# EXTENSIBLE FACE VENTILATION SYSTEMS - DUCT AND BRATTICE

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

by

FOSTER-MILLER ASSOCIATES, INC.
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Final Report

on

Contract No. H0155016
Extensible Line Curtain or Duct System
for Face Ventilation



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16. Abstract


This report describes the results of a 2-year investigation of extensible face ventilation techniques and systems for use at the working face in underground coal mines. The goal was to provide a safe and convenient method of maintaining the extensible system within 10 feet of the face, thereby ensuring good ventilation. A summary of approximately 20 extensible ventilation systems proposed or tried in the past is included for reference, together with a detailed description of the design, construction, and underground testing of a new extensible brattice panel and a new fiberglass duct system.

The extensible brattice system utilized a special panel which could be pushed forward as the miner advanced. Brief testing in three mines revealed some conflict with the mining cycle and led to recommendations for two improved designs.

The extensible duct system was designed for a Goodman borer and utilized a telescoping tube on the left side of the roof, so that it could be extended without interfering with the miner operator. For mine sections with right-hand return ventilation, a special flat tube section is used to cross over the entry. Underground testing showed substantial improvement in face ventilation without interfering with production.


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# FOREWORD

This report was prepared by Foster-Miller Associates, Inc. of Waltham, Massachusetts under USBM Contract No. H0155016. The contract was initiated under the Coal Mine Health and Safety Program. It was administered under the technical direction of PM&SRC with Mr. Edward F. Divers acting as the Technical Project Officer. Mr. A. G. Young was the contracting officer and Mr. Frank M. Naughton the contract administrator for the Bureau of Mines.

This report is a summary of the work recently completed as part of this contract during the period September 1974 through July 1976. This report was submitted by the authors on September 30, 1976.

The technical effort was performed by the Engineering Systems Group at Foster-Miller under the supervision of Mr. Adi R. Guzdar. The Program Manager was Mr. David A. Monaghan with Mr. D. Randolph Berry acting as Senior Staff Engineer.

The cooperation of Eastern Associated Coal Corp. (EACC) throughout the program is gratefully acknowledged. Mr. H. E. Harris and Mr. William Deseighart of EACC's Research and Development Center in Everett, Massachusetts, provided valuable assistance in gathering background information early in the program. Mssrs. Larry Jackson, Robert Stuzen and Lloyd Hunter of EACC's Federal No. 1 Mine in Grant Town, West Virginia were particularly patient and supportive during the several periods of underground testing throughout Phase II of the program.

## SUMMARY

The extensible face ventilation program consisted of three major parts:

(1) Historical review of face ventilation systems and generation of new concepts.

(2) Design, fabrication and underground evaluation of extensible brattice concepts.

(3) Design, fabrication and underground evaluation of extensible duct concepts.

The historical review includes a discussion of prior state-of-the-art in some detail, including specific examples of previous attempts to develop new methods for face ventilation. This information was gathered from three major sources:

(1) Literature review, mine visits
(2) Patent search,
(3) Discussions with knowledgeable individuals in government and industry.

After the state-of-the-art review, various new concepts were evaluated. These concepts fall into three major categories:

(1) brattice line systems
(2) duct systems
(3) hybrids, or systems compatible with either duct or brattice.

For several alternatives, one brattice concept and two duct concepts were chosen for further development and underground implementation.

The chosen concept for brattice was a sliding panel system. The basic system consisted of a brattice panel, 14 feet long and as high as the coal seam. The panel consisted of a hanging brattice curtain on a 14-foot length of pipe. This pipe was supported by special jack-stands with adjustable rollers. At the start of the mining cycle, when the standard brattice curtain is mounted as close as possible to the face, the jack stands are positioned next to the brattice and the special panel installed on the rollers. The brattice man could stand at the outby end of the panel while pushing it forward on the rollers, keeping the inby end within 10 feet of the advancing face without exposing the man to unsupported roof. Underground testing of the system showed that this advantage was outweighed by physical conflicts with the mining cycle. Several significant improvements have been identified, and a new panel design is proposed. It is recommended that the new panel design be built and held in reserve. An underground test program should be instituted only after a mine is identified which has an expressed need for improvement of their current brattice ventilation.

Both of the selected duct systems were specifically designed for sections employing Goodman boring machines. Because of the size of these machines, the current face ventilation systems severely restrict the visibility and mobility of the operator when the tubing is employed on the roof at the right-hand rib.

The second duct system eliminated any interference with the operator by mounting the tubing at roof level on the left side of the entry, even when the return was on the right. This was possible by utilizing a special cross-over system, which allowed the tubing to bridge the entry through a duct only 5 inches thick. Underground evaluation of the system provided the following conclusions:

(1) Face ventilation was definitely improved.

(2) Obstruction to the miner operator's vision and mobility was eliminated.

(3) The system is compatible with the mining environment.

(4) More effort is required to install the new system.

(5) Acceptance by management was good; the opinions of the work force were mixed.

(6) The system is applicable on any mine section where limited space makes left-hand mounting desirable.

(7) The system continued in underground use for approximately one month after the test program ended.

Underground experience with several new ventilation systems proved that, in order to be accepted, a new system had to do more than improve the existing ventilation. In general, any new system must satisfy at least one of three basic "guidelines":

- Satisfy a particular need;
- Be required by law;
- Be easier to use.

This program considered only ventilation systems which could be adapted to, or added on to, present underground equipment. The final recommendation is that future development be directed toward a completely integrated face ventilation system which is designed into underground equipment rather than added on.

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## 1. Introduction

This report describes the results of an investigation of extensible face ventilation system for use in underground coal mines. The program was completed by Foster-Miller Associates of Waltham, Massachusetts under USBM Contract No. H0155016. The objective of the program was the development of a system that would permit ventilation to be maintained within ten feet of the working face without exposing the user to hazardous roof conditions or adversely affecting production. Such a system was developed and demonstrated for sections employing Goodman boring machines and auxiliary fans.

The system utilizes oval rigid fiberglass tubing mounted at roof level along the left-hand rib. For those frequent situations where the main ventilation returns to the right, specially constructed flat sections permit the ventilation to cross over the active entry or buggy road without restricting vehicular motion. Benefits observed during the mine demonstration include: improved face ventilation; improved operator's visibility; use of both left and right-hand shuttle cars; and more reliable hanger straps. Undesirable features are increased weight of the sections and the additional installation effort required.

The report also describes an extensible brattice system using a rigid pole mounted brattice panel which cantilevers on rollers from under supported roof out toward the face to maintain the ten-foot distance as the face is advanced. A first prototype of this system and its mine demonstration are described. Also presented is the design for an improved system of this type.

A summary of face ventilation systems proposed or tried in the past is also presented in this report. Where possible, specific systems are described in detail with reference to either the inventor or the place where they were demonstrated. The features of each system are discussed along with the reasons for their rejection by the user.

## 1.1 Background

Mine ventilation for control of dust and methane generated at the face has been and continues to be an important area of USBM investigation. These efforts have led to the widespread use of auxilliary fans with ventilation tubing. Rapidly improving continuous mining equipment with high advance rates and the stringent dust control requirements and safety regulations specified by MESA demand improved face ventilation techniques to assure maximum safety at the increased production rates.

With ripper type continuous miners, it is currently common practice to advance as much as 20 feet before backing out for roof bolting. This advance distance permits the operator to remain under supported roof. The need to maintain the ventilation system within ten feet of the furthest point of advance, as required by the Coal Mine Health and Safety Act of 1969, often makes extension of the ventilation system both difficult and dangerous, requiring the use of temporary roof supports.

With borer miners, unsupported roof presents fewer problems because of more stable roof geometries, but space limitations on and around the bulky machines make effective face ventilation extremely difficult with equipment that is currently available. The results can be inadequate face ventilation.

Line curtain or brattice cloth systems have historically been the principal coal mine face ventilation technique for conventional mechanical mining and, until recently, for continuous miner operations as well. These line curtains, when properly installed and maintained, can provide adequate ventilation to the operating face. However, difficulties associated with installation, the effect of equipment moving through such curtains and the limited side space in continuous miner operations have led to the replacement of many of these brattice systems with ventilation duct or tube. Notwithstanding these difficulties, brattice or line curtain installations remain the ventilation main-stay in many low coal areas where roof clearance is insufficient for an overhead duct.

Presently, the advancement of these line brattice systems beyond permanent supports without exposing workmen to roof fall hazards can be accomplished only with specially designed extendable devices, or more commonly, by the use of safety jacks and spring operated posts. Several mechanical concepts for "automatic" line curtain extension have been developed and tested. Most have failed due to the harsh working face environment. Several of these systems are discussed in detail in this report.

The current trend toward replacement of line brattice systems with vent tubing or ducting has only gained momentum in the past six or seven years. This trend was pioneered by USBM investigative and research group studies. These studies demonstrated that auxiliary ventilation systems employing duct or tube could effectively control both methane and environmental dust provided adequate horsepower was available and tubing or duct of sufficient size was used.* (1, 2) Earlier availability and acceptance of these systems was hindered by size and strength limitations of available tube and by a lack of auxiliary fans with suitable horsepower. Presently, however, auxiliary fans of proper horsepower are available and light duct and flexible spiral reinforced tubing of adequate size have been developed. As a result, these auxiliary ventilation systems are now in general use throughout the industry and are replacing the common line brattice systems in high coal. Since their introduction, these systems have demonstrated greatly improved flexibility and performance in those situations with limited side and overhead clearance. They can be used in combination, both exhaust and blowing, and also may be adapted to machine mounted diffusers and machine mounted dust suppression scrubbers.

The most recent development in auxiliary ventilation using tubes has been the advent of rigid fiberglass and poly vinyl chloride (PVC) tubing, which first came into common underground usage in 1971. The smooth walls of these materials provided a substantially smaller pressure drop than the spiral wound flexible tubing. Both of these new types of tubing have shown inherent disadvantages, however. The fiberglass tends

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* Numbers in parentheses refer toreferences listed in the Bibliography.

to chip and flake, exposing small glass fibers which penetrate the workers' clothing and skin. PVC has very low impact resistance and is therefore subject to breakage. The newest material on the market, polyester tubing with fiberglass reinforcement, may prove to be superior to either the old fiberglass or PVC tubing.

The greatest problem now evident in tube or duct face ventilation is the development of a practical means to advance auxiliary duct or tubing as the miner advances beyond the permanent roof supports. This problem will be magnified when remote control systems become more universal and penetration into solid coal is increased from the present 20 feet to 40 feet or more.

An examination of the state-of-the-art of the line brattice, tube and duct type ventilation systems in light of projected mining equipment improvements certainly supports the need for new "extensible" concepts to keep pace with these improvements.

The remaining portions of Section 1 outline the design and performance specifications established for the extensible face ventilation systems developed during the program. Also included is a summary of the tasks which led to the development of the recommended system.

Section 2 presents a detailed description of the recommended system and its demonstration test on an operating section. Section 3 describes the development program in detail while Section 4 and Section 5 describe an extensible brattice system and an alternate extensible duct system which were also developed during the program.

## 1.2 Program Objectives

The broad objectives of this program were the design, fabrication and in mine testing of an extensible curtain or duct system for ventilation of an underground coal mine working face. Specific tasks include:

a. review of existing systems including on-site observation

b. detailed design of promising concepts for implementing both extensible brattice and duct systems

c. review by USBM and MESA and selection of the optimum concepts.

d. fabrication of prototype hardware for installation on an operating section

e. laboratory testing at a ventilation facility.

f. installation and operation on a working section.

The design and performance specifications are as follows:

a. extensible range of at least ten (10) feet

b. system must be one man operable

c. time for operation and assembly must be compatible with the normal mining cycle

d. system must deliver at least 3,000 CFM air to the face

e. must meet MESA safety standards

f. must be operable in seam height variations of $\pm$ 20 percent

g. prototype must not interfere with coal production during the test program.

In addition to the above performance specifications defined in the contract, the following factors were considered during the development effort.

a. Adaptability to the normal mining cycle and compatibility with other equipment being used.

b. Consideration of new designs in mining machinery. (e.g., remote control units which mine more than 20 feet between cycles).

c. Minimization of cost, special equipment, complexity and operator skill requirements.

The Phase I effort included the review of existing systems and the detailed design of promising extensible tubing and brattice systems.

Phase II included the fabrication and mine testing of one prototype extensible system for brattice line and one for ventilation tubing. After the initial mine tests the ventilation tubing concept was altered, new equipment fabricated, and additional mine tests performed.

## 2. Extensible, Left-Side, Oval Duct System

During the preliminary mine investigation program and during the underground testing with the extensible systems described later in this report the following characteristics of face ventilation systems employing auxiliary fans and duct were noted.

a. Ventilation was generally more effective when the return was along the left rib. More effective here implies that conditions at the operator's station were improved.

b. The operator's visibility and mobility is usually restricted by vent tube mounted on the right hand side whether it is mounted on the rib or the roof. The restriction becomes more severe as the duct is kept closer to the face.

c. A manually extended slip tube arrangement is generally mounted on the right hand side in easy reach of the operator. Use of the slip tube is frequently avoided because of operator restriction.

d. No duct components are available which permit installation of vent tubing on the left side in places where the primary mine ventilation returns on the right. Commercial components restrict overhead clearances excessively if they attempt to cross roadways, etc.

These characteristics indicate that it is desirable to have the tubing on the opposite side of the miner operator. However, this is not always possible because:

(1) Continuous miner controls are located on the right hand side of the machine.

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(1) Continuous miner controls are located on the right hand side of the machine.

(2) Tubing is usually located on the side which is closest to the return air entry to avoid crossing the roadway with the duct. Normal practice is shown in Figure 1.

Foster-Miller Associates has developed the components necessary to provide extensible duct ventilation exhausting on the left hand side of the machine regardless of the location of the primary return. The system utilizes the lightweight oval fiberglass tubing recently developed by Peabody ABC for most of the straight runs. An assortment of "sweep" elbows, pancake sections, adapters and transitions were required to facilitate the use of the oval flat duct against the roof on the left hand side of the entry.

The details of the system description and its proposed application are presented in the following section. Subsequent sections describe the demonstration of this system at the Federal No. 1 mine on a Goodman 430 machine. Recommendations for minor modifications to the system and other potential applications for the system are summarized in Section 2.3.

## 2.1 System Description

The extensible, left-side, oval duct system is functionally identical to the commonly used ventilation systems utilizing rigid fiberglass tubing and auxiliary fans. Additional components required have included:

a. flat "pancake" duct sections to bring ventilation across the entry if required without restricting vehicular travel.

b. "sweep" elbows to provide for turns of the standard oval tubing mounted flat against the roof.

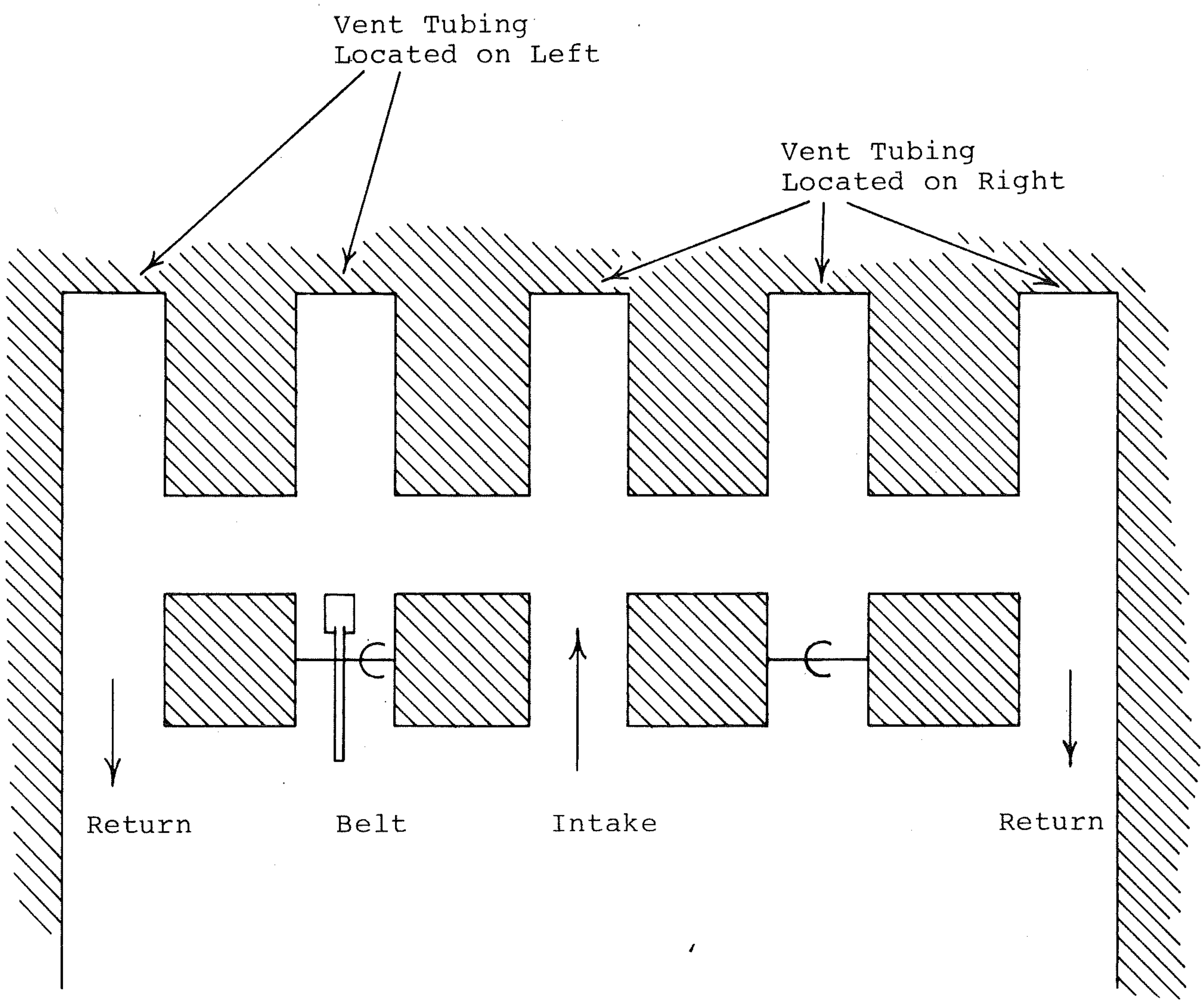


Figure 1 - Typical Face Ventilation Pattern

c. adapters to mate standard round and oval duct to the required custom components.

d. special 16" oval slip tube.

A plan view of a typical system installation is shown in Figure 2. This is the general configuration for places where the primary ventilation returns to the right. Figure 3 shows a modification of the installation, used when it is necessary to bridge the crosscut instead of the entry.

Beginning at the face the elements shown in Figure 2 are:

1. special oval slip tube fabricated from 16" equivalent oval duct

2. standard 18" equivalent oval duct, random lengths 2' to 10'

3. special "sweep" elbows fabricated from standard oval tubing in 30°, 45°, 60° and 90° bends

4. special 90° oval to pancake duct adapter fabricated from standard oval tubing

5. special 5" thick pancake duct designed and built by FMA*

6. special adapter - pancake duct to 14" round tubing - designed and built by FMA*

7. standard 14" round fiberglass tubing - 10' long

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* All components built by FMA utilized special resin materials and additives to comply with MESA requirements: a flame spread index of 25 or less according to ASTM E-162.

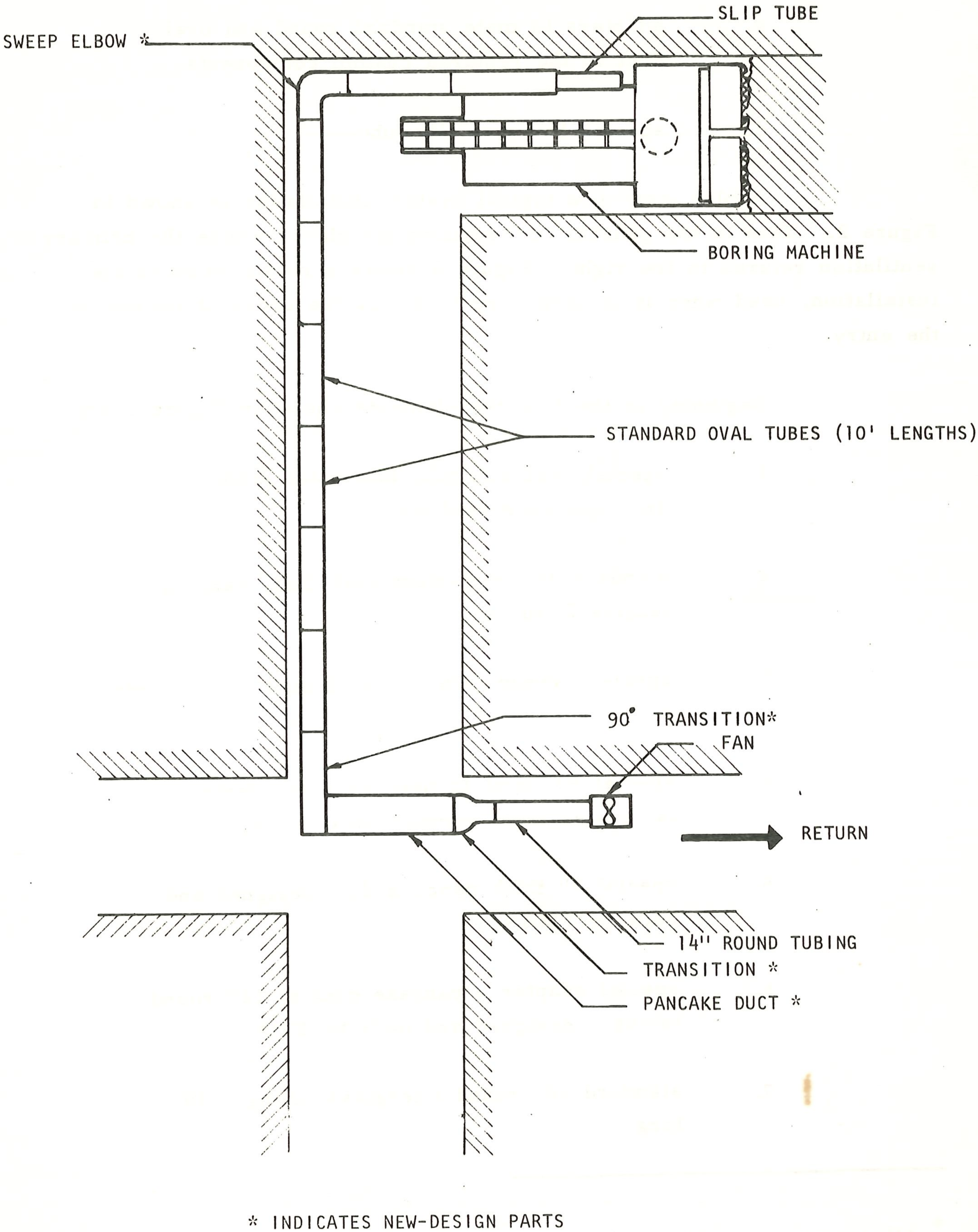



Figure 2 - Left-Hand Ventilation System, with Entry Cross-Over

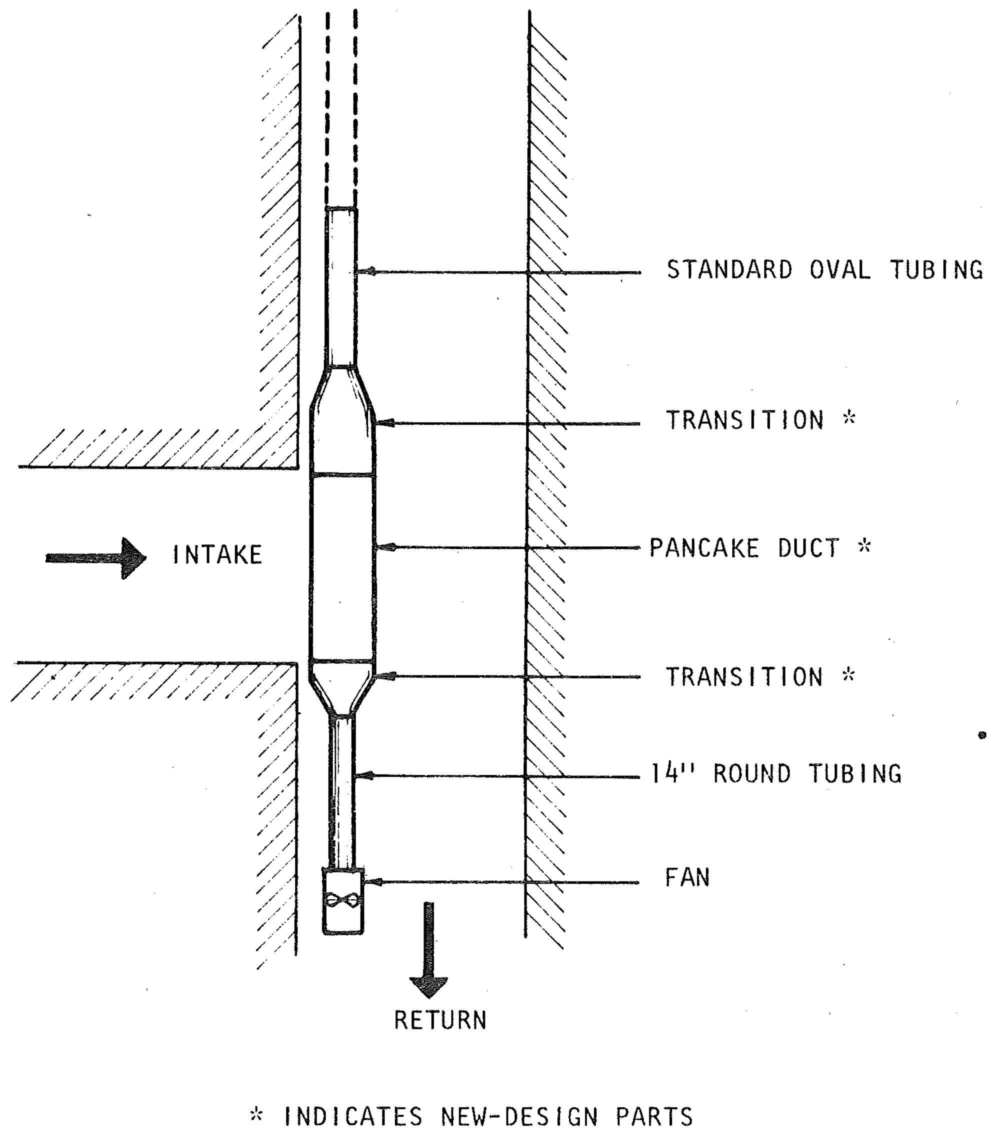



Figure 3 - Left-Hand Ventilation System, with Crosscut Cross-Over

For the return directly back from the face, item 4 is not required; instead an additional component is substituted (as shown in Figure 3):

- special straight oval to pancake duct adapter - designed and built by FMA

For the return to the left, an elbow is used with a standard adapter which goes from 18" equivalent oval to 14" diameter round. Descriptions of each of the components employed in the system follow.

### 2.1.1 Slip Tube

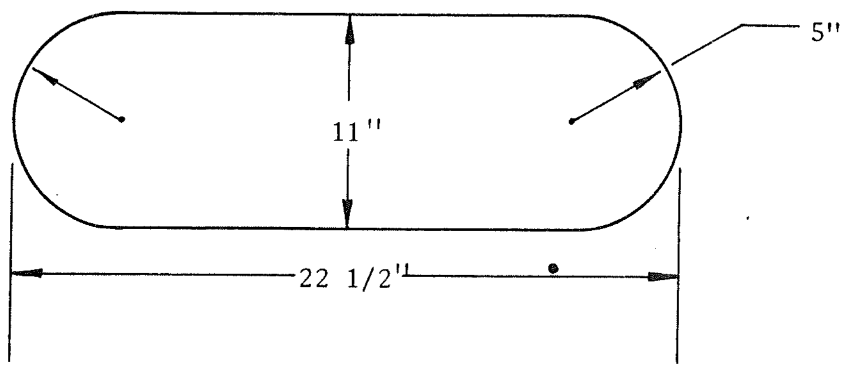
The slip tube was fabricated from standard 16" equivalent oval tubing manufactured by Peabody ABC, modified to allow it to slide inside standard 18" equivalent oval tubing. The cross section of the duct is as shown in Figure 4a with a total flow area of 173 inches.

An elastic link can be fitted to the forward end of the slip tube for attachment to the mining machine for automatic extension. The slip tube is shown in a detail view and in operation position in Figure 5.

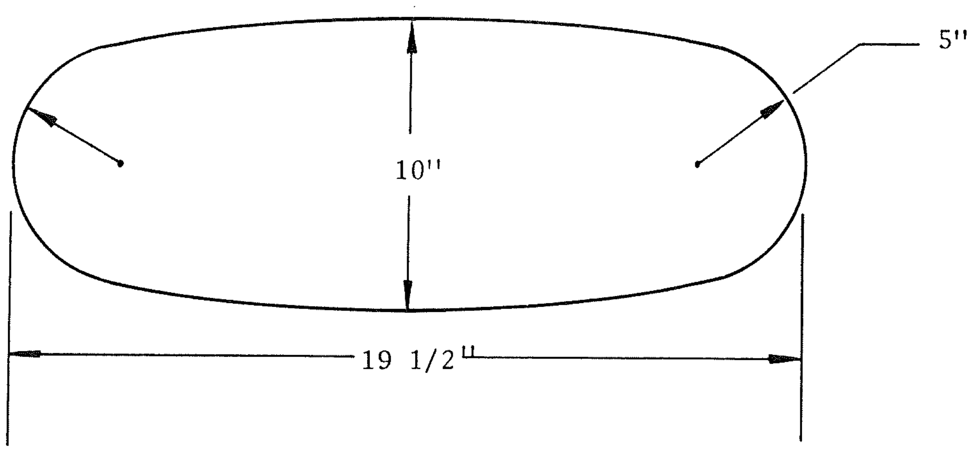
### 2.1.2 Standard Oval Duct

The system is based upon standard 18" equivalent oval fiberglass duct manufactured by Peabody ABC. The cross section of the duct is as shown in Figure 4b with a total flow area of 210 square inches.

The duct is employed as supplied by the manufacturer except for the hangers. To ensure that the duct is held tightly against the roof, thus minimizing interference with vehicular and personnel traffic, a new hanging system was developed using standard nylon straps and steel "D" rings. The adjustable hangers are further described in Section 2.1.8.

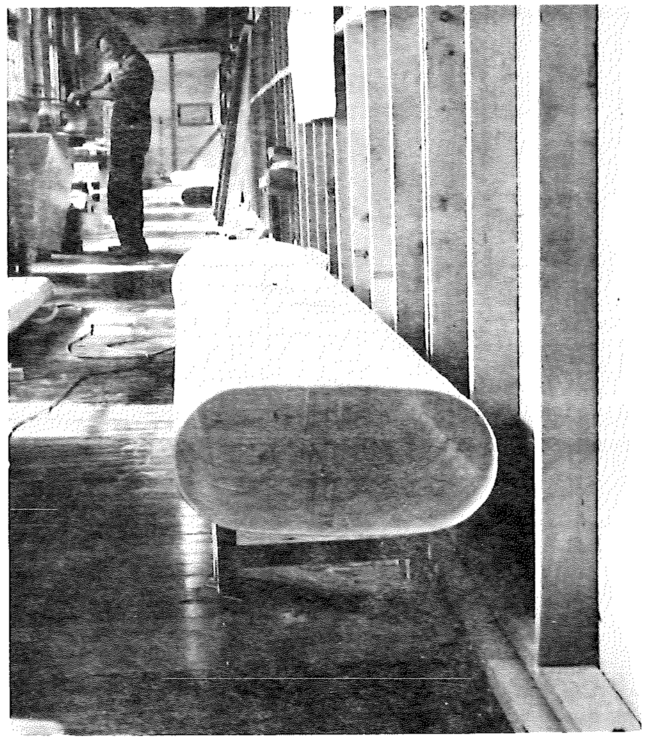



(a) Slip Tube

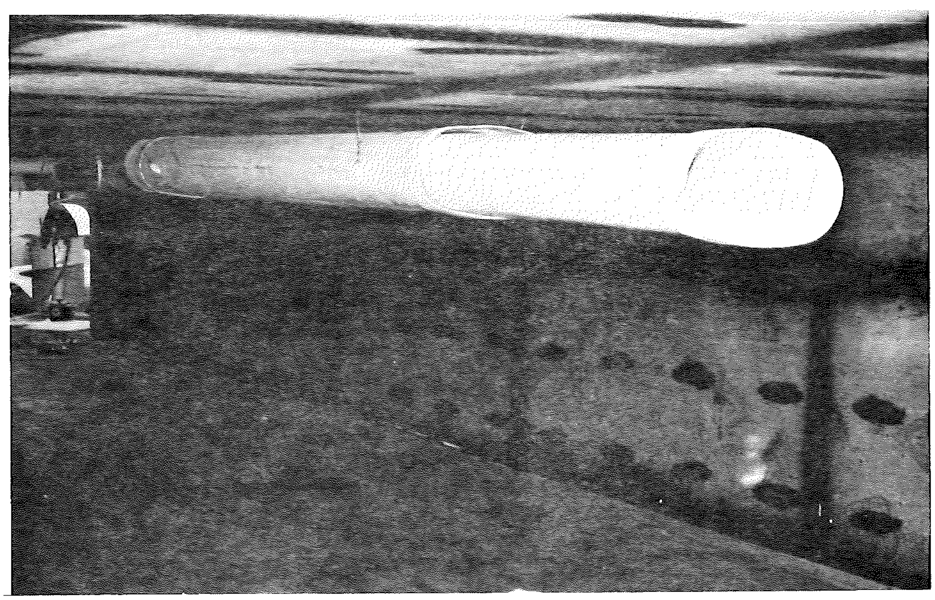



(b) 18" (Equivalent Diameter) Oval Tube

Figure 4 - Cross-Sectional Geometries of Standard Oval Tubing



(a) Modified 16" oval Slip Tube



(b) Slip Tube in Extended Position

Figure 5 - Details of Oval Slip Tube Construction

Four of these hangers were attached to each of the otherwise standard oval tubing sections.

### 2.1.3 "Sweep" Elbows

"Sweep" bends are those that allow the tubing to remain flat against the roof when turning a corner.

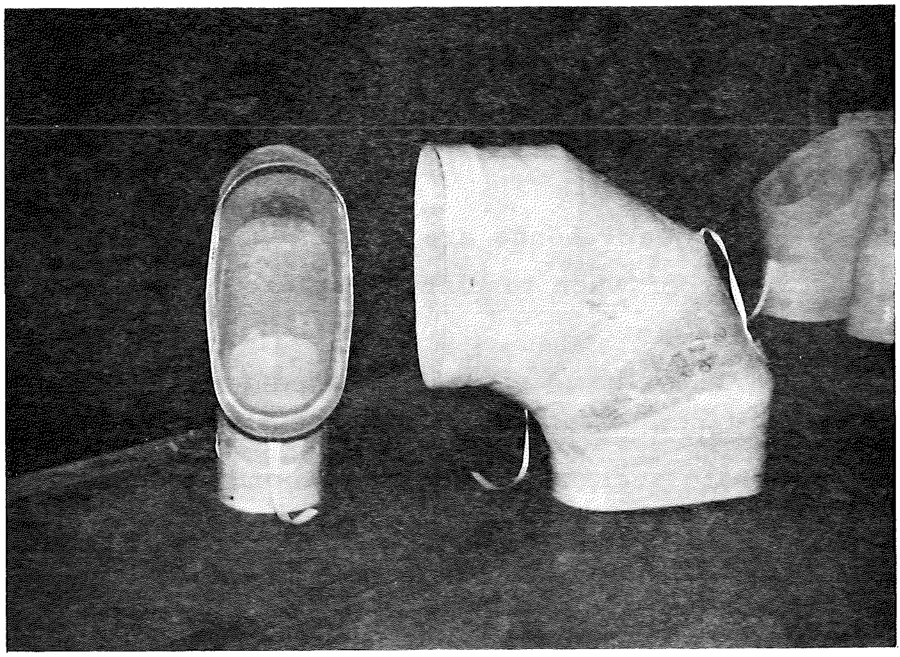
The elbows were fabricated from straight lengths of the standard 18" oval duct by cutting the duct into wedge shaped sections, rotating alternate sections $180^{\circ}$, and rebonding the sections with 4 inch fiberglass mat and resin. Effort was made to maintain a smooth surface on the inside of the duct to minimize flow losses.

Elbows of $30^{\circ}$, $45^{\circ}$, $60^{\circ}$ and $90^{\circ}$ were fabricated in this fashion to provide flexibility in the mine application. They were reinforced externally where required to extend their life. Adjustable hangers were attached to the inside and outside of the bends at the midpoint so each elbow may be used for either left or right turns.

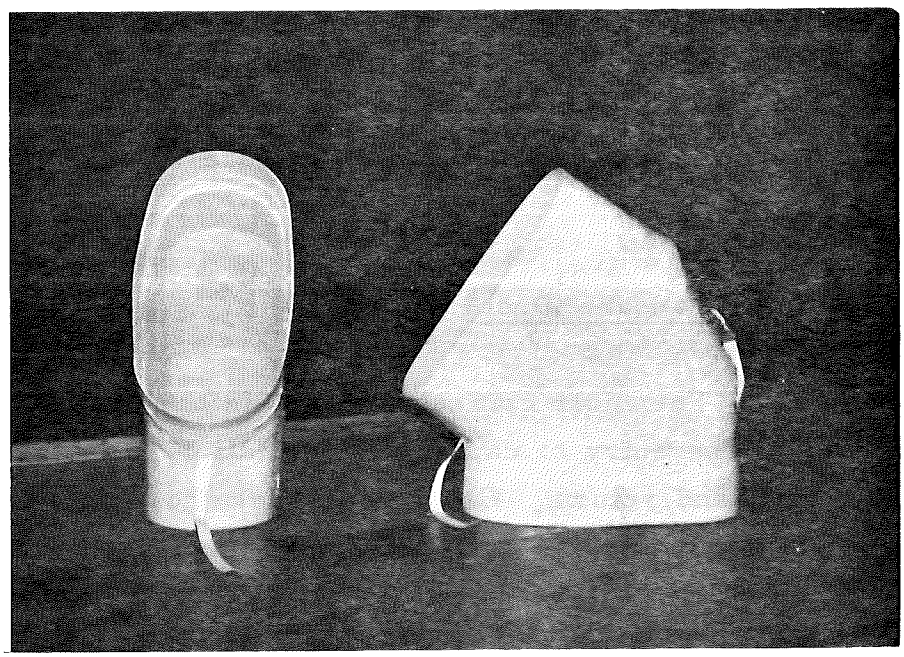
Photographs of typical elbows are presented on Figure 6.

### 2.1.4 Pancake Duct

The most critical element in the system is that section which crosses the entry to carry the ventilation from the left hand rib to the right hand return. Clearance under the duct at this location must be maximized for vehicular and personnel traffic and to reduce the likelihood of damage to the duct. On the other hand the duct must have adequate flow area to provide effective face ventilation.



(a) 90° Elbows



(b) 60° Elbows

Figure 6 - Fabricated Sweep Elbows

To accommodate these two conflicting requirements it was necessary to design and construct a special pancake duct. The duct is 5 inches thick and 32 inches wide with rounded corners yielding a flow area of approximately 140 square inches. Wall thickness is a nominal 1/8 inch.

The duct is formed on a sheet metal mold, one half at a time in sections 5 feet in length. Each section is formed from fiberglass mat completely impregnated with resin. By placing the two sheets of fiberglass mat in the mold with their rough sides together it was possible to achieve a relatively smooth surface on both the outside and inside of the duct.

Two duct halves were bonded together using 4 inch fiberglass mat and resin as described earlier to yield a pancake duct 5 feet in length with a bell-mouth fitted to one end. Several pancake ducts can then be fitted together to span the entry.

To minimize deflection of the duct walls under ventilation pressures, stiffeners were placed internally along the duct centerline. These stiffeners are somewhat compliant to yield rather than break under loads imposed by impact or contact with mining equipment.

Sections of pancake duct are shown in Figure 7. Lying in front of the pancake duct is a piece of standard 14" round tubing, which has the same cross-sectional area as the pancake.

### 2.1.5 $90^{\circ}$ Oval to Pancake Duct Adapter

The interface between the standard oval duct running at roof level along the left rib and the pancake duct crossing the entry toward the auxiliary fan must include considerable flexibility. It must accommodate the end of the pancake duct mounted tight to the roof at an angle of $90^{\circ} \pm 30^{\circ}$ from the duct centerline. This flexibility must be obtained without excessive leakage at the joint.

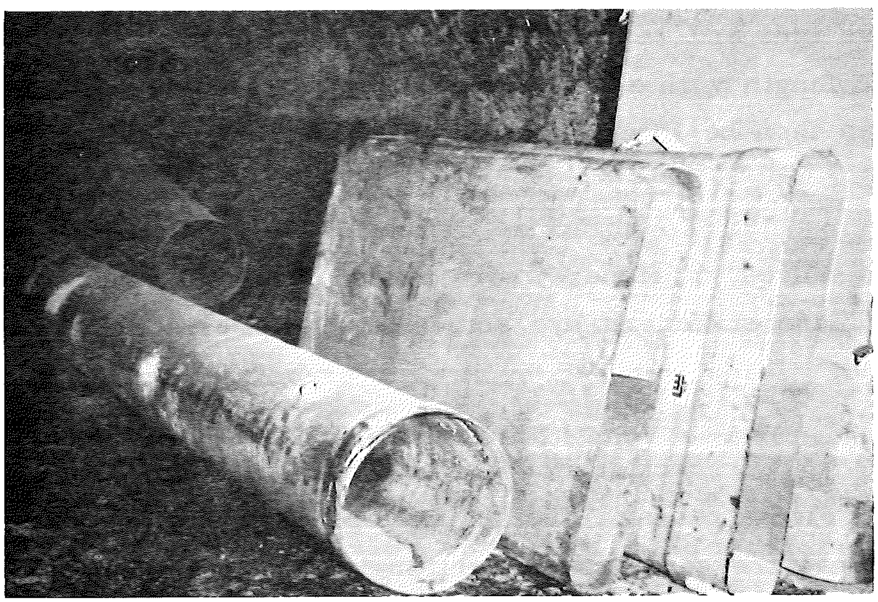


Figure 7 - Pancake Duct, with 14" Round Duct in Foreground

An adapter was fabricated from standard 18 inch oval tubing. One end was blanked off with a sheet of fiberglass, the appropriate opening carved in the duct wall and stiffeners and flow deflectors added as required. The adapter is shown during fabrication in the photograph of Figure 8.

### 2.1.6 Pancake Duct to 14" Round Adapter

To accommodate the outlet end of the pancake duct and direct the flow into a standard 14" round tube connected to the auxiliary fan, a special adapter was constructed around a framework of open mesh screen used to provide the required contour. The outlet of the duct utilizes a short section of standard 14" round duct. The outlet is tipped downward at an angle of approximately $10^{o}$ to direct the round duct toward the fan mounted at floor level.

A photograph of the adapter is shown on Figure 9.

### 2.1.7 Straight Oval to Pancake Adapter

For installations where the pancake duct has to bridge the crosscut instead of the entry, a straight adapter replaces the $90^{o}$ adapter as shown in Figure 10. This adapter bells over the standard oval duct and fits inside the bell mouth on the pancake duct. Photographs of this adapter with one length of pancake duct attached, are shown in Figure 11.

