., v. 36, No. 12, 1989, pp. 1672-1676.

9. Ely, K. W., and R. C. Bethard. Controlling Underground Coal Mine Methane Safety Hazards Through Vertical and Horizontal Degasification Operations. Paper in Proceedings of the Fourth U.S. Mine Ventilation Symposium. SME, 1989, pp. 500-506.

10. Divers, E. F., R. A. Jankowski, and J. Kelly. Ventilation Drum Controls Longwall Dust and Methane. Paper in Proceedings of the Third U.S. Mine Ventilation Symposium. SME, 1987, pp. 85-89.

11. Cecala, A. B., S. R. Rajan, R. A. Jankowski, and F. N. Kissell. Cut Longwall Ignitions by Lowering Methane Concentrations at Shearers. Coal Age, v. 91, Aug. 1986, pp. 66-67.

12. Foster-Miller, Inc. Optimizing Water Sprays For Dust Control on Longwall Shearer Faces - Design and Installation Manual (contract JO308019). USBM OFR 42B-86, 1983, 79 pp.; NTIS PB 86-205416.

13. U.S. Bureau of Mines. Improved Filtering System for Water Sprays Resists Clogging. Technol. News 20, 1981, 2 pp.

INT.BU.OF MINES,PGH.,PA 29978

☆ U.S. Government Printing Office: 1994—509-008 — 00040