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ILLUSTRATIONS

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

fpm	foot per minute	mg/m^3	milligram per cubic meter
ft	foot	pct	percent
gpm	gallon per minute	ppm	parts per million
in	inch	psi	pound per square inch
m	meter		

IMPROVED SHEARER-CLEARER SYSTEM FOR DOUBLE-DRUM SHEARERS ON LONGWALL FACES

By Natesa I. Jayaraman,[1] Robert A. Jankowski,[2] and Fred N. Kissell[3]

ABSTRACT

This report describes recent improvements the Bureau of Mines made in the design of its shearer-clearer water-spray system for dust control on longwall shearer faces. The improvements were based on findings from a field survey of six mines and laboratory test results. The report includes information on installation and use of the improved shearer-clearer system and describes a field installation and 3-week underground test of the system.

The improved shearer clearer, like its predecessor, reduces dust concentrations in the shearer operator's walkway by splitting the airflow on the upwind side of the shearer and confining the dust cloud to the face side of the shearer. The improved shearer-clearer system utilizes more practical-mounting locations for the water sprays and requires less water consumption. In the underground test, the improved system maintained the clean-air split in the walkway up to 40 ft downstream from the shearer. To further improve dust suppression, cooling-water manifolds were relocated into the loading zone. The laboratory and underground tests showed that the improved shearer-clearer system and the techniques described can significantly reduce the respirable dust exposure of shearer operators from shearer-generated dust.

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INTRODUCTION

The shearer clearer is an external water-spray system that modifies the airflow pattern over the shearer body and holds the dust cloud against the face, out of the operator's walkway. It has been found to be a very effective and practical dust-control technique for longwall shearers.

The original shearer-clearer system was developed by the Bureau of Mines and Foster-Miller, Inc., under Bureau contract J0308019. Underground evaluations by the Bureau, tests by the Mine Safety and Health Administration (MSHA), and independent installations by coal producers have confirmed the system's effectiveness. The Bureau's Technical Progress Report (TPR) 111[4] fully describes the original shearer-clearer system and its applications.

The laboratory development of the shearer-clearer system described in TPR 111 resulted in two basic systems, one system for cutting against the ventilation airflow and another for cutting with the ventilation. For faces cutting bidirectionally, each system required valving to allow independent operation for each cut direction.

The two basic systems were installed and evaluated on four operating longwalls. Feedback from the field, coupled with the Bureau's own field testing experience, indicated that the shearer-clearer system was being modified to suit particular mine conditions. For example, sprays on top of the shearer were being removed either because of maintenance problems or because of excessive water mist.

As a result of this feedback, the shearer-clearer program was expanded in scope. The additional work, performed by Foster-Miller under Bureau contracts J0318097 and J0308019, included (1) a field survey of mines using water-spray systems similar to the shearer-clearer systems designed by the Bureau and (2) laboratory study of improved spray systems. The results of this effort led to the development of an improved, more practical shearer-clearer system. The developmental research and the improved shearer-clearer system are described in this report.

ACKNOWLEDGMENTS

The authors thank the following employees of Foster-Miller, Inc., for their contributions: Terry L. Muldoon, division manager, and Steven K. Ruggieri, senior engineer, for cooperation in designing and fabricating the improved shearer-clearer system; William E. Schroeder, senior engineer, and Setlur R. Rajan, project engineer, for designing and conducting the full-scale model studies; and Charles Babbit, senior engineer, for planning and conducting the field surveys.

FIELD SURVEY

The purpose of the field survey was to gather and document information concerning the operating history, acceptance, and current use of water-spray systems for shearer-clearers in use on several longwall faces across the United States. Each of the systems surveyed was similar to the Bureau's shearer-clearer system with respect to the locations and design of the water sprays. One mine also used passive barriers in combination with its shearer-clearer system. Of six mines visited, only one was not using a shearer-clearer system at the time of the survey. All of the other five faces had made use of external water sprays, spray bars, or splitter arms to modify airflow patterns over the shearer body. The systems in use at four of the mines surveyed are described briefly below.

[4]Kissell, F. N., N. I. Jayaraman, C. D. Taylor, and R. A. Jankowski. Reducing Dust at Longwall Shearers by Confining the Dust Cloud to the Face. BuMines TPR 111, 1981, 21 pp.

MINE 1

At this mine, the face was cut from head to tail, with the downwind drum doing all the cutting. The bottom bench was then cut on the tail-to-head pass using the trailing drum. The upwind drum was used only to make the sump at the headgate. This cutting sequence, coupled with good primary face ventilation, exposed the shearer operators to very little shearer-generated dust.

The external sprays consisted of two cylindrical venturis mounted on a short tailgate splitter and one cylindrical venturi mounted on top of the shearer towards the tailgate end of the machine. The sprays were all pointed downwind.

MINE 2

This mine also used a head-to-tail unidirectional cutting sequence at the face, with the headgate drum not cutting any coal. The tailgate drum cut the bottom bench on the tail-to-head cleanup pass.