### 2.1.8 Mounting Straps

As previously discussed, considerable effort went into developing a duct system with the lowest possible profile - in order to provide the greatest possible clearance for machinery travelling underneath the duct. However, this advantage can be entirely negated if the tubing is not mounted tightly against the roof. Underground surveys

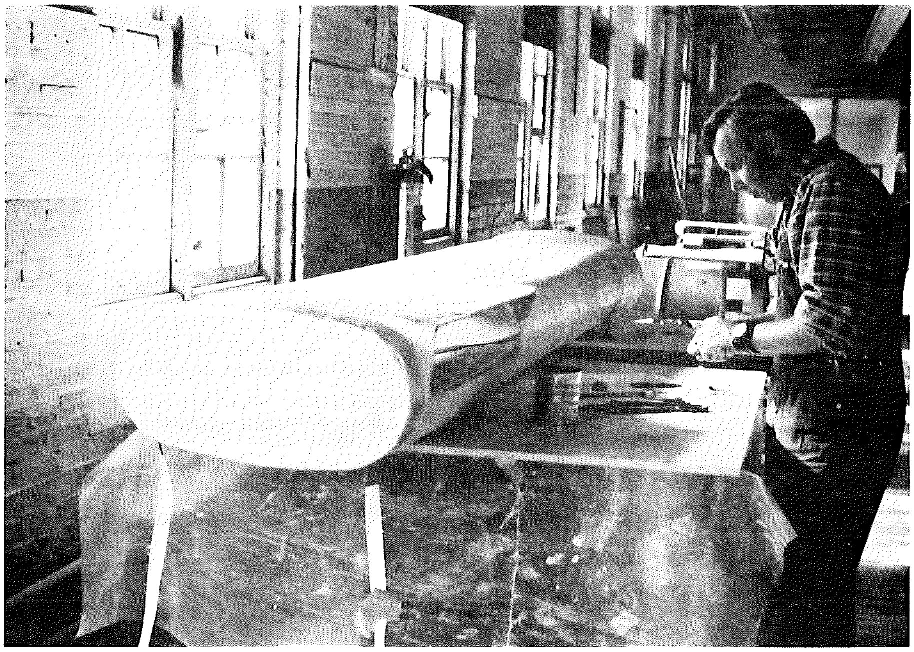


Figure 8 - $90^{\circ}$ Oval to Pancake Adapter

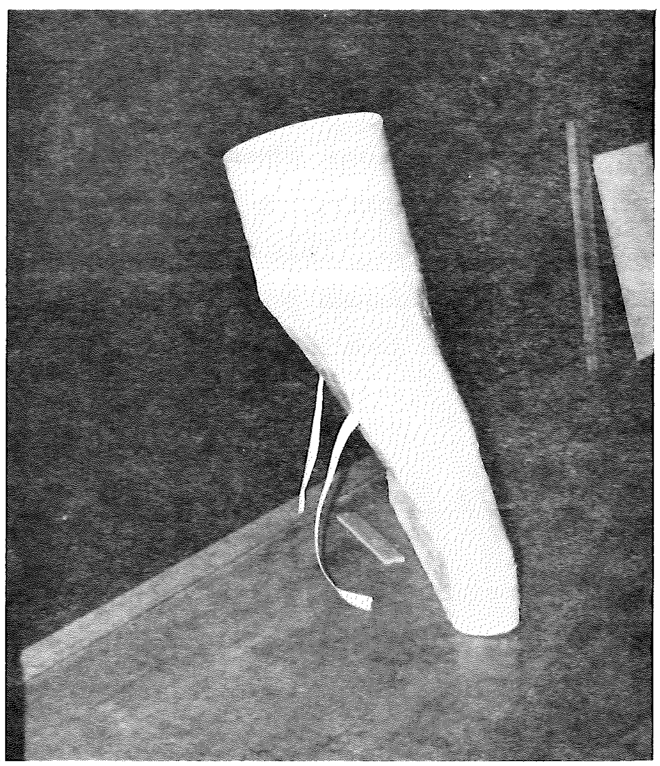
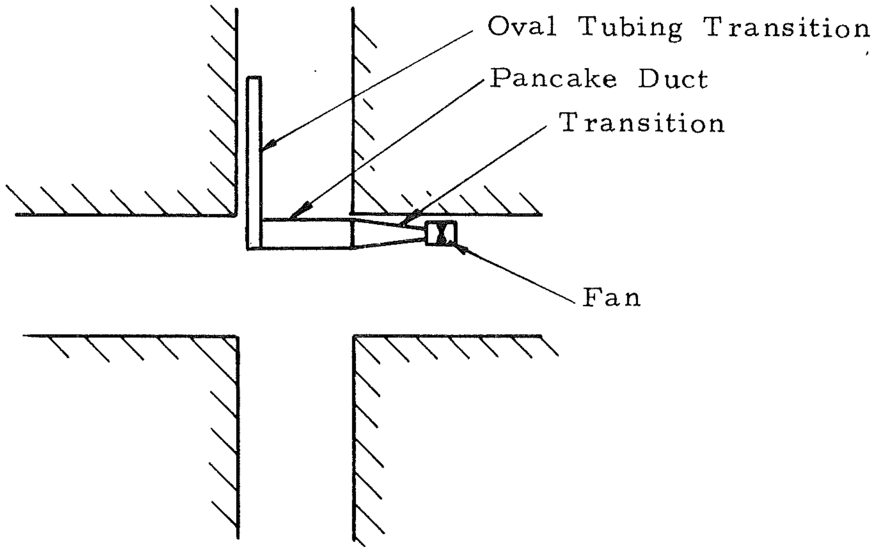
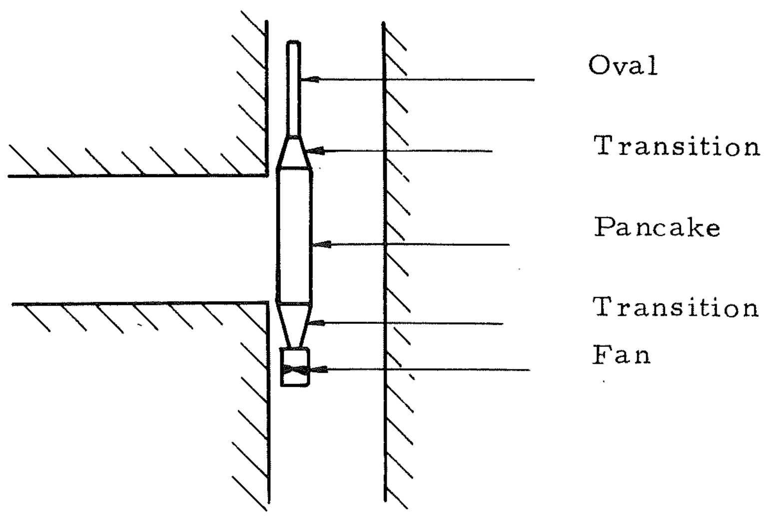


Figure 9 - Pancake Duct to 14" Round Adapter




(a) Pancake Duct Across Entry




(b) Pancake Duct Across Crosscut

Figure 10 - Alternate Pancake Duct Installations

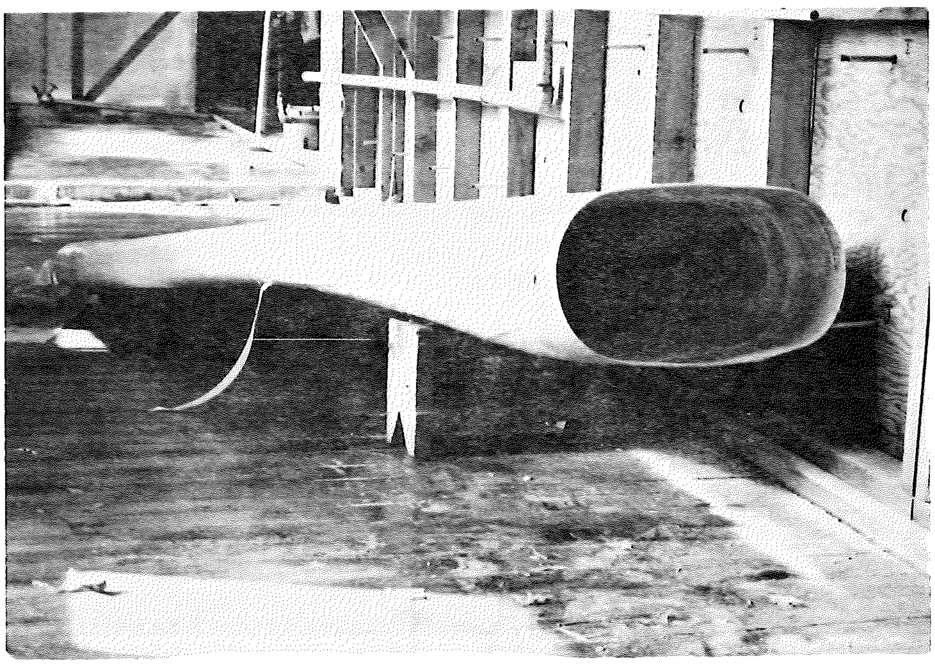


Figure 11 - Straight Oval to Pancake Adapter

had shown that the conventional mounting methods left a gap of as much as six inches between tubing and roof. A new system was therefore designed to make it possible to mount tubing tight against the roof. One-inch nylong strapping is employed - the same material used for conventional mounting. However, rather than terminating in one D-ring, the strap is threaded through a pair of D-rings as shown in Figure 12. Attached to the D-rings is a hook which is inserted through the hole in the spad. Pulling on the free end of the strap while simultaneously pushing up on the duct locks the system tightly against the roof.

## 2.2 Laboratory Testing

Before actual mine testing of the system, it was laboratory tested to determine ease of handling and to verify the theoretical flow characteristics which had previously been determined analytically. The system was assembled in a simulated mine passage developed by Foster-Miller on another USBM project.

Figure 13 shows the tubing assembly used for the first series of flow measurements. A second test was run with the same tubing plus the addition of two back-to-back 90° elbows. The system is shown mounted in position in Figure 14(a). The pancake duct was used to bridge the "entry"; it fits into the right-angle oval transition, followed by a straight oval piece and back-to-back 90° sweep elbows to simulate a jog in the rib. Barely visible in the photograph is an additional straight length of oval tubing with the slip tube inside it. The other end of the pancake duct was attached to the pancake-to-round transition, as shown in Figure 14(b). The round tubing was plumbed to a mine fan for flow tests. The fan was regulated to produce 6 inch water gauge pressure, the same output as the fan which was to be used underground during subsequent mine testing.

A hot wire anemometer was used to determine the velocity profile in the straight duct (and thus the air flow rate) and a manometer to measure the pressure. Measuring points are shown in Figure 13. The results of the testing are summarized in Table I.

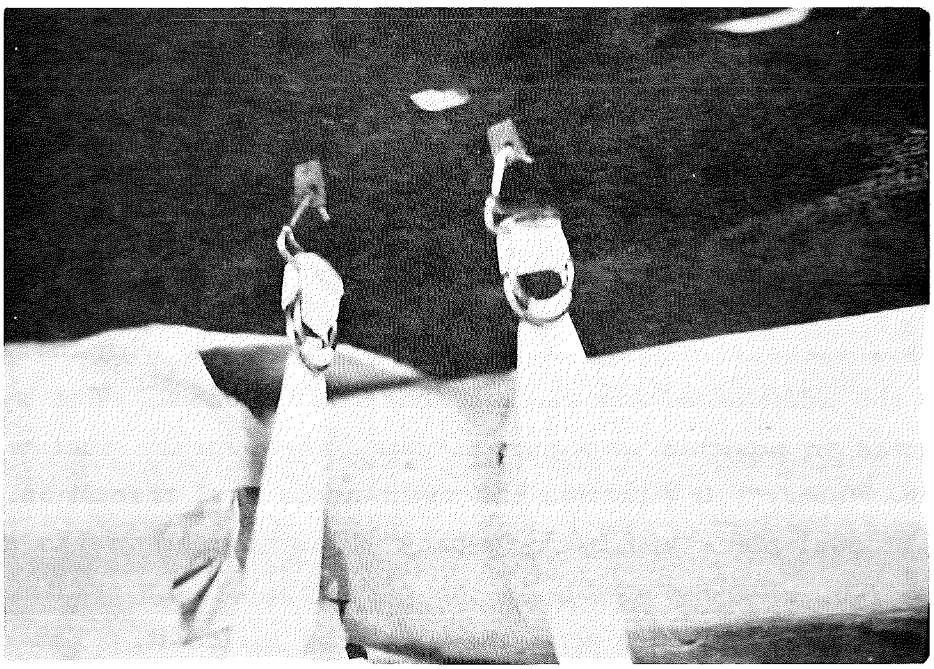


Figure 12 - Adjustable Mounting Straps

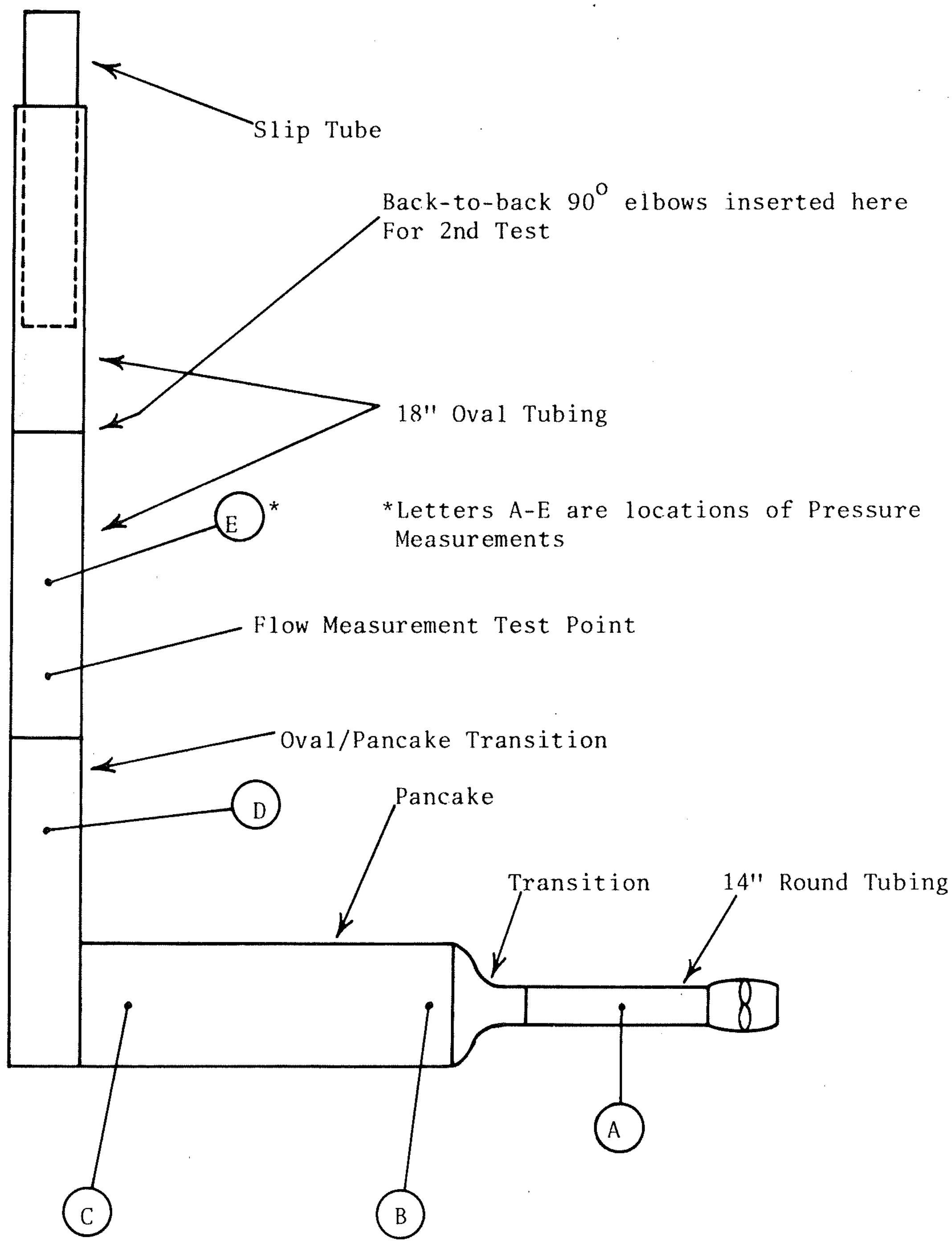
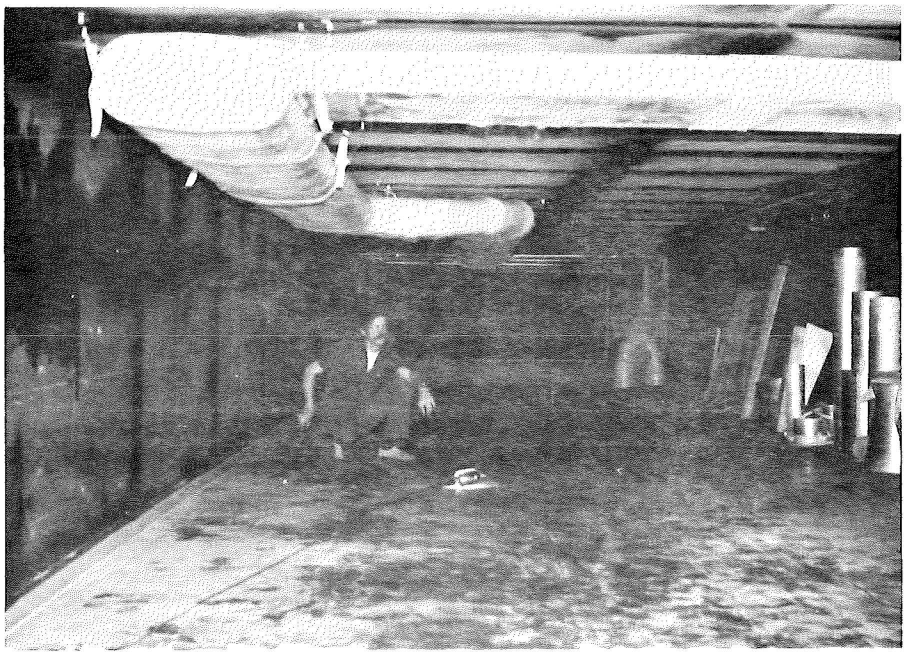
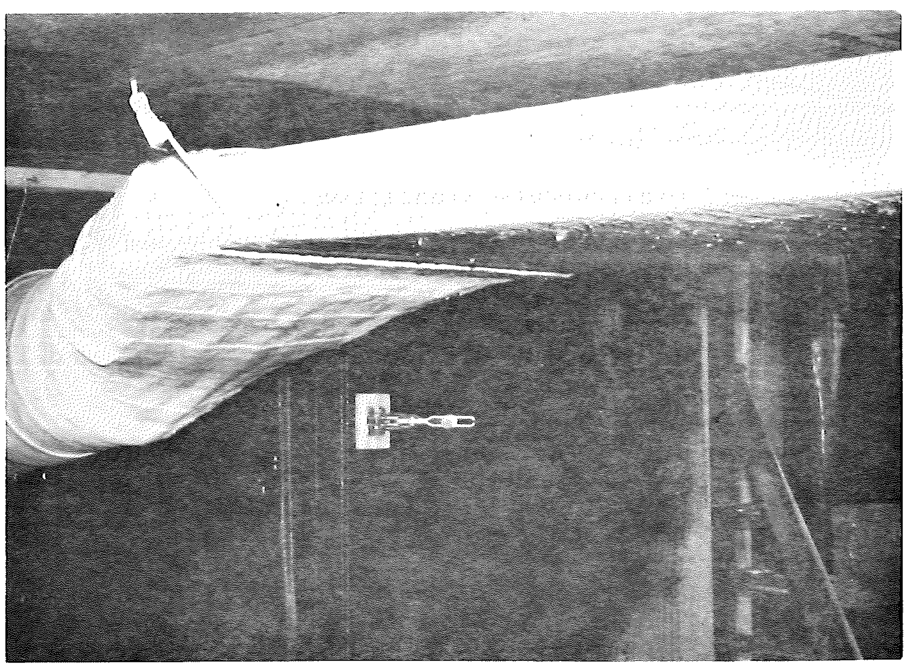



Figure 13 - Tubing Assembly For Flow Measurements



(a) Tubing in Simulated Mine Entry



(b) Tubing Leading to Fan

Figure 14 - Lab Evaluation of Tubing System

# TABLE I

## RESULTS OF FLOW TESTS

| | Air Flow CFM | Pressure at Indicated Locations (inches water gauge) "A" | "B" | "C" | "D" | "E" |
|---|---|---|---|---|---|---|
| Test 1 - Pancake, transitions, 3 oval tubes, slip tube | 4,400 | 5 7/8 | 5 1/4 | 5 | 1 1/4 | 1 1/4 |
| Test 2 - Same as above plus (2) 90° elbows. | 4,125 | 5 7/8 | 5 1/4 | 5 | 1 3/4 | 1 3/4 |

Pressure readings ± 1/8"

Flow measurements ± 10%

In general, it was found that 6" pressure at the fan could draw over 4,000 CFM through the system. Furthermore, most of the pressure loss occurred where the air entered the pancakde duct, as predicted by air-flow calculations.

During assembly of the duct system, it was found that while the special pieces were heavy and somewhat bulky, they could be handled by two men.

## 2.3 Mine Evaluation Program

The left-hand duct system was evaluated in two underground test programs by Foster-Miller personnel. The first test program pointed up several weaknesses in the system. Although the duct system remained in underground use for one week after the first test program, it was then set aside to await improved hangers and lighter-weight sections of the special duct pieces. After these modifications were accomplished, a second test program was initiated. The system was left in service following the second test program, and at the time this report was written, the left-hand tubing was still in underground use.

Details of the two test programs are presented in Appendix B. This section presents a summary of the underground testing by Foster-Miller personnel.

### 2.3.1 Test Site

The left-hand duct system was introduced to the #14 Section of Federal No. 1 Mine (Eastern Associated Coal Corp.) in Grant Town, West Virginia, where a Goodman 430 borer was being used to develop a new longwall panel. The development was in the 6 Right section of the mine. Figure 15 shows a simplified map of the section, in which the number 1 heading was for the belt, the number 2 heading the intake, and the number 3 heading was the return. This meant that in all headings, face ventilation would be exhausting to the right. Thus, the cross-over system would be required in every heading.

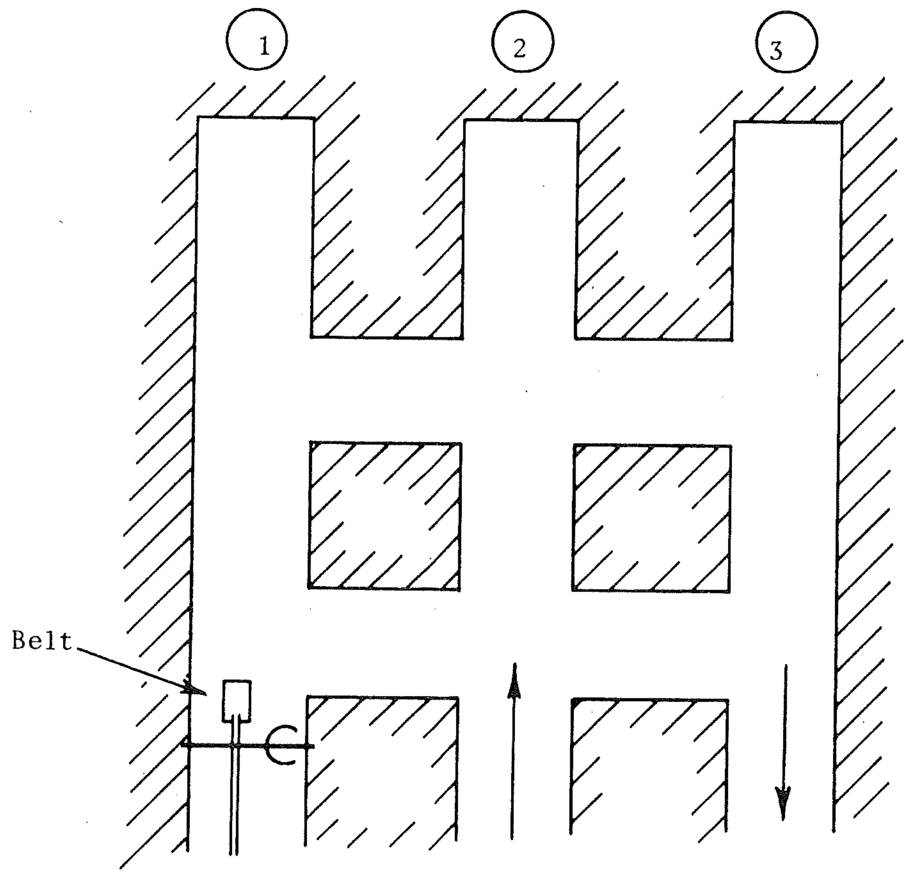



Figure 15 - Simplified Plan of #14 Section

Face ventilation, prior to introduction of the new system, utilized a 15 horsepower Joy fan and 14" round rigid tubing. Although the fan had a nameplate rating of 9,500 CFM at 5.8 inches water gauge, the fan blades had been badly eroded. It is probable that the actual fan output was no better than half of the nameplate rating.

The fan was drawing through a 10 foot long 12 inch slip tube, 4-10' lengths of 14" round tubing and a single 90° bend as shown on Figure 16(a). The tubing was hung from the roof on the right hand side of the machine. Pitot tube measurements, taken by a MESA ventilation engineer, indicated total flow through the tube of 3,200 CFM.

### 2.3.2 Installation of Left-hand Tubing System

The 14" rigid tubing was replaced by the new oval tubing as shown in Figure 16(b). In this application, the pancake tubing was used to bridge the crosscut instead of the entry. The components used were the 10' long 16" oval slip tube, one 10' long 18" oval tube, the oval-to-pancake transition, two 5' long pancake ducts, the pancake-to-round transition, a 90° round ell and two 10' lengths of 14" round tubing. Figure 17 shows photographs of the installation, including the pancake duct. The fan is in the crosscut at the right of the picture, with the oval tubing going up the entry (to the left of the photograph). A slip tube, telescoped inside the last joint of standard 18" oval tube, was manually extended as the miner advanced. Figure 18 shows a view from the left side of the miner looking toward the face, with the slip tube almost fully extended.

When the round tubing installation of Figure 16(a) was replaced with the left-hand tubing of Figure 16(b), the air flow increased from 3,200 cfm to 4,500 cfm. In addition, dust levels at the miner operator's station were improved because the air was being pulled away

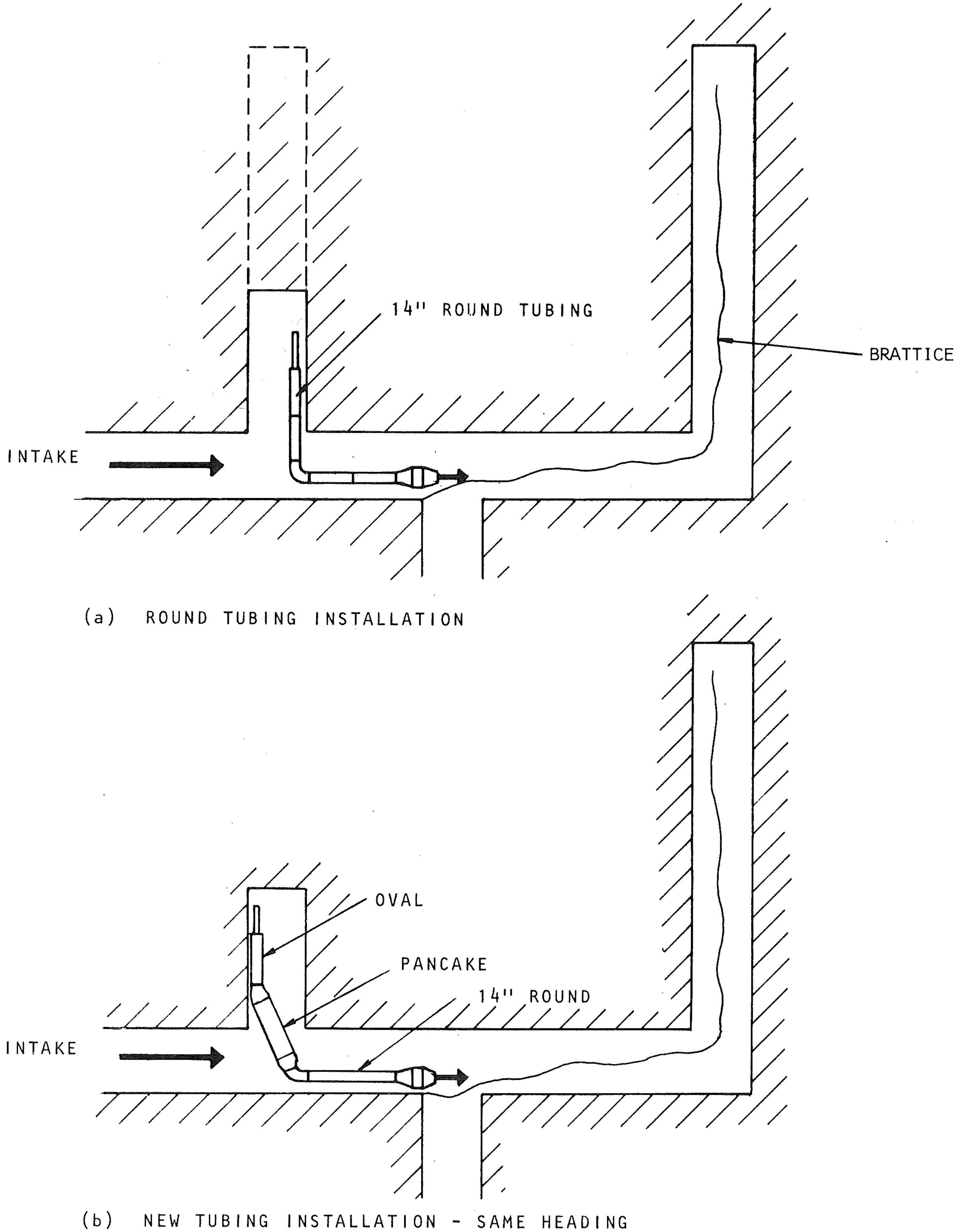



Figure 16 - Tubing Installations

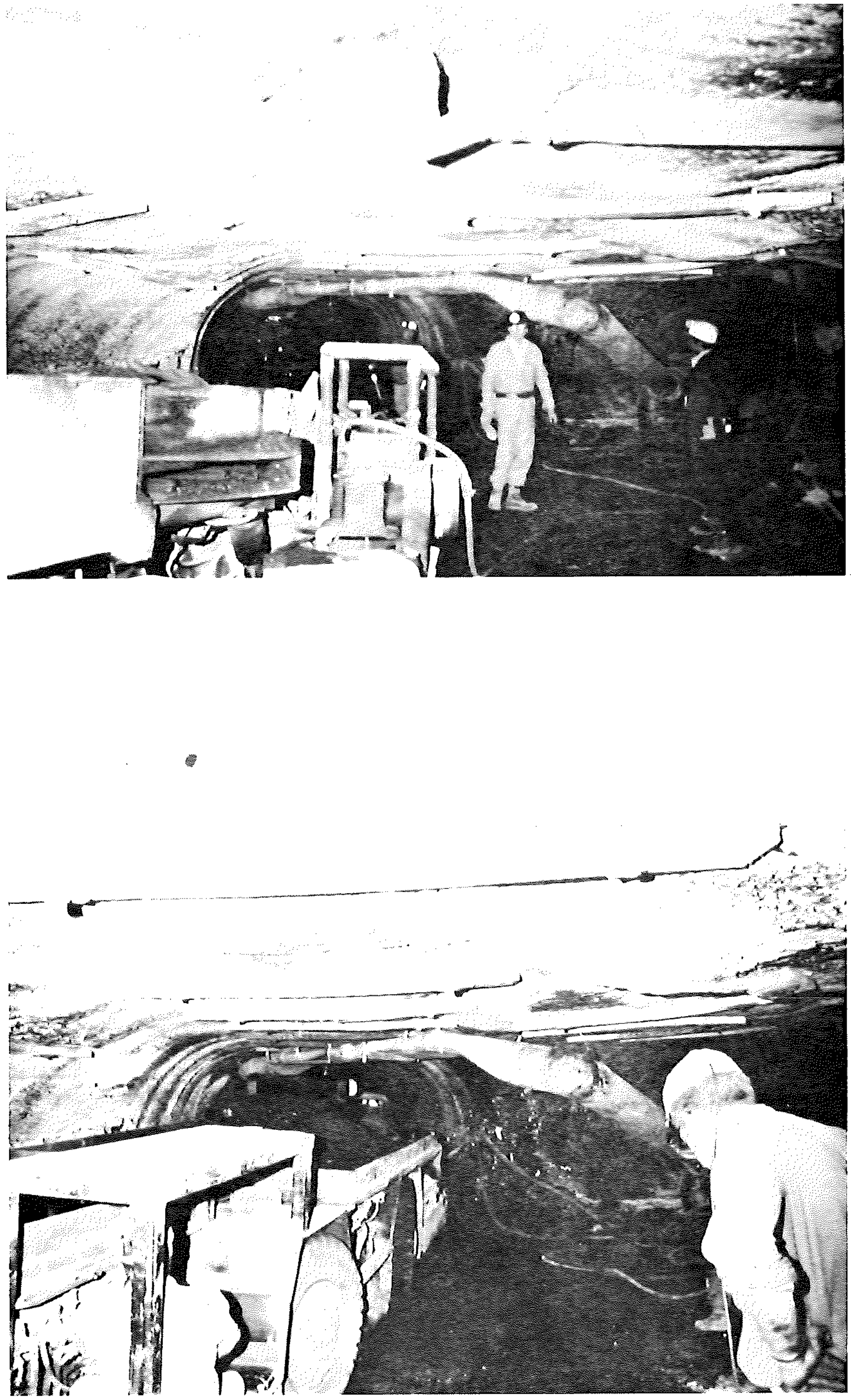


Figure 17 - Mine Installation of Pancake Duct

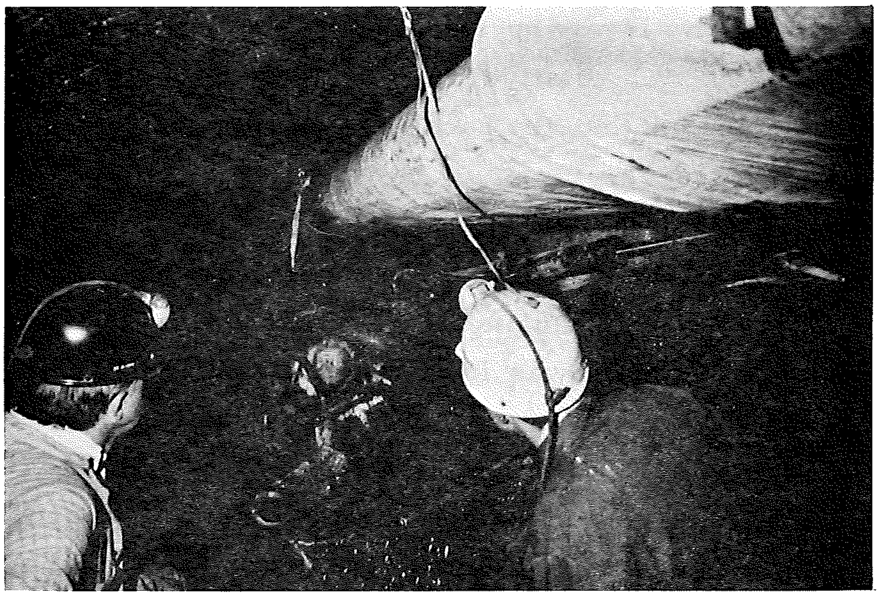


Figure 18 - Telescoping Tube at Face

from him instead of toward him. At a later date, with seven, 10-foot long lengths of oval-tubing in place, an instantaneous dust reading of 3 $mg/m^3$ was recorded* during machine operation at the miner operator's station. Note that this is an instantaneous reading taken when the heading was advanced almost its full length. When this reading is averaged over a full shift, readings well under 2 mg should be obtained.

On a later shift, the system was subjected to the worst case situation, involving a tubing run of almost 200 feet, as shown in Figure 19. Qualitative evaluation by mine personnel and USBM observers indicated that the face ventilation was better than any borer section they had seen.

A new installation technique was developed by the day-shift brattice man for hanging new joints of tubing as the miner advanced. It was found that it was impossible to first insert the new tube in the end of the last one and then drive the spads to mount the forward end of the new tube, as was formerly done. The reason is that the brattice man cannot reach over the miner and around the tube to get at the hanger furthest from the rib. The new technique involved driving the two spads in place in front of the slip tube when it is almost fully extended. A temporary mounting strap is then hooked to these spads. The slip tube is then removed from the last joint of mounted tubing; the new joint is then telescoped over the slip tube and inserted in the end of the last mounted tube. The forward end of the new tube is then mounted to the roof with the adjustable strap. When the miner has advanced enough to provide room to reach the inside hanger of the tube, permanent mounting is possible and the temporary strap may be removed for use in mounting the next joint.

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* Done with special USBM research instruments - SRI

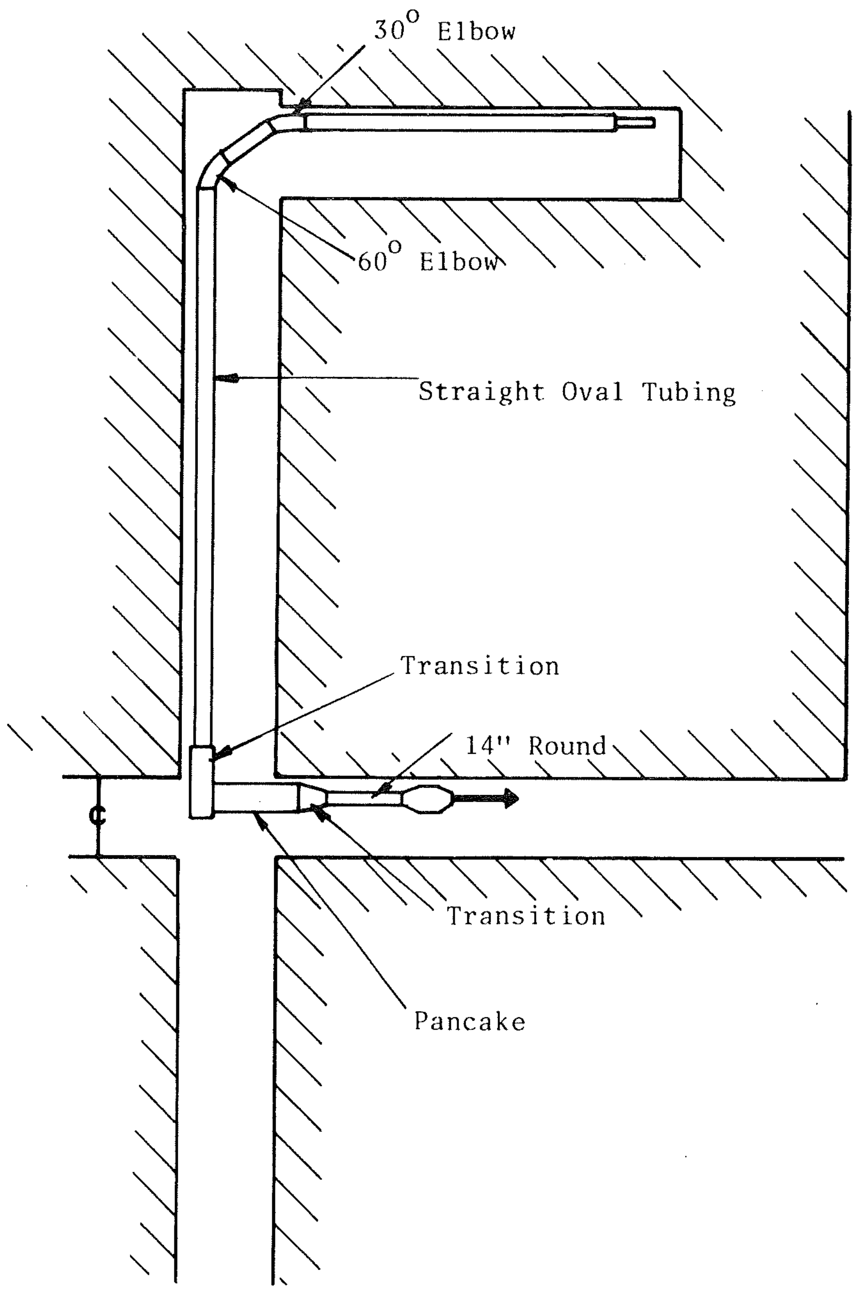



Figure 19 - Mine Installation with 200 Feet of Tubing

### 2.3.3 Compatibility with Mining Cycle

In addition to improving face ventilation, the new system permitted the tubing to be mounted closer to the roof. Figure 20 shows one section of tubing, tight against the roof, using the special mounting straps described in Section 2. 1. 8. This arrangement provided adequate clearance for machinery to travel underneath the pancake duct which spanned the crosscut.

Use of the oval tubing also provided sufficient clearance for the shuttle car canopies, as shown in Figure 21. Because the canopy could pass underneath the tubing, it was possible to operate both "standard" and "off-standard" (i.e., left-canopy and right-canopy) shuttle cars. This was the first time both shuttle cars could be utilized since canopies were installed one year ago. On several shifts during the test program, use of the double-haulage system resulted in one-shift production of twice the section average.

Although the new tubing did not cause any production downtime, there were several occasions in which improper installation caused minor interferences with maximum productivity. Careful positioning of the tubing is important, both for the conventional oval tubing and the cross-over section.

Figure 22 shows a cross-section of the entry with the oval tubing installed. If the tubing is allowed to get too close to the rib, the curved geometry of the entry will force the tube to hang lower. The oval tubing must be mounted on the flat part of the roof in order to minimize its downward projection. Even the few inches of head room which is lost by mounting the tube too close to the rib caused an interference with one of the shuttle car canopies and necessititated the relocating of several joints of tubing at the start of the next shift.

Careful positioning of the cross-over section is also important so that only the pancake duct is located over the shuttle car roadway. Figure 23 shows an example of incorrect mounting and how

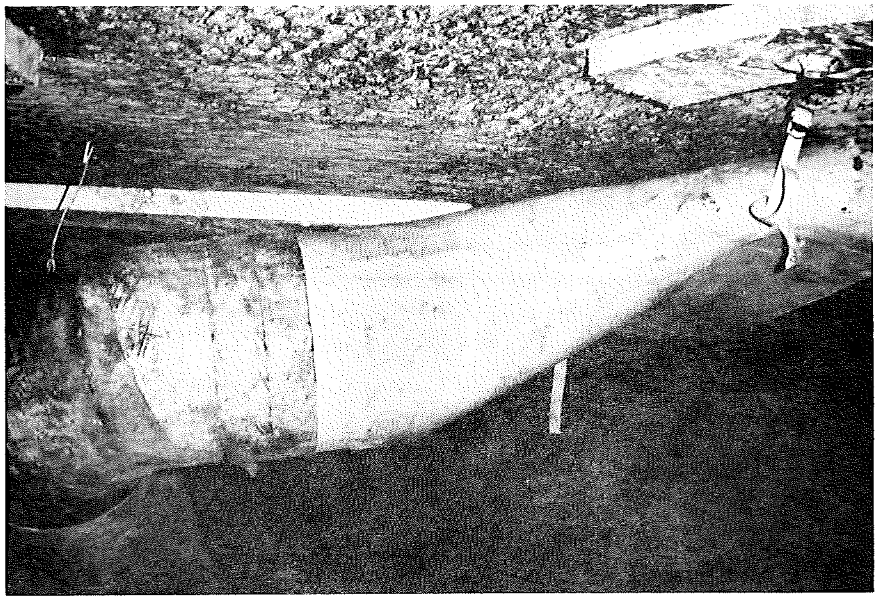


Figure 20 - Strap Mounting Tubing to Mine Roof

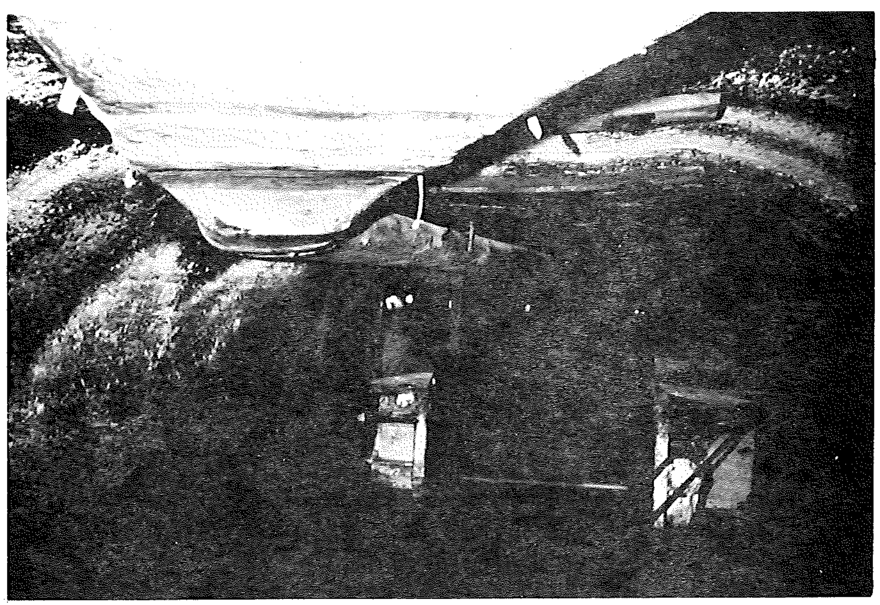


Figure 21 - Canopy Clearance under Oval Tubing

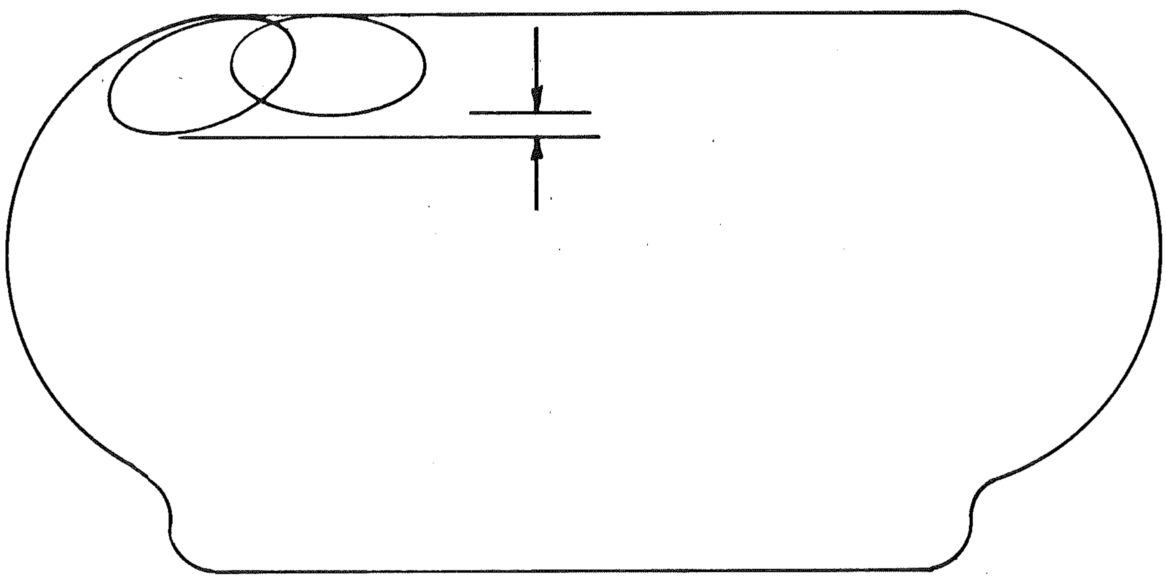
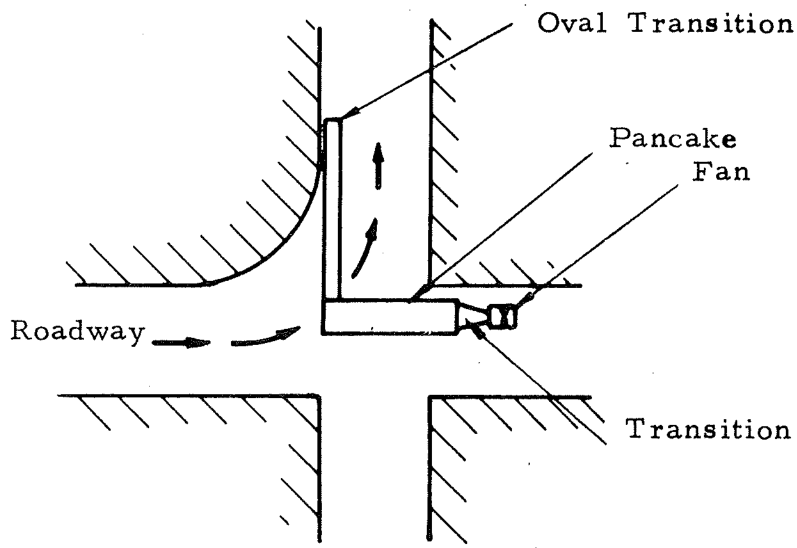
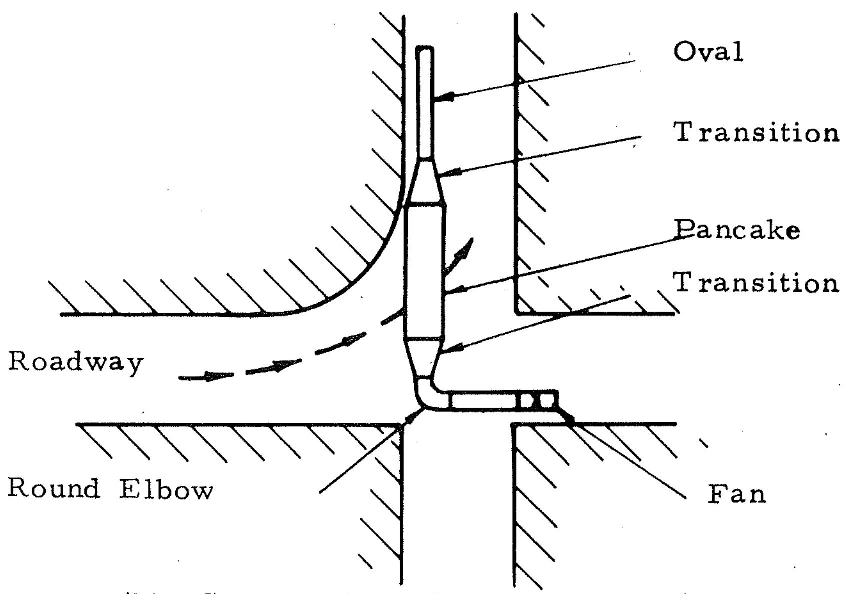


Figure 22 - Clearance Lost through Incorrect Tubing Installation




(a) Incorrect Installation - Shuttle Car Interference




(b) Correct Installation - Free Shuttle Car Passage

Figure 23 - Correct and Incorrect Tubing Installation over Roadway

it was corrected. Note that the coal pillar has been rounded off to permit the shuttle car to negotiate the turn. If the oval tubing (11" high) is allowed to protrude into the roadway, as in Figure 23(a), then the coal pile on the shuttle car must be reduced so that it does not hit the oval tubing. However, when the straight transition was used to enable the pancake duct (5" high) to span the roadway, as shown in Figure 23(b), the miners were able to load the shuttle cars more fully. Except in very unusual cases, the shuttle car could be loaded as close to the roof as possible, and the load barely brushed as it passed underneath the pancake tubing.

## 2.4 Conclusions

Based on the mine evaluation program it may be concluded that it is possible, using the left-hand oval tubing system, to provide adequate face ventilation to a borer machine without restricting either the operator's view of the roof or the operation of loading equipment and shuttle cars in the heading. More specific conclusions are as follows:

(1) By maintaining the tubing within 10 feet of the face, ventilation improved markedly as indicated by improved visibility and personal comfort.

(2) Obstruction to the miner operator's vision and mobility was eliminated.

(3) The system is compatible with the mining environment.

(4) More effort is required to install the new system.

(5) Acceptance by management was good; the opinions of the work force were mixed.

(6) The system is applicable on any mine section where limited space makes left-hand mounting desirable.

(7) The system was used for approximately one month following the completion of the test program.

Conclusions (1) and (2) are not surprising: the system was specifically designed to meet these two objectives by placing the tubing on the left. Because the tubing is always on the left, it pulls the dust-laden air away from the miner operator, it is not in his line of vision, and it does not impede his mobility. Furthermore, as long as the system is used, it will continue to provide these benefits. If the only consideration is to keep the tubing on the left, then it would be possible to use the cross over system in conjunction with conventional round tubing. However, the use of the oval tubing made it possible to obtain the equivalent area of an 18" round tube while projecting down from the roof no more than a 10-inch round tube. The increase in cross-sectional area from a 14" round tube to an 18" equivalent oval tube provided substantially greater air flow with the same fan, even though the air is temporarily restricted as it passed through the pancake duct used in the cross over.

Conclusion (3) (compatible with the mining environment) relates primarily to the minimal interference created by the new system. The improved mobility of the miner operator has already been mentioned. In addition, the left-hand tubing system provides the same, or even less obstruction, to mining equipment as do conventional rigid tubing systems. The straight run of oval tubing actually provides less restriction than does the round tubing, for two reasons: first, the oval tubing is only 10 1/2" deep; and second, the mounting straps enable a miner to mount the tubing much closer to the roof. This combination of factors enabled the section to operate both shuttle cars simultaneously, for the first time since canopies were installed one year ago. The cross over section of the tubing system does provide some obstruction that the conventional tubing did not have. However, when the pancake duct is properly installed, it extends only about six inches from the roof. The protrusion usually does not interfere with any of the machinery, but it is occasionally brushed by the coal pile on a shuttle car as the buggy passes underneath.

Except in unusual circumstances, this slight interference did not restrict the mining operation. It must be noted that there is no interference with mining operations so long as the tubing is properly installed. Poor installation of the oval tubing on the pancake duct can create problems. Two of the more common examples of poor installation were discussed in Section 2.3, together with suggestions on how to avoid these problems.

Conclusion (4) (more installation effort) is a result of the use of oval tubing. First of all, the oval tubing is larger and therefore heavier and more cumbersome. This makes it harder to move and somewhat more difficult to install. The oval tubing also requires two spads to install instead of one.

As discussed in Section 2.3, the inside spad cannot be driven after the tubing is in place, which requires using an installation procedure different than that used for conventional tubing systems. The miners' reaction to this is discussed in the next paragraph. The more difficult installation procedures described thus far refer only to the straight runs of oval tubing and not to the pancake duct used in the cross over section. Although using a cross over system obviously involves extra effort not required for conventional tubing, it was the unanimous opinion of the miners that this was not a problem, because the cross over is installed only once per heading (i.e., every 100 feet of advance). When the heading is started, extra men are available to help with the installation, just as extra men help to move the fan.

Acceptance by management of the new tubing system was good (Conclusion #5). First, they appreciated the improved ventilation which was obtained, even though the fan was not in optimum condition. Second, they were pleased that the lower profile of the new tubing enabled them to operate both shuttle cars. There was some concern when the tubing leading into the pancake duct protruded too far into the entry and necessitated reduced coal-loads in the shuttle cars, but this problem was resolved by proper location of the tubing in subsequent headings. Reaction of the underground work force was mixed. One brattice-man preferred the new tubing system to the conventional and independently developed his own techniques for installation.

His reasoning was that although using two spads to mount the tubing required more initial work, the greater strength of the installation enabled the system to withstand more jostling by the loading machine boom. This jostling, inevitable with any roof-mounted tubing system, would often dislodge the round tubing and require the brattice-man to reinstall it - in some cases, five or more times in a single heading. On the other hand, another brattice-man did not like having to handle the larger oval tubing.

Based upon the underground evaluation, it may be concluded that the left-hand duct system could be used on any section where limited space makes a right-hand duct system undesirable (Conclusion #6). The most extreme case of limited space is the Goodman miner, but there may be several other applications, including other types of borers and also ripper machines with canopies which obstruct the right side of the entry. It should be noted that the key ingredient in the design is the low-profile pancake duct which bridges the entry; this crossover section, together with appropriate transitions, can be made compatible with whatever standard tubing the mine is currently using.

The final conclusion is that the tubing was used for one month after the test program ended. Whatever subjective osbervations may be made, the final evaluation of the system depends upon the long-term underground acceptance. At this writing, an investigation is underway to ascertain the reason for discontinuing use of the system--especially to determine if the reasons lay in the hardware, the underground application, or the basic concept.

## 2.5 Recommendations

As mentioned in the last paragraph, the viability of the new tubing system cannot really be evaluated until the mine gains more experience with the system and discovers more about its strengths and weaknesses. In that regard, recommendations about possible improvements or extensions to the system are somewhat premature; however, while the mine continues to use the system, there are several possibilities for future effort which are worth considering:

Another possibility for future effort is to investigate methods of providing greater clearance between shuttle car canopies and the oval tubing. Nominally, there is about 3 to 5 inches of clearance with this system. However, if the tubing is mounted too close to the rib, the clearance is reduced, as discussed in Section 2.3.3. Other factors which reduce clearance include loose mounting of the tubing, roof bolts and header bars preventing the tubing from being pulled against the roof, or loose coal on the floor elevating the shuttle car. Therefore, there are three courses available:

(1) Lower the canopies
(2) "Squash" the tubing
(3) Give proper attention to tight hanging of the tubing and proper floor cleanup.

The shuttle car canopies were lowered 3 inches for this program. Further lowering is possible, as even the tallest operators still have several inches of clearance above their hats. However, additional lowering of the canopy will restrict visibility which has been the biggest complaint of the operators since the canopies were first installed about one year ago.

The second choice is to use a tubing of less depth. This would be difficult: first, because no such tubing is commercially available; and second, because changes to the current design either restrict air flow drastically or else make the tubing weaker or more cumbersome. Specifically, if the depth is decreased only one inch, then either the area will be decreased by 10 percent or else the width will have to be increased by nearly 3 inches.

Although it may sound strange, the best choice might be to ignore the problem. The reason for this is that, as already stated, gains of as much as one inch involve a sacrifice somewhere else. And, it is highly likely that if the nominal clearance were as much as 10 inches, less precise tube mounting and more debris on the floor would lower the clearance to the same inch or two now prevailing.

As a second choice, the canopies could be reduced further. It should be pointed out that the canopies are adjustable: if they were reduced in height, they could be raised back up where conditions permitted.

### 2.5.2 Production Tooling

A second area for future consideration is the availability of the special-design tubing in production quantity and at production costs. There are three basic parts not currently available:

- pancake duct
- straight tube-to-pancake transition
- pancake-to-round transition

In addition to these three, a right-angle tube-to-pancake transition is required, which can be fabricated from standard tube which is sealed at one end and has a hole cut in the side to accomodate the pancake duct.

In some applications, a special slip tube may also be required. For example, the slip tube for the 18" equivalent oval is a 16" equivalent oval tube, modified to permit it to telescope freely inside the 18" tube. It is desirable that the slip tube be as light as possible because installation of the standard joints of tubing as the mining machine advances required lifting the standard tube with the slip tube inside it. Light weight is possible because the slip tube is usually protected inside the larger standard tubing.

A short-term solution to this problem is the availability of plans which would permit a fiber-glass fabricator to make the necessary parts. These plans are contained in Appendix A. It must be cautioned that any portion of a ventilating system must conform with MESA standards. Of particular importance is the flamability requirement, which mandates a flame spread index of 25 or less when the duct material is sugjected to testing according to ASTM E-162. The required materials are discussed in Appendix A. The components must be carefully mixed so that the cured product has the correct flame spread; furthermore, the incorrect use of the components can create an extremely explosive mixture. Therefore, experienced and qualified fiber-glass fabricators should be chosen to make the desired parts.

### 2.5.3 Dissemination of Information to Potential Users

Underground evaluation has shown that, in one application of the left-hand tubing system, both ventilation and operator visibility, comfort and mobility were improved with no adverse effects on productivity. It might, therefore, be desirable to make this information available to other potential users, especially those with conditions similar to the test installation. It must be stressed that the new tubing system is not a "cure-all" for face ventilation problems. Rather, it provides a viable alternative for miner operators, particularly users of large, borer-type miners, who may be unhappy with their present methods of face ventilation.

## 3. State-of-the-Art Review and Concept Generation

An extensive investigation of face ventilation systems in general and extensible ventilation systems in particular preceded the design effort which led to the system described in Section 2. This investigation included three specific tasks:

a. visits to operating sections to observe various face ventilation techniques under a broad range of operating conditions.

b. a thorough search of the literature and patent files of the past ten years.

c. discussions with persons actively involved with mine ventilation problems and likely to be aware of recent developments.

The results of the investigation are summarized in the following sections. In some cases the details are presented in appendices as specified. General conclusions based on the investigation and a compilation of extensible ventilation concepts, tried or merely considered, are presented at the end of this section.

### 3.1 Summary of Site Visits

Several mining companies were contacted, and underground visits were conducted in seven mines. This underground exposure supplemented the literature review to provide a more complete understanding of face ventilation problems and past attempts of solving them.

The mines visited during this phase of the effort included:

| | |
|---|---|
| Keystone No. 1 | Keystone, W.Va. (EACC) |
| Federal No. 1 | Grantown, W.Va. (EACC) |
| Loveridge No. 22 | Fairview, W.Va. (Consol) |
| Kopperston No. 2 | Kopperston, W.Va. (EACC) |
| Harris No. 1 | Bald Knob, W.Va. (EACC) |
| Old Ben No. 21 | Sesser, Illinois (Old Ben CC) |
| Ellsworth No. 51 | Ellsworth, Pa. (Bethlehem) |

These visits are summarized in the following sections. More detailed descriptions of each visit are presented in the appendices. These descriptions discuss the general mining cycle used, the ventilation systems on the sections visited, specific equipment used, unusual or interesting techniques observed and general impressions of the operation with specific needs outlined. These summaries are not intended to be complete documents but rather to highlight critical areas.

Section 3.1.4 includes the results of the impressions formed based on our site visits. Here we discuss the equipment and types of operations where we observed the greatest need for improved face ventilation - those situations where extensible face ventilation systems are most likely to find acceptance.

### 3.1.1 Site Visits to Keystone No. 1. - Federal No. 1 - and Loveridge No. 22

Late in October 1974, Foster-Miller personnel visited the three subject mines and observed five operating sections. Keystone No. 1 employs brattice for face ventilation while Federal No. 1 and Loveridge (Consol No. 22) employ vent tubing. Four mining machines were observed. The machines observed and the ventilation system employed with each were:

(1) Lee Norse 105 Hardhead - brattice line ventilation

(2) Goodman 430 Borer - ventilation tubing

(3) Jeffrey 120 M Heliminer - ventilation tubing

(4) Joy Twin-Borer - ventilation tubing

All ventilation techniques included extension during interruption of the mining cycle to permit the addition of discrete lengths of tube or brattice cloth. The exception was the Goodman 430 section where standard 10 foot sections of duct held a slip tube which was manually extended by the miner operator during normal operation.

Details of the operation observed at each section are presented in Appendix C, D, and E.

### 3.1.2 Site Visits to Kopperston and Harris Mines

On January 8 and 9, 1975, Foster-Miller personnel visited two EACC mines in Southern West Virginia accompanied by Mr. William Desieghardt of EACC and Mr. Edward Divers, the project officer from USBM. The purposes of the trip included:

a. familiarize EACC R & D personnel with the objectives and practical aspects of the program,

b. familiarize all personnel with the practical problems to be encountered in meeting the contract goals as well as limitations of existing brattice operations.

Summaries of the overall mining operation and the details peculiar to particular sections are presented in Appendix F and G.

### 3.1.3 Site Visit to Old Ben No. 21

On February 4, 1975, Old Ben No. 21 Mine near Benton, Illinois was visited by Foster-Miller personnel with Mr. Edward Divers, technical project officer on this project, and Tony Covelli, and Frank Nagy, two other USBM personnel.

Appendix H summarizes the most improtant observations.

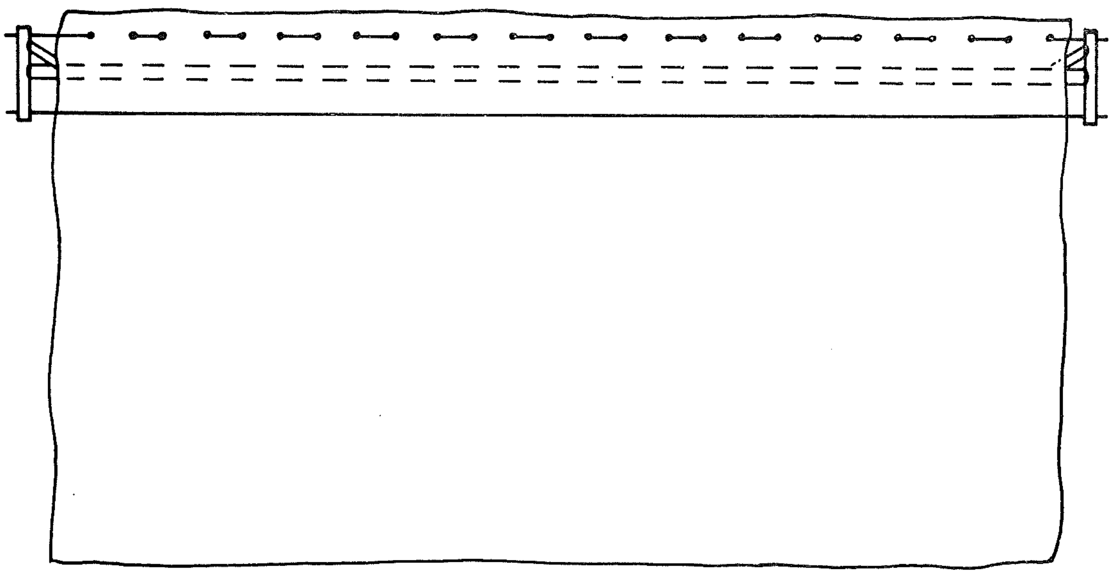
### 3.1.4 Site Visit to Ellsworth No. 51 Mine

FMA personnel visited Bethlehem Steel's Ellsworth No. 51 Mine in order to witness the operation of an extensible curtain system. The system consisted of a 15-foot section of brattice cloth mounted on an iron pipe frame, as shown in Figure 25. This frame was held against the roof by adjustable hooks mounted on roof bolt plates. As the mining machine advanced, the frame can be pushed forward on the hooks. This system was not used on a regular mine-wide basis.

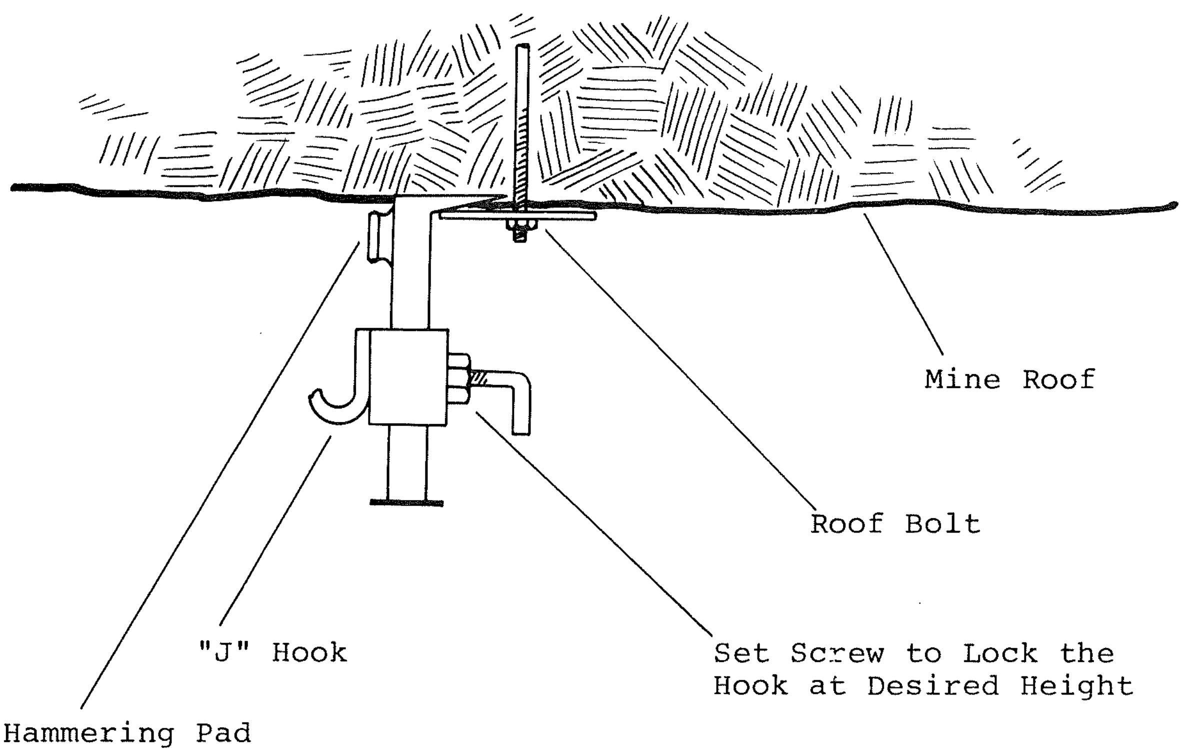
An improtant point which was made by the mining personnel was that the extending curtain should not be installed until the miner had advanced ten feet from the last roof bolt. They had found that if the brattice frame was positioned when the cycle first started, the chances were good that it would become entangled with the cutting head, often requiring major repairs of the brattice frame.

### 3.1.5 Conclusions Regarding Need for Extensible Systems

Based on the personal observations during the visits to operating sections and numerous discussions with miner operators, section bosses and superintendents, the following conclusions were drawn regarding the need for extensible ventilation systems:



(a) Brattice Frame




(b) Adjustable Roof Hook

Figure 25 - Extensible Curtain System

A. Ventilation Tubing and Auxiliary Fans

1. Ventilation tubing and auxiliary fans provide effective ventilation if the tubing is kept within 10 feet of the working face.

2. Keeping the tubing close to the face is most critical with boring machines because the borer's large size impedes air flow.

3. Keeping the tubing near the face is also more difficult with boring machines because of space limitations.

4. Ovalized tubing would be extremely useful on borer sections and on ripper sections where canopies damage the ventilation tubing.

5. Because of the severe ventilation problems associated with borer miners, they should be a primary goal for extensible ventilation.

6. If possible, the system developed should be adaptable to full face ripper miners as well.

B. Line Brattice

1. Brattice materials and fastening techniques require improvement on many sections visited.

2. Full face ripper machines could profit from the "sideboard" concept (Section 3.4.3) --providing the brattice line was on the left rib.

3. An extensible curtain that remains in the working place after the miner has pulled back would be desirable. This precludes machine-mounted systems, which would retreat with the machine.

4. A cantilevered curtain, manually extended by the miner helper, would be useful during mining and could remain in place during bolting.

5. This cantilevered curtain would be adaptable to "two-step" mining sequences, as well as full-face operations.

## 3.2 Patent and Literature Search

A patent and literature search was conducted, in order to learn from the experience of others and to avoid re-inventing someone else's design.

The patent search included the U.S. Patent class 98-50 "Ventilation, Mines" (the primary classification and subclassification) for the years 1960 through February 4, 1975. Several interesting inventions were uncovered but very few pertained specifically to extensible applications. Those patents which are of any potential interest are listed and capsulized in Section 3.2.1 for future reference. Those of particular interest are discussed briefly at the close of that section.

The Engineering Index for the years 1960 through 1974 was searched under the subject of "Mine Ventilation". This index covers the publications of mining societies, the Bureau of Mines and most mining and mining engineering journals. No specific references to extensible face ventilation systems were found but a number of papers which contain pertinent background information on face ventilation were uncovered. Abstracts of those papers of particular interest are presented in Section 3.2.2.

### 3.2.1 Review of Existing Related Patents

A patent search revealed only two U.S. Patents which applied directly to an extensible ventilation system. These are described briefly as numbers (1) and (2) below. These patents are reproduced in their entirity in Appendix I and Appendix J, respectively.

Other patents which relate to face ventilation techniques or which include technology which might be borrowed for this application are also summarized in the paragraphs below.

1. Ventilation Control System No. 3,464,756 J.V. Burgess 1969

Window shade (stretched out horizontally) deployment and retrieval of vent curtain. Cannister mounted on pogo stick--leading edge attached to mining machine. See Appendix I.

2. Mine Ventilation Control System No. 3,715,969 J.V. Burgess 1971

Extensible brattice system. Utilizes brattice support frame with prestressed cables and bars to slide along secondary supports complete with rollers and mounted on vertical columns which extend floor to roof. See Appendix J.

3. Coal Mine Curtain Rod No. 1,398,909 J.M. North 1921

An adjustable vertical post which spans floor to roof and provides a means for supporting brattice in contact with the roof.

4. Stiffening Fabric No. 2,301-047 J.A. Hendley 1942

A system of fabric and stiffening elements which lends stiffness to a fabric in one direction while providing rigidity in the other. This could be applied to the top edge of an extensible brattice system to improve sealing at the roof.

5. <u>Mine Ventilation Control System</u> No. 3, 118,363 J.V. Burgess 1964.

Another vertical post for supporting line curtain. It is spring-loaded, adjustable and reusable.

6. <u>Tunnelling or Mining Machine Canopy with Ventilation Ducts</u> No. 3,558,193, A.W. Howarth, 1969

A canopy for a tunnelling or mining machine includes a plurality of ducts or pipes along the axial direction to transport dust-laden air from the region in advance of the machine to the rear of the machine where it is collected or further transported.

7. <u>Mine Ventilation Apparatus and Method</u> No. 3,603,644, H.C. McCleary 1969

A method and apparatus for fully ventilating the face of a mined area by means of an auxiliary flow of air which ducts the normal flow ventilating air such that a relatively greater area of the face is contacted by the ventilating air.

8. <u>Mine Ventilation Control System</u> No. 3,636,852 J.V. Burgess 1970

This invention combines ventilation curtain and support members or stays. The stays are flexible and may be bent to fit between floor and roof. When released they straighten to contact floor and roof fixing their location and the position of the line curtain.

### 3.2.2 Literature Search

The literature search uncovered no reports related specifically to techniques or attempts to implement extensible face ventilation systems. Several documents have been found that relate to the need for improved ventilation at the face with continuous mining equipment. Other papers describe improvements to conventional face ventilation systems which may apply directly or indirectly to the extensible system proposed.

1. "Maintaining Ventilation to within Ten Feet of the Face While Mining with Continuous Miners," the topic of two different papers presented at the 1970-71 Mine Inspectors Institute of America by Michael Janc (Ohio Valley Division, Consol) and J. W. Fleming (Clinchfield Coal).

The paper by Janc gives several specific examples of extensible ventilation systems developed by the Lee Engineering Division of Consolidation Coal Company. Some of these efforts are discussed further in Section 3.3.1. The paper by Fleming describes the difficulties encountered in keeping face ventilation within 10 feet of the face.

Abstracts of those papers found most interesting are presented in the balance of this section. They are presented in reverse chronological order based on their publication date.

2. "Studies on the Control of Respirable Coal Mine Dust by Ventilation;" D. S. Kingery, et. al., U. S. Bureau of Mines Tech. Progress Report, 19 October 1969.

Experimental work has demonstrated the effectiveness of ventilation for controlling concentrations of respirable coal mine dust. Substantial reductions in dust concentrations have been attained by increasing the volume and rate of air movement across the face and by controlling the airflow pattern. Data secured from industry show that maintaining an airflow approaching 100 fpm across the entry, the experimental system reduced the concentration of respirable dust by factors as great as 6.4. In all mines where the system was used, the face-generated dust concentrations were reduced to below 3 mg/cu m.

3. "Applicability of Air Curtains as Air Stoppings and Flow Regulators in Mine Ventilation," G. Grassmuck (Ecole Polytechnique, Montreal, Que), Can Mining Met Bull v. 62 n 691 November 1969, p. 1175-85.

Question of whether the air curtain principle could be used under conditions prevailing in Canadian metal mines was investigated. A vertical, portable BERRY air curtain was tested, at first in a wind tunnel built at Ecole Polytechnique at full scale (8 x 8 ft cross section) to simulate a drift and its lateral connections, and then in the haulage ways of a metal mine under actual conditions. Results permit the prediction under what conditions this type of air curtain is capable of acting as an air stopping or flow regulator and how it could be further developed. 13 refs.

4. "Face Ventilation in Underground Bituminous Coal Mines - Airflow and Methane Distribution Patterns in Immediate Face Area - Line Brattice," J.V. Luxner, U.S. Bureau of Mines R17223, February 1969, 16 p.

The airflow and methane distribution patterns developed in an equipment-free entry 6.5 feet high and 12 feet wide, ventilated by line brattice operated blowing to or exhausting from the face, were determined by the Bureau of Mines for varying conditions. Results of these studies show that blowing line brattice systems of face ventilation dilute methane more effectively than comparable exhaust systems. The ventilating efficiency of any line brattice system is dependent upon the method of ventilation, the face distance, the tight rib distance, the volume of air delivered to the end of the line brattice, and the volume of methane released at the face. Experimental results indicate that maximum face ventilation efficiency is achieved when the inby terminus of the line brattice is installed 5 feet from the face and at a distance less than one-third the entry width from the nearest rib. Analyses of data are based upon the ability of a face ventilation system to dilute methane in the immediate face area.

5. "Face Ventilation in Underground Bituminous Coal Mines - Airflow Characteristics of Flexible, Spiral-Reinforced Ventilation Tubing," R.G. Peluso, U.S. Bureau of Mines R17058, February 1969, 13 p.

Methods and results of studies to determine friction and shock losses encountered in auxiliary face ventilation systems utilizing flexible, spiral-reinforced ventilation tubing are presented. The results, tabulated in graphic form, simplify fan selection and enable mine operators to design adequate auxiliary ventilation systems. A sample problem illustrates the use of graphs.

6. "Face Ventilation in Underground Bituminous Coal Mines - Performance Charcteristics of Common Jute Line Brattice," R.W. Dalzell, U.S. Bureau of Mines RI6725, 1966, 30 p.

The performance characteristics, efficiency, and operating pressure of jute line-brattice systems were studied under varying underground conditions; various fabric grades and installation methods were used. The test results indicate that line brattice system efficiency is dependent upon the method of ventilation, the method of installation, porosity of fabric, and size of tight rib area.

7. "Ventilation for Continuous Miners in Northern West Virginia," A.E. Belton, Coal Age v. 69 n 3 March 1964, p. 74-9, 82, 84.

Three case studies of ventilating systems for continuous mining demonstrate planning and operating discipline; application of face ventilation to various development systems shows that large volume of air is delivered to section; work cycle is simple and efficient; ventilation equipment and controls are simple and well-maintained; intake air travels over operating equipment; normally, shuttle cars do not pass through curtains; working places are concentrated, and ample rock dust is applied; diagrams show how maximum quality in ventilation is achieved.

8. "Ventilation of Continuous-Miner Places in Coal Mines," D.P. Schlick, R.W. Dalzell, U.S. Bureau of Mines - Information Circular 8161, 1963, 18 p.

Methods successfully used to ventilate continuous-miner places and factors that should be considered when selecting auxiliary ventilating equipment; line brattice can direct fresh air to active face reasonably well, provided adequate area for installation is available; continuous mining equipment, however, often restricts clearances to such extent that proper installation of line brattice is impossible; consequently, methods of auxiliary ventilation for continuous-mining equipment have been developed.

9. "Face Ventilation with Continuous Mining," P.C. Lingo, Mechanization v 26 n 9 September 1962, p. 39-43.

Results obtained from experiments and application of auxiliary fans used with continuous miners under actual mining conditions show that line brattice systems of ventilation are inefficient and very often fail to meet all requirements of proper face ventilation. Auxiliary fans and tubing, properly used, offer much more positive, efficient and reliable method of face ventilation.

10. "Determining Ventilation Requirements for Continuous-Miners," H.L. Hartman, Min Eng. v 14 n 3 March 1962, p. 58-62.

Rational analysis and systematic solution to problems of ventilation requirements of continuous miners consists of determining extent of methane and coal gas; selection of control measures which are most suitable; calculation of dilution required at face; effectively supplying ventilation; methods of ventilation.

11. "Face Ventilation and Dust Control," J.S. Todhunter, Min. Congress J v 48 n 1 January 1962, p. 38-40, 48.

Adoption of continuous mining equipment in Central Pennsylvania region has led to rapid liberation and accumulation of gas at face; since continuous miners are operated in congested areas, it is virtually impossible to extend line brattice to source of gas at face; experiments led to installation of auxiliary diffuser unit; diffuser is dual inlet centrifugal fan with impeller capable of withstanding 10,000 rpm, powered by 2 hp 3,450 rpm, d-c motor, and develops 900 cfm under normal voltage conditions.

12. "Brattice for Better Ventilation," S. African Min and Eng. J. v 72 n 3590, November 24, 1961, p. 1225, 1227.

Venticorset consists of heavy Vynide brattice cloth fastened at 12 in. intervals with spring stays; these are made of galvanized or coated tensile steel sewed on to Vynide with treated twine; sealing capacity improves with compression of Venticorset as surplus brattice cloth is pressed horizontally against hanging and footwall; application in channeling cool dry air to working faces.

13. "Face Ventilation with Auxiliary Fans," D.S. Kingery, Coal Age, v 65 n 2, February 1960, p 138-40, 142.

Solving problems of face ventilation in continuous mining of coal with auxiliary fans and tubing; comparison of various systems; using small blower or diffuser in combination with exhaust system provides advantages of both blowing and exhaust systems; diffuser capacity in combination system should be one-third to one-fourth that of intake when gas emissions are heavy; system installation and maintenance; safety problems; recommendations.

14. "Face Ventilation and Dust Control in Continuous Mining," C.M. Smith, Mechanization v 24 n 1, January 1960, p 45-52.

Release of methane; necessity of auxiliary ventilation; line bratticing; fans and tubing; current practices of face ventilation in coal mine; suppression and measurement of dust; problems concerning dust control.

15. "Survey of Face Ventilation Practices in Coal Mines," R.W. Stahl, F.F. Kapsch, U.S. Bureau of Mines Report Investigations, n 5560, 1960, 13 p.

Systems adaptable for condition due to increasing use of continuous miners, especially boring type, considered best from theoretical and experimental standpoints; installation of plastic brattice cloth increases air flow.

16. "Face Ventilation and Dust Control with Borer-Type Continuous Miners," paper presented by John J. Adams (Mountaineer Coal Co.) at 1959 National Safety Conference.

Describes underground experience with various experiments using blowing and exhausting fans with tubing--used on borer sketches.

17. "Auxiliary Ventilation of Continuous Miner Places," paper by R. W. Stahl presented at Annual Meeting of Coal Mining Institute of America, Dec. 13, 1957.

Describes a test program to improve face ventilation for a Colmol boring miner, using various combinations of duct brattice, and auxilliary fans, using both blowing and exhaust systems.

### 3.3 Industry Survey

In order to efficiently pursue new concepts in extensible ventilation systems, it was necessary to perform a brief survey of the industry, including equipment manufacturers, mining companies, and government personnel. This survey was undertaken with three major objectives:

a. To document previously unpublished experience in novel face ventilation techniques, particularly those systems which advanced with the mining machine.

b. To identify the major needs and/or shortcomings of existing face ventilation systems.

c. To identify commercially-manufactured equipment which could be useful in new extensible face ventilation systems.

There has been little documentation of previous attempts with extensible systems. For the most part, these systems were homebuilt and did not progress beyond use in one or two sections of a particular mine. However, identifying previous underground experience was valuable in several ways:

a. Identification of the factors that prompted experimentation with new systems.

b. Appreciation for the level of complexity acceptable to the men who designed and worked with such systems.

c. Exposure to the successes and failures of others.

Because so little of past experience has been documented, the only practical way to investigate the activity is through personal communication with personnel involved with this activity on a daily basis. Foster-Miller has contacted a number of people to seek information on activity in the extensible ventilation area. These included ventilation experts from MESA and USBM, operating personnel from a variety of mines and manufacturers of ventilation and mining equipment.

A list of those personnel contacted specifically with regard to this program is shown in Table II. These contacts provided additional insight into the requirements and limitations of extensible face ventilation systems. They also, in some cases, were aware of recent attempts to utilize extensible systems, some of which have been accepted and are used on several sections. These attempts are discussed in the following sections, together with a short history of face ventilation and the major conclusions reached during this state-of-the-art survey.

## TABLE II

## PERSONAL CONTACTS

### USBM Personnel

Divers, Edward

Kissel, Fred

Stein, Richard

Stahl, R. W.

### MESA Personnel

Bioni, Ted

Mitchell, Don

Dalzell, Robert W.

Cook, Joe

Elam, Bob

### Coal Industry

John Boroski - Superintendent Keystone No. 1

Larry Jackson - Superintendent Federal No. 1

Paul Carter - Superintendent Loveridge No. 22

John Paynter - Safety Director Kopperston No. 2

Chas. Johnson - Safety Director Harris No. 1

Al Salvadore - Safety Director Elsworth Division Bethlehem

Wayne Carmann - Chief Engineer Maple Meadowa Mine

Bill Laird - EACC

Carl Schaeffer - EACC

Dave Hazen - Lee Engineering

Travis Wellman - Peabody, Western Underground

Woods Talman - Former Safety Director, U. S. Steel

### Ventilation and Mining Equipment

Robert Stevenson - Vice President Sales - ABC Peabody

Mr. Force - Johnston-Morehouse-Dickey Company

Mr. Wm. G. Wilson - Sales Mgr. Johnston-Morehouse Dickey Company

R. Borowski - Schauenburg

Douglas Bolton - Production Mgr. Jeffrey Manufacturing

### 3.3.1 Brief History of Face Ventilation

Attempts at improving the face ventilation (beyond the brattice system) have been going on for a long time. The motivations for these attempts are discussed in the following section. In this section, a few of the many experimental approaches are discussed.

Some of the first attempts to bring air right up to the face occurred well before continuous miners were used. After shooting the face, the smoke hanging in the air often caused delays before loading could commence. This production bottleneck stimulated attempts to bring additional air to the face in order to rapidly improve visibility. Techniques employed included extending the brattice line and the use of compressed air or booster fans to blow air onto the face.