The mine used a spray system very similar to the shearer clearer in combination with passive barriers mounted on top of the shearer, as shown in figure 1. The passive barrier was 12-in-high, 1-in-thick belting supported by angle iron, running the full length of the shearer body. Flat fan nozzles with adjustable tips were used in the spray system. Cooling water was dumped through two

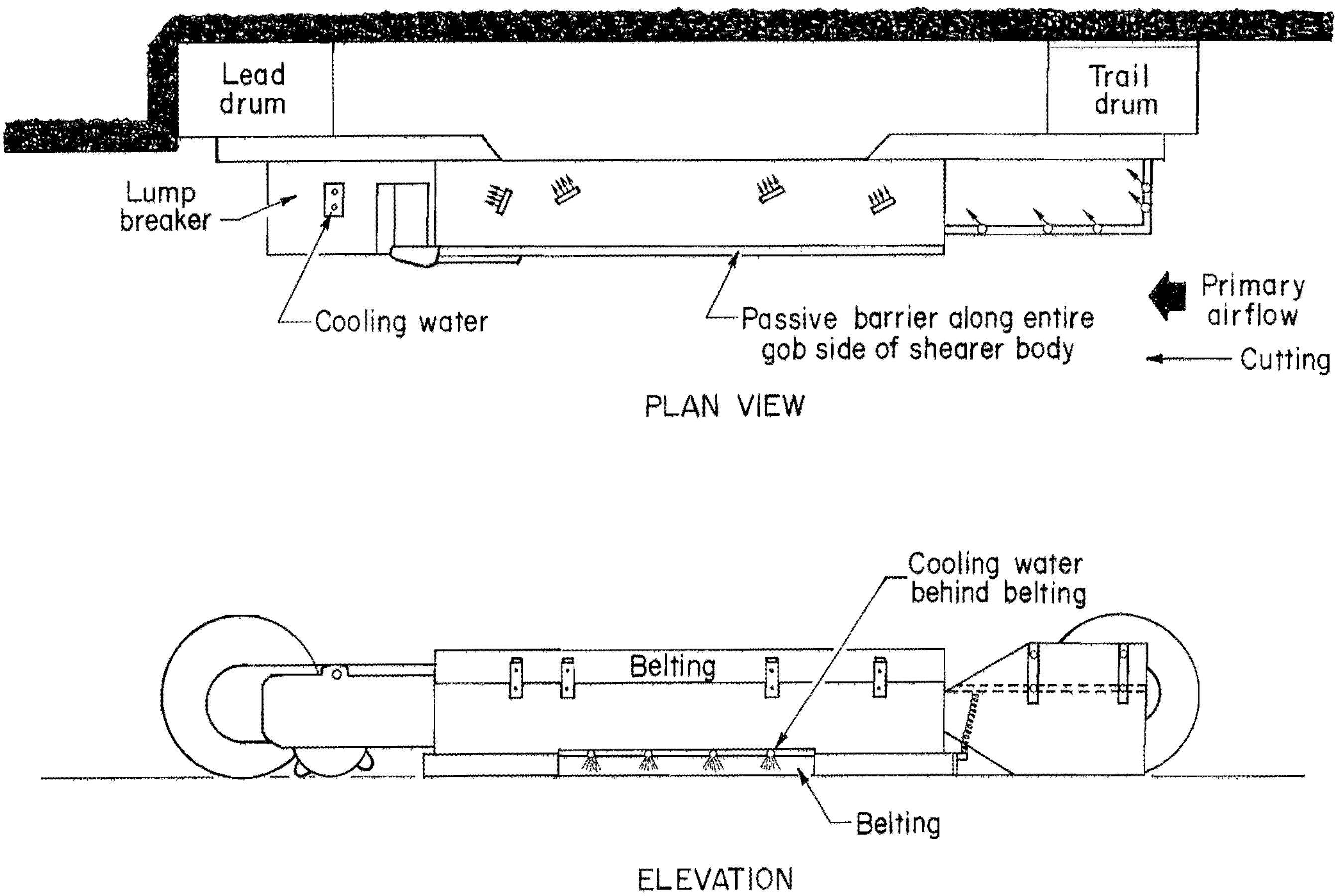


FIGURE 1. - Passive barriers (belting) and water sprays in use on shearers at mine 2.

sprays at the lump breaker on the tailgate end of the shearer and four sprays in the shearer underframe.

MINE 3

A combination water-spray and passive-barrier system was used on the bidirectional shearer at mine 3 (fig. 2). The passive barrier consisted of three conveyor-belt panels mounted on top of the shearer at an angle of approximately 30° in relation to the airflow. The barriers varied from 24 to 30 in high, with the shortest barrier on the upwind end. A hole was cut into this barrier so the operator could see the cutting drum. The spray system consisted of flat fan sprays, 1 cylindrical venturi, and 13 crescent ring sprays on the upwind ranging arm, as shown in figure 2.

MINE 4

The shearer at mine 4 cut from tail to head with cleanup going from head to tail. The face used a spray system with splitter arms on both ends of the shearer as shown in figure 3. Mine personnel had chosen not to install shearer-clearer sprays on top of the shearer body. Cooling water was dumped on the face side of the shearer, and a crescent spray ring was mounted on the upwind ranging arm. The shearer was also equipped with a 12-in-high conveyor-belt barrier running the full length of the shearer body.