As continuous mining machines came into prominence, numerous attempts were made to mount booster fans on the machines. These were probably the first true self-advancing face ventilation systems. At this time, there were two primary motivations - extremely high gas liberation on some sections, and the difficulty of providing adequate primary ventilation (using brattice), particularly on boring-type machines such as the "Colmol". Some of the techniques are worth mentioning. As background, it should be mentioned that virtually all face ventilation at this time involved blowing systems - that is, fresh air was brought up behind the canvas where it then swept across the face and exited back down the entry.

It should be noted that during the early days of experimenting with booster fans a number of unfortunate experiences occurred, primarily because of recirculation of "used" air. These experiences actually led to the prohibition of booster fans in some states. To this day, there is a sizeable segment in the mining community which retains a prejudice against the use of booster fans.

The Colver-Sonman (EACC) slope mine was experiencing extremely high methane concentrations on one section which used a Colmol miner. This type machine was all-hydraulic, and included one hydraulic pump which ran a small tail conveyor. A small hydraulic fan was plumbed into this circuit and mounted in the throat of the machine to blow 500 or 600 CFM of air on the face. Ten or twelve inch tubing ran back from the fan and attached to either the left or right side of the conveyor boom, depending upon which side of the entry the canvass was on. In this way, the brattice had to be advanced only to the back end of the miner when the air would be induced into the tubing and blown on the face by the fan, as shown in Figure 26. In order to obtain approval, this system was demonstrated to USBM inspectors, where it was proven that methane concentrations at the face could be reduced from 10 percent down to 1 percent by the use of the fan. The system worked well while mining the gassy seam and continued in use until Colver-Sonman was mined out and closed in 1960.

There were a number of variations on this theme tried by other people in other mines, including several documented by R. W. Stahl in R. I. No. 5414, a 1958 USBM publication. These included mounting the fan at the rear of the machine and ducting up to the cutter head, using a portable fan which was positioned on the floor at the end of the canvass. Blowing systems were also used in combination with an exhausting auxiliary fan at the crosscut and non-collapsing tubing extending up the entry as far as the miner. This latter approach was motivated primarily by the desire to decrease dust levels in the entry, and could be considered the precursor of the modern system of a diffuser fan used in conjunction with an auxiliary fan and tubing.

Efforts were also made to get the ventilation closer to the face without using auxiliary fans. One technique used with boring machines took advantage of the arch-rib geometry to hang brattice without restricting the roadway. This involved hanging the canvass with spads at the roof and then tucking the brattice under at

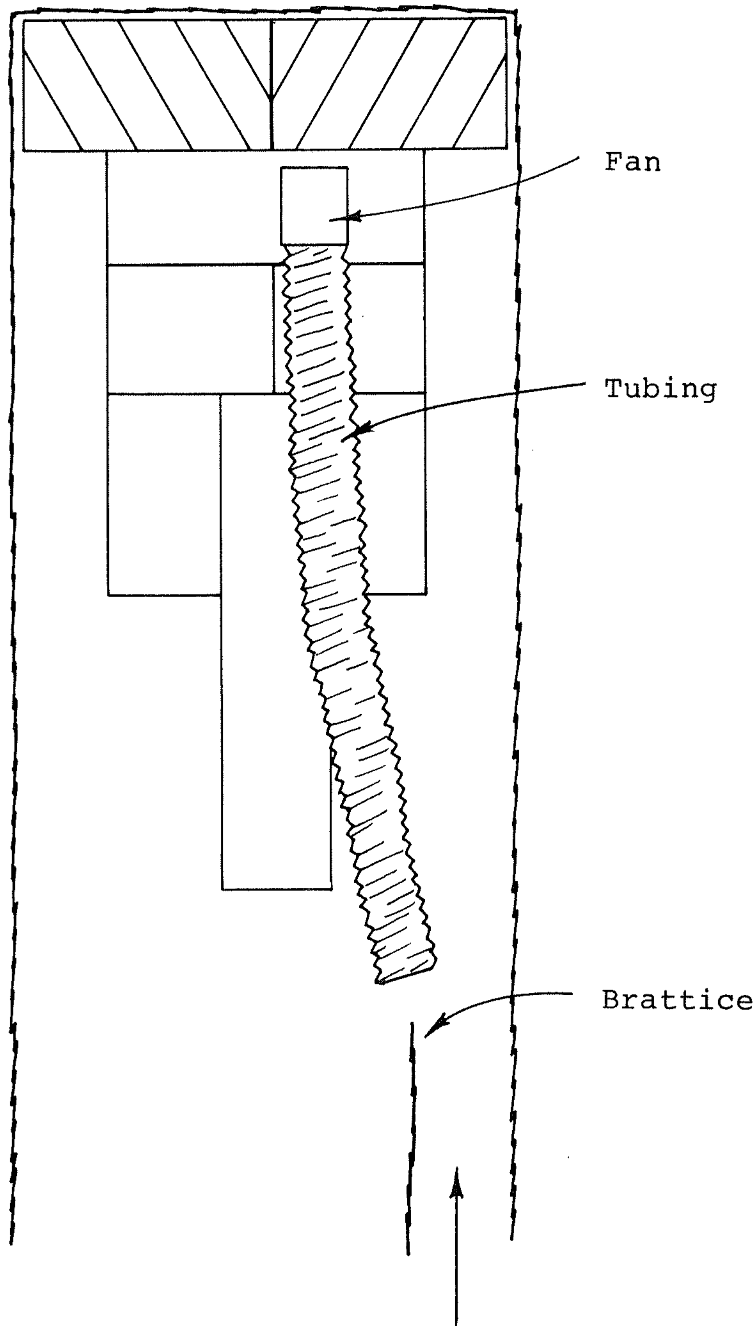



Figure 26 - Auxiliary Ventilation System Used at Colver-Sonman Mine

the bottom, also holding it with spads, as shown in Figure 27. In this way, at least 8 square feet of area behind the curtain could be assured and yet the curtain did not protrude into the main part of the entry. Note however that this system would be impractical with an exhausting ventilation system, because the curtain would collapse against the rib.

Barnes and Tucker also worked on a novel brattice system for use with the Colmol. This involved a special section of curtain mounted on a frame like the one in Figure 28 which could be pushed forward as the miner advanced. Such a system is still employed today in a number of mines including the Ellsworth Division of the Bethlehem Mines, discussed in Section 3.1.4. Other mines, such as the Midwestern Division of Peabody, are investigating such systems because they are being forced to convert to exhausting face ventilation, maintaining the curtain within 10 feet of the face.

One of the first self advancing, exhausting systems of which we are aware was tried by Mountaineer Coal in the late fifties. This system utilized an exhausting fan and dust collector mounted in the throat of a Joy boring machine. Ducting was then extended back along the machine, over to the rib and back to the crosscut (using flextubing since this was a pressurized system). There were major deficiencies to this system including:

1. Insufficient air flow (3500 cfm) during times of high methane liberation.

2. Minimal equipment clearances, which resulted in damage to fan and tubing.

3. Undesirability of having to shut down the fan to add joints of tubing as the machine advanced.

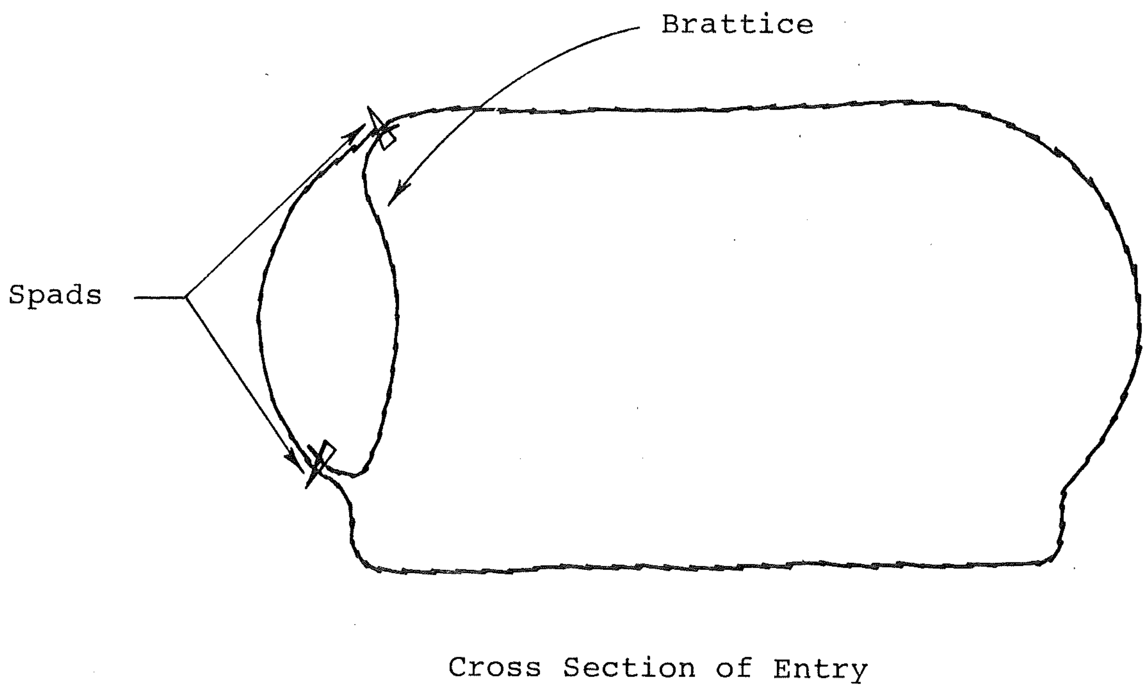



Figure 27 - Brattice Application for Borer Ventilation

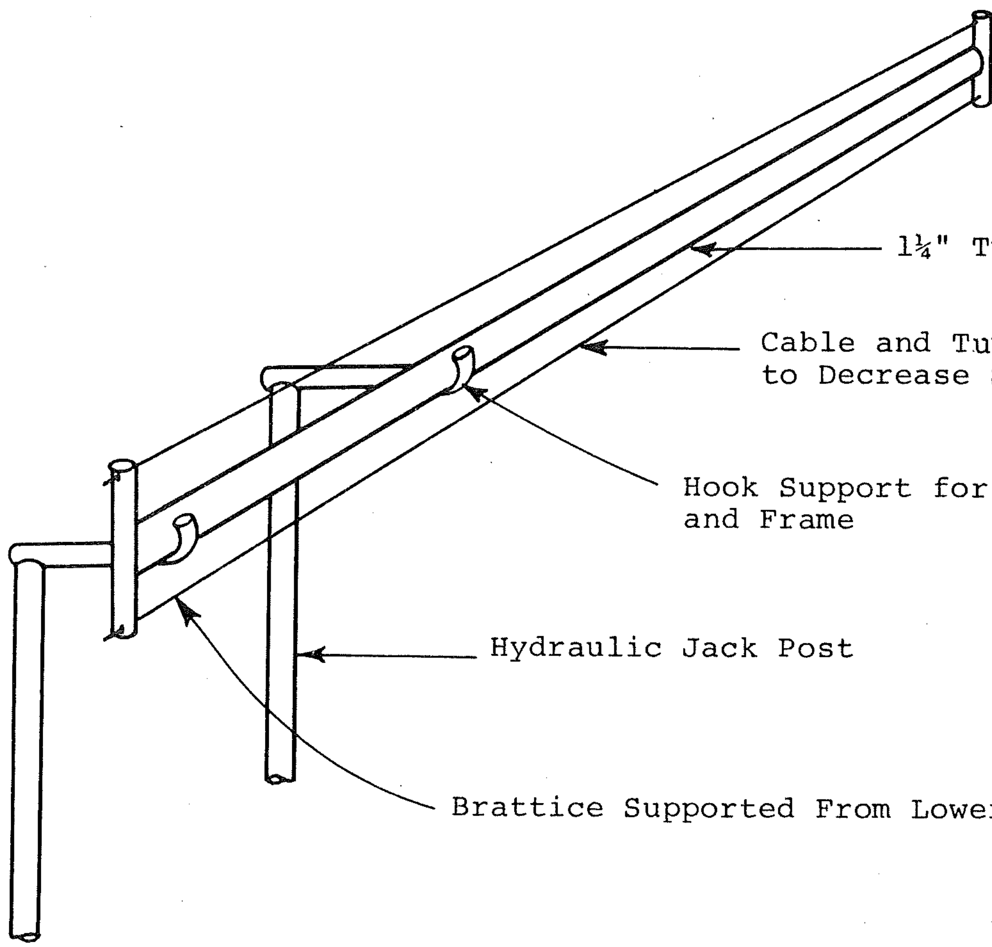



Figure 28 - Barnes & Tucker Extensible Brattice Support

Recent attempts at implementing extensible face ventilation systems have concentrated on auxiliary fan and tubing. There are a half dozen systems that are worth mentioning in order to paint a representative picture of contemporary thinking in the industry.

The British for years have used a self-advancing face ventilation system which utilized the flexible wire-wound non-collapsing tubing. Because of the high roofs in their permanent entries, they are able to suspend a wire from the face back along the roof. The flexible tubing is then hung from this wire cable. Several joints of tubing are then compressed onto a mandrel which is mounted atop the mining machine. As the machine advances, the tubing "accordians", increasing in length as it is pulled off the mandrel, as shown in Figure 29. This mandrel is used to keep the tubing from buckling while it is in the compressed state. The system is unidirectional in the sense that there is no provision for compressing the tubing back onto the mandrel if the machine has to back up or tram out of the place. This system was tried in the U.S. on continuous miners (Ohio Valley division of Consol) using a machine-mounted pipe of adjustable height to hold the mandrel. One of the major technicalproblems has been finding a way to tension the compressed tubing on the mandrel, allowing it to pay off in a controlled manner without all falling off in a heap.

A variation of this design has been developed by Lee Engineering, in which a 1/8" steel wire extends from an arm on the miner, goes a short way down the entry, and attaches to the rib. Using a motor-operated tensioning reel, the cable can pay out as the miner advances while still staying taut. Flexible tubing is then suspended from the cable. When the tubing is fully stretched, a joint is disconnected, several sections are compressed, and a new length added. Other Lee concepts include a machine mounted fan, with blower tubing discharging into larger tubing mounted on the roof.

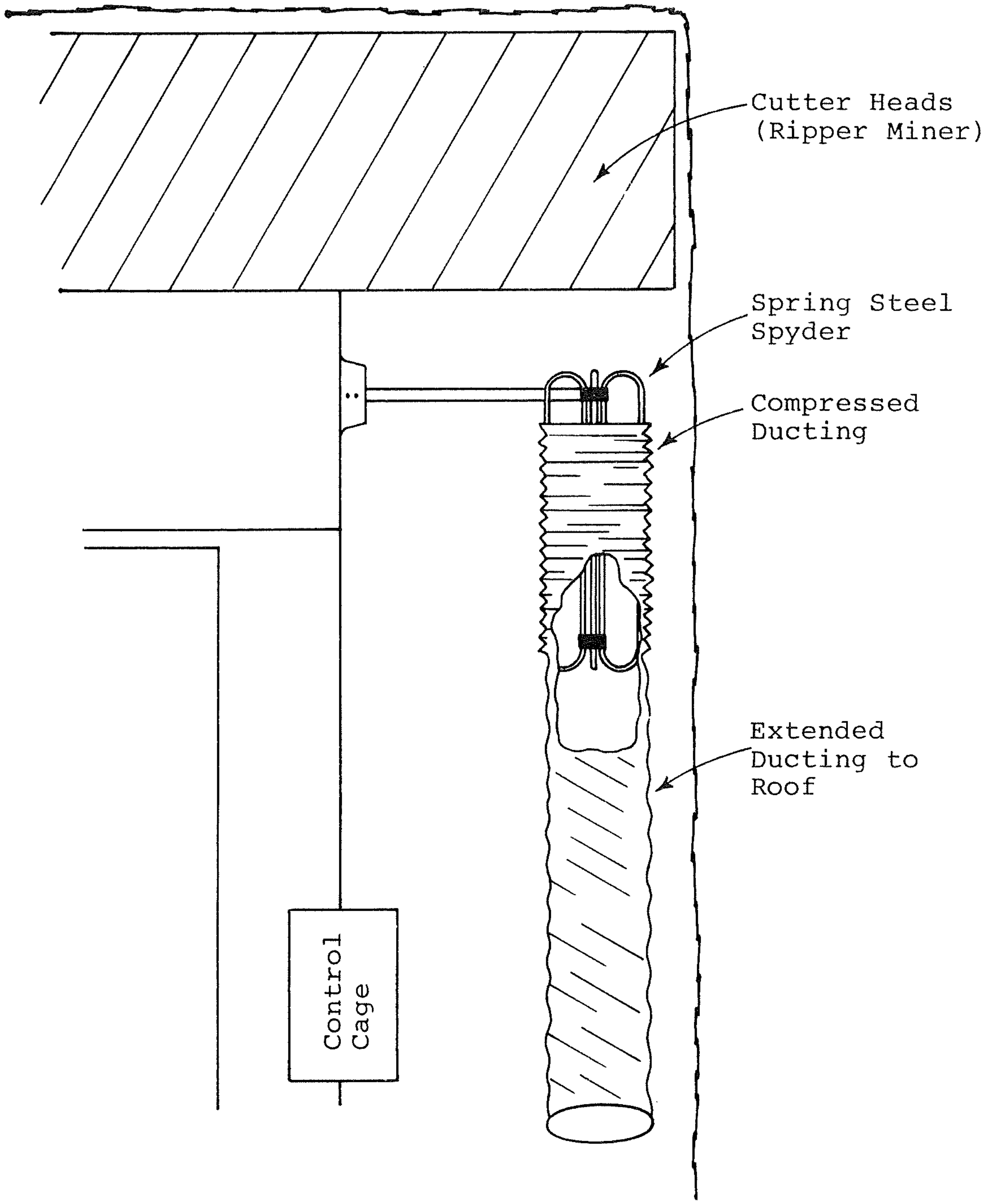



Figure 29 - British Self-Advancing Face Ventilation System

Consol has also worked on a cantilevered tubing support system similar to the curtain rod concept described earlier for use with brattice cloth. Several mining companies have installed machine-mounted fans which exhaust through blower tubing which trails along the floor behind the miner. These systems generally failed because of damage to the tubing. On the other hand, if the tubing was positioned along the rib to keep it out of the way, it became difficult for the tubing to slide forward as the miner advanced.

A very popular system in use today is the telescoping tube system, in which rigid tubing is suspended along the roof up to the last roof support. A smaller size tubing is then placed inside the last section and is pushed forward to keep the end within 10 feet of the face. Considerable sag occurs as the smaller tube is advanced, and Lee Engineering, among others, developed a set of rollers which they installed on the tubing to keep the smaller piece co-axial during extension, as shown in Figure 30. The tubing was designed for use with a new roof support system which was never used.

This brief history will serve to give some insight into what areas have been investigated in the past, why they were tried, and what kind of results were obtained. The following three sections outline the major conclusions which were formulated as a result of this study.

### 3.3.2 Face Ventilation Requirements

The major requirements of a face ventilation system, all of which at one time or another have prompted experimental extensible systems, include the following:

1. To improve visibility, i.e., lower dust and/or smoke levels.

2. To improve a local mining condition, such as unusually high methane liberation on one section.

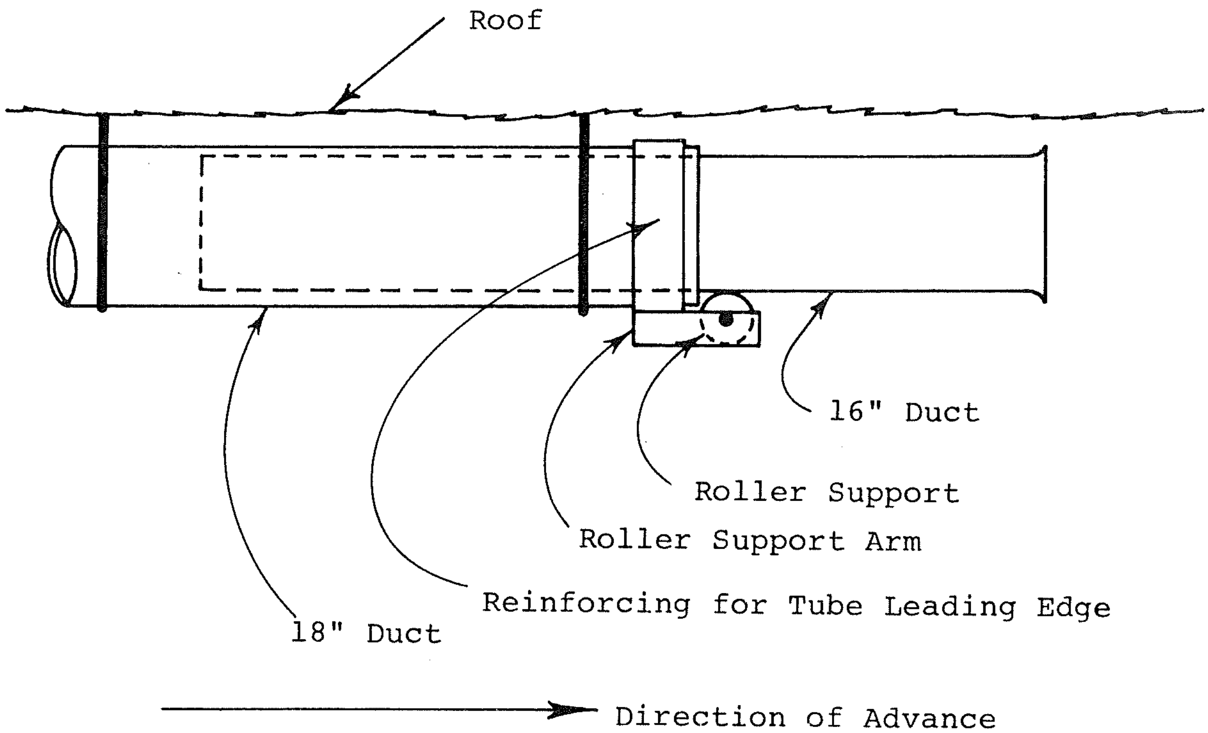



Figure 30 - Roller System for Telescoping Ventilation Tubing

3. To minimize an equipment problem, such as the difficulty of ventilating around big miners like the boring machines.

4. To satisfy the law, including methane standards, dust standards, and the maximum-distance-from-the-face standard.

Virtually, all of the experimental systems described in the previous section were directed at one or more of these requirements. Unless a new system is directed toward a specific need, the probability of successful underground implementation is small.

#### 3.3.3 Available Equipment

During the design phase of this program, attempts were made to use commerically available equipment wherever possible. Unfortunately, the new ventilation concepts often required new hardware. However, several manufacturers indicated a willingness to market new products if they were needed in the implementation of new face ventilation systems which had proven successful on an experimental basis.

### 3.4 Extensible Ventilation Concepts

Based on observations during mine visits, general requirements were formulated for extensible ventilation systems. These requirements were discussed with knowledgable individuals during the industry survey and descriptions of previously attempted or proposed solutions were solicited. A number of concepts for extensible ventilation systems were generated or discovered in this way. In some cases, solutions proposed by Foster-Miller personnel recalled past attempts by mine operators and produced suggested modifications based on past experience. As a result of observations, discussions, and patent information a number of concepts for extensible ventilation systems were conceived. These are summarized on Table III and described in some detail in the remainder of this chapter.

TABLE III

EXTENSIBLE VENTILATION CONCEPTS

| | Concept Designation | Concept Description |
|---|---|---|
| Brattice Line | Extensible Sliding Panel | Brattice panel supported by rigid pipe which cantilevers from jack or roof mounted roller supports located under bolted roof. |
| | Farm Gate | Brattice panel stretched over lightweight frame which swings from single jack support at the end of the brattice line. |
| | Sideboard | Vertical panel mounted from machine to roof to direct air close to the face as machine advances. |
| | Retractable Screen | Machine mounted cannister from which brattice cloth is drawn as machine advances. Opposite end of brattice attached to end of brattice line. |
| | Multi-Stage Scissors | Flexible or folding brattice extended by multi stage scissors arrangement cantilevered from post at end of brattice line. |
| Tubing and Brattice | Machine-Mounted Fan | Class of concepts using small fans and a system of ducts mounted on the miner to draw contaminated air from the face and discharge it behind line brattice or into rib or roof mounted tubing. |
| | Independent Mobile Fan | Auxiliary fan mounted on tracks or wheels and capable of self advance either automatically or by remote control. The fan could be adapted to extend tubing during advance or interface with brattice. A similar concept, funded by USBM, is currently being developed in which a trailer-mounted scrubber is towed by the mining machine. |
| Ventilation Tubing | Cantilevered Slip Tube | Conventional ventilation tubing mounted on roof or rib with slip tube extended, but not supported, by machine during advance. |
| | Machine-Mounted Duct | Ducts, integral to, or mounted on the mining machine interface with roof or rib mounted ventilation tubing and an auxiliary fan through an extensible member such as sliding or accordian section. |
| | Telescoping Wire-Reinforced Tubing | Flexible tubing stored on a mandrel expands lengthwise as the miner advances. |
| | Rib Ventilation | Duct is formed by using sheet metal pushed against side of rib which is curved (borer) or hollowed out. |

The concepts have been divided into four categories based on their potential application - brattice line systems, vent tubing systems, combination systems, and systems which use the entry itself as part of the duct. Many of the concept categories include several variations. These are presented in the disucssions which follow in the remainder of this chapter.

Two specific concepts - the extensible sliding panel and the rib configured duct for borer applications - are described in extensive detail in Section 4 and Section 5 of this report. Included are detailed hardware descriptions, proposed operating sequences, mine test descriptions, results and recommended system modifications.

The recommended, roof-mounted, machine-extended duct system was discussed in Section 2.

### 3.4.1 Extensible Sliding Panel

The sliding panel concept for extending brattice line systems comprises a rigid or flexible panel supported from a rigid frame which cantilevers from a support or pair of supports located under permanently supported roof at the end of the conventional brattice line. Figure 31 portrays a typical panel in use. The panel is advanced toward the face during the cycle by sliding on the support surfaces or on rollers which capture the frame or panel.

This concept was originally mentioned by Mr. Ted Bioni, of MESA. A number of variations of this concept have been tested in mines with varying results. One version tried by Barnes and Tucker is mentioned in Section 3.3.1. Another version has been patented by Mr. J.V. Burgess as described in Section 3.2.1. Other versions have been tried in mines across the country, usually credited to the individual who introduced the hardware into the particular mine, e.g., "Sullivan Slider", or "Kisky Curtain."

In general, panels of this type are workable but tend to be cumbersome due to the required length and the weight necessary to achieve the desired stiffness. A detailed description of one possible panel configuration and the results and suggested modifications based on in mine testing is presented in Section 4.

### 3.4.2 "Swinging Farm Gate"

The "swinging gate" concept is sketched in Figure 32. It comprises a pair of rigid panels or flexible panels stretched over rigid frames and hinged together along one side. This assembly cantilevers from a hinged support on a roof jack placed at the end of the conventional brattice line under the last row of roof bolts. At the start of the cycle the gate is folded back along the brattice line. When required the gate can be swung around to extend the

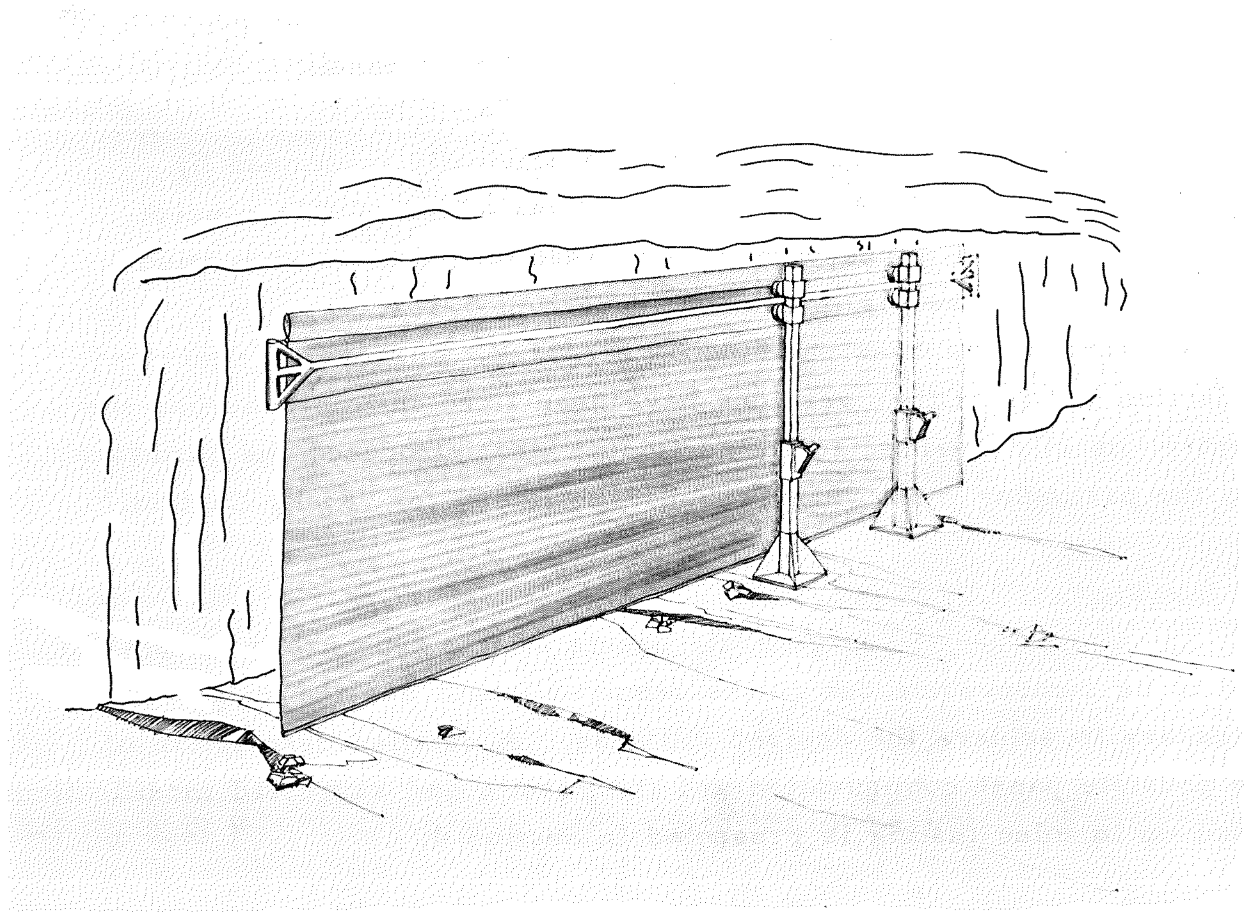


Figure 31 - Extensible Sliding Panel Concept

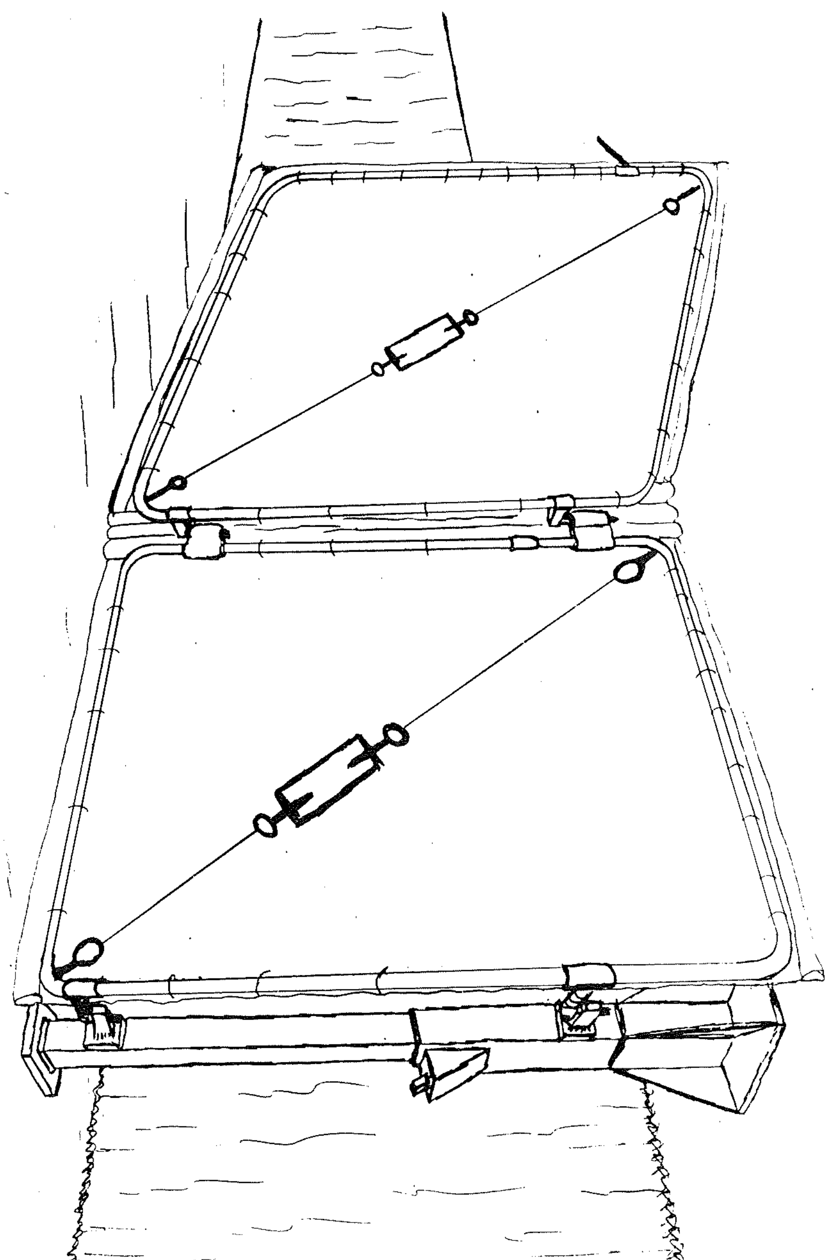


Figure 32 - Farm Gate Extensible Panel

ventilation an amount equal to a single folded gate length. After additional face advance the secondary gate panel can be unfolded from a safe location under supported roof by using a light weight pole or bar.

This concept was brought to our attention by Mr. Woods Talman, formerly of U S. Steel Corp. The concept was implemented by him and Mr. John Dickinson, Chief Inspector, Gary District. They feel that, with adequate primary air, losses at the roof and floor clearances will not present problems.

The advantage of this type of system is that the "gate", when extended does not protrude back into the "safe" area (i.e., under supported roof. Thus, if a roof fall collapses the gate no part of the mechanism will protrude back to harm men working in the zone of supported roof. The major disadvantage is the large amount of space required to swing the gate into position.

### 3.4.3 Sideboard

This machine mounted system is shown on Figure 33 It comprises a semi-rigid machine-mounted panel which extends vertically from the side of the machine to the roof. It is mounted so that the leading edge is within ten feet of the front of the cutting drum. Construction materials can range from compliant materials such as belting which could be permanently fixed in position to a rigid hinged frame which can be lowered during machine tramming.

The gap between the brattice line and the sideboard is critical, particularly for sections using "two-step" advance of the face. This gap may be closed by a flexible panel or "flap" attached to a post at the end of the brattice line. This permits some lateral motion of the mining machine while maintaining adequate ventilation.

A serious limitation of this concept is the reduced operator visibility. This is particularly objectionable if the sideboard

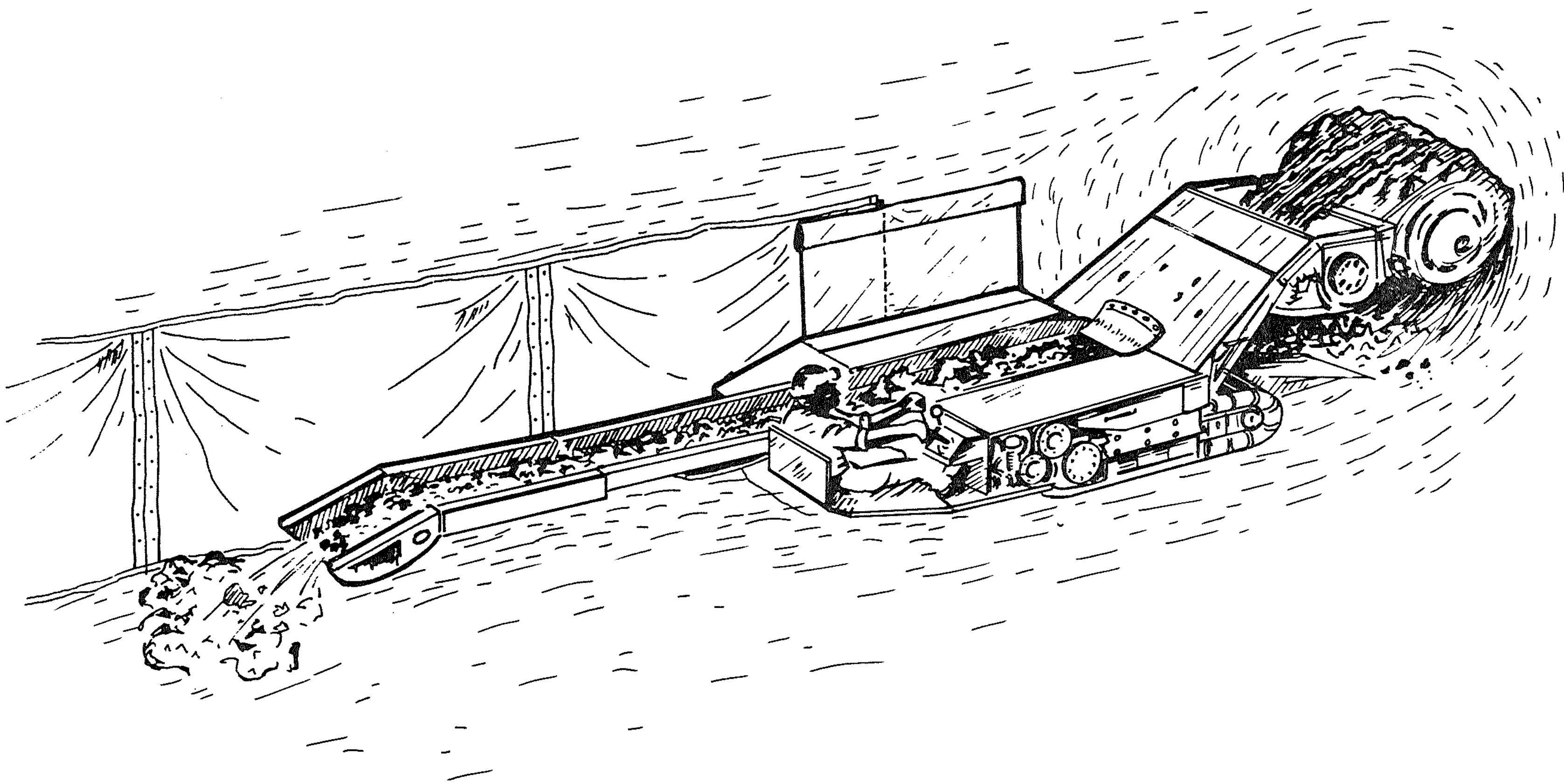


Figure 33 - Continuous Miner With "Sideboard"

is on the operator's side of the machine. To minimize the effect on visibility, the sideboard must be lowered during tramming.

No evidence has been found to date of the use of this system or a similar system in any coal mine.

### 3.4.4 Retractable Screen

The retractable screen system utilizes a spring-loaded canister containing brattice cloth on a retractable roll. It resembles a home movie screen turned on its side and mounted on the miner as shown in Figure 34. The end of the rolled up curtain is fastened to a post at the end of the fixed brattice line.

As the miner advances the curtain material unrolls, automatically extending the ventilation system as far as the fixed mounting location on the mining machine. During backing, the spring loaded action rerolls the outstretched brattice material. Such a system was fabricated, installed and tested at one time by American Brattice Cloth Corporation of Warsaw, Indiana.

A particular problem with this concept was the development of a static charge and subsequent adhesion of dust to the plastic material, eventually causing malfunction. This could be overcome by using conductive brattice materials, but similar problems with the retractor are likely in the mine environment. The design would require the use of large operating clearances to minimize failures of this type.

### 3.4.5 Multi-Stage Scissor Support

This concept is presented in Figure 35. It is built around a multi-stage scissor assembly similar to that used in automotive jacks of the same name. This scissor arrangement extends horizontally from a rigid post at the end of the brattice line. The

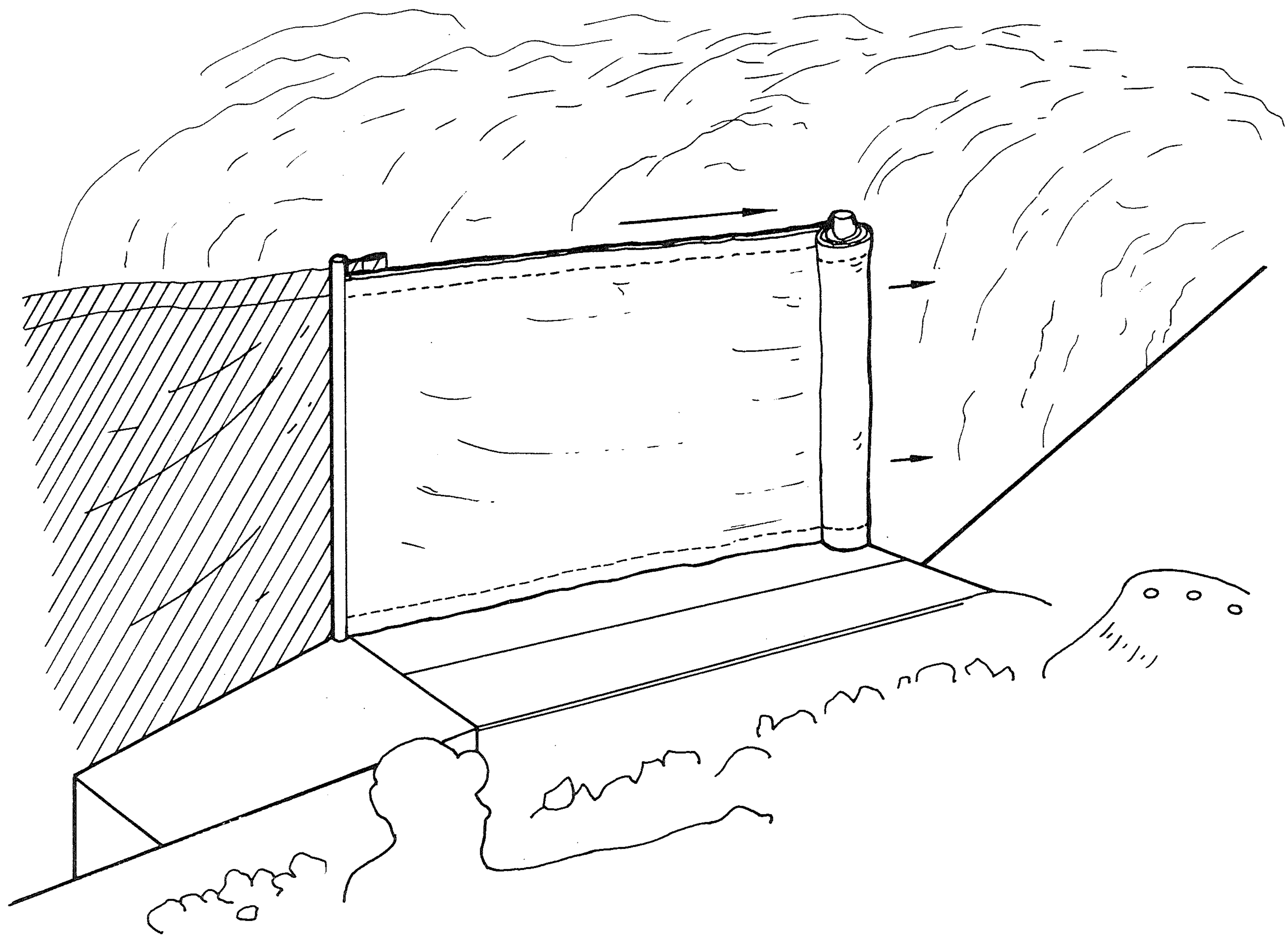


Figure 34 - Retractable Screen on Mining Machine

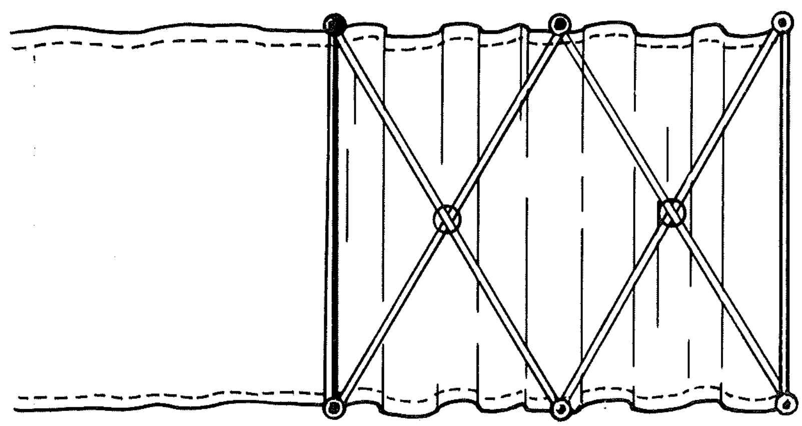


Figure 35 - Multi-Stage Scissor Support

scissor frame supports either overlapping sheets of semi-rigid, light-weight plastic or a flexible brattice material with vertical stiffeners to minimize deflection toward the rib under ventilation pressures.