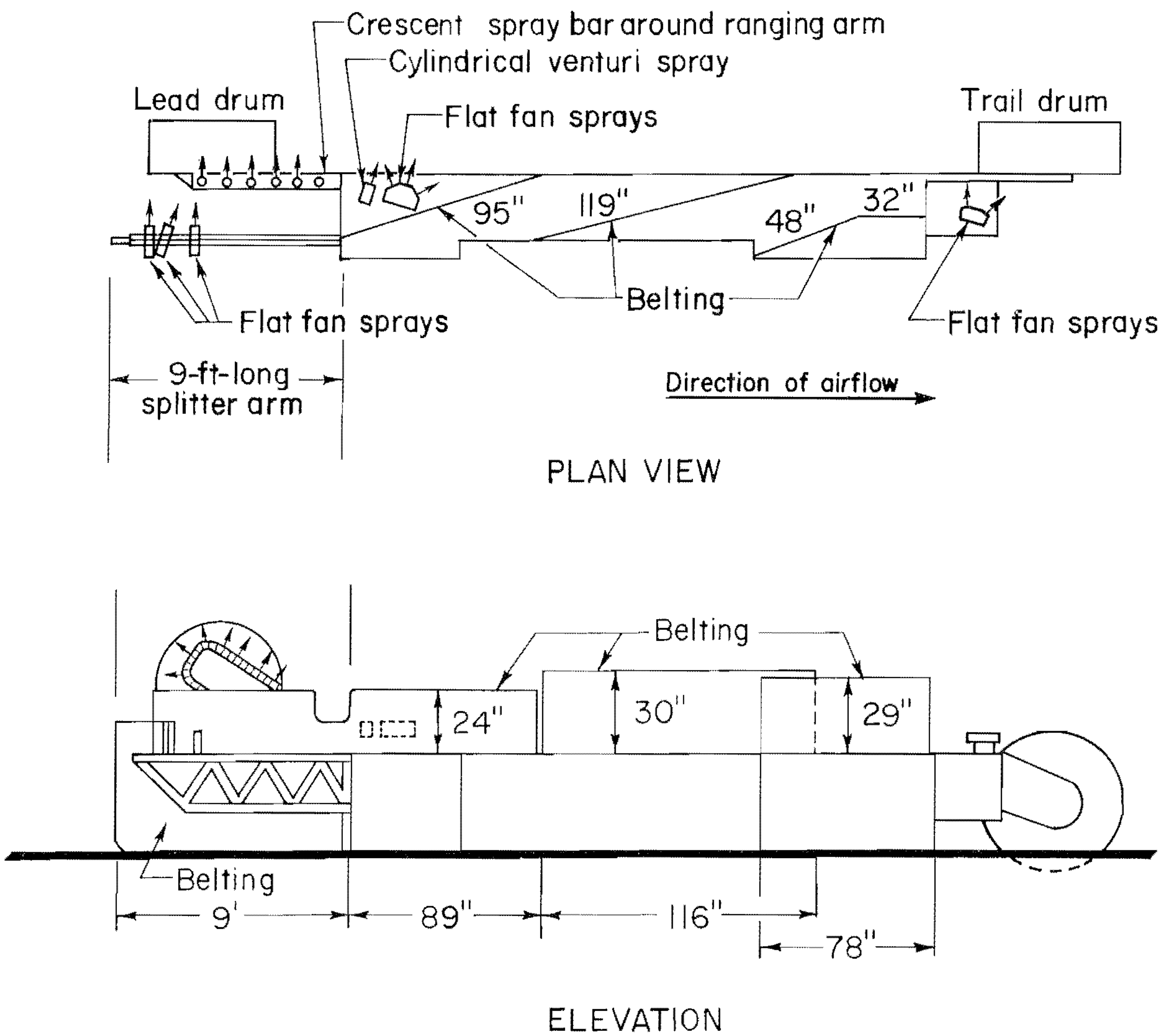


FIGURE 2. - Passive barriers and water sprays in use on shearers at mine 3.

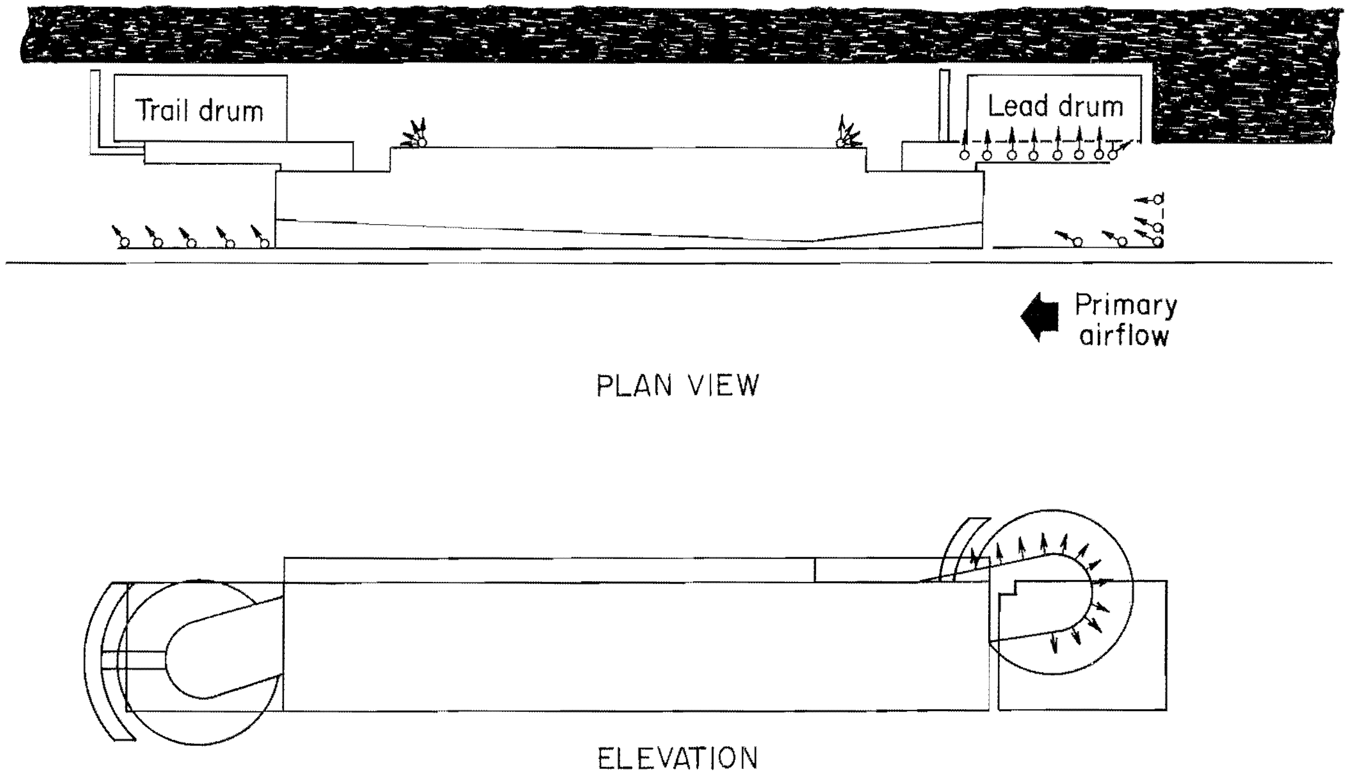


FIGURE 3. - Passive barriers and water sprays in use on shearers at mine 4.

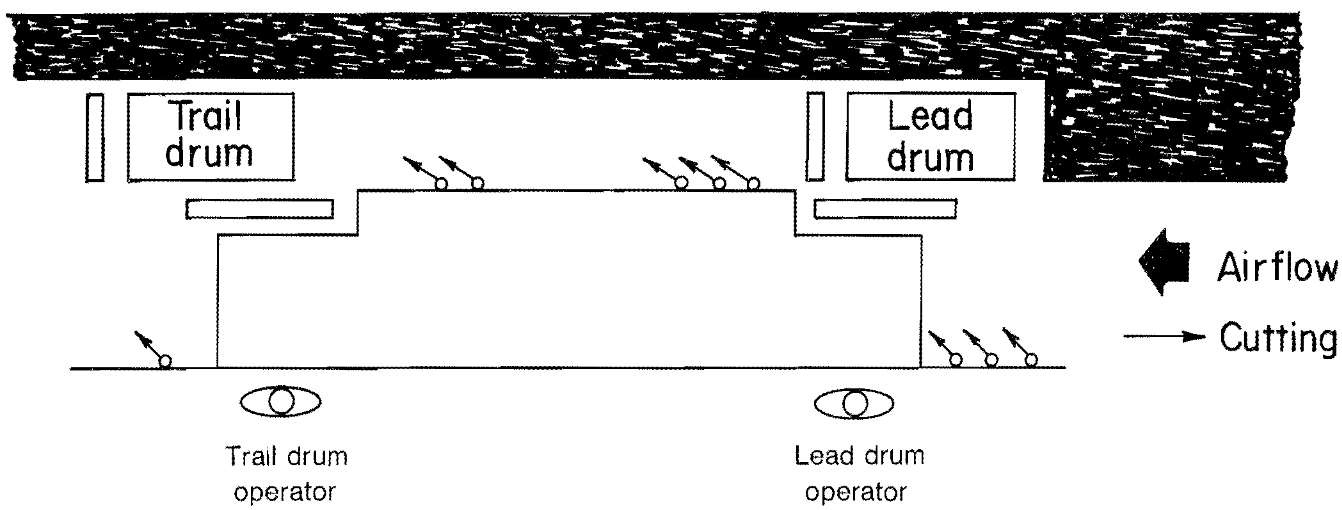


FIGURE 4. - Improved shearer-clearer spray configuration.

LABORATORY DEVELOPMENT OF IMPROVED SHEARER-CLEARER SYSTEM

The purpose of the laboratory testing was to determine if the Bureau's original shearer clearer design could be made more practical by eliminating sprays mounted on top of the shearer. Several face-side spray combinations were tested and compared with the full shearer-clearer system. Three of the combinations resulted in dust concentration levels at the operator position that were close to those obtained with the full shearer-clearer system. One combination with three sprays on the upwind face side of the shearer and two sprays on the downwind face side maintained the lowest concentration downstream of the shearer. This system was selected for further evaluation.

The improved system (with no sprays on top of the shearer body) was tested using various spray combinations on the downwind tailgate end of the shearer. This testing was aimed at further reduction in the walkway contamination levels downstream of the shearer, to improve conditions for support personnel. Of the spray locations and orientations tested, one spray mounted on the downwind splitter, aimed in the direction of the primary airflow, proved to be the most effective.

The final spray configuration for the improved shearer-clearer system is shown in figure 4. The improved system eliminates all sprays mounted on the top of the shearer body and uses fewer sprays than the original system.

A comparison of the two systems (fig. 5) shows that these practical improvements did not deteriorate system performance, and, in fact, improved downstream contamination levels. Operating the system at water pressures higher than 140 psi improved performance along the shearer but caused increases in contaminant levels downstream. Lowering system pressure reduced system effectiveness somewhat along the shearer with no impact downstream. For mines cutting against ventilation with support advance following the shearer, system pressures should be kept below 200 psi to minimize the spread of downstream contamination into the walkway. The system was also tested at face airflows ranging from 200 to 500 fpm. As expected, the higher the airflow, the lower the contaminant level in the walkway.