In its collapsed mode this device is relatively compact, having no parts longer than the height of the coal seam. Because of the construction, with many pinned, load-carrying joints, it is heavy and susceptible to damage from mechanical loadings and careless handling. It offers no significant advantages over the less complex, lighter weight systems discussed earlier. We are aware of no application of this or a similar device in any mine.

### 3.4.6 Machine Mounted Fans

Fans mounted on the mining machine in close proximity to the cutter heads are valuable in maintaining adequate ventilation of the face for both brattice line and ventilation tubing installations. They may be used as diffuser fans with the outlet directed toward the face in such a way as to assist primary ventilation, or as collectors, drawing air from the face and ducting it toward or directly into the primary system - used with or without integral scrubbers. Used as collectors in conjunction with machine mounted ducts the fans can be integrated into an extensible face ventilation system.

With the fans mounted at the front of the machine, the ducts are under positive pressure-permitting the use of light, flexible material rather than rigid ducting. This simplifies retrofitting of existing machines and minimizes damage due to roof falls or careless handling.

The most desirable long-term solution would be ducts designed into the machine and located internally where possible. This would eliminate the damage problem associated with externally mounted fans and ducts. It would permit fans location at any point along the machine-mounted duct length. This type of system is further discussed in Chapter 6.

The critical problem with the machine-mounted fan/duct system is the transition from the machine to the fixed tubing or brattice line. For tubing installations the outlet from the machine must connect directly to the duct. For brattice line installations the outlet may simply trail behind the curtain discharging into the return. No truly satisfactory solution has been found for the transition in either case. In both cases the solution is simpler for ventilation returning on the left rib. For right hand ventilation systems, the transition interferes with operator visibility if it crosses between the operator and the face and with operator mobility if it crosses behind him. Operator interference is eliminated with left hand ventilation although damage to the transition pieces is a potentially serious problem. These transition pieces are difficult to envision for machines that operate over a range of distances from the rib, such as in a two-step mining cycle. A system that permitted ventilation to return along the left rib under all circumstances would generally improve ventilation quality and facilitate the machine-mounted fan concept.

The primary disadvantage of machine-mounted ventilation systems is the loss of their effect as the miner backs away from the face. For a "two-step" cutting operation their effectiveness during the cut opposite the ventilation is unsatisfactory.

Machine-mounted fans have been used in the past in a number of applications. Use of a fan as a diffuser with a Colmol at the Colver-Sonman mine was discussed in Section 3.3.1 as was a similar effort by R. W. Stahl. In both of these applications fresh air was ducted to the face from the rear of the machine. An attempt by Mountaineer Coal to mount an exhausting fan and dust collector on a Joy machine is also discussed in Section 3.3.1.

### 3.4.7 Self-Propelled Fan

To provide the advantages of a fan near the face without the problems and disadvantages associated with machine mounted fan and duct systems, the possibility of a free standing, self-propelled fan with tubing attached was considered. A remotely controlled, track-mounted unit was envisioned that could be advanced beyond permanently supported roof behind the mining machine. This system would provide a means for ventilating the first cut on a two-step cutting cycle while the mining machine made the second cut. It would be very valuable with a remote mining system where the ventilation system must extend up to forty feet or more.

At the present time, however, the self-propelled fan and duct system has limited applicability because of space limitations near the face. Its potential for use with a remote mining system may prompt additional interest in the future.

A variation on this theme is currently being developed with USBM funding. The current design provides a fan-scrubber on a transfer car which is towed behind the mining machine. A model of this system is presented in Figure 36.

### 3.4.8 Cantilevered Slip Tube

A telescoping, cantilevered slip tube is widely used to provide extension capability for tubing ventilation systems. In its simplest form it consists of a length of rigid tubing slightly smaller in diameter than the tubing mounted to the roof. As the miner advances, the slip tube is extended by the operator so that it cantilevers from the end of the fixed tubing. In some mines effort has been devoted to techniques for reducing the sag of the tubing by using rollers and guides (described in Section 3.3.1), or by propping the free end on the miner. This concept remains the simplest, most satisfactory general approach to extensible ventilation.

Disadvantages of this approach observed in the field include:

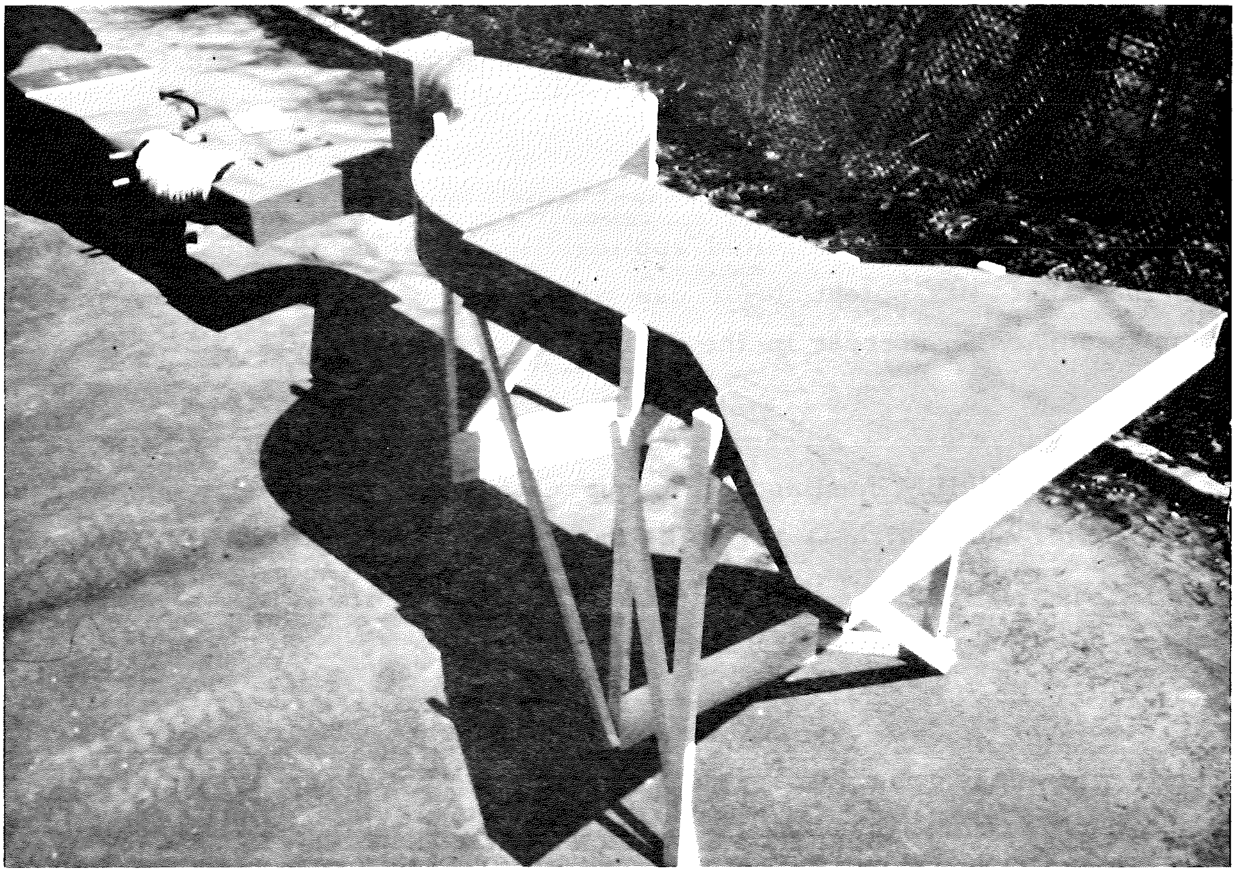


Figure 36 - Trailer Mounted Fan and Scrubber

a. interference with operator's position or visibility when installed and used correctly on the operator's side.

b. interference with canopies on loaders and shuttle cars - particularly with large diameter tubing.

c. Extension to within ten feet of face is at the discretion of the operator.

d. On sections using boring machines, removal of all tubing was required before tramming the machine out of the place.

The above limitations, observed on a number of sections ventilating with the aid of a cantilevered slip tube, rigid duct and auxilliary fans prompted the following suggested modifications:

a. Where possible, install vent tubing on the left side (opposite the operator) - this minimizes interference with the operator and generally provides him with better air. Custom fabricated sections are required to cross the entry if the primary return is on the right side.

b. Use commercially available oval duct instead of round to minimize canopy interference. Special pancake sections are required at intersections.

c. Attach the leading edge to the machine so that extension as the machine advances is automatic.

d. For borer applications, tuck the tubing into the arched rib to minimize roadway intrusion and permit the borer to tram past the tubing without its removal.

These modifications were incorporated in two extensible tubing systems built and tested under this contract. These systems are described in Sections 2 and 5.

### 3.4.9 Machine-Mounted Extensible Duct

A natural outgrowth of the machine-extended cantilevered slip tube system described above is a machine-mounted duct system that interfaces with the fixed tubing through an extensible link. The duct must be sufficiently rigid to support the negative pressure produced by the auxilliary fan exhausting into the return.

A system of this type utilizing a machine mounted mandrel containing flexible wire-wound non-collapsing tubing is commonly used in British mines. Another system developed by Lee Engineering uses a machine mounted steel cable to support flexible tubing in a similar manner. Both approaches are presented in Section 3.3.1.

Problems with this general concept as with the machine mounted fan concept discussed in Section 3.4.6 are in bridging from the machine mounted duct to the fixed tubing without interfering with the operator. Where the tubing must run along the right side of the entry, operator interference is unavoidable.

A machine-mounted, rib-configured duct system for use on borer sections was built on this program. Its goals were:

a. minimize effect on operator visibility and passage clearances by keeping oval duct against the rib at mid passage height.

b. permit borer to tram out of place with tubing intact.

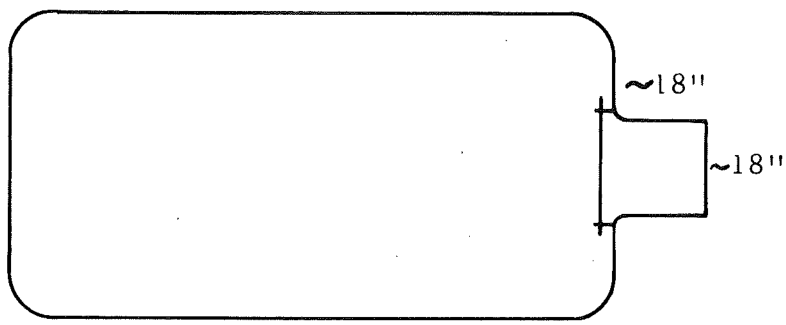
c. maintain duct within 5 feet of the face for drastically improved ventilation.

Although a conceptually simple and lightweight system was envisioned, the modifications required to provide adequate support, component strength and geometric flexibility increased the weight and size of the components significantly. The system was found to be impractical for use in the severely limited space available beside the borer. A detailed description of the system is presented in Section 5.

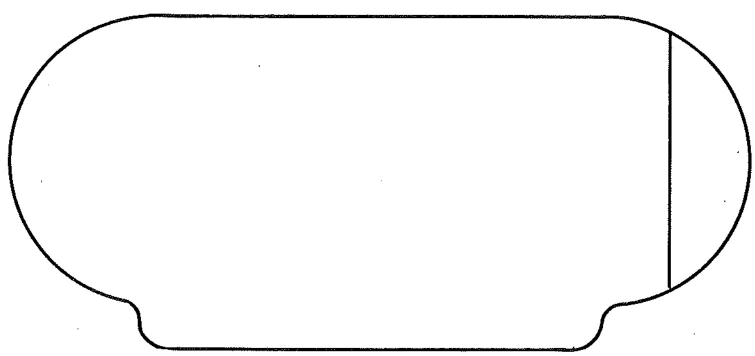
### 3.4.10 Integral -rib System

The ideal tubing system is one which takes up little or no space in the entry. Theoretically, such a system is possible by cutting an entry with a cross-section geometry as shown in Figure 37(a) The open side of the "duct" could be sealed with strips of brattice cloth, sheet metal, etc. Since the miner is used to cut the "duct", the "duct" is always extended to the face. Unfortunately, problems of roof and rib control keep this solution in the "theoretical" category.

A variation on this theme could be applied to borer sections, utilitizing the curved rib as shown in cross-section in Figure 37(b). Again, practival considerations unfortunately enter the picture--in this case, the fact that the miner often "jogs" (i.e., does not cut ahead in a straight line) - sometimes producing right-angle breaks in the rib-line of 3 or more feet.




(a) Cross Section of Entry Showing "Duct" Created By Rib-Cut, Sealed With Cover and Brattice or Sheet Metal



(b) Cross Section of Borer Entry, With Duct Formed By Curved Rib, Sealed With Brattice, Sheet Metal, Etc.

Figure 37 - Integral-Rib Face Ventilation Concepts

## 4. Extensible Brattice Panel

Based on the results of observations at the face, discussions with interested persons and the literature and patent review discussed in previous sections, a specific design evolved for an extensible brattice panel. The panel is particularly applicable to cycle mining where the face is advanced no more than 20 feet without roof bolting. The panel would be workable on a ripper section with the line curtain running on either the left or right rib.

The design and intended operating procedures are presented in the following section. This is followed by a description of the in-mine test program, a discussion of the limitations of the system, and a summary of the modifications recommended for an improved system.

### 4.1 System Design and Operation

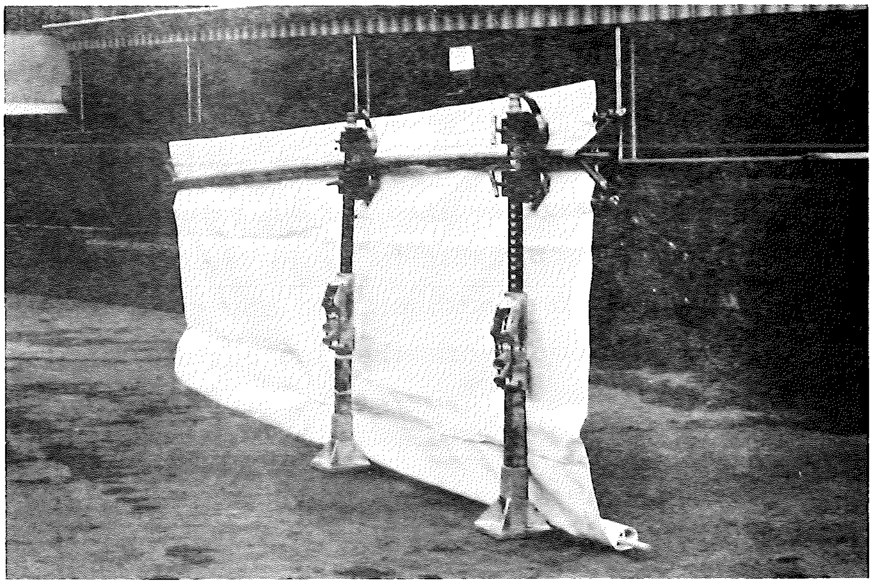
The extensible brattice system built and tested during this program consists of three major components:

a. a brattice panel 14 feet in length suspended from a reinforced steel pipe frame.

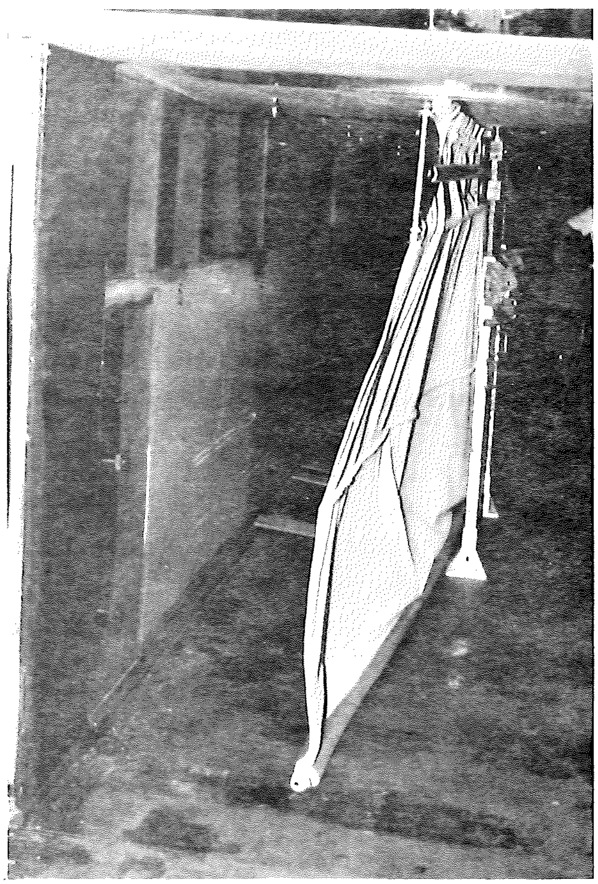
b. three mechanical roof jacks modified for the particular application

c. a pair of rollers on adjustable mounts for each jack assembly.

Photographs of the system are shown in Figure 38. Details of component construction are shown in Figure 39. Simple, rugged construction was stressed with ease of repair or replacement of parts in the mine environment a primary design consideration.

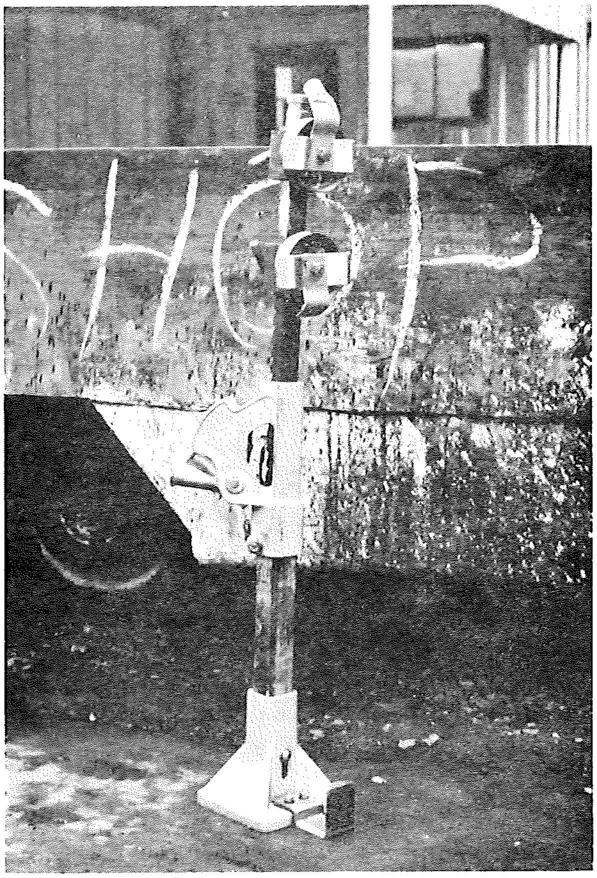


(a) Extensible Brattice Panel System

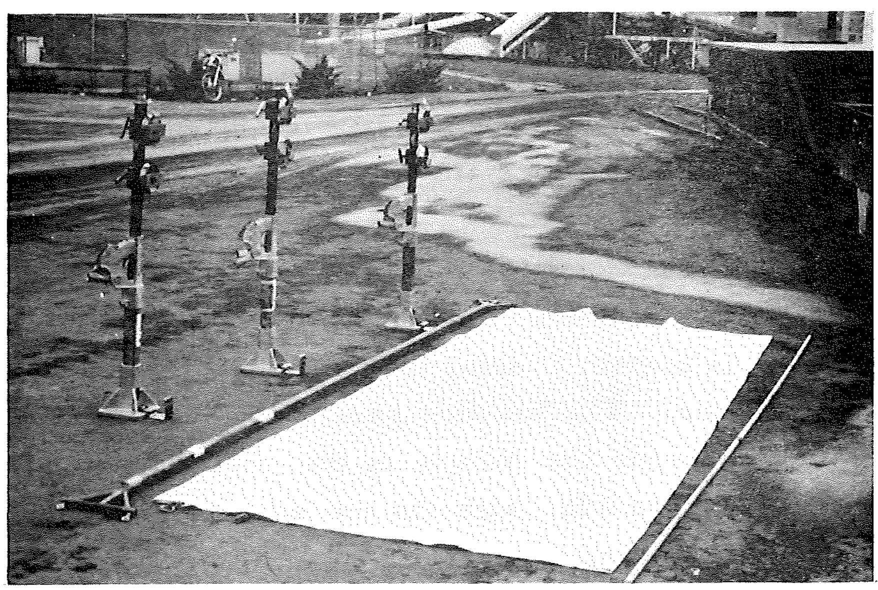


(b) Brattice Panel - Installed in Gallery with 6,000 CFM Air

Figure 38 - Extensible Brattice Panel



(a) Roller Assembly for Panel Support



(b) Disassembled Brattice Panel System

Figure 39 - Components of Extensible Panel System

During operation the brattice frame is supported by two of the mechanical jacks. The jacks are adjustable for roof height variations and the independent adjustment of the roller clamps permits location of the top edge of the panel tight against the roof to minimize air loss. The top edge is compliant to seal effectively without excessive resistance to motion.

The adjustable roller mounts capture the pipe frame between the rollers, permitting motion only in the desired direction with little resistance. This extensible panel permits the miner operator or helper to advance the panel up to 14 feet during a cut of 20 feet. The leading edge of the panel is kept within 10 feet of the face without exposure of personnel beyond the last set of roof bolts.

The following is a typical operating sequence which refers to Figure 40.

a. The panel is installed at the end of the fixed brattice line either immediately following the bolting operation or after the miner has advance the face ten feet beyond the fixed brattice. The choice depends on interference between the miner and the rigid jack required at the end of the brattice line.

b. When installed, one jack is positioned 4' outby the last roof bolts (end of the brattice line), and a second is located 4' outby the first along the fixed brattice line. The brattice panel frame is clamped between the rollers in the position shown in Figure 40b with the top edge touching the roof to minimize leakage.

c. As the miner advances the panel may be pushed forward on the rollers as shown in Figure 40c.

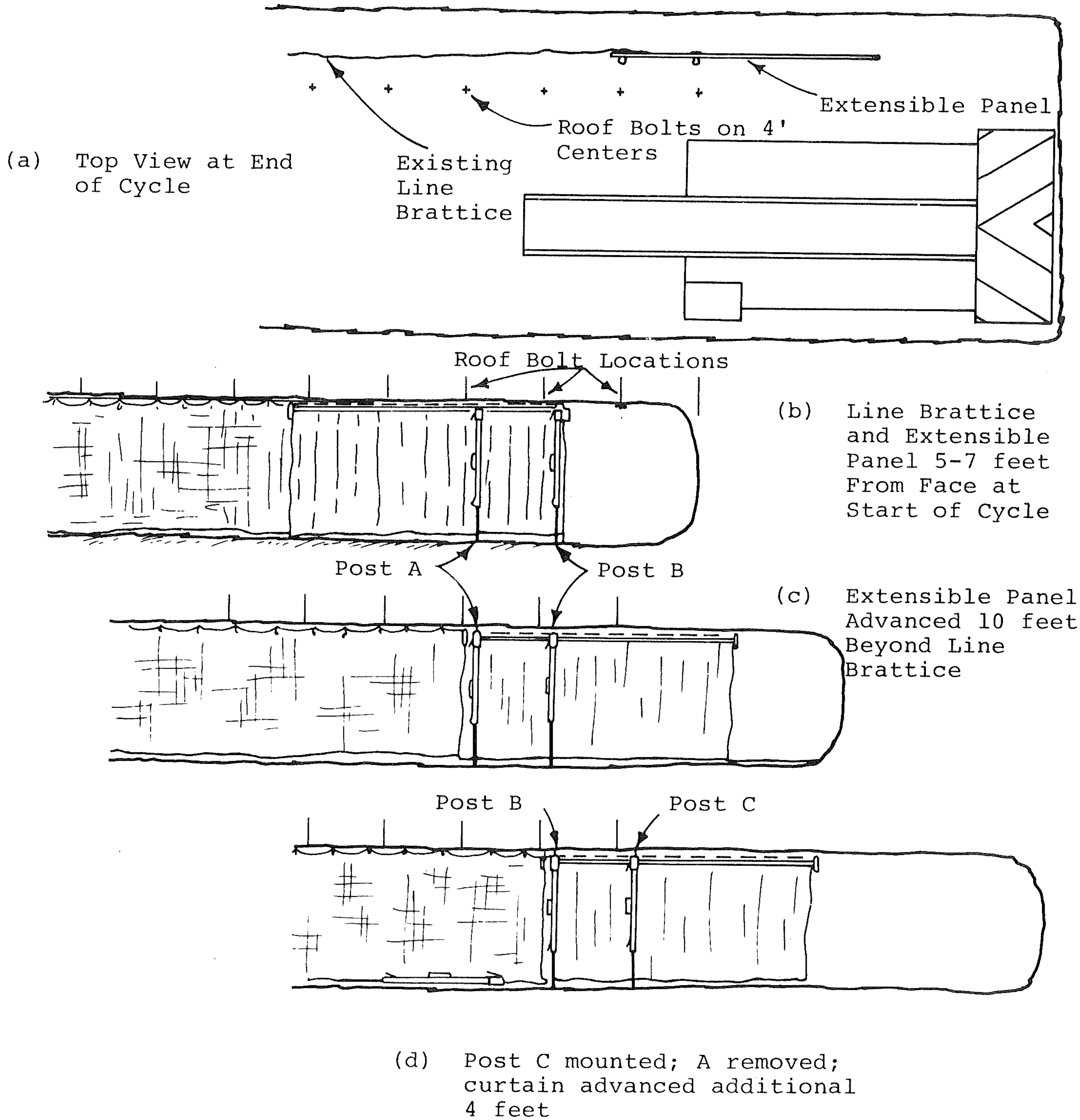



Figure 40 - Operation of Extensible Brattice System

d. When the limit of travel is reached (approximately 10 feet) the third jack is placed four feet inby the first jack, the roller clamps adjusted, and the outby jack removed. This permits the panel to be advanced an additional four feet as shown on Figure 40 d.

Note that the face has been advanced a full 20 feet with jacks placed only under permanently supported roof. For mining cycles where a full 20 feet of advance is not standard, a shorter brattice frame may be used.

## 4.2 Mine Demonstration of Brattice Panel

The extensible brattice panel was demonstrated in three mines during November and December of 1975. These were EACC's Keystone No. 1 and Keystone No. 5 mines and U. S. Steel's Dilworth mine. Details of the tests are presented in Appendix G.

The purposes of these demonstrations were twofold--to establish the effectiveness of a manually extended brattice panel and to determine the modifications to the prototype design required to adapt it to the mining cycle.

The differences in operating procedures at the three demonstration mines were marked. Modifications were made to the brattice panel system and the manner in which it was employed. Based on the results of the mine tests, the following general conclusions have been drawn:

- Solutions must be tailored to specific operations and the operations modified to accept the improved ventilation system.

- Where the extensible panel can be adapted to the mining cycle or the cycle can be adapted to the panel, improved face ventilation can be achieved without exposure of personel to unsupported roof.

### 4.2.1 System Limitations

In addition to the above, generally encouraging conclusions that extensible features are desirable and feasible under the proper conditions, several very specific limitations of the proposed system were defined during the three test attempts. These limitations are stated on Table IV. Most of them were evident at more than one test site, indicating that the limitation is with the design of the prototype system rather than with the particular situation in which it was applied.

Throughout the tests, for instance, it was evident that jacks rigidly positioned along the brattice line interfere with the operation of the mining machine and the loader during the cleanup operation. In addition to making it difficult to maintain a smooth rib, the jacks positioned along the brattice line render the ventilation system vulnerable to damage from the equipment. Jacks positioned more tightly against the rib or a system mounting directly from the rib or roof would eliminate much of this problem.

The independent support of the two pairs of rollers requires precise alignment of the jacks to, first, prevent "cross binding" of the roller pairs during advance and, secondly, to permit the panel to advance in the proper direction. This problem is emphasized by the length of the frame and the rigidity of the positioned jacks. In order to make minor corrections for roof or rib irregularity, at least one jack must be unloaded, relocated as desired and reloaded.

TABLE IV

LIMITATIONS OF PROTOTYPE BRATTICE PANEL

- Jacks positioned along brattice line are vulnerable to damage from the miner.
- Pulley alignment requirements demand accuate jack alignment to prevent "crossbinding"
- Direction of brattice panel advance demands accurate jack positioning relative to one another
- Length of frame and rigidity of positioned jacks permits no minor correction for rib of roof irregularity
- At extremely high ventilation flows the curtain is sucked in, reducing available flow area
- Ends of brattice panel frame pose some hazard to personnel
- The part of the panel extending back under supported roof is a potential hazard in the event of a fall on the unsupported end

At very high ventilation flows (in excess of 10,000 cfm) the curtain was drawn into the rib, reducing the flow area by approximately 50 percent. For applications with flows of this magnitude, stiffening members are recommended.

During operation it was noted that the ends of the brattice frame are potentially hazardous if walked into. The design of the frame ends should be improved to minimize this hazard. It has also been mentioned that the portion of the frame extending back under permanently supported roof is a potential hazard if a roof fall on the opposite end should dislodge the frame from the roller supports. A locking device to minimize this possibility is desirable.

Section 4.3 presents modified designs that eliminate the shortcomings discussed above or minimize their impact on system operation.

### 4.2.2 Desirable Section Characteristics

Although the extensible brattice panel in its proposed configuration was not completely compatible with the mining cycle at either of the demonstration mines, the tests did indicate certain characteristics of face operations which are compatible with an extensible brattice system of the type proposed. These characteristics are summarized on Table V. It is recommended that subsequent efforts in this area consider the importance of these characteristics in selecting demonstration or test sites for extensible brattice systems.

## 4.3 Recommended System Modifications

To eliminate the system limitations which became apparent during our in-mine test program a list of desired design changes was prepared. These are specified in Table VI. A number of new designs were prepared, reflecting these desired changes to whatever extent possible. These concepts fall into three general categories - single jack supported systems, rib mounted systems and roof mounted systems.

## TABLE V

## CHARACTERISTICS OF FACE OPERATIONS COMPATIBLE WITH EXTENSIBLE BRATTICE SYSTEM

- Brattice line within six feet of the face at the beginning of the cycle without interferring with mining cycle

- Adequate primary air available

- Good ventilation important to men on the section

- Desire to avoid exposure to roof not permanently supported

- Willingness to expend some additional effort to achieve good face ventilation

TABLE VI

PROPOSED DESIGN CHANGES

- Minimize jack exposure by redesign or elimination of jack
- Extend brattice line to last permanent support before mounting extensible panel
- Shorten length of panel as permitted by above
- Mount all pulleys on single rigid frame to minimize alignment problems
- Provide easy adjustability of advance direction
- Provide "Battens" to stiffen curtain as required
- Improve design of ends of brattice frame

### 4.3.1 Single Jack Support System

The single jack support system for the extensible brattice panel is shown in Figure 41. Two views of the support jack and cantilevered roller assemblies are shown in Figure 42 . It retains the portability and the simplicity of installation inherent in the prototype support system while minimizing the protrusion of the jack into the entry. The fixed alignment of the pulley pairs eliminates "cross-binding" and simplifies curtain alignment.

With this system, the jack base may still hinder cleanup of the rib on the ventilation side but this should present no major problem. Pulley positions are not adjustable from the entry with this system. To raise or lower the panel or adjust its slope it is necessary to work behind the curtain.

### 4.3.2 Roof-Mounted Support

The roof-mounted support system shown in Figure 43 is both mechanically simple and compartively light in weight. With this system the jack is eliminated completely and replaced by an assembly which supports the brattice panel from a single short roof bolt. This offers the "neatest" installation but requires the bolter crew to install an additional bolt. It also requires the installation of a bulky object overhead - a generally undesirable operation.

With this system the height and slope of the brattice panel are adjustable from the entry and there is complete flexibility in the location of the curtain relative to the rib.

### 4.3.3 Rib-Mounted Support System

Figures 44 and 45 show two slightly different rib-mounted support systems. One is lighter in weight but permits pulley adjustment only from behind the curtain. The other is heavier but permits adjustment from the entry.

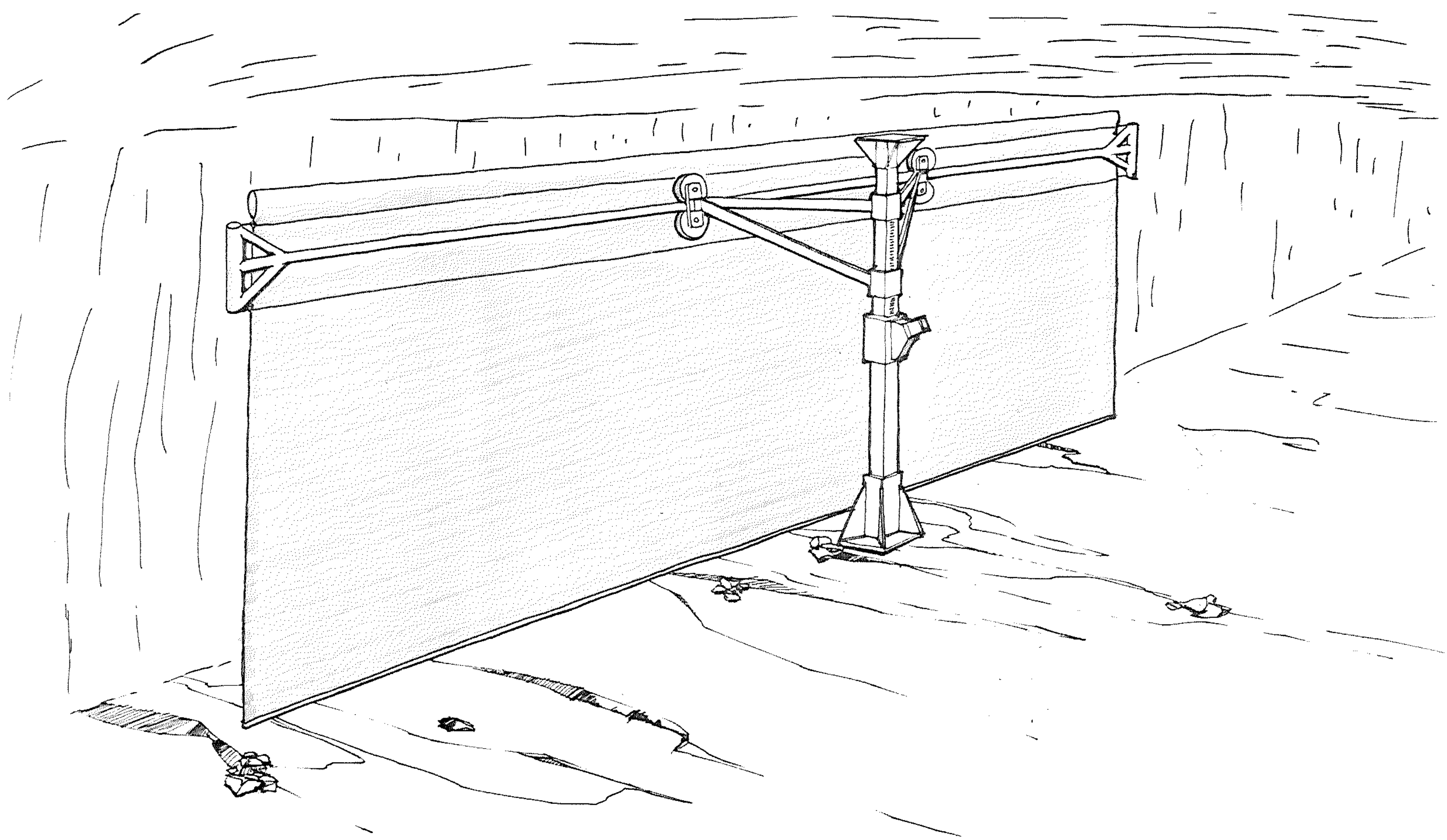


Figure 41 - Single Jack Support System - Sliding Brattice Panel

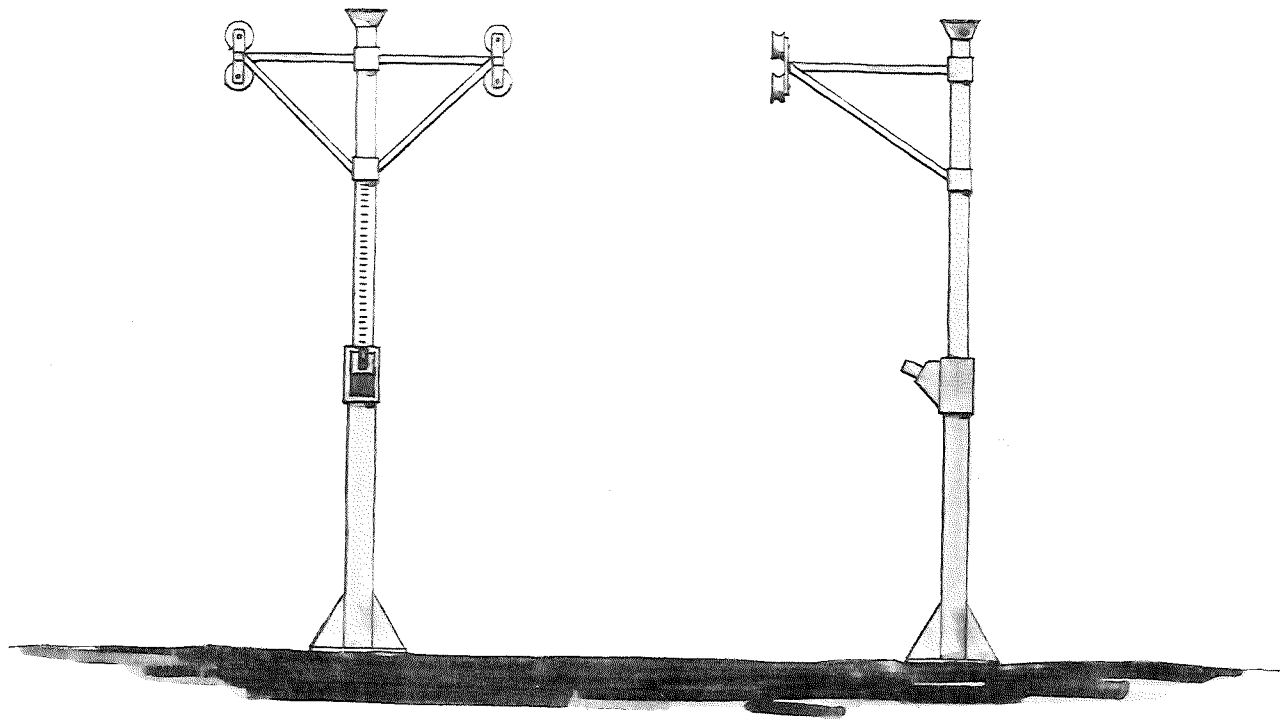


Figure 42 - Jack Assembly - Single Jack Support

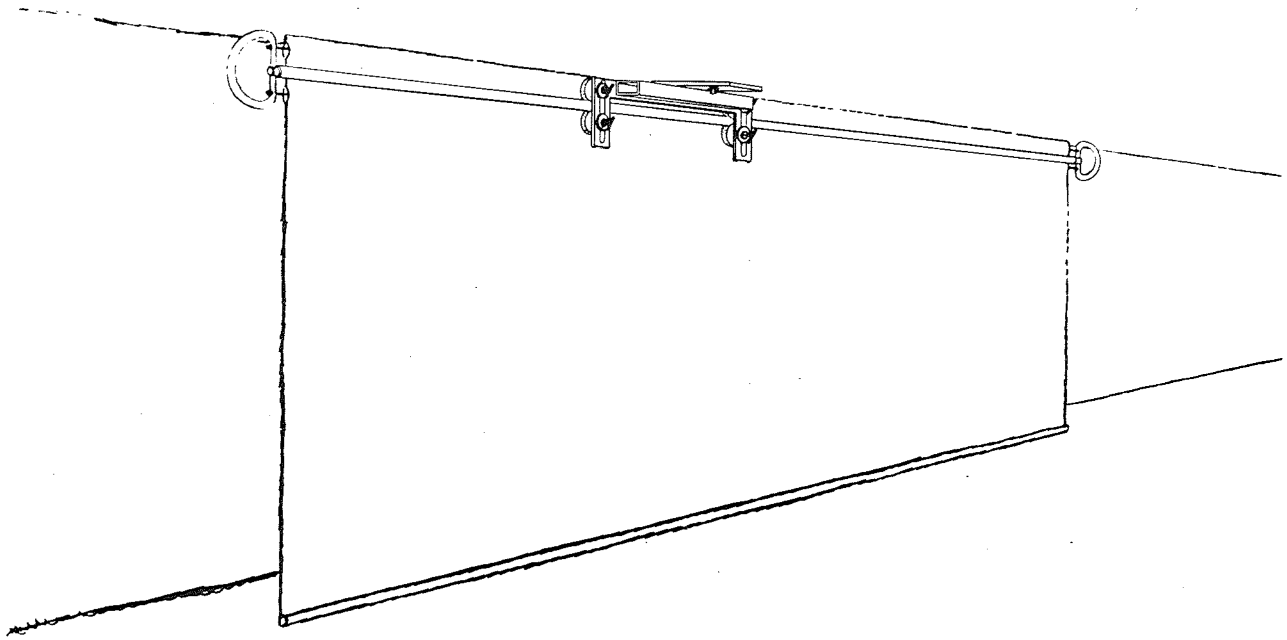


Figure 43 - Roof Bolt Mounted Sliding Brattice Panel

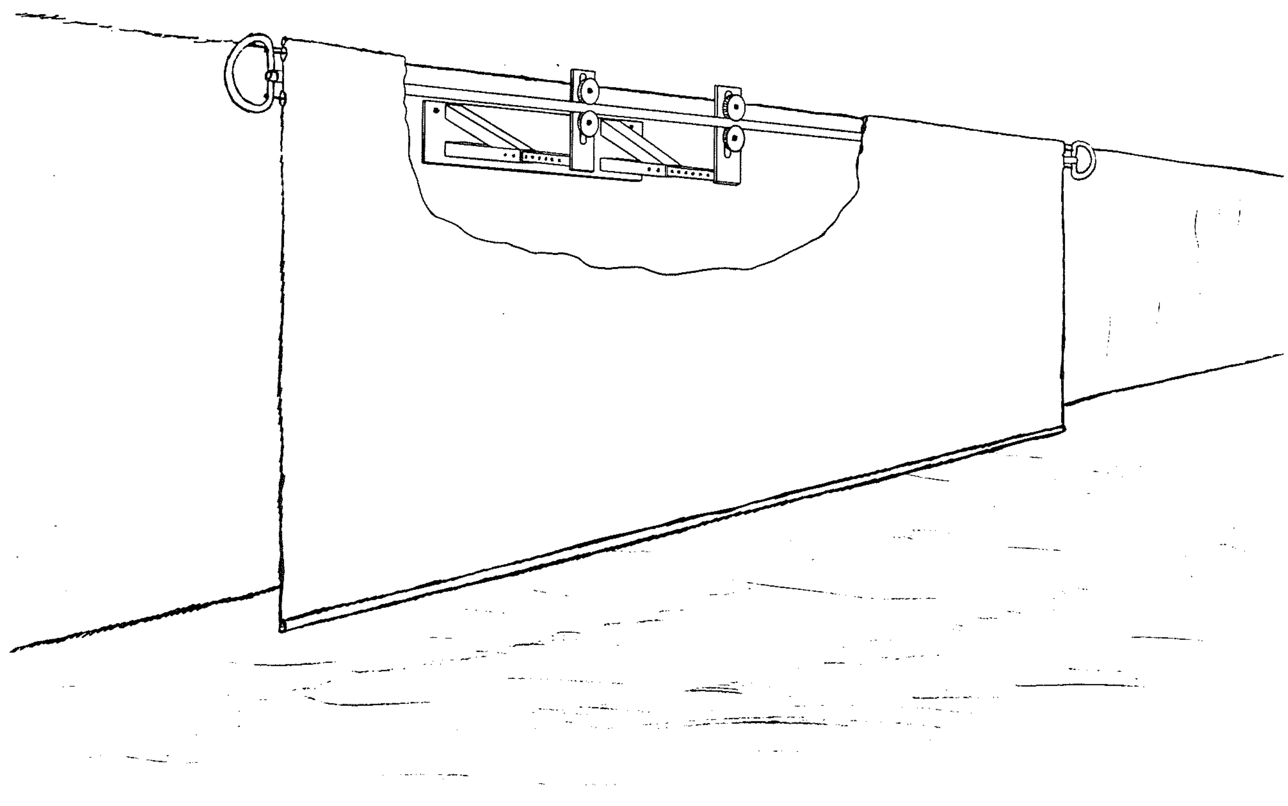


Figure 44 - Rib Mounted Sliding Brattice Panel - Adjustable From Return Side Only