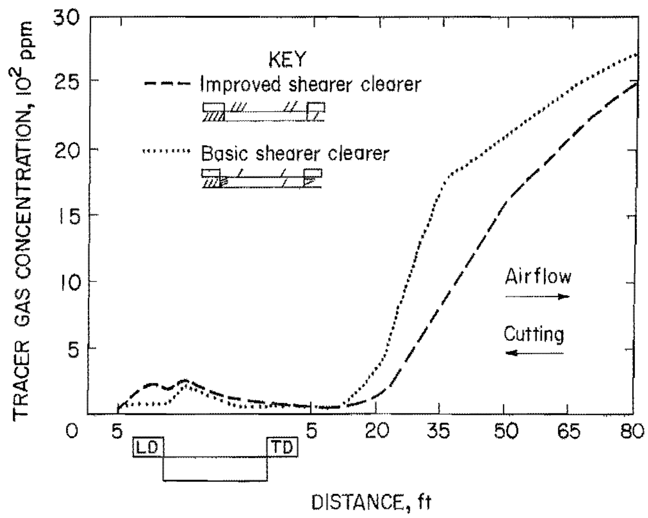


FIGURE 5. - Comparison of basic and improved shearer-clearer performance.

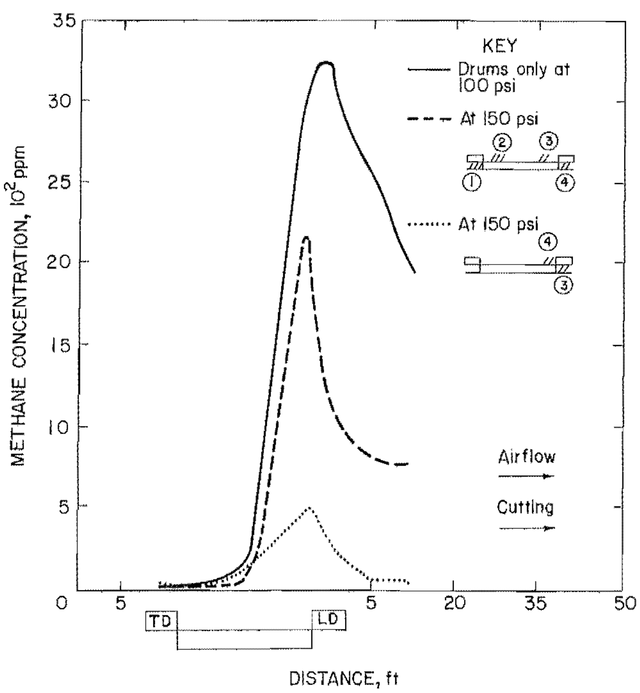


FIGURE 6. - Performance of improved shearer-clearer cutting with ventilation. (Circled numbers identify spray manifolds.)

IMPROVED SHEARER-CLEARER CUTTING WITH VENTILATION

The improved shearer clearer, which was developed for cutting against the airflow, was also tested with the shearer cutting in the same direction as airflow. The system provided excellent control at the trailing drum operator's position, as shown in figure 6, but created excessive water mist in the walkway at the leading drum operator's position. Tests were then run with spray banks 1 and 2 (fig. 6, key) completely shut off, which improved the conditions at the lead drum operator's position. The improved system for cutting with ventilation is shown in figure 7. Increasing the system water pressure improved system performance. Boosting the pressure from 150 psi to 250 psi, for example, reduced levels at the leading drum operator's position by approximately 50 pct.

IMPROVED SHEARER-CLEARER FINAL CONFIGURATION

The final configuration of the improved shearer-clearer system is illustrated in figure 8, which includes a table that shows the discharge angles for optimum air-moving performance on most shearers. The improved system uses only 10 nozzles mounted in 7 manifolds, with none mounted on top of the shearer body. For faces cutting against ventilation, all ten sprays are operated at 150 psi. For faces cutting with ventilation, only spray manifolds 5, 6, and 7 are operated. On bidirectional faces, the full system would be installed and valved to turn on all seven manifolds when the machine is cutting against the ventilation and to cut off manifolds 1 through 4 when cutting with ventilation.

FIELD INSTALLATION

The improved shearer-clearer system was installed and evaluated on one face in the Western United States. For the field installation, the face-side sprays, banks 4 and 5 (fig. 8), were machined-steel manifolds. The manifolds were mounted flush with the face side of the shearer body under the cover plates. The upwind barrier (splitter) was spring mounted (fig. 9) to prevent damage from falling coal. Machined-steel blocks were used to mount sprays on the splitter. The