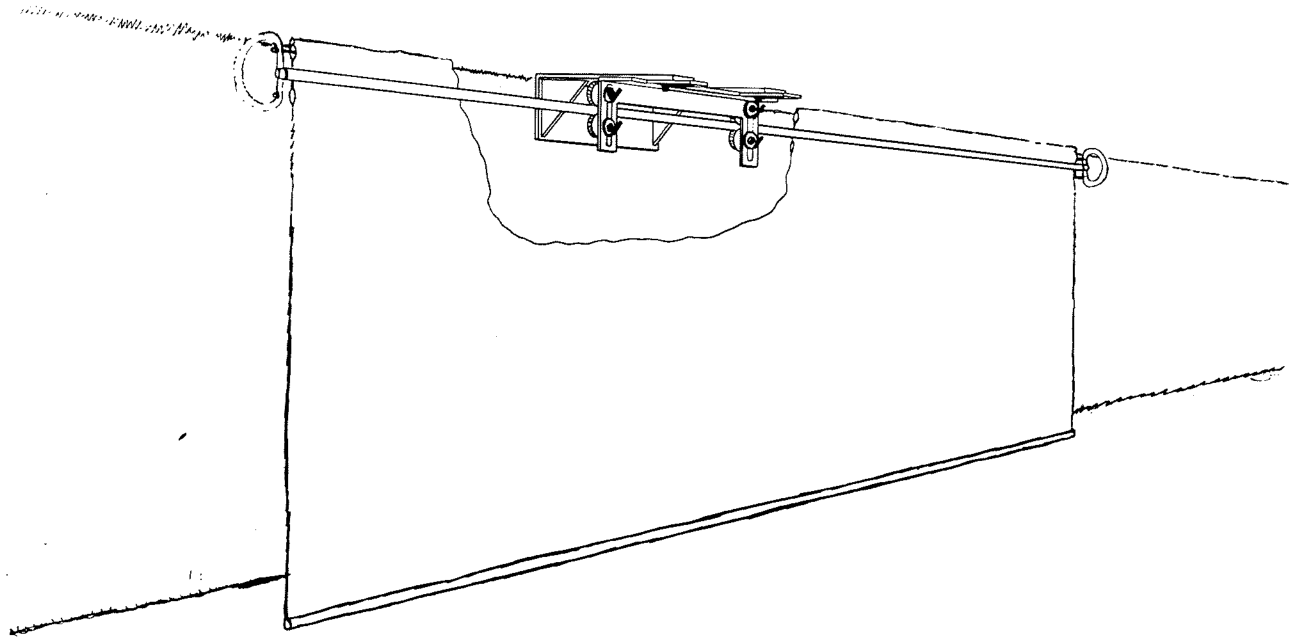


Figure 45 - Rib Mounted Sliding Brattice Panel - Adjustable From Entry Side

Both systems are possible alternatives to the roof mounted system in situations where the bolter crew controls the mining cycle. The rib-mounted bracket could be installed without the bolter by using the hand auger mounted on the miner. This presumes that holes can be hand drilled with sufficient accuracy and reliability.

The disadvantages of this system are the addition of a hand operation to the mining cycle and the difficulty of implementation in situations where the curtain is mounted at considerable distance from the rib.

### 4.3.4 Summary of Modified Systems

A summary of the features of each extensible panel concept is presented for convenience on Table VII. The relative advantages and disadvantages are summarized in tabular form on Table VIII.

The selection of the most satisfactory system for a specific application requires a careful evaluation of the characteristics of the mining cycle on the section of interest.

## TABLE VII

## SUMMARY OF EXTENSIBLE BRATTICE PANEL FEATURES

| | |
|---|---|
| SLIDING PANEL - SINGLE JACK SUPPORT | • Placed under last permanent support after miner makes first or second cut on that side. Post placed only once per cycle<br>• Minimizes exposure of jack to damage from miner<br>• Eliminates pulley "crossbind" by fixing alignment<br>• Easy directional adjustment by jack rotation<br>• Panel length approximately 12 feet |
| SLIDING PANEL - SINGLE ROOF BOLT SUPPORT | • Placed on bolt specially placed as part of bolter cycle<br>• Adapter plate retrieved by bolter crew on next cycle<br>• Eliminates jacks completely, simplifying cleanup<br>• Lightweight pulley support assembly capable of easy directional adjustment<br>• Panel length approximately 12 feet |
| SLIDING PANEL - RIB SUPPORT | • Mounted on rib using hand auger on miner<br>• Eliminates extra task for bolter crew - makes task for miner helper or bratticeman<br>• Heavier than roof mounted system<br>• Not practical for low coal applications with 3-4 feet behind brattice<br>• Panel length - 12 feet |

## TABLE VIII

## COMPARISON OF THE ALTERNATIVE SUPPORT SYSTEMS

| | ADVANTAGES | DISADVANTAGES |
|---|---|---|
| SINGLE JACK SUPPORT | • Protrusion of jack into entry is minimized<br>• Vulnerability of system minimized<br>• Removal and installation requires no tools | • Jack base may still hinder cleanup activity<br>• Pulleys not adjustable from entry side<br>• Shaft of jack cannot support brattice panel against air pressure |
| ROOF MOUNTED SUPPORT | • Eliminates jack completely<br>• Lightest weight of all support systems<br>• Location of curtain relative to rib is not critical | • Requires additional short bolt installed by roof bolters<br>• Requires overhead installation of bulky object |
| RIB MOUNTED SUPPORT I - PULLEYS ON RETURN SIDE | • Mounting on rib permits use of auger mounted on miner<br>• Rib mounting may be less difficult than overhead | • Pulleys not adjustable from entry side<br>• Difficult to implement if curtain is far from rib |
| RIB MOUNTED SUPPORT II - PULLEYS ON ENTRY SIDE | • Rib mounting has above advantages<br>• Pulley adjustment from entry side of panel | • Difficult to implement if curtain is far from rib<br>• Heavier than rib mounted support above |

## 4.4 Conclusions and Recommendations

According to MESA records,[3] in 1975, 53 miners were killed in falls of roof, rib, or face. Included in this figure are seven men who were killed while setting temporary supports during the mining cycle and one man who was killed while installing brattice. The extensible brattice concept was developed primarily to enable a miner to advance the face ventilation without exposing him to the unsupported roof or the potential danger of setting temporary roof supports. However, particular operating conditions in each of the three sections made the brattice panel less desirable than their conventional method of advancing the ventilation. Furthermore, it is probable that the proposed brattice panels, although permitting compliance with the law without exposure to roof not permanently supported, will only be accepted and employed where there is a specific problem--such as methane, dust, or other factors discussed further in Section 6.1.

It is recommended that the brattice concept be modified to incorporate the improvements discussed in the previous section. Complete extensible brattice panel systems should be designed and fabricated for use in a minimum of two seam heights, say 3 to 4 feet and 5 to 6 feet. These systems should be available for use by MESA when a serious need at a specific mine is defined. Informal discussions have been held with MESA Technical Support, and it appears that MESA will lend full support in implementing the brattice panel on a section. USBM would inform MESA when the panel was available; MESA would in turn inform USBM when a mine was identified which had a problem which might be solved with the brattice panel. Furthermore, the mine would have responsibility for implementing the system and making the small hardware changes which may be required in order to ensure compatibility with their particular mining operation.

## 5. Rib-Configured Extensible Duct System

Based on personal observation during visits to operating sections and discussions with mine personnel, the critical nature of the ventilation problem on borer sections became evident. The massive size of the borer restricts ventilation at the face more than ripper miners. In addition, their size makes it extremely difficult to get tubing past the machine and close to the face.

Because of the renewed popularity of borers due to cycle mining requirements on ripper sections, borer miners were selected for a custom-designed extensible ventilation system to mount on the machine and fit into the arch of the rib. Oval tubing, mounted on the rib at mid-passage height was to be used with this system to minimize interference with the loader and shuttle car canopies.

The advantages expected of the proposed system included:

1. The leading end of the duct would be maintained within ten feet of the face at all times. Extension would be automatic as the miner advanced.

2. With the tubing mounted in the arched portion of the rib, it would offer no restriction to the operator's visibility.

3. Rib mounting minimizes space requirements, allowing equipment to operate freely in the roadway and permitting the miner to leave the place with the tubing still in position.

4. The extending portion of the duct is completely supported by the miner with spring loaded arms holding the duct against the rib. This permits one man to add the tubing sections required for advance.

Disadvantages foreseen for the system were:

1. The applicability of the system is limited to borers.

2. Space at the operator station may be inadequate if the tubing is mounted on the right side.

3. If the tubing is mounted only on the left rib, a crossover system similar to that used for the system described in Section 2 is required.

A prototype system was designed and fabricated in Phase II of this program and introduced into Federal No. 1 Mine. With the actual hardware in place, the restriction on operator mobility outweighed the advantage of improved ventilation. Re-evaluation of the problem led to the system described in Section 2 which satisfies the ventilation requirements of boring machines and ripper miners as well. In favor of the less complex, more universal system, effort on the rib configured system was abandoned.

The actual design of the system is described in the balance of this chapter, along with the abbreviated test program. The recommendations based on the experience gained are listed at the close of the section. These recommendations defined the system finally developed for tubing installations, as described in Section 2.

## 5.1 System Description

The system developed specifically for borer applications utilized a "rib-configured" flat duct, mounted on one side of the machine and held against the rib. This section was specially designed to draw air from close to the face without excessively crowding the miner operator. Outby the operator, where some additional space is available, a transition section adapts this flat tube to standard oval tubing which stretches down the entry to the auxilliary fan. Extensibility is achieved using a slip tube in the standard oval portion of the duct. A plan view of the system as described above is presented in Figure 46

As mentioned earlier, it was established during the design phase that the area around the miner operator was the critical part of the new system. For mine sections with a right-hand return, it would be necessary for the tubing to be mounted on the right side of the miner and pass between the rib and the operator. Although drawings showed that there would be adequate space when the miner was in a perfectly straight entry, a paper study could not predict what interferences would exist as the mining machine cut offsets, or "snakes" in the entry. Accordingly, a simple, 3-dimensional model was constructed which would enable the simulation of any entry irregularities, including step-changes in the rib and smooth curves, both to left and right. Figure 47 shows a picture of the model, which was approximately 1/10 scale. The mine "passage" was made of a series of individual wooden plates with the entry cross section cut through each plate. By sliding the plates to left or right, any desired entry irregularity could be created. The miner in the foreground, with tubing attached, was then pushed down the "entry" to determine if there was any interference with the tubing.

From these studies, it was found that a straight run of tubing which was attached to the miner would not be able to negotiate the bends and offsets found in a typical coal mine entry. After several experiments which varied the number and the location of flexible joints, a final design was established. This design utilized three separate pieces of tubing which were joined together to provide vertical rigidity but allowed the separate pieces to flex left or right, in order to conform more closely to the rib and allow adequate room for the operator.

The prototype system employed standard 18" equivalent oval tubing from the auxilliary fan to the rear of the machine. A standard 16" equivalent oval tube formed the slip tube which provided the desired extensibility. This tube attached rigidly to a custom made transition from the 16" oval to the rib-configured flat duct. This "rib-configured" duct was fabricated from standard 24" equivalent oval tubing modified as shown in Figure 48 to yield the flat cross section.

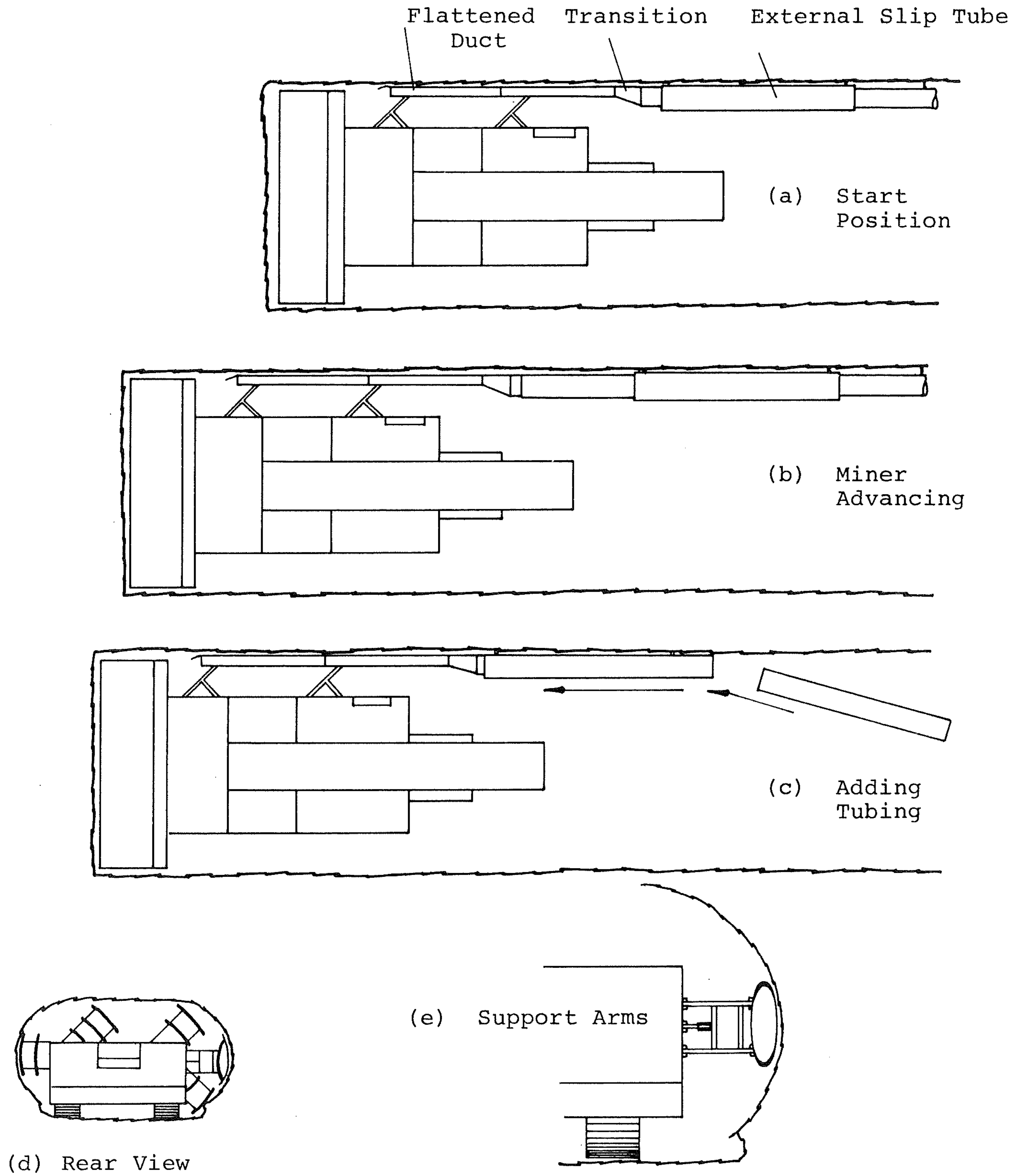



Figure 46 - Extensible Duct System for Boring Machines

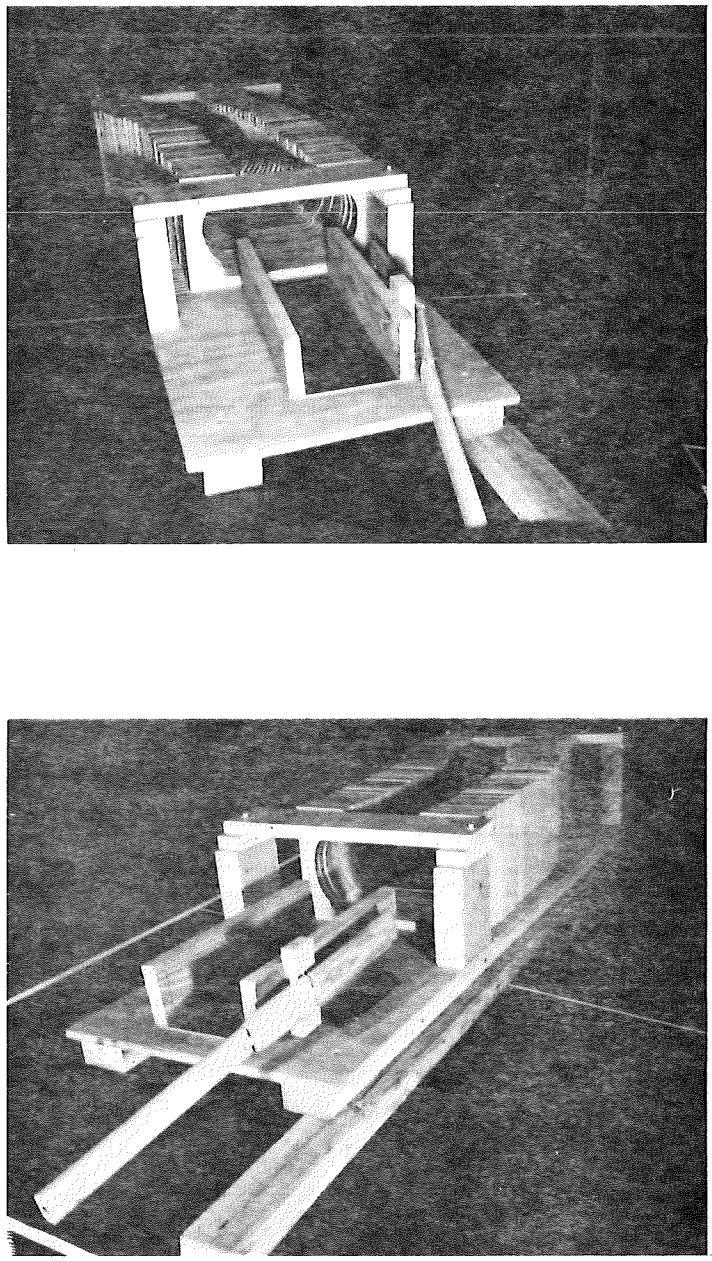


Figure 47 - 1/10 Scale Model of Borer and Entry

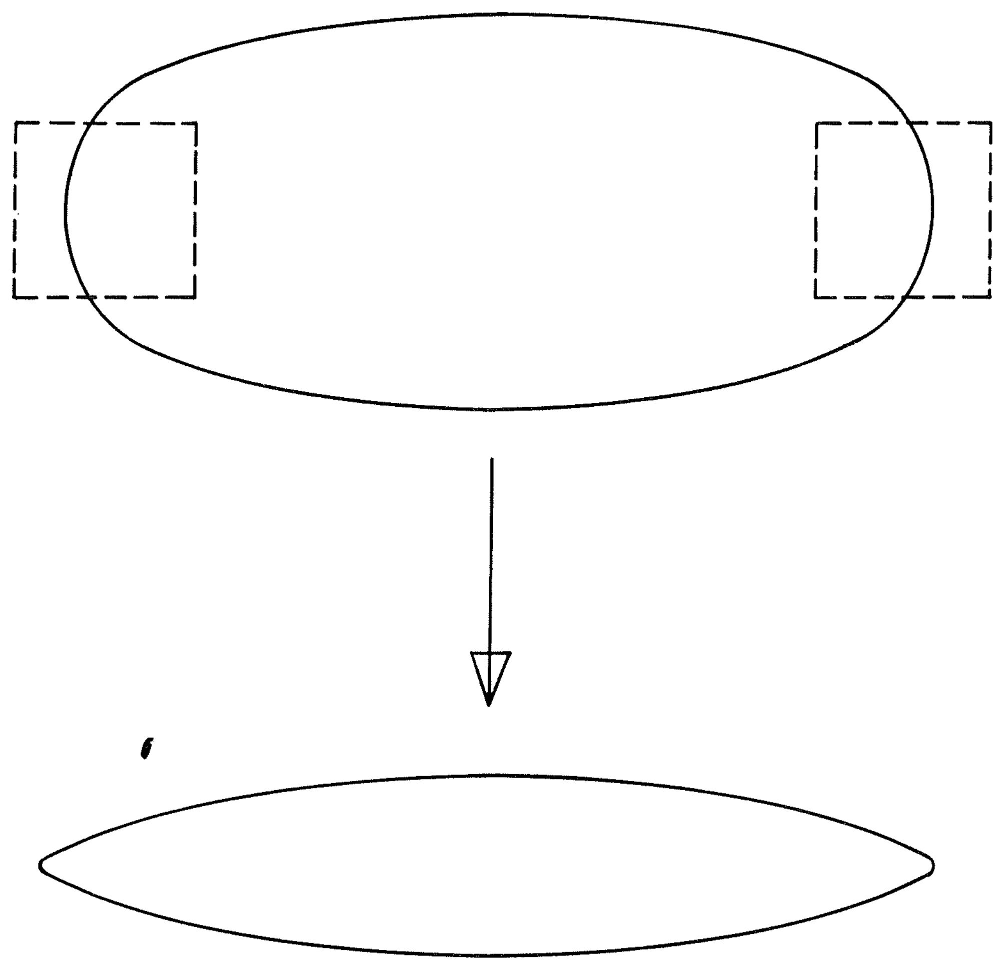


Figure 48 - Low Profile Cross-Section Made From Standard Oval Duct

An alternative system for applications where extremely high ventilation flows are required is conceptually identical but employs standard 12 x 30 oval tubing and a custom wound "rib-configured" duct to pass behind the operator to the face. In order to maximize flow area and minimize operator interference, a shape is required that must be wrapped on a special mandrel rather than fabricated from modified standard sections.

Two flexible joints were included in the "rib-configured" portion of the duct - both located between the transition from the standard oval duct and the rear machine mount.

Figure 49 shows the entire system mounted at the FMA test facility. In the foreground is the "rib-configured" extensible duct mounted on the supports from the wood panel which represents the side of the mining machine. Note the skid plates on the duct to resist the abrasive action of the rib as the system advances. The "skis" were fabricated from high density polyurethane sheet.

Lying behind the machine-mounted portion of the duct is the section with the two flexible joints and the flat-to-oval transition. This assembly clamps rigidly between the flat duct on the machine and the small oval slip tube shown protruding from the row of oval tubes located toward the rear in the photograph. The slip tube moves forward with the rib-configured duct and thus provides the extensibility required.

The operating sequence is described easily with reference to Figure 46 on page 122.

1. At the start of the cycle the 10 x 20 oval section attached to the borer is completely enclosed inside the external slip tube (fixed to the rib) and the remaining oval tube.

2. As the borer advances 10 feet the duct is withdrawn and a band is exposed indicating an additional length of tubing is required.

Figure 49 - Machine-Mounted Duct Shown in Laboratory

3. The miner operator detaches and slides forward the external slip tube, adds a 10-foot length of oval tubing, attaches it to the rib and resumes operation.

4. The entire system can be detached from the machine and spadded to the rib, allowing ventilation to continue while the miner trams out of the place.

## 5.2 Test Program

### 5.2.1 Laboratory Evaluation

After the prototype system was fabricated, it was assembled in the laboratory. This permitted at least a preliminary evaluation before initiating a full underground test program. The paper study and design phase had shown that the critical area was next to the miner-operator position when the tubing was on the right-hand side. Therefore, it was this area that was mocked up to test the system.

Figure 50 shows the laboratory testing mock up in which a plywood wall was used for the side of the mining machine; several other pieces of wood simulated the geometry of the rib. Although this short test program was no substitute for underground experience, it did point out several potential weaknesses in the system:

1. The two flexible joints in the machine-mounted duct made the tubing extremely difficult for two men to handle when it was being mounted to the brackets on the miner.

2. The mounting brackets on the miner were difficult to attach to the tubing and easy to dislodge.

3. Even after the tubing was properly attached to the machine, space for the miner operator was quite limited.

Before proceeding to the underground testing, the afore-mentioned problems were solved in the following manner:

1. One of the flexible joints was removed from the tubing system. Although this reduces the

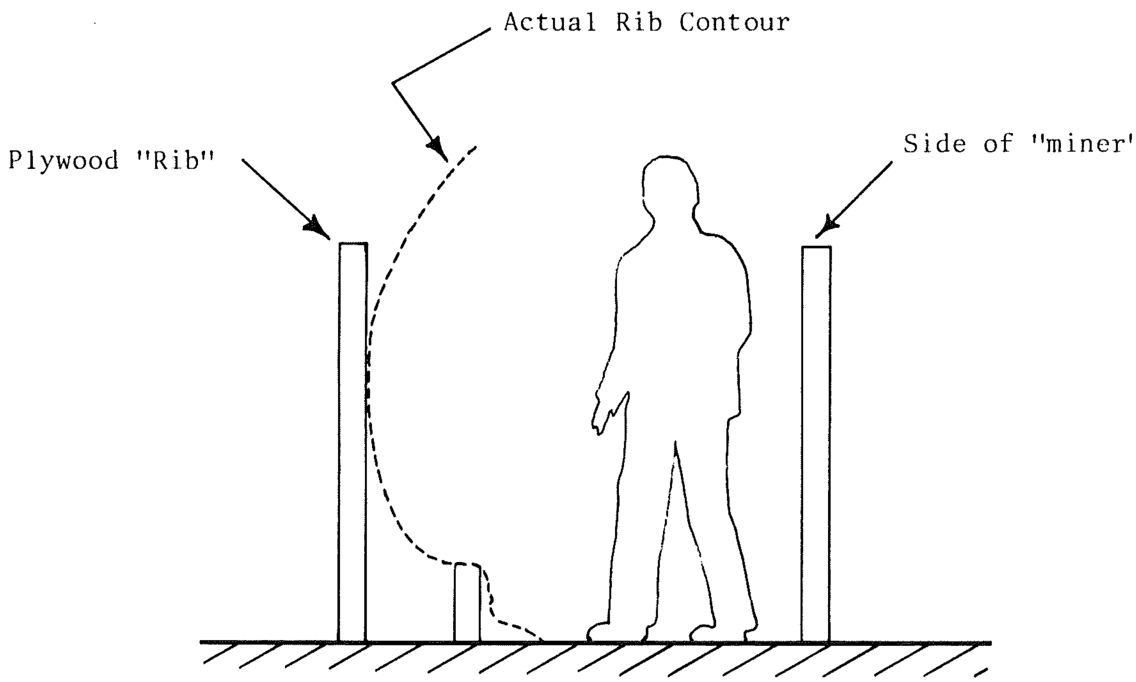



Figure 50 - Schematic of Lab Mock-Up To Simulate Borer Entry

ability of the system to negotiate local bends or offsets in the rib, it was necessary to enable two men to comfortably be able to mount the tubing to the miner under typical underground conditions.

2. The mounting brackets were redesigned to make them:

   - more rugged
   - easier to attach to the tubing
   - more difficult to vibrate loose from the tubing

3. There was no way to increase the space available to the operator. Underground testing of the system would be required to determine whether or not the available space would be adequate.

### 5.2.2 Mine Evaluation

The modified rib-mounted tubing system was shipped to Federal #1 Mine, Grant Town, West Virginia, for underground testing. Foster-Miller personnel went underground on a maintenance shift to permanently attach the mounting brackets to the borer. Unfortunately, the borer which was originally to be used had been scrapped and a different machine was working the 3 Left Section. It was found that the location of the light, methane sniffer, and the cables to one of the electric motors interfered with the desired mounting location on the operator's side.

However, even without installing the brackets, it was possible to position the tubing in its approximate location next to the machine controls. For the balance of the shift, experiments with slightly different mounting locations showed that there was no position which would afford adequate room for the miner operator. This was verified by the men on the section, all of whom felt that the prototype system did not permit enough room for the operator. Because this system had no cross-over section, it had to be operable from either the left or the right (operator) side. Thus, although mounting to the left side produced no interferences, the lack of room for the operator when the tubing was on the right side was a fatal flaw.

Foster-Miller personnel stayed on the section for the rest of the week, in order to observe every detail of the production operations. This effort produced the conclusions discussed in the next section, and was directly responsible for the development of the new system described in Chapter 2.

### 5.3 Conclusions

Experiments with the rib-mounted system and further observations of the borer operation led to the following conclusions:

1. Virtually any tubing system mounted on the right (operator's) side will be very difficult to implement, because of restrictions to the operator's mobility and visibility.

2. If a tubing system is restricted to the left-hand side, some provision must be made for crossing the entry in the case of a right-hand return air entry.

3. Rib-mounted tubing can be tucked out of the way in most of the entry, but even special-design tubing is bulky and unwieldy in the rib area around the mining machine, especially on the right-hand side.

4. Oval tubing, when properly installed, can be used to provide greater cross-sectional area while simultaneously providing a lower profile.

5. If a cross-over section is employed, it must be done across the roof. Other locations, such as across the back of the miner (underneath the boom), could restrict emergency egress of the miner operator, and is also vulnerable to damage from equipment operating in the entry.

6. Because of the need to clean up loose coal next to the ribs, the loader operator at times has space limitations (i.e., between his machine and the rib) at least as critical as that of the miner operator.

7. Any tubing system must have sufficient versatility to accommodate local discontinuities in the entry--both along the rib and the roof.

8. In the mining community, both management and labor are ready and willing to try something new which will improve ventilation.

# 6. Conclusions and Recommendations

## 6.1 Guidelines for Successful Implementation of Face-Ventilation Systems

If only one conclusion could be drawn from the entire extensible face ventilation program, it would be that the application is a lot more important than the hardware. To put it another way, the probability of successful implementation of a new ventilation system depends largely upon how great a need exists when that system is to be used. This conclusion accounts in part for the different degree of success between the experimental brattice panel and the experimental left hand tubing system. The brattice panel was an attempt to permit extension of the face ventilation without requiring men either to venture beyond supported roof, or to set temporary supports. However, acceptance of the system was poor because the intended users saw no real need--people were content with the systems already being used. The left-hand tubing, on the other hand, was specifically designed to satisfy a real need - satisfactory ventilation on sections where the size of the mining machine was a major interference. It was interesting to note that during the underground test program, not a single man asked why a new face ventilation system was being tried - it was taken for granted that an improved system was desire-able. In fact, the miner operator on the section had once actually refused to work with the conventional tubing system because it interferred with his visibility.

In general, any new face ventilation system is going to have to satisfy at least one of three requirements:

- satisfy a particular need
- be required by law
- be easier to use.

Satisfying a particular need was the prime motivation for many of the experimental ventilation systems which were tried in the past and documented in Chapter 3. This need may not necessarily be related to ventilation. For example, it may be that a mine operator feels that his current face ventilation is inhibiting productivity, in which case he might try new systems which provide equally effective ventilation but allow for greater productivity. Reduced cost is another ever-present need. Virgin territory in a mine, with abnormally high gas liberation, is a further example which can provide a need for improved ventilation. New mining techniques, such as remote-control miners, will also create new needs.

The requirements of mining laws can also encourage acceptance of new ventilation systems. For example, the dust standards have recently forced many mines to change from a blowing face ventilation system to an exhausting system. At a time like that, a mine might be particularly receptive to a new, or experimental system.

Making any system easier to use than the current method is a sure-fire way of gaining rapid underground acceptance. In the case of face ventilation, systems which are easier to use have a two-fold advantage. Firstly, miner acceptance can be easily achieved. Secondly, and even more important, it stands a better chance of being used properly. Any of the face ventilation systems in use today are properly maintained and kept within 10 feet of the face when management and MESA inspectors are present. The real question is how the system is used on a day-to-day, unsupervised basis. Any system which is easier to use will have a greater chance of being properly used - kept within 10 feet of the face - on a day-by-day basis.

## 6.2 The Future of Face Ventilation

There is no doubt that there are still many improvements which can be made in future face ventilation systems - improvements which will fill all three of the requirements discussed in the previous sections.

Virtually all of the concepts investigated in this program were "add-on" items. The mining machine, the mining plan, the auxiliary fan, were all existing items to which the new tube or brattice had to be fitted. "Add-on" items have several inherent disadvantages which no amount of clever engineering can overcome. Because they are added on, they take up more space in an already crowded environment. This not only causes possible interference with men and machinery but can also make the "add-ons" particularly susceptible to abuse and damage.

Building the inby end of the face ventilation mechanism into the mining machine is a concept which continues to attract interest. However, this is only one part of what should be a total system, including the fan, ductwork in the miner, and interface to the fixed duct or brattice (or new air-flow carrying device) which carries the air to the return. Other parts of the system might include diffusers, water sprays, (to direct air flow as well as reduce dust), and scrubbers (to protect fan blades from damage as well as to reduce respirable dust).

A specific example of an integrated system might best illustrate the case. This particular system would include the following features:

- small diameter, high performance fan
- scrubber to protect fan blades
- fan and duct mounted inside mining machine
- water sprays to direct air flow towards duct inlet
- exhausts from miner through collapsible tubing
- compatible with line curtain <u>and</u> tube systems
- requires less effort than does present system
- could accommodate advances of greater than 20 feet.

It is our recommendation that future effort in improved face ventilation be directed at providing a completely integrated face ventilation system which is designed into underground equipment rather than added on. The goal is to provide a complete system which would not be compromised by having to include some existing components just because they are already in underground use. However, parts of the concept could and should be individually evaluated underground to avoid the risk of installing a complete underground system which was not acceptable. The Bureau of Mines, for example, has several current projects to evaluate new auxiliary fan installations which are built into the mining machine and therefore move forward as the miner moves. Such a design could be one part of a totally new system.

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1. D. S. Kingery, et al, "Studies on the Control of Respirable Coal Mine Dust by Ventilation", USBM Tech. Progress Report, 19 October, 1969.

2. D. S. Kingery, "Face Ventilation with Auxilliary Fans", Coal Age v. 65, No. 2, February 1960.

3. Personal communication with Mr. Bill Pascoe, Tech. Support, MESA.

# APPENDIX A

## FABRICATION OF SPECIAL DUCT COMPONENTS

The left-hand duct system may be used with any standard rigid tubing. The required special components are:

- 5-foot lengths of pancake duct
- transition-standard duct-to pancake, straight
- transition-standard duct-to pancake, right angle
- transition-pancake to standard duct.

Fiberglass fabrication is recommended, primarily because of the high strength-to-weight ratio.

CAUTION: MESA requires that any ventilation material must have a flame spread index of 25 or less according to ASTM Standard E-162. Commonly available fiberglass materials will not comply with this standard.

There are several fiberglass resin-plus-additives currently available which can satisfy the flame spread requirements. The materials used for the test program were as follows:

- Polyester Resin, Koppers #3463-5M, fully promoted
- Hardener, 60% MEK Peroxide in Dimethyl Phthalape "Lupersol DDM", Catalyst, variable ratio according to desired working time and curing temperature.
- Antimony Tri-oxide additive, 1 part per 20 parts Resin, by weight.

CAUTION: Some resins (not "fully promoted") require mixing with an accelerator prior to adding the catalyst. Incorrect mixing of these three ingredients can result in violent spontaneous explosion. These components should only be used by an experienced and qualified fiberglass fabricator.

## A. 1 Fabrication of Pancake Duct

A cross section of the pancake duct is shown in Figure A-1. The duct is fabricated in two halves, using a sheet-metal mold as shown in Figure A-2. The following steps should be followed:

(1) Coat mold with mold release.

(2) Lay-up one layer of "fab-mat" in mold, with woven-side up; allow to cure.

(3) Trim off both ends and along sides, as shown in Figure A-2.

(4) Remove from mold.

(5) Repeat steps (1) through (4) to make other half of duct.

(6) Install a fiberglass stiffener down the middle of one half of the pancake duct.

(7) Use a 5-foot long fiberglass strip, approximately 4" wide, down each side to band the two halves together.

After the basic pancake duct is made, a bell-mouth must be made on one end to permit one duct to be inserted into another. The bell mouth is made by using the basic duct as a mold, in the following manner.

(1) Using tape or other material, install a band, 3/8" thick and 8" wide at one end of the duct, as shown in Figure A-3.

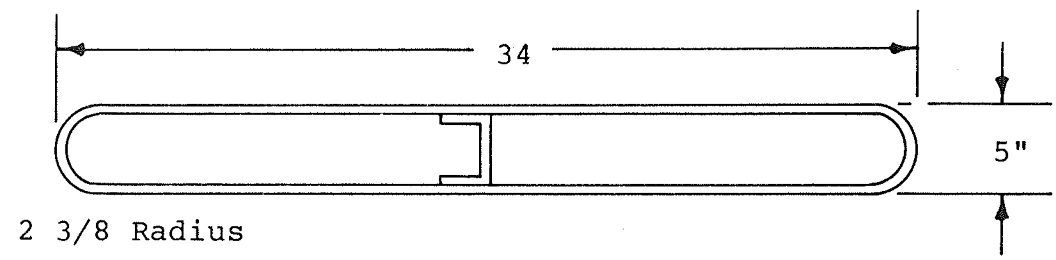



Figure A-1 - Cross Section of Pancake Duct

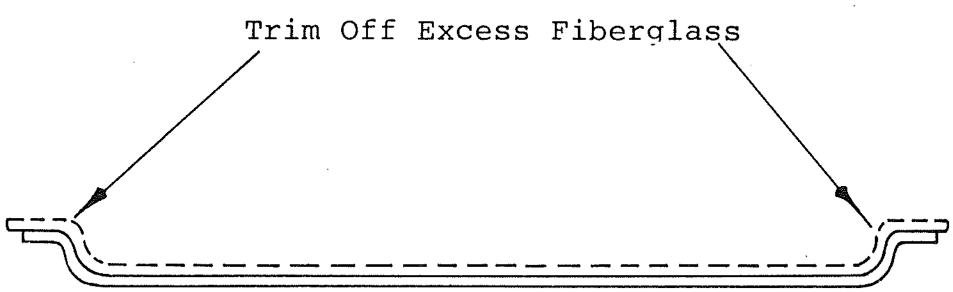



Figure A-2 - Cross Section of Pancake Mold

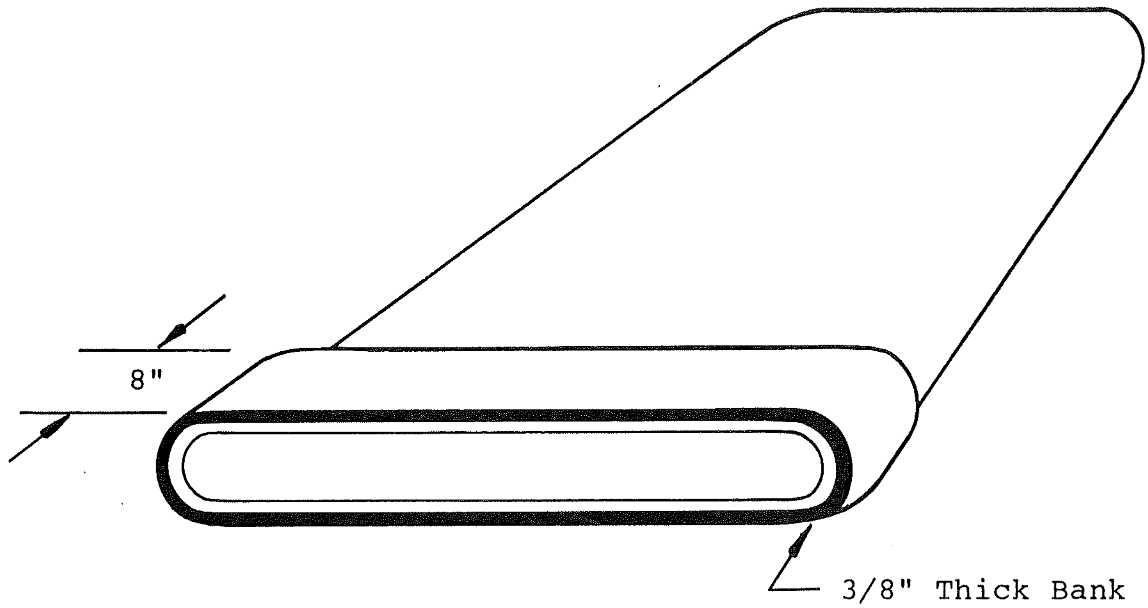



Figure A-3 - Band for Bell-Mouth Mold

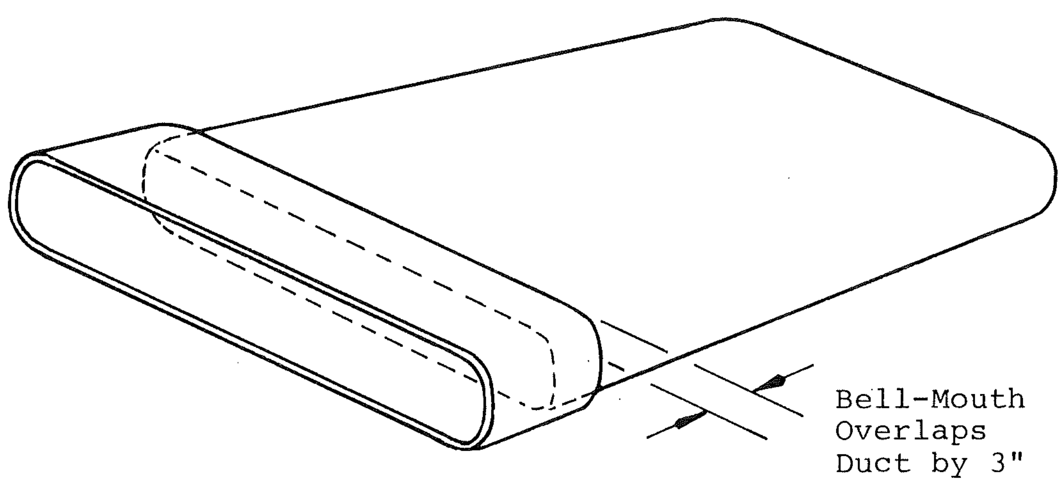



Figure A-4 - Installation of Bell-Mouth

(2) Coat the band with mold release.

(3) Using one layer of fab-mat, lay-up a layer around the band.

(4) Remove the fiberglass bell-mouth after curing.

The bell-mouth can now be bonded to the duct, allowing 5" to protrude beyond the end of the duct, as shown in Figure A-4.

One pancake duct should be left without a bell-mouth, in order to interface with the part described in Section A.3.

## A.2 Fabrication of Straight Transition from Standard Duct to Pancake

The straight transition from standard duct to pancake duct, shown in Figure A-5 consists of 3 parts:

(1) bell-mouth for standard duct, approximately one foot long.

(2) transition section

(3) 1-foot length of pancake duct.

Part 1 should be cut off a standard duct (short lengths are commercially available; this will minimize waste). Part 3 should be cut from a piece of the fabricated pancake duct. These two parts must then be joined by a hand lay-up. Hardware screen is recommended to hold parts 1 and 3 in place, and to form a mold for the intermediate transition section, as shown in Figure A-6. One thickness of fab-mat should be used.

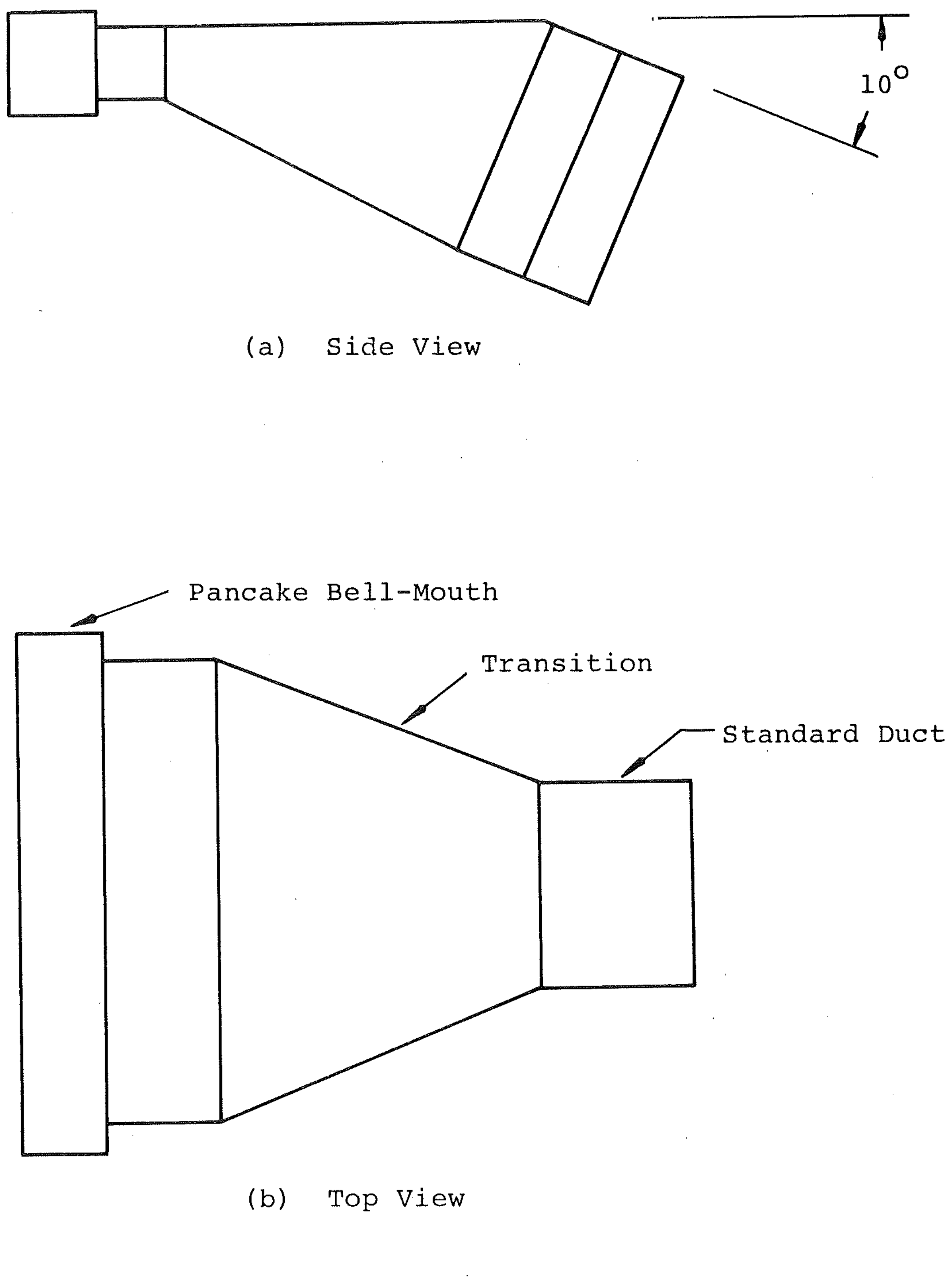



Figure A-5 - Straight Transition, Duct-to-Pancake

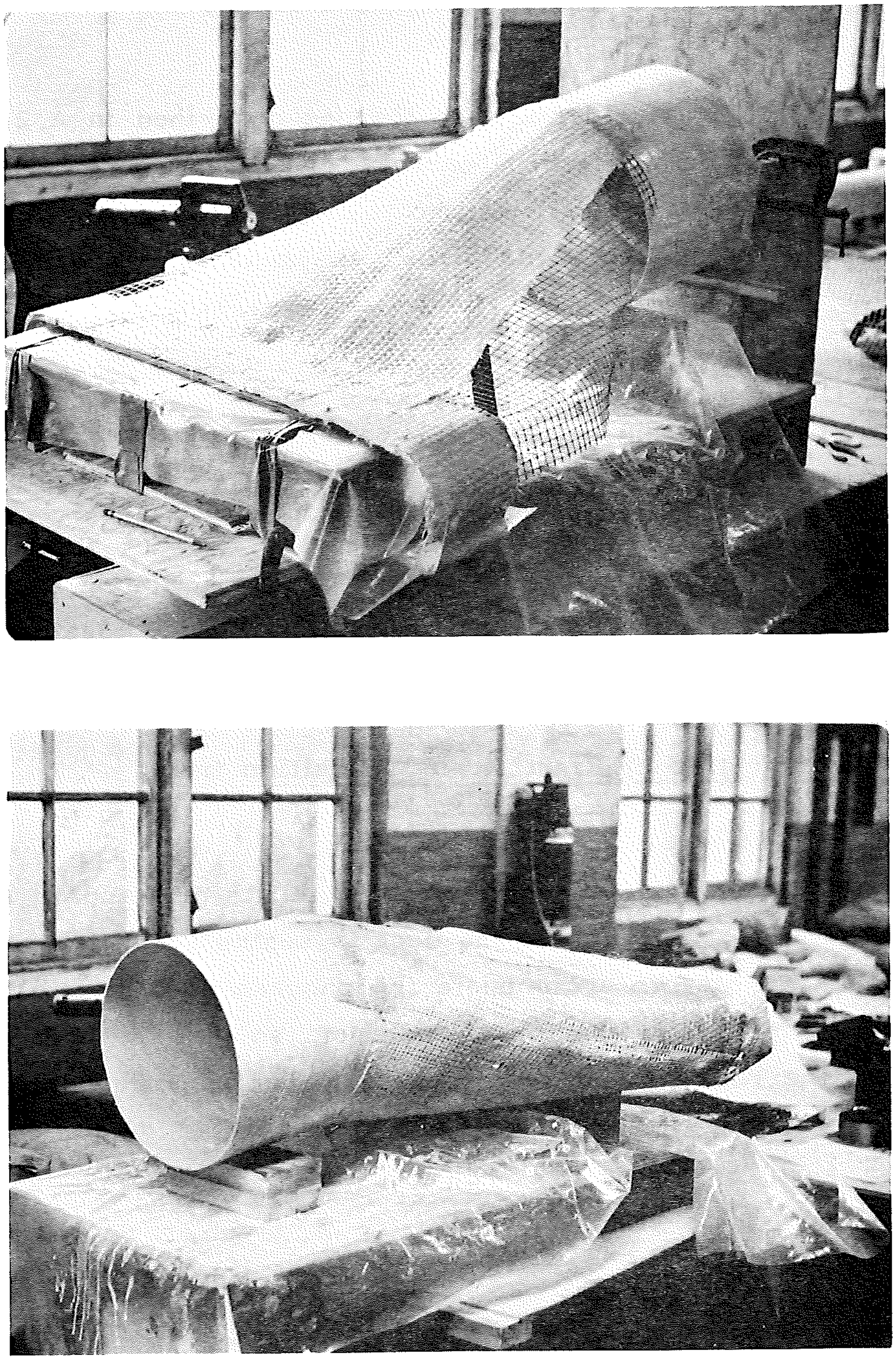


Figure A-6 - Fabrication of Transition Duct

### A.3 Fabrication of Straight Transition from Pancake to Standard Duct

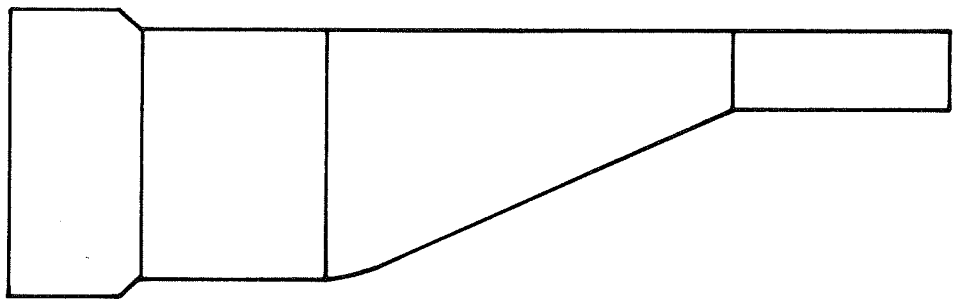
This piece is identical to the one described in A.2, except that the bell-mouth is on the pancake end, and the transition section includes a $10^{o}$ angle, so that the tubing can slant down from the roof to the auxiliary fan. This piece, shown in Figure A-7, consists of 3 parts:

(1) bell-mouth for pancake tubing
(2) transition section
(3) 1-foot length of standard duct

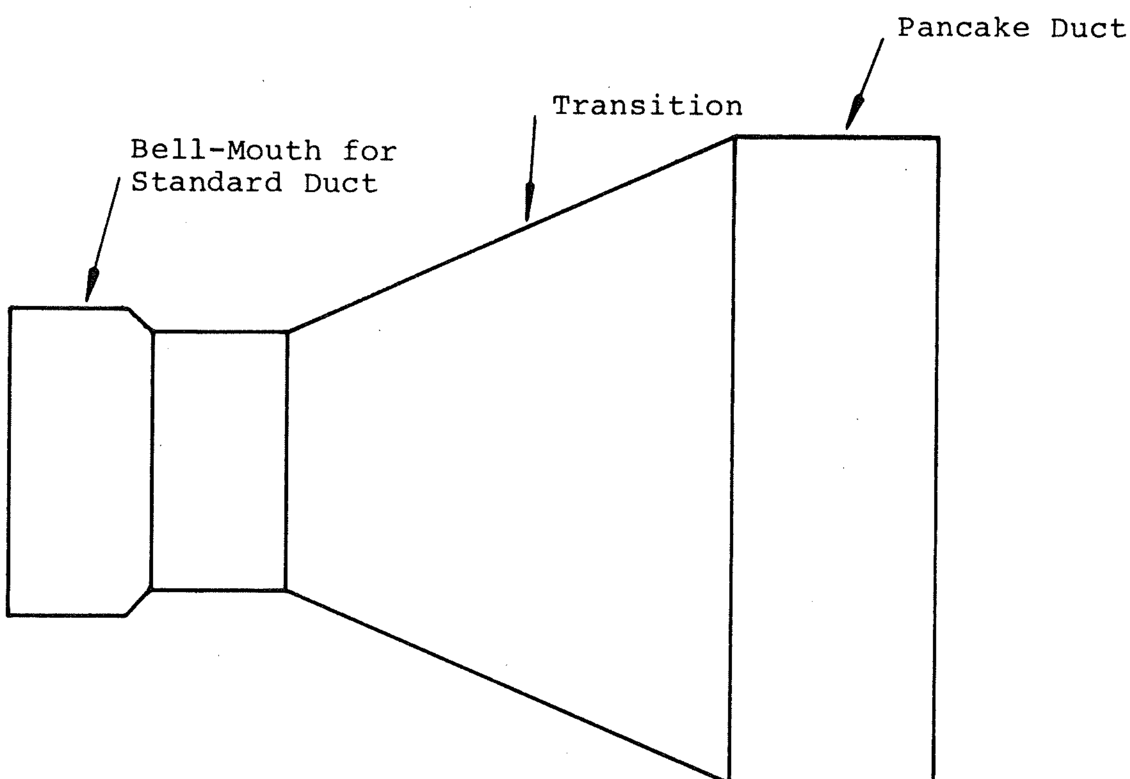
Park 1 is fabricated as described in Section A.1; part 3 is cut from standard duct. These two pieces are bonded together by a transition section in a manner similar to that described in A.2.

### A.4 Fabrication of Right Angle Transition from Standard Duct to Pancake

This piece is fabricated from a length of standard tubing, as shown in Figure A.8. One end of the duct is sealed off and a hole is cut in the side, in order to accomodate the pancake duct. Note that this hole must be placed at the top of the duct, so that the pancake duct is against the roof after it is installed in the transition duct.

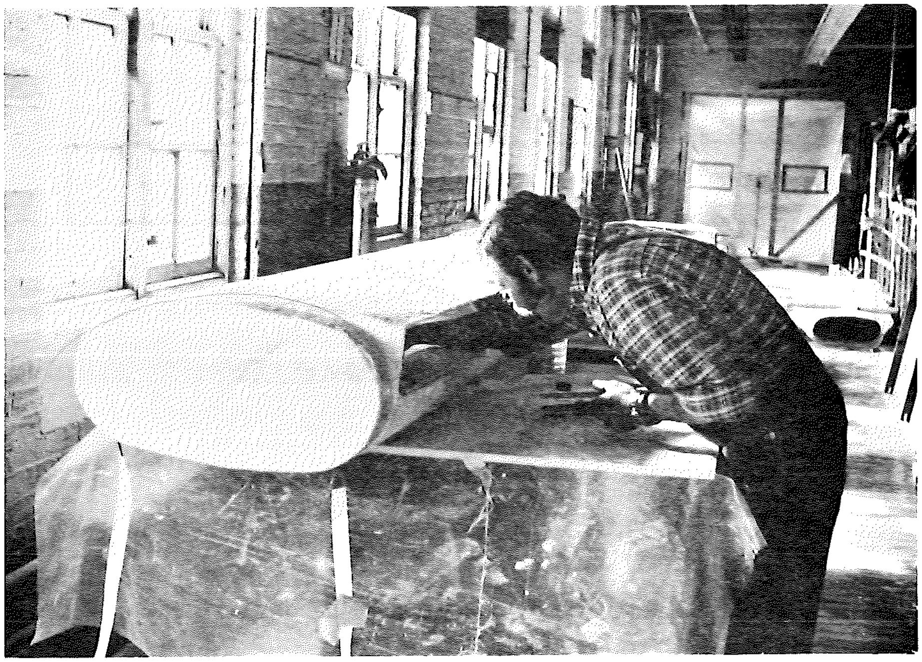


(a) Side View




(b) Top View

Figure A-7 - Straight Transition, Pancake-to-Duct



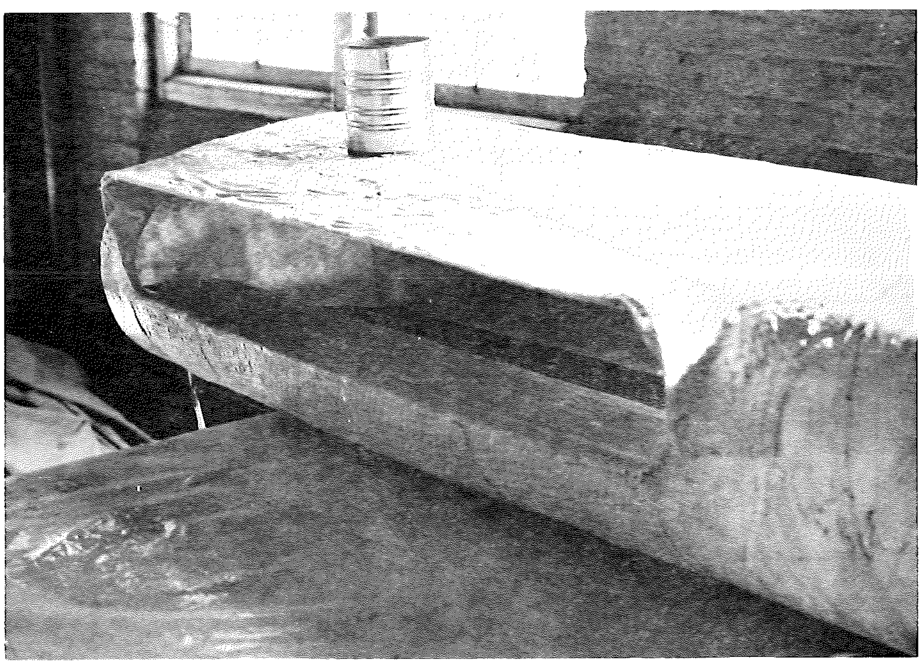


Figure A-8 - Right-Angle Transition, Duct-to-Pancake

# APPENDIX B

## MINE EVALUATION OF LEFT-HAND TUBING SYSTEM

During the week of 24 May 1976 the left-hand oval duct system was first demonstrated at the Federal No. 1 Mine of Eastern Associated Coal Corp. in Grant Town, West Virginia. It was employed on #14 Section, where a Goodman 430 borer was being used to develop a new longwall panel. The development was in the 6 Right section of the mine. A map showing the general area is presented in Figure B-1 where the proposed development is indicated by broken lines.

The components sent to the section are shown on Table B-I, specifying those components required for a complete standard system as well as those which were taken as spares.

Mr. Randy Berry and Mr. Dave Monaghan of Foster-Miller Associates supervised the introduction of the system to #14 Section. For the first shift - day shift on 25 May 1976 - they were accompanied by Mr. Raymond Leon Ash, a ventilation inspector from MESA District 3. At the start of the shift, headings 1 and 5 were driven to a full 100 feet depth and heading 4 driven to roughly 35 feet. The belt was in the extreme left, or number 1 heading, which means that the route of the shuttle cars was out of the working place and to the left. Primary ventilation was provided by using the number 2 heading as an intake and number 5 as a return. This meant that in all five headings, face ventilation would be exhausting to the right. Face ventilation, up until introduction of the new system, utilized a 15 horsepower Joy fan and 14" round rigid tubing. Although the fan had a nameplate rating of 9,500 cfm at 5.8 inches water gauge, the fan blades had been badly eroded. It is probable that the actual fan output was no better than half of the nameplate rating.

The fan was drawing through a 10' long 12" slip tube, 4-10' lengths of 14" round tubing and a single 90° bend as shown on Figure B-2(a).

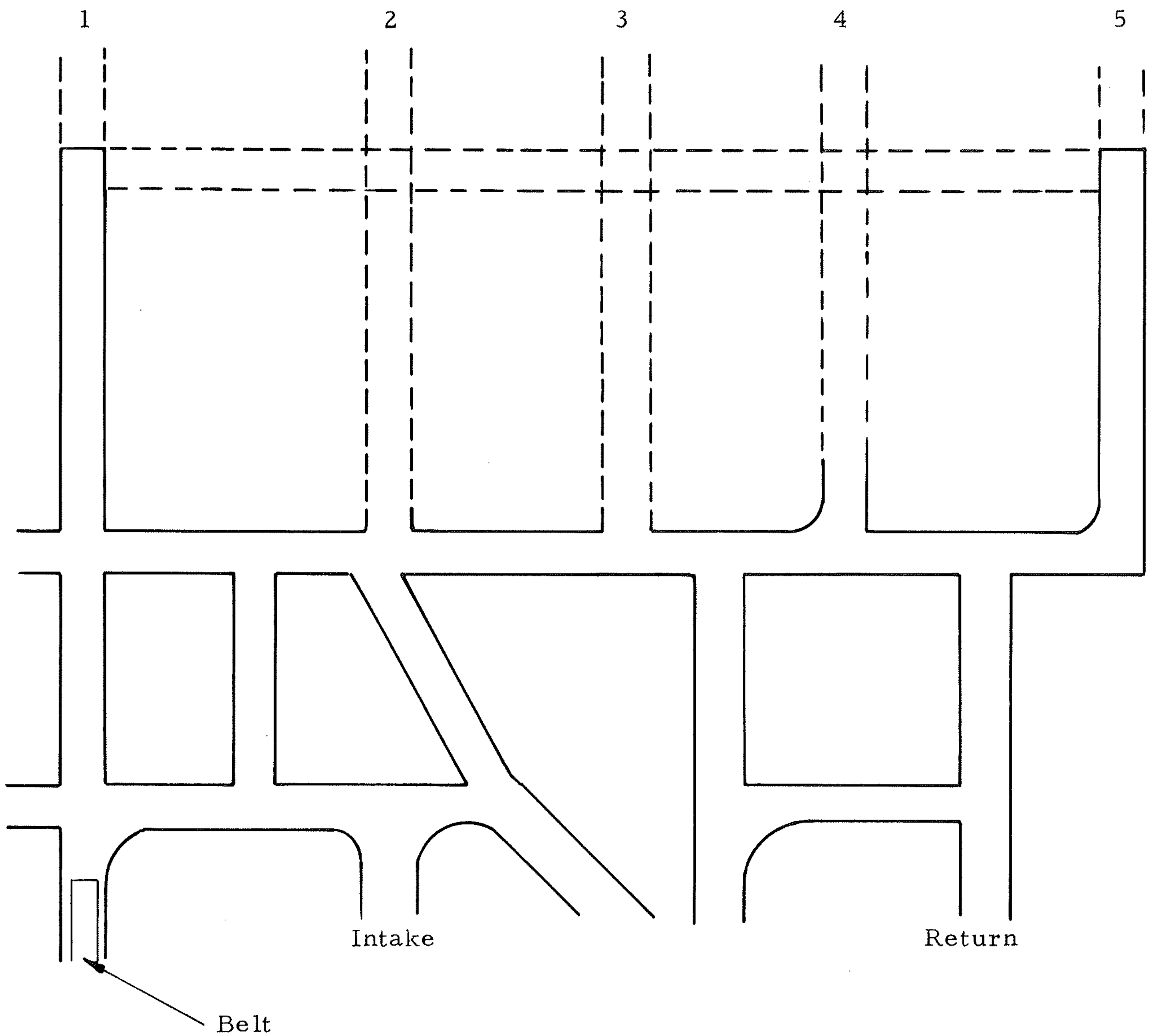
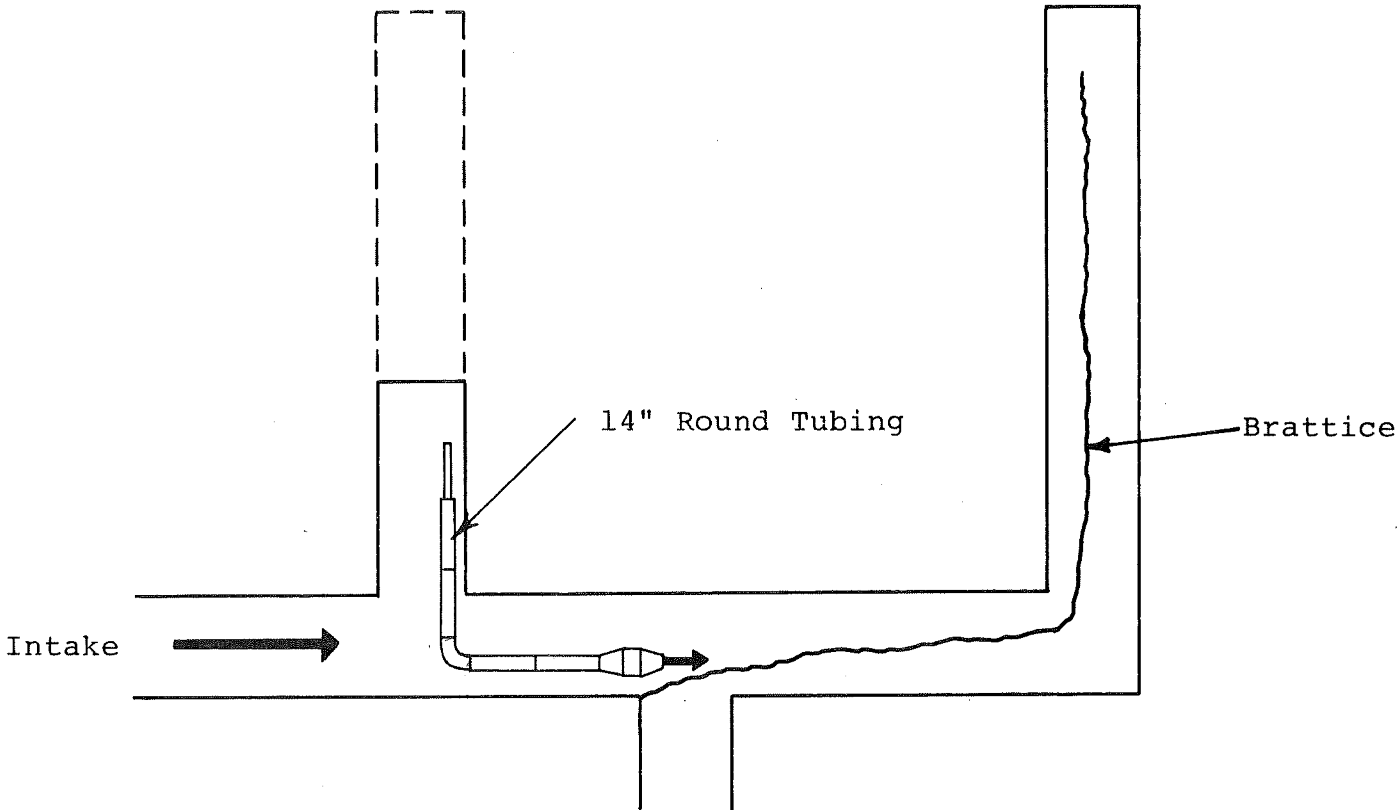



Figure B-1 - Mine Map of #14 Section, 5/25/76

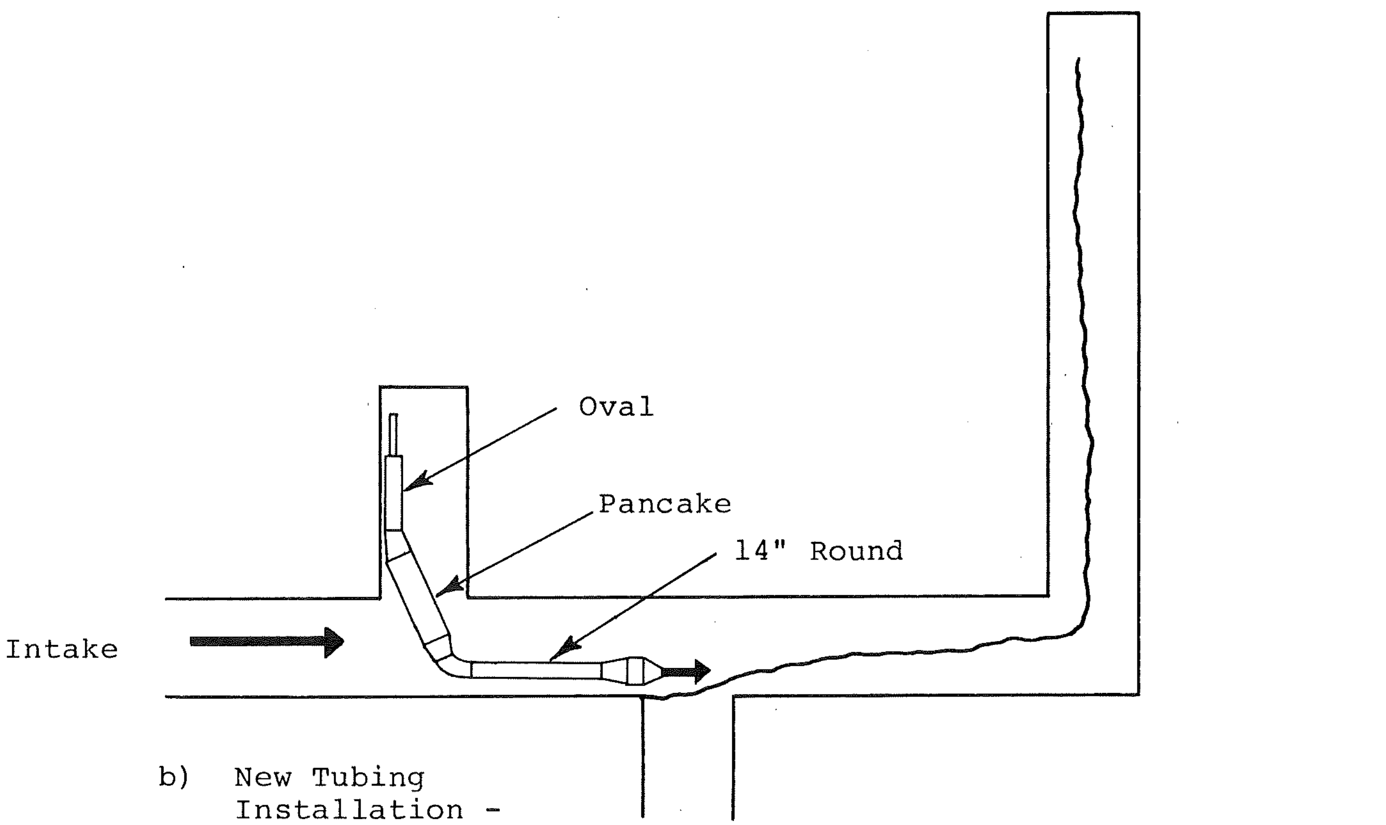
TABLE B-I

COMPONENTS USED FOR DEMONSTRATION

| Component Description | No. Required | Spaces Taken |
|---|---|---|
| Standard 18" oval tubing - 10' length | 19 | 0 |
| " " " 6' " | 1 | 0 |
| " " " 4' " | 1 | 0 |
| " " " 2' " | 1 | 3 |
| Sweep Elbows - 30° | 2 | 2 |
| " " - 45° | 1 | 1 |
| " " - 60° | 1 | 1 |
| " " - 90° | 1 | 1 |
| 90° oval-to-pancake transition | 1 | 1 |
| straight oval-to-pancake transition | 1 | 0 |
| pancake ducts - 10' long | 1 | 1 |
| pancake-to-round transition | 1 | 1 |
| slip tube - 16" oval, 10' length | 1 | 0 |
| 14" round tube - 10' length | 1 | 0 |
| round-to-oval fan adapter | 1 | 0 |




a) Round Tubing
Installation




b) New Tubing
Installation -
Same Heading

Figure B-2 - Tubing Installations

The tubing was hung from the roof on the right hand side of the machine. Pitot tube measurements, by Mr. Ash, indicated total flow through the round tubing of 3200 cfm.

The 14" rigid tubing was replaced by the new oval tubing as shown in Figure B-2(b). In this application, the pancake tubing was used to bridge the crosscut instead of the entry. The components used were the 10' long 16" oval slip tube, one 10' long 18" oval tube, the oval-to-pancake transition, the 10' long pancake duct, the pancake-to-round transition, a 90° round ell and two 10' lengths of 14" round tubing.

Air flow measurements taken with no other changes, indicated an increase in air flow to 4,500 cfm. This significant increase in air flow produced a visible improvement in ventilation at the face, as confirmed by both the miner operator, miner helper and loading machine operator.

Production was resumed with the loader operator making an effort to avoid the tubing with his boom. He was successful, although the shuttle car was loaded to only 75 percent of capacity for several trips. Clearance under the pancake duct was adequate for the loader boom and the canopies on both the loader and shuttle cars, the latter measuring 72" in height. Clearance under the oval duct was not sufficient for confident operation of the shuttle car with a left-side canopy. Since the other shuttle car was not operational, extreme care was required in operation of the shuttle car for the remainder of the shift. By keeping the tubing tight to the roof, and the roadway free of debris, it was possible to operate the shuttle car with the canopy directly below the oval duct. A total of 24 carloads of coal were loaded during dayshift on #14 Section using the new ventilation system. This is roughly average production for the crew. The heading was driven to within 15 feet of its end.

During the shift, Mr. Larry Jackson, Mine Superintendent, and Mr. Bob Stuzen, Mine Foreman, both visited #14 Section to observe the new system. They were impressed by the quality of the face ventilation and pleased with the proposed of operating both shuttle cars because of the additional clearance between the tubing and shuttle car canopies which the oval tubing provides. To accommodate the system, they idled the section for afternoon shift and instructed the mechanics to lower the canopies on both shuttle cars a full three inches.

The FMA representatives returned to the section with the midnight shift on 26 May. While movement of the belt delayed production for roughly 2 1/2 hours, the purpose and potential of the new ventilation system were described to the men. When production was resumed, only the left-hand shuttle car was operational but the canopy cleared the oval duct by 3 inches. The face was advanced the remaining 15 feet and the placed cleaned up as required.

At this time the borer was trammed out of the heading with the tubing left in place. While considerable care was required by the operator, at no time did the machine scrape the tubing at any point. The possibility of leaving tubing in the working place provides important safety and production benefits.

Prior to the end of the shift, heading 3 was advanced apprxoimately 15 feet. This was done using standard 14 inch round tubing because of the considerable amount of motion required of the borer to begin the heading. With practice and some additional effort, the flat tubing could be employed during this operation too.

The day shift (5/26/76) crew was asked to install and continue use of the oval tubing and to leave it available for use by the afternoon shift. Although FMA personnel were not present at the close of the day shift, it appears that equipment malfunction and the availability of only one shuttle car permitted them to advance the heading only 80 feet of the required 100 feet. No particular clearance problems were experienced with shuttle car canopy or the loader boom. The shuttle cars were loaded only to about 90 percent of capacity, however, to minimize distrubance of the duct.

Afternoon shift (5/26/76) worked 14 Section with no prior instruction in the use of the oval duct. They found the duct left in heading 3 by day shift personnel and completed that heading making use of the duct. After that, heading number 2 was started and the oval duct installed in a fashion similar to that in heading 3. The installation was excellent as observed by FMA personnel when they returned on the midnight shift, (5/27/76) but the oval tubing extended too far into the roadway, providing some interference with the loader boom and the shuttle car canopy. Although the entire heading was driven with no particular problem, several sections of duct at the intersection were knocked down by the loader boom during final cleanup of the heading. After this, the remaining tubing was taken down and the miner trammed to the end of heading #1 where a right-hand 90° turn was required.

A slightly different tubing installation was employed in heading #1 since the shuttle cars are not required to turn under the pancake duct. This installation utilizes the 90° pancake-to-oval transition as shown in Figure B-3. In this configuration, with the bottom cleaned properly, there was no interference with the buggy canopy or loader boom at any point.

Furthermore, since the coal-laden shuttle car passes directly under the 5" high pancake, instead of the 11" high oval duct, the shuttle car could be loaded more fully, although still not to maximum capacity. A more detailed discussion of this matter is contained in the next section.

Although no quantitative flow measurements were made, the ventilation was judged to be excellent even with over 200 feet of tubing installed. Drs. Fred Kissel and Joe Matta and Mr. Ed Divers of the Bureau observed the operation of the system during much of day shift (5/27/76). Even at the miner operator's station or brattice man's station on opposite sides of the machine, the ventilation was perceived as good by these USBM representatives.

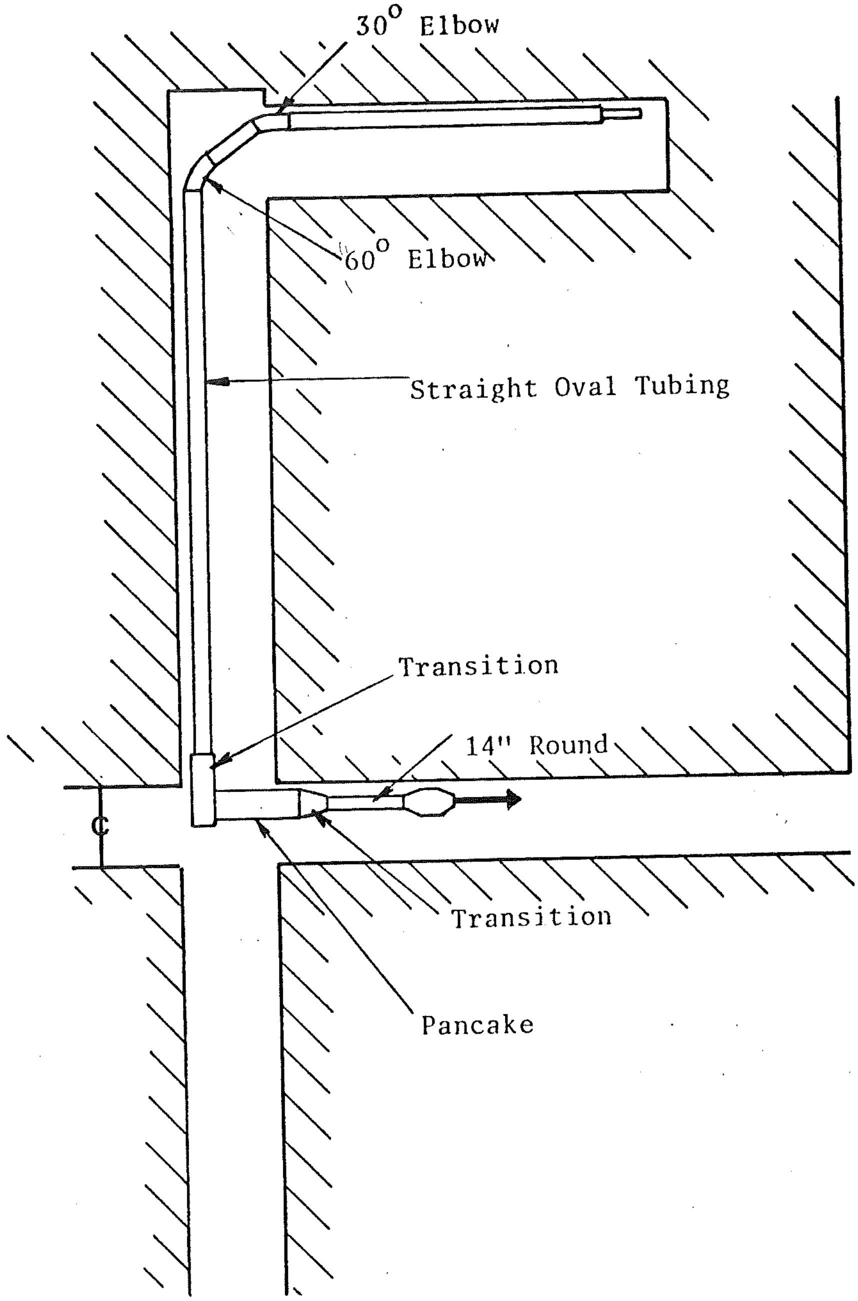



Figure B-3 - Mine Installation with 200 Feet of Tubing

This effective ventilation was achieved at no cost to production. For the first time, both shuttle cars were available and ran simultaneously for part of the shift until one developed a cable reeling problem. A total of 37 1/2 cars of coal were loaded from 14 Section during this particular shift.

By the end of the shift the breakthrough into heading #2 had been completed and the fan and tubing were no longer required. Since the tubing was not to be needed for several more shifts, the demonstration was considered complete and the tubing left on the section to be used temporarily at the mine's discretion. Up to this point, the new tubing system had been used virtually continuously for six straight production shifts in which approximately 1,800 tons of coal had been mined.

The new system was used for the balance of the week and all of the following week, with no supervision by the contractor. At this time it was set aside to await further improvements discussed in the next section.

After the first underground tests, the duct system was modified as follows:

- Larger, stronger hooks were fabricated for the adjustable hangers on the duct.

- New pancake duct was fabricated in 5-foot lengths instead of the original 10 feet.

- Both the pancake ducts and the transition pieces were replaced with new pieces, using thinner fiberglass which cut the weight by about 40 percent.