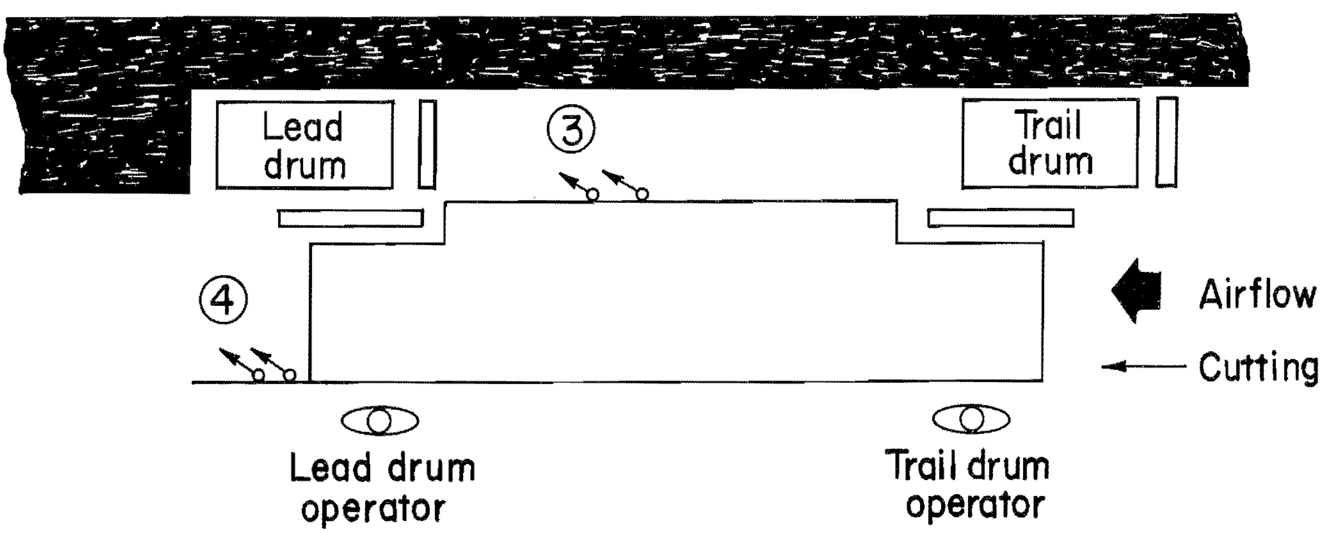
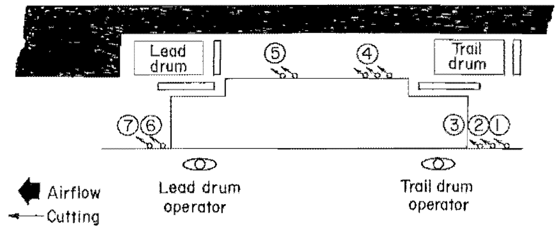


FIGURE 7. - Improved shearer-clearer system installed on shearer cutting with ventilation. (Circled numbers identify spray manifolds.)

system was valved to operate all four spray banks when the shearer was cutting against ventilation and to operate only banks 3 and 4 when cutting with ventilation (fig. 7).

A 3-week underground test of the new system was conducted by a team of test engineers. The existing dust suppression system at the mine site consisted of drum sprays only. When the improved shearer clearer was in operation, the drum sprays were also in operation, but at a reduced water flow. Both systems used a total water flow of 70 gpm. A dust profile around the shearer for a typical tail-to-head cut is shown in figure 10. The data indicate that when the mine's existing system (drum sprays only) was in operation, dust levels in the walkway and downstream of the shearer were relatively high, even though the drum sprays were operated at the higher water flow. When the shearer clearer was in operation, the dust was held to the face up to 40 ft downstream of the shearer. It is important to note that when the improved system was in operation, water flow to the drums was reduced. This field evaluation proved that shearer operators' exposures can be significantly reduced if some of the drum spray water is used to operate a shearer-clearer system.



Specifications

Manifold	No. of nozzles	Location of nozzle(s) on shearer	Spray discharge angle	
			X	Y
①	1	8 in. in from outby end of splitter arm	20° toward face	15° up
②	1	Midway between manifolds ① and ③	30° toward face	15° up
③	1	12 in. out from headgate end of shearer	40° toward face	30° up
④	3	Outby end of manifold located approximately 12 in. from end of headgate ranging arm	30° toward face	20° up
⑤	2	Inby end of manifold located approximately 40 in. from end of tailgate ranging arm	30° toward face	20° up
⑥	1	8 in. out from tailgate end of shearer	25° toward face	15° down
⑦	1	6 in. from inby end of tailgate splitter arm	25° toward face	15° down

X Angle measured from a line parallel to the face.
Y Angle measured from a line parallel to the floor.

FIGURE 8. - Improved shearer-clearer system specifications. (Circled numbers identify spray manifolds.)

ALTERNATIVE USES FOR COOLING WATER

During the earlier field trials of the shearer clearer, the negative effects of face-side cooling-water discharge sprays were minimized by simply deflecting the sprays downward. This water, however, is essentially wasted from a dust-control standpoint, although it could be used if it could be discharged on the cut coal. Two alternatives have been evaluated.

The first alternative, panline sprays, directs the water downward onto the panline at the ends of each gearhead. The system uses flat fan sprays mounted in a pipe manifold. The sprays provide significant coal wetting without creating adverse air turbulence.

The second alternative, crescent spray rings, directs the cooling water into the drum cutting and loading zones. This system (fig. 11) uses flat fan sprays mounted on a pipe manifold welded to the ranging arm. The sprays are aimed at the circumference of the drum with the sprays on top of the ranging arm pointed slightly downwind. This system should only be operated on the leading drum where it will provide increased wetting without creating adverse turbulence. Either of these alternatives may be used with a shearer clearer to minimize air turbulence and improve dust suppression.

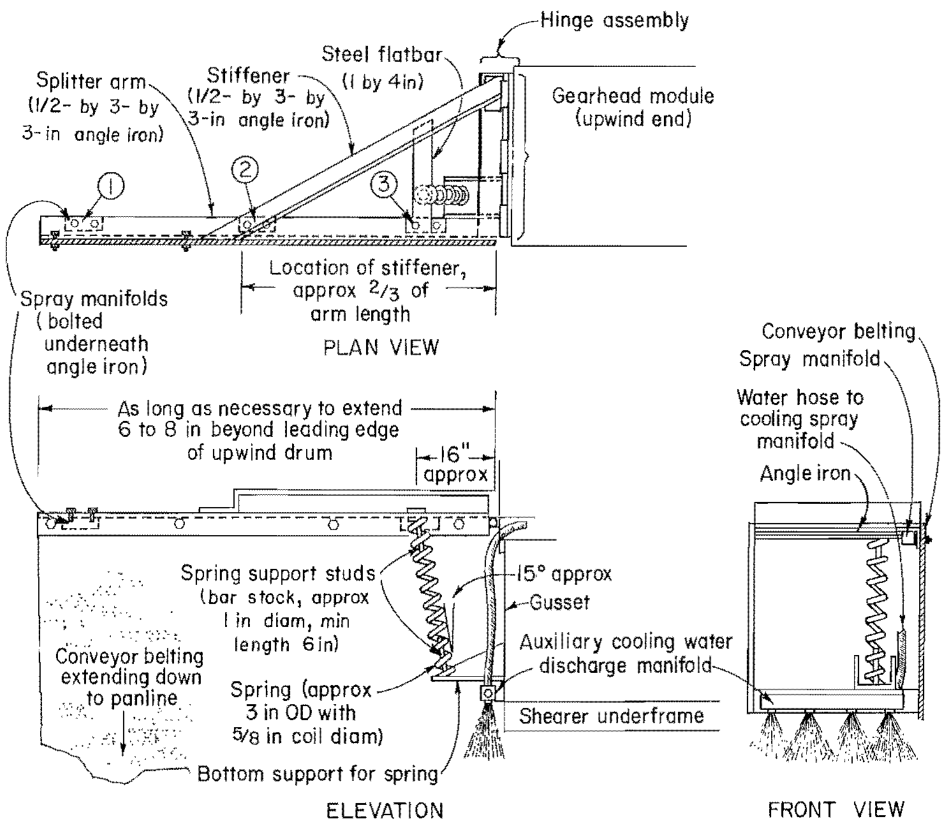


FIGURE 9. - Spring-mounted passive barrier. (Circled numbers identify spray manifolds.)

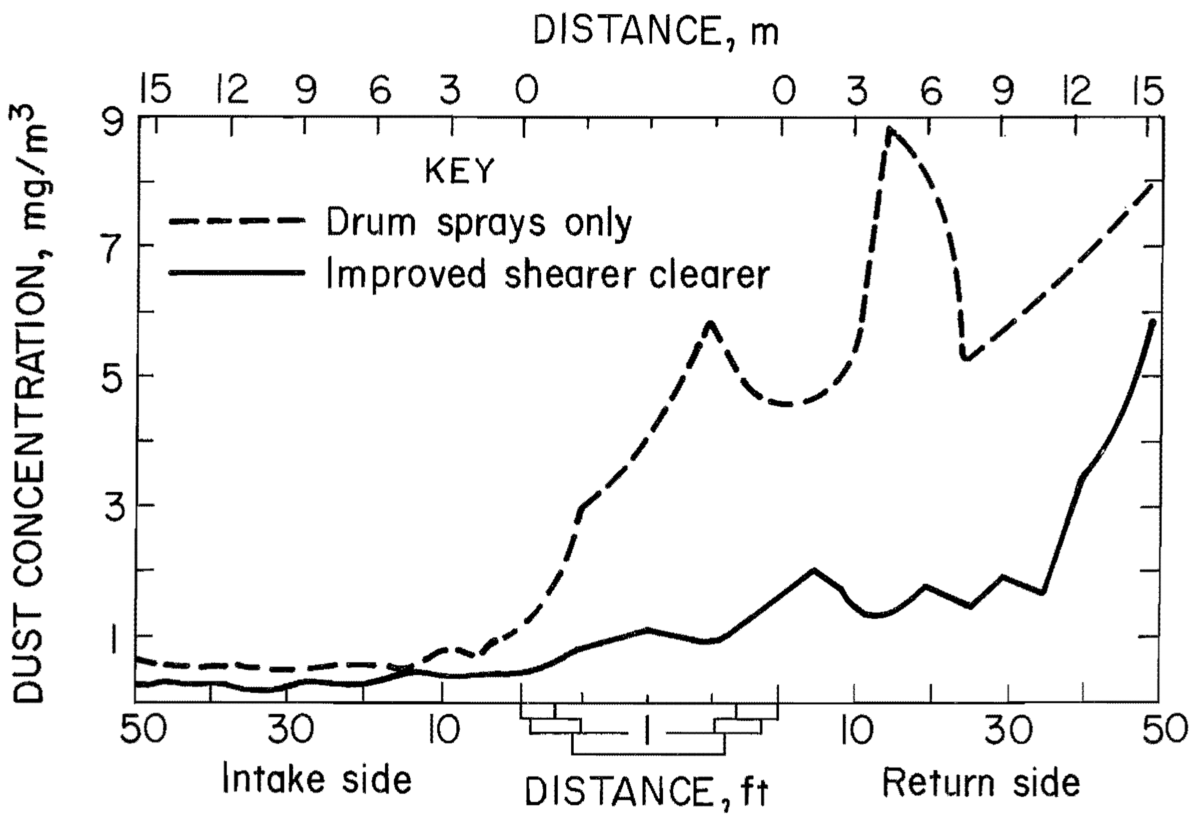


FIGURE 10. - Respirable dust concentration profile around shearer during tail-to-head pass.

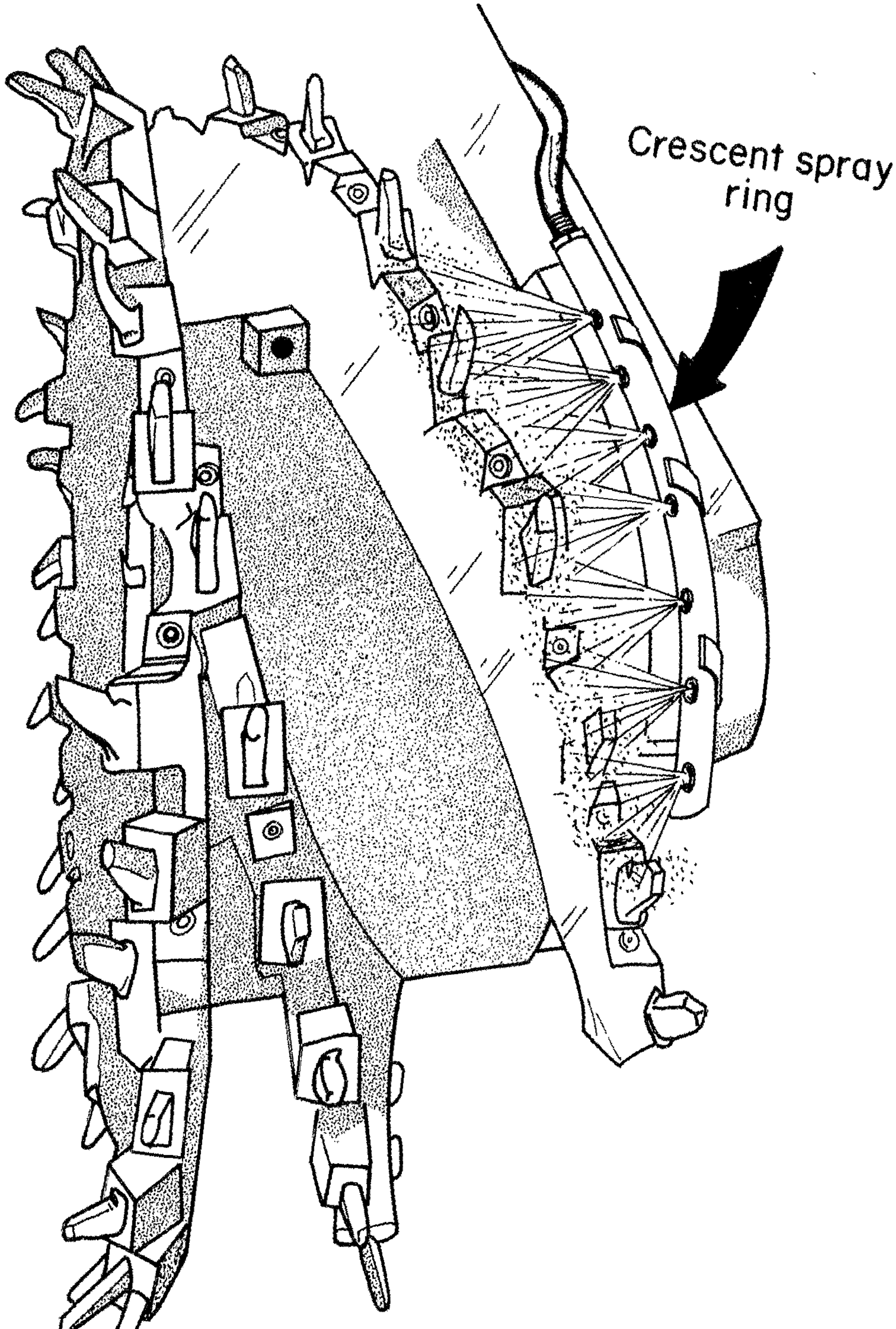


FIGURE 11. - Crescent spray rings, one alternative for using cooling water.

SUMMARY

Spray systems similar to the shearer-clearer system were observed during field visits and were installed and evaluated in the laboratory. The purpose of the evaluation was to determine if the shearer clearer could be made more practical by eliminating sprays mounted on top of the shearer. An improved system was developed that uses fewer sprays than the original system did, with none mounted on top of the shearer body. On bidirectional faces, the full system would be turned on when the machine is cutting against the airflow direction, and a partial system would be used when cutting with the airflow direction. The system development also involved relocating cooling-water manifolds into the loading zone for improved dust suppression. The improved shearer clearer was installed and evaluated on one longwall face.

Results of tests using full-scale models and underground tests indicate that the improved shearer-clearer system lowers dust contamination levels both at the operator and downstream locations while eliminating sprays on top of the shearer body. MSHA now requires mine operators to include shearer-clearer systems in their longwall dust-control plans; this is indicative of the widespread acceptance of the shearer-clearer system for controlling dust on longwall faces.

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