The new parts were shipped to the mine and re-introduced to #14 Section following Miner's Holiday. At this time, the section was as shown in Figure B-4. Although the tubing was on the section on Monday 7/19/76,

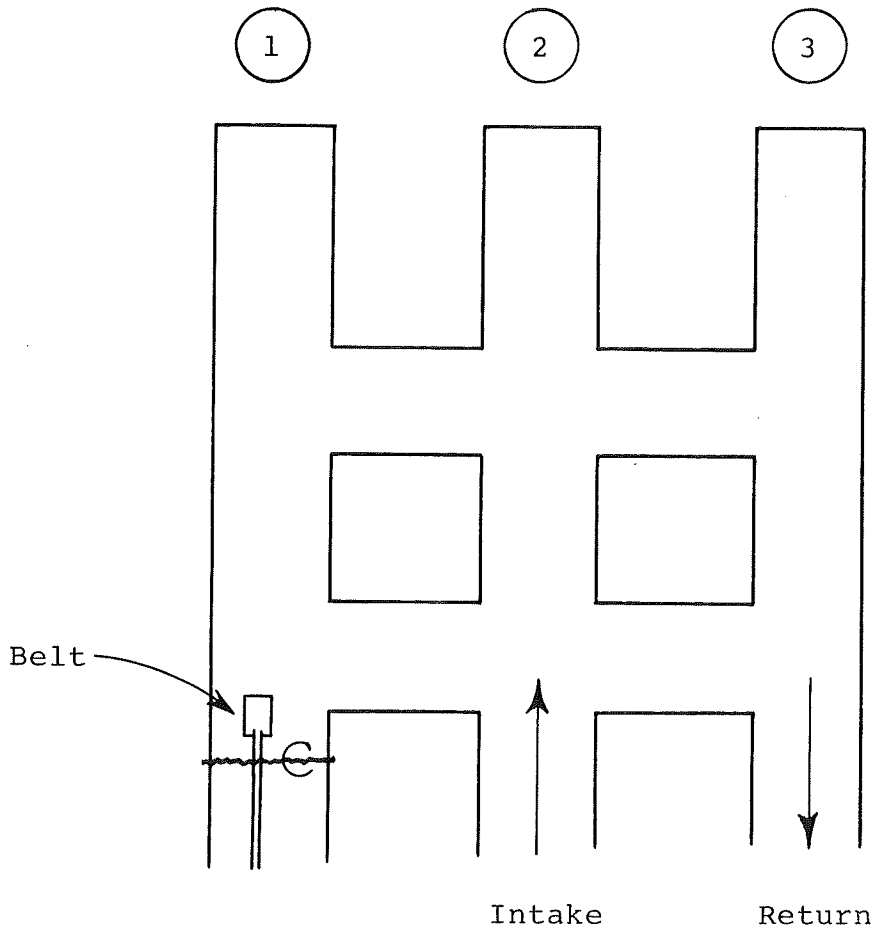



Figure B-4 - Simplified Plan of #14 Section the section was down for a number of consecutive shifts due to mechanical difficulties unrelated to the tubing system. Production was resumed with the tubing system under Foster-Miller's supervision on midnight shift early Wednesday morning (7/21/76). Fred Kissel, USBM, was also present as an observer. During the half-shift that was worked, the tubing system was in full time use and 20 cars of coal were loaded.

As expected, the lighter duct was much easier to use. This was verified during the initial installation of the pancake duct, which had to be employed in the intersection while the mining machine was in the way. Although the mining machine did somewhat impede the installation, two men were able to hang the cross over section with no difficulty.

The only disappointment occurred with the use of the new hooks, some of which snapped during the shift. Examination of the defective hooks gave clear evidence of brittle fracture, evidently due to excessive heat-treating of the material.

Day shift (7/21/76) continued use of the tubing system, with Foster-Miller supervision and USBM observers Messrs. Ed Divers and N. I. Jayaraman. Mr. Ron Copley was also present to photograph operations.

As on the previous underground testing, the day shift crew took full advantage of the new tubing system by operating both shuttle cars, enabling the crew to load over 40 cars of coal during the shift. During this shift the number 2 heading was finished and the number 1 heading was started.

Foster-Miller supervision ended as of day shift on July 21, 1976. The tubing continued in use for the balance of the week, at which time a wildcat strike stopped all underground work.

# APPENDIX C

## REPORT ON FIELD TRIP TO KEYSTONE NO. 1

| | |
|---|---|
| Date: | 30 October 1974 |
| Location: | Keystone, West Virginia |
| Superintendent: | John Boroski |
| Seam Height: | Approximately 56 inches |

1. They use mostly Lee-Norse 105 "Hard-head" miners in a "2-step" mining system although "two-step" is a misnomer. On the section we visited, 3 steps were used. The first cut was made in the middle, and then cuts were made to the left and right. This means that any proposed machine-mounted ventilation system must interface to the fixed portion of the line brattice when the miner is in a wide variety of positions.

2. Miner helper is responsible for setting the line brattice.

3. It is very difficult to keep brattice within 10 feet of face for at least three reasons:

   a. requires additional length to be added while working underneath unsupported roof,

   b. restriction of visibility, and

   c. difficulty of cutting along rib on the brattice side.

4. Ventilation pattern at this face is shown in Figure C-1. The line curtain is held up with nails on cap boards. Installation of a new overcast will allow bringing air up the No. 3 entry as shown in Figure C-2.

5. This section was "cycle-mined" : advance 20'; pull miner out to new place; bolt old place; repeat. Coal flow was miner to buggy to belt to track haulage.

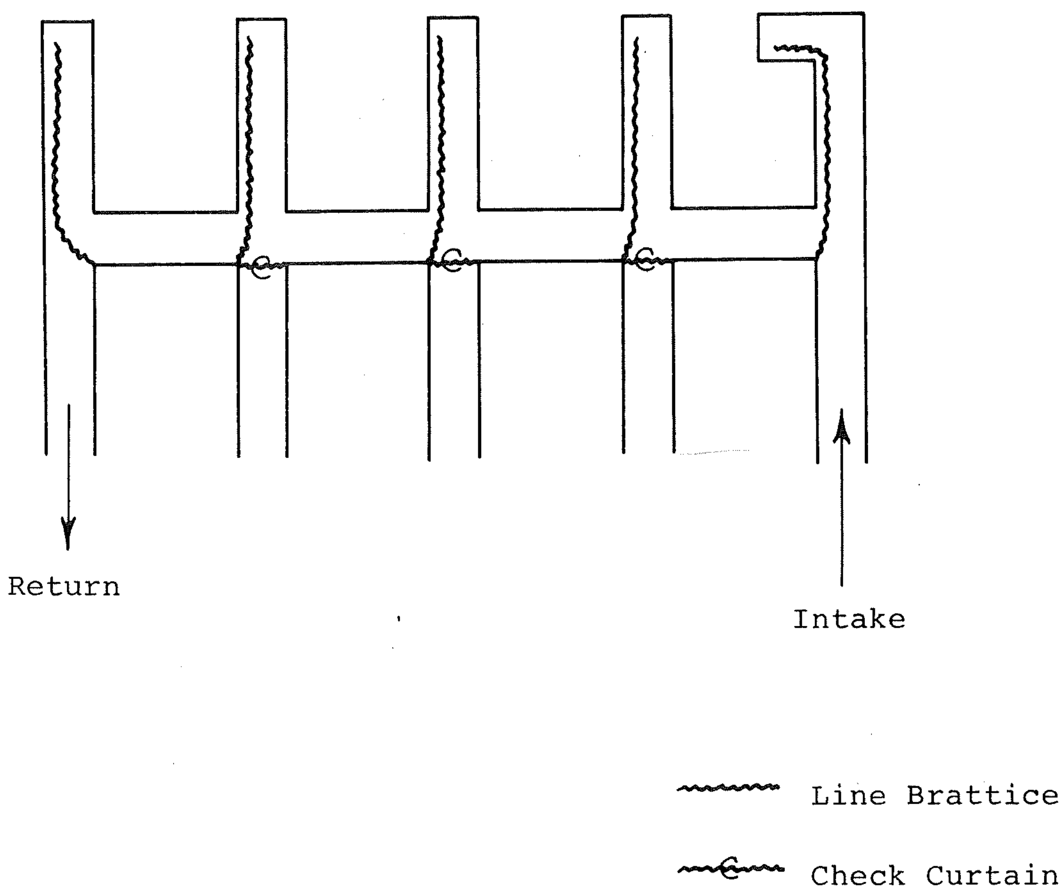



Figure C-1 - Existing Ventialation on Keystone System

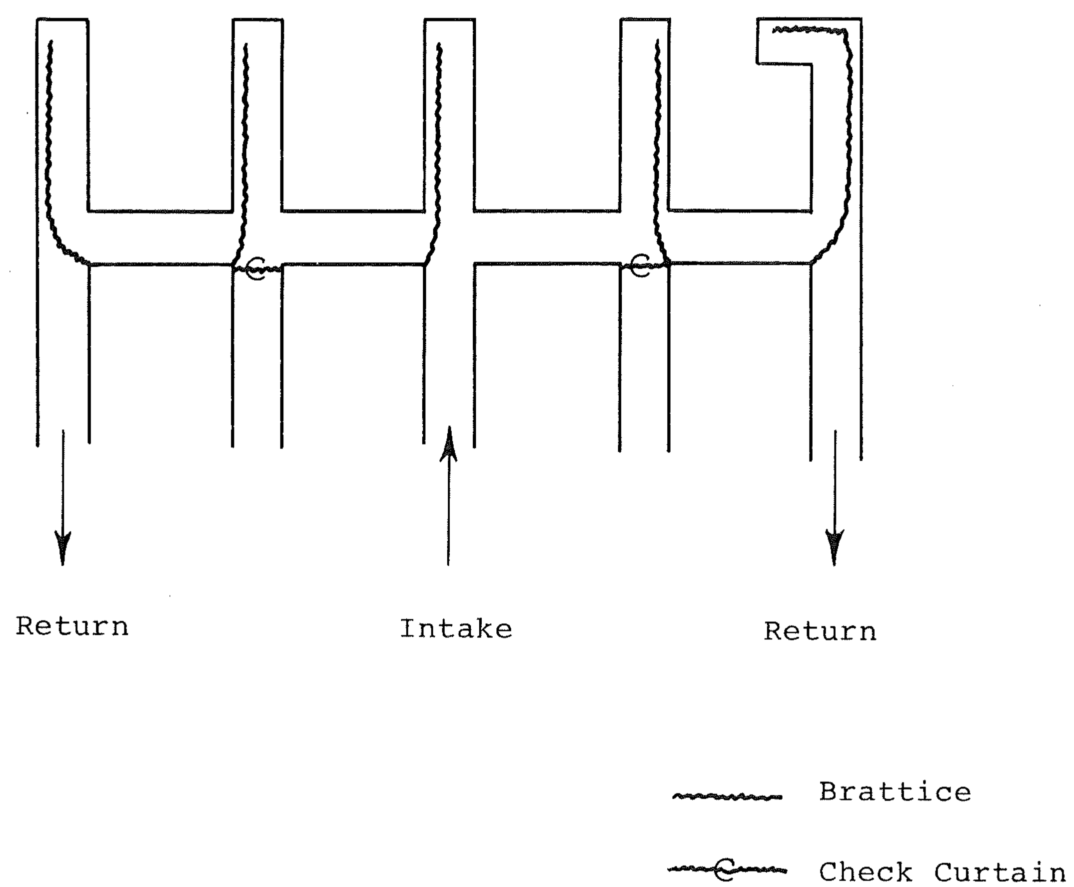



Figure C-2 - Proposed Ventilation for Keystone System

## APPENDIX D

## SITE VISIT TO FEDERAL NO. 1 MINE

| | |
|---|---|
| Date: | 31 October 1974 |
| Location: | Granttown, West Virginia |
| Superintendent: | Mr. Larry Jackson |
| Seam Height: | Approximately 80 inches |

1. Mine uses Goodman 430 Borers and Jeffrey 120M Heliminers, all with Joy Loading Machines and Buggies.

2. All continuous sections use rigid tubing with auxiliary fans on the working place. Idle places require brattice line which is put up by roof bolter and helper.

3. New rule for district 3 (Northern West Va.) requires all ripper-miner sections to be cycle-mined.

4. This mine uses a slip tube with their rigid tubing; the slip tube section is often damaged.

5. Newly-required canopies on buggies often interfere with tubing and destroy it. Mine superintendent thinks an oval shaped tube would help if employed as shown in Figure Figure D-1.

6. Miner operator on heliminer section appears receptive to machine-mounted telescoping tube concept.

7. They are starting to use 2 fans/section so that system would be as shown in Figure D-2.

8. Vent tubing and auxiliary fans are used with Goodman in much the same way as in the ripper sections.

9. Due to the gasiness of Federal No. 1, they try to keep 9,000 cfm on the working face.

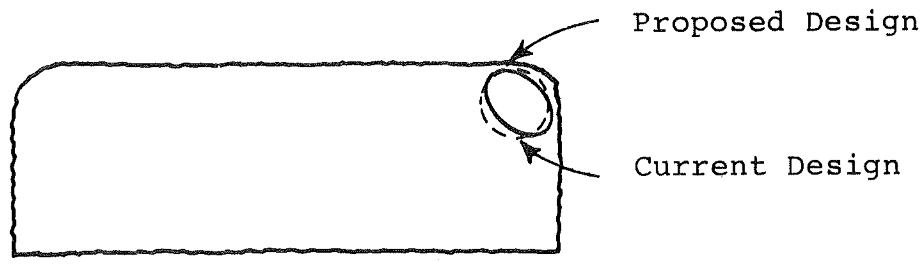



Figure D-1 - Ovalized Vent Tubing

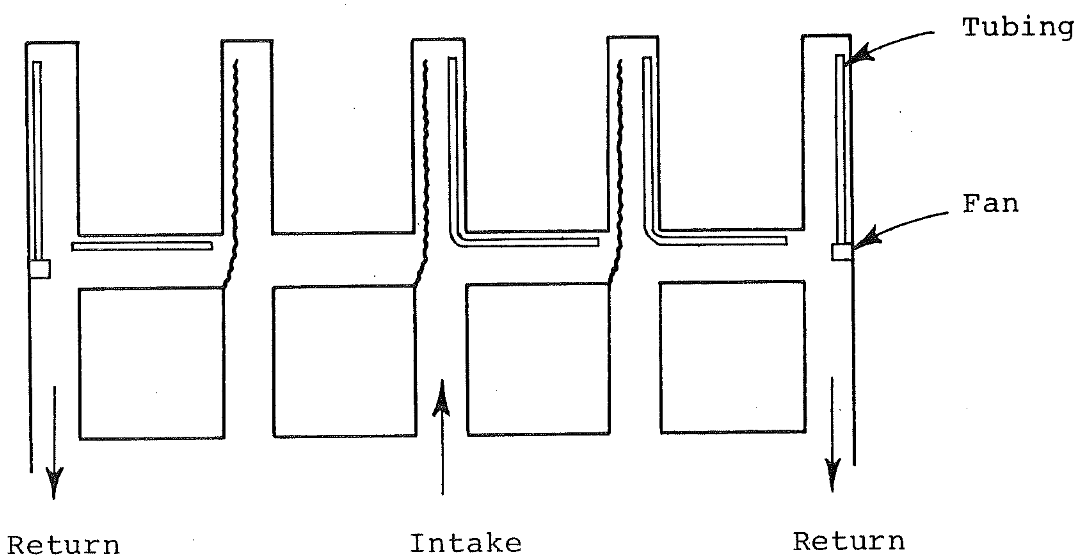



Figure D-2 - Ventilation with Two Auxiliary Fans

# APPENDIX E

## FIELD TRIP TO LOVERIDGE NO. 22 (CONSOL)

| | |
|---|---|
| Date: | 8 November 1974 |
| Location: | Fairview, West Virginia |
| Superintendent: | Paul Carter (for Sugar Run Portal) |
| Ass't. Super.: | Darrel Auch |

1. Mine has one Heliminer section (being phased out). All the rest (11 machines) are Joy Twin Borers, modified to provide seat, front-facing controls, and canopy. Loading machines are used on every section.

2. Auxiliary fans require 25 HP to put 6,000 cfm on the face.

3. Vent tubing as long as 200 feet is used. Eighteen inch flexible tubing to 16" rigid tubing to 14" slip tube manually extended by miner operator.

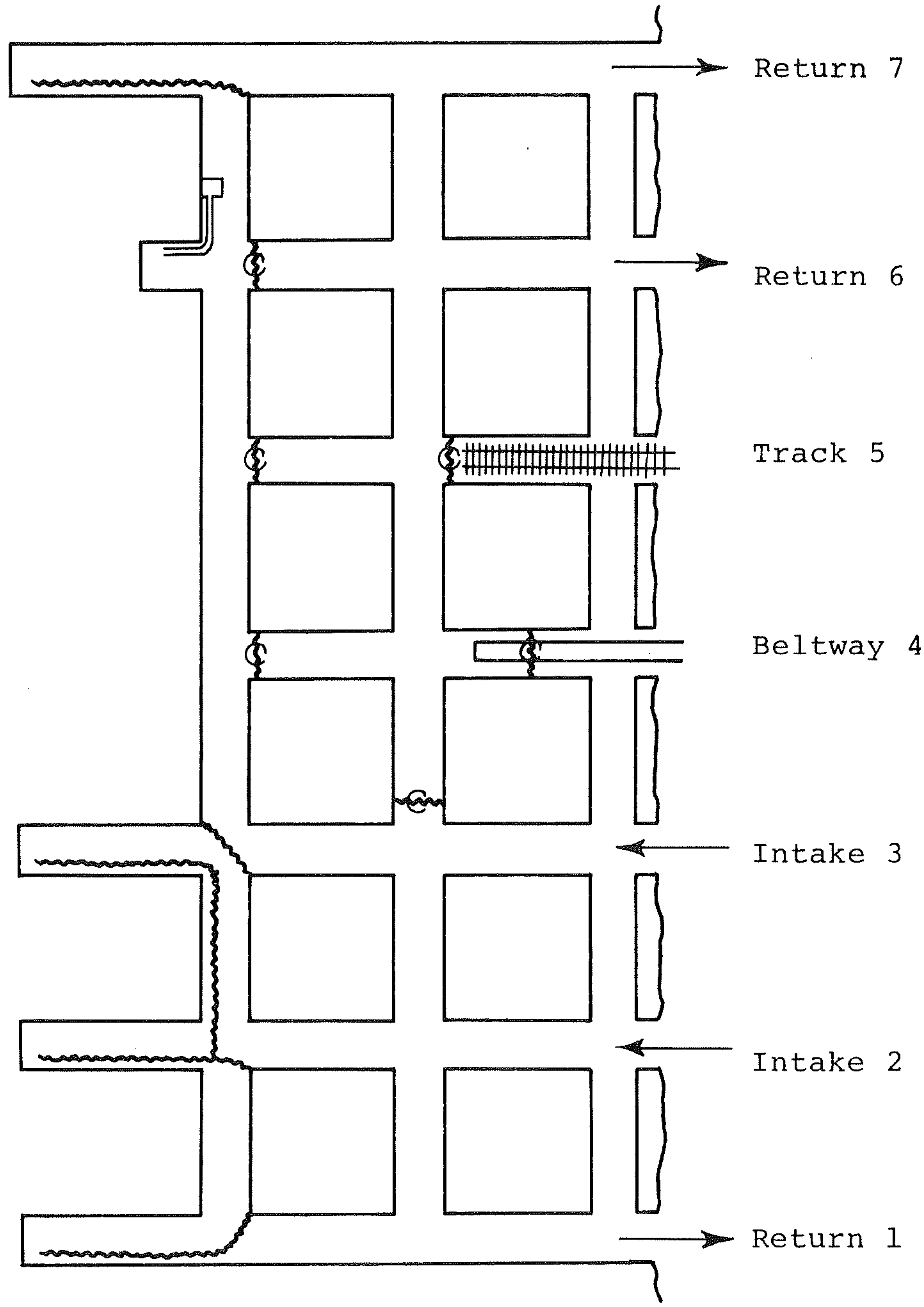
4. Section ventilation is shown on Figure E-1 and Figure E-2. for "3 North" and "C-Face" respectively.

5. Ten foot joints of tubing are used rather than longer lengths because:

   (a) Supply cars are only 15 feet long.

   (b) Ten foot lengths are easier to handle.

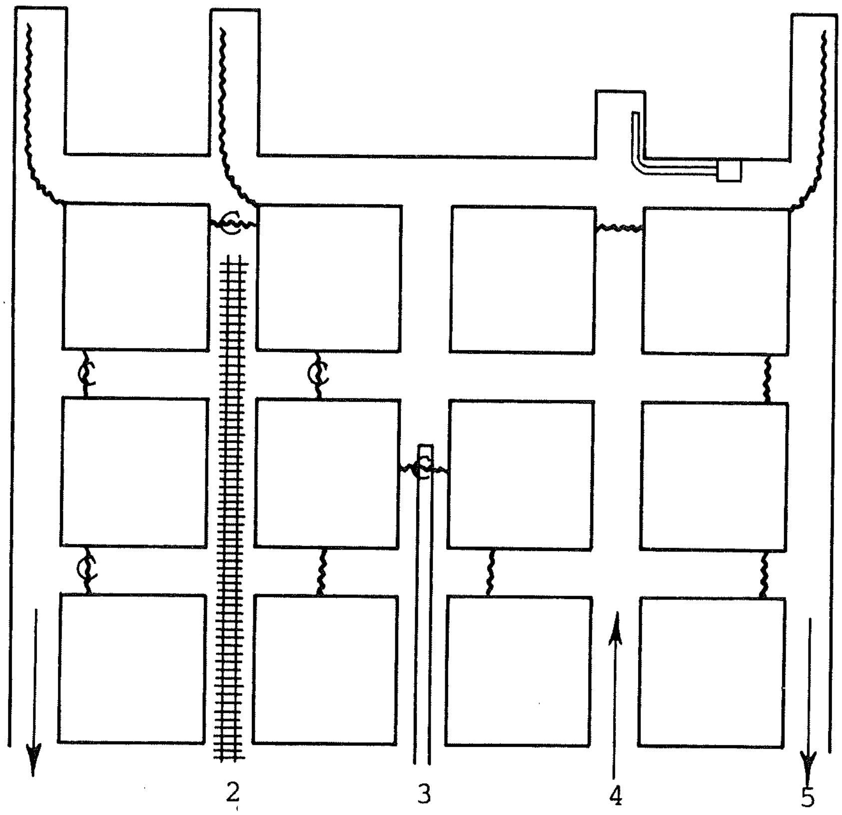
6. With the twin-borers, they can cut ahead one full block before pulling out to bolt. Because the slip tube joint is only 11 feet long, it must be held up with a spad and piece of wire to get the last 5 feet of travel. This is just marginally superior to just adding a new length of tubing.




Mining Sequence:

1 Advance 7, 6, 5 venting into return 7 and 6
2 Advance beltway heading (4)
3 Drive crosscut across 3, 2, 1
4 Advance 1, 2, 3 venting into return 1
5 Drive crosscut across 5, 6, 7
6 Repeat

Figure E-1 - Ventilation Pattern - "3 North"





Mining Sequence:

1 Advance beltway heading (3)
2 Drive Crosscut across 2, 1
3 Advance 1, 2 with duct on left side venting into 1 (shown)
4 Drive crosscut across 4, 5
5 Advance 5, 4 (shown)
6 Repeat

Figure E-2 - Ventilation Pattern - "C-Face"

7. Miner operator is responsible for setting tubing, with help from the loading machine operator.

8. Tubing replacement - 50 percent of the 200' length is lost in a 2,500' heading. At $38.00/10 feet this works out to about $400/2,500 feet of advance.

9. The ripper section is cycle mined but they do not alternate headings. Rather they pull back the miner, bolt the roof, extend the ventilation and return the miner. They feel the production lost by waiting rather than switching headings is compensated for by reduced wear and tear on equipment and reduced safety hazard.

10. Cycle time is about one hour and ten minutes.

11. Cycling has reduced tonnage from 380 to 250 per shift. If they were not phasing out the ripper miner they would develop a more efficient operation.

12. Haulage - not miner operation or ventilation limits production.

13. Visibility is extremely poor on Joy Twin-Borers. Even though the controls have been relocated, the operator still stands to the side and operates the machine like a loading machine. Sometimes he even leaves the machine while it's running to go see where the head is cutting (e.g., on turns). This may be different when he's driving straight ahead after his points are lined up.

14. The frame for the upper chain cutter on the Joy Twin Borer makes mounting a tube over-top of the machine impossible, although there is room down the side of the machine. (Although it would probably be smashed in this position when the cutters are retracted and the borer trams to another location.)

## APPENDIX F

## REPORT ON FIELD TRIP TO KOPPERSTON NO. 2

| | |
|---|---|
| Date: | 8 January 1975 |
| Location: | Kopperston, West Virginia |
| Superintendent: | High Blackburn |
| Seam Height: | 56" to 84" |

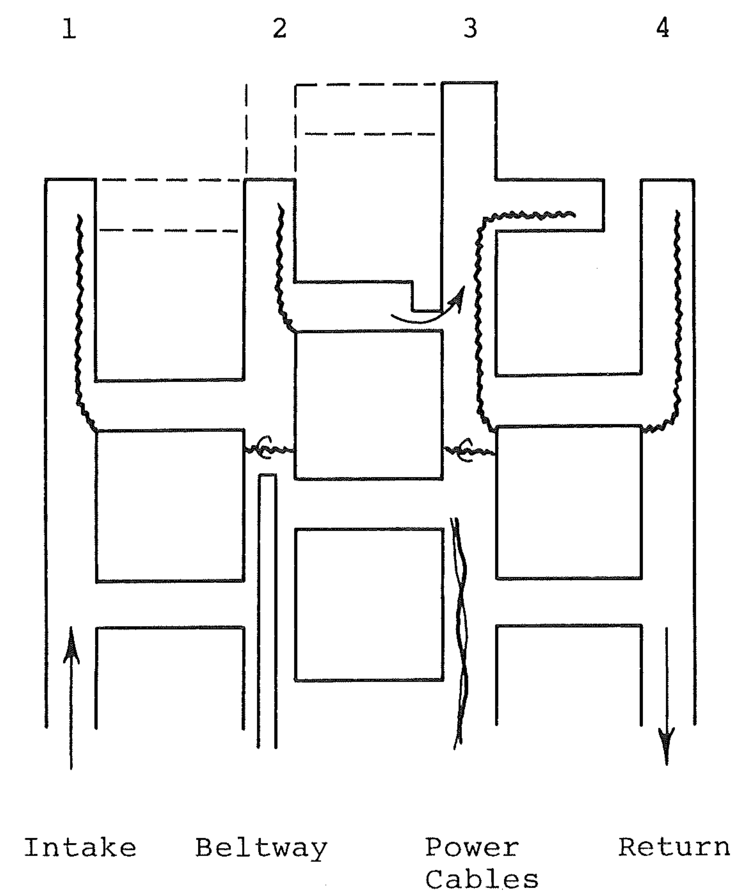
1. The Kopperston mines - Nos. 1 and 2 are located above one another. Kopperston No. 1 is located in the Eagle Seam under Kopperston Mountain while No. 2 is located in the Campbell Creek Seam some 250 feet above the No. 1 mine. Much of the No. 1 mine has been mined out permitting subsidence and causing severe roof and rib control problems in the newer No. 2 mine. This unhappy sequence was chosen since the lower seam was easier to mine initially.

2. Both mines are drift mines, entered where the coal seam outcrops. We were escorted by John Paynter, the Safety Director and ex-superintendent of the Kopperston Mines.

3. We first visited the Lacey Fork, 2 Right section, where a Joy 11CM was being used to drive a 4 entry heading. The breakthroughs are staggered as shown in Figure F-1. to minimize roof control problems.

4. At the time of our visit face ventilation was restricted because of small area breakthroughs between 2 and 3 and leakage through the brattice stoppings and the line curtain.

5. The posts used every 3' for "rib control" and the bars on 3' centers for roof control provide considerable




Main and Butt Entries on 80 Foot Centers

Figure F-1 - Staggered Crosscuts at "Lacey Fork, 2 Right" restriction to air flow. They do provide excellent support for line curtain however.

6. The mining operation at each face is as follows:

   (a) Advance 18 to 20' on left rib - 10 1/2 feet wide.

   (b) Pull back - set 3 posts for roof control.

   (c) Slab right side - clean up.

7. On the North Mains section a Joy 8CM was employed to drive another 4 entry heading with opposite ventilation, as shown in Figure F-2. The 8CM produces more dust than the 11CM because of the air cooled motors and the oscillating cutter heads. This leads to a slight dust problem, but gas does not seem critical.

8. Line curtain on left side seem much more satisfactory in terms of keeping operator in fresh air and in terms of operator visibility.

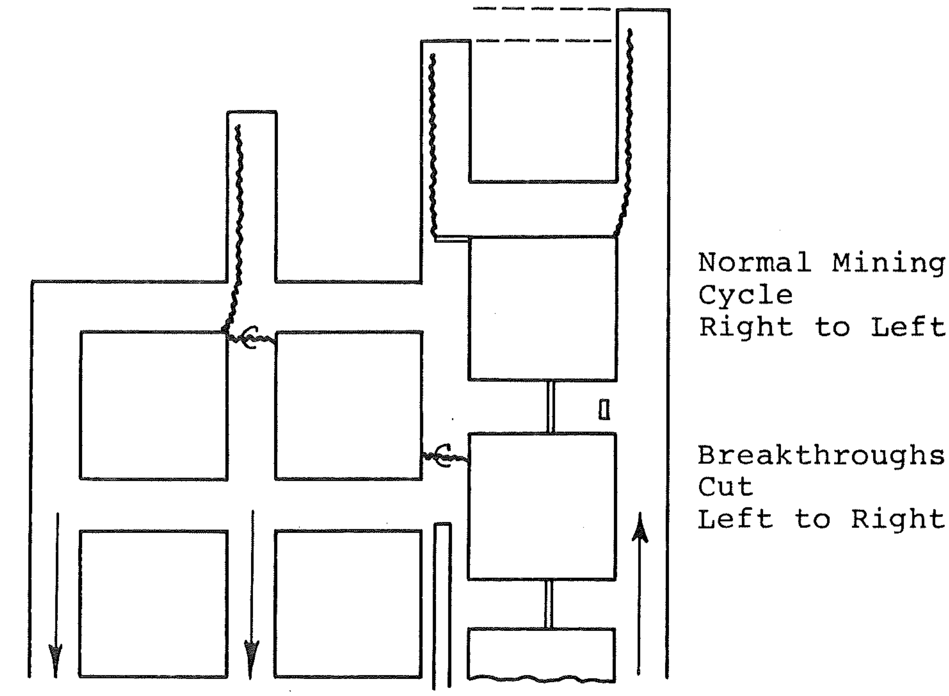



Figure F-2 - Ventilation with Two Auxiliary Fans

# APPENDIX G

## REPORT ON FIELD TRIP TO HARRIS NO. 1

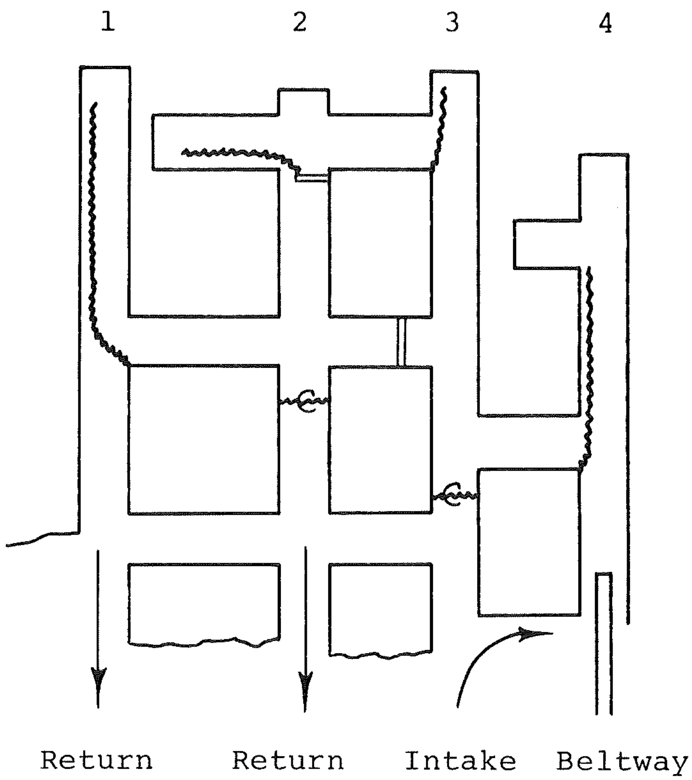
| | |
|---|---|
| Date: | 9 January 1975 |
| Location: | Bald Knob, West Virginia |
| Safety Director: | Charles Johnson |

1. The Harris Mines (Nos. 1 and 2), like the Kopperstons, are in different seams - No. 2 lying above No. 1. Harris No. 1 is apparently a "text book mine" with little gas, good roof and adequate ventilation. Harris No. 2, like Kopperston No. 2 is plagued with roof and rib control problems because the seam below has been worked out in many locations cusing subsidence and the associated problems.

2. A roof control plan has been obtained from Harris No. 1 which provides considerable insight into the mining sequence. We visited one "ideal" development section and one pillaring section. The pillaring section utilizes line curtain only infrequently because of the return directly into the gob. It was visited to broaden our exposure to various mining cycles - not specifically for face ventilation schemes.

3. 7 Right, 1 West is a 4 entry heading which already extends 3,000 feet. The heading is preparing a 450' x 3,200' panel for longwall mining. Because of this intended use, particular care has been exercised in the development of this heading. Ventilation is excellent, the beltway is immaculate and roof control is thorough.

4. The ventilation patterns on the section visited are shown in Figure G-1.




Mining Sequence:

1 Breakthrough 4-3; 3-2; 2-1
2 Advance 1, 2, 3, 4
3 Breakthroughs cut right to left

Figure G-1 - Ventilation Pattern at "7 Right, 1 West"

5. Several practical and apparently simple innovations improved the face ventilation on this section and provided for a "neat" operation. For example:

(a) The entries being cut were 20' wide instead of the more usual 16 or 18 feet. The standard header bars are mounted offset to the right on the roof so that the brattice can be tacked to the ends of the bars rather than the lower side. This permits more satisfactory sealing at the roof and a much neater brattice installation.

(b) The vent curtain is always hung on the left rib with the air returning behind the curtain. This keeps the operator in the cleanest location possible and minimizes the interference with his visibility.

The mining sequence on the continuous sections is as follows:

(a) Roof bolt to within 4' of the face and hang brattice.

(b) Cut 20' box cut along the left rib.

(c) Pull back and make 20' "slab" cut.

(d) Set temporary posts across entire cut.

(e) Bolt roof.

6. Compliance with the law would require maintaining ventilation within 10' of the face. This would require temporary support along the left rib to extend the line curtain toward the face during the sump cut. This post placement is dangerous and interferes with the cleanup

of the left hand side of the entry prior to bolting. In mines where this is required there is a definite need for an extensible ventilation system but it should be cantilevered from existing roof supports - not attached to the miner!

7. The pillar recovery operation using continuous miners was visited at 4 Butt left. A Lee Norse 35Y miner of 1954 vintage was being used.

## APPENDIX H

## REPORT ON FIELD TRIP TO OLD BEN NO. 21

Date: 4 February 1975
Location: Sesser, Illinois
Superintendent:
Industrial Engineer: Gary Gray

1. Old Ben No. 21 is currently mining in the Illinois No. 6 or Herrin Seam. The section we observed was developing the 9th thru 24th East South Mains. Old Ben uses boring machines for developing their mains and then ripper miners on the panels. No. 21 currently operates 6 Goodman machines and intends to continue their use. The ripper sections were more productive until recent roof control requirements led to cycle mining.

2. Face ventilation varies with the machine used. Standard 16" exhaust tubing and Buffalo Forge fans are used on ripper sections. Flexible 14" blower tubing and Joy high pressure blowers are used to blow onto the borer faces. The Joy fans are rated at 4,000 cfm at 17.5" w.g. The tubing dumps fresh air behind the operator, theoretically keeping him out of the dust. This air then "washes" the face and returns with dust and gasses entrained along the buggy roads which are, in effect, the returns. Turbulence and recirculation of the air at the face keeps the miner operator in a cloud of dust and the use of buggy roads as returns exposes the buggy operators to high concentrations as well.

3. The mine workers appeared unconcerned about the dust situation. There were very few operational water sprays on the miner.

4. The observed conditions indicated the importance of improved ventilation on Goodman sections. Some observations related to installation of the proposed extensible system are listed below:

(a) Some preference for the installation of vent tubing along the left rib has been expressed.

(b) Rib and roof clearances are extremely tight on the Goodman equipment. Oval tubing may be essential because of minimal clearances.

(c) Attachment to the miner can conveniently be made using the tapped holes used to lift the electric motors which power the cutters, or the bolts on the gear box.

(d) Two holes (7/8" or 1") are available at similar locations on each motor.

(e) The tops of these motors come within approximately 18" of the roof and within 2 feet of the rib.

(f) A member which holds the tubing against either the roof or rib and drags it along the coal may be a reasonable approach. Flexibility vertically or horizontally is required but fairly rigid characteristics along the direction of travel are necessary.

(g) Turns and corners will be critical area. We may have to abandon extensibility during the initiation of cross cuts, etc.

(h) Procedures for extending the rigid portions of the tubing must be considered. The sequence of operations during attachment and detachment of the extensible member is critical.

APPENDIX I

REPRODUCTION OF U.S. PATENT #3,464,756

"VENTILATION CONTROL SYSTEM"

Sept. 2, 1969 J. V. BURGESS, JR 3,464,756

VENTILATION CONTROL SYSTEM

Filed Nov. 15, 1967 2 Sheets-Sheet 1

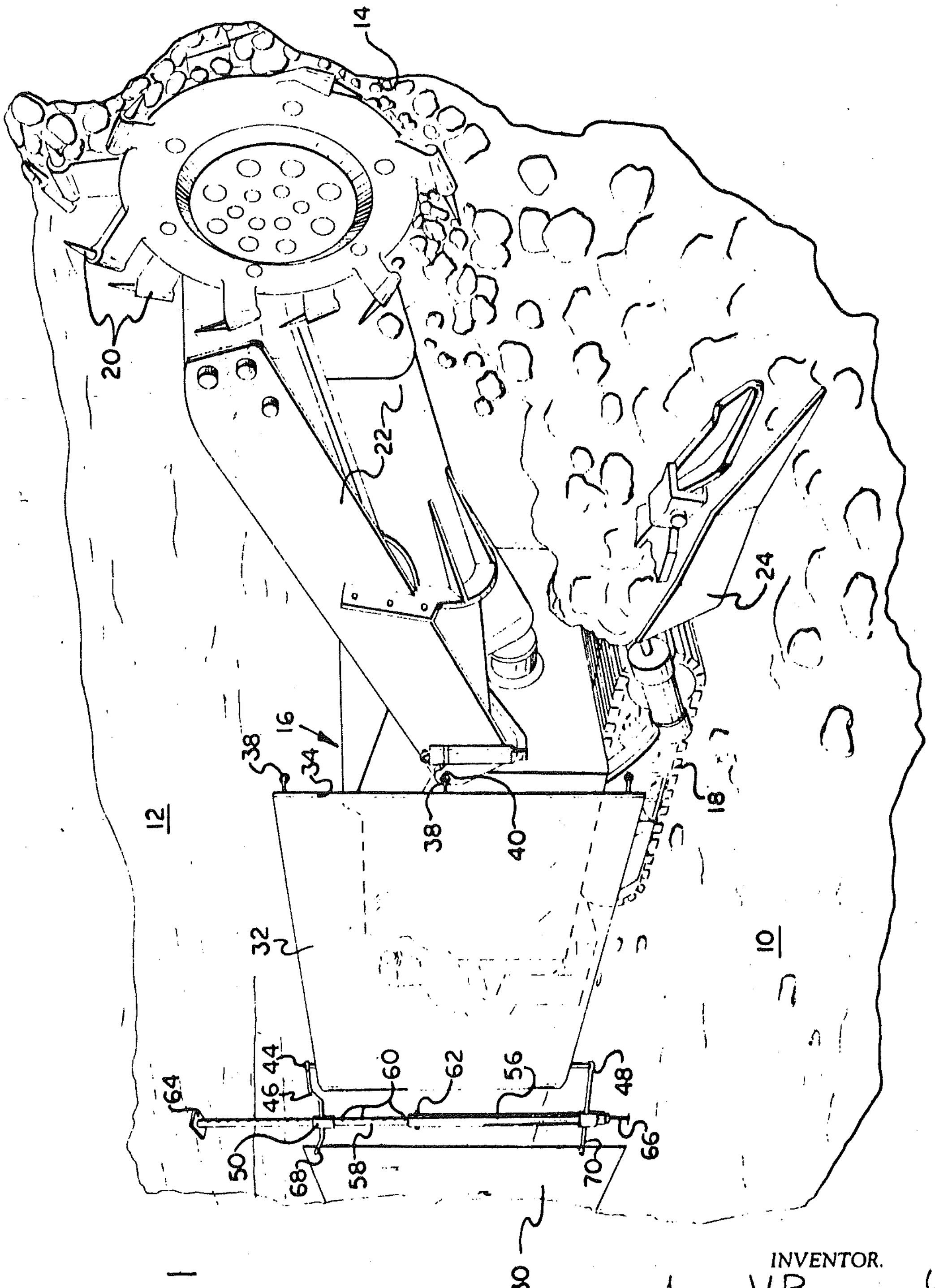



FIG. 1

INVENTOR.
JAMES V. BURGESS JR.
BY
Wilson + Fraser
ATTORNEYS

FIG. 2

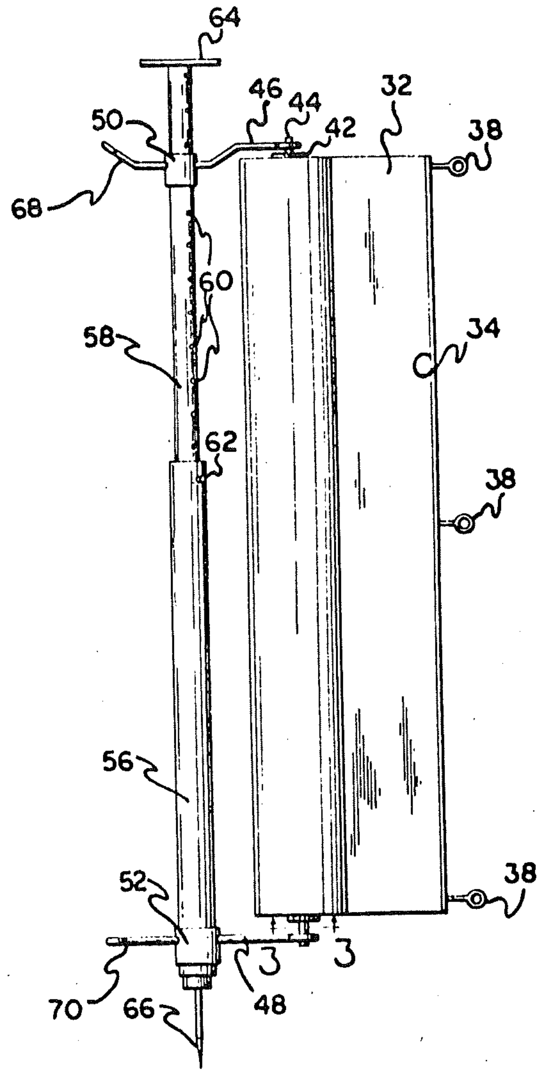
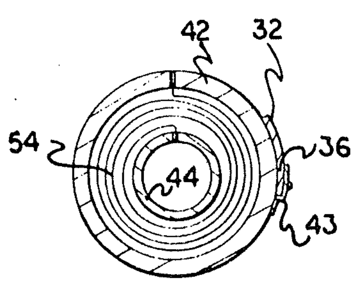



FIG. 3




INVENTOR.
JAMES V. BURGESS JR
BY
Wilson & Fraser
ATTORNEYS

# United States Patent Office

**3,464,756**
**Patented Sept. 2, 1969**

1

3,464,756

**VENTILATION CONTROL SYSTEM**

James V. Burgess, Jr., Box 385, Madison, W. Va. 25130

Filed Nov. 15, 1967, Ser. No. 683,199
Int. Cl. E21f 7/00, 3/00; E21c 29/22
U.S. Cl. 299—19 6 Claims

## ABSTRACT OF THE DISCLOSURE

A ventilation control system consisting of an extensible and retractable air current directing curtain attachable to an underground mining machine to direct the flow of air over the cutting bits of the machine and as close to the working face of the mine as possible to render harmless any gas emissions, and to provide a current of air to sweep away dust that has become suspended by the cutting action of the machine.

### Background of the invention

In the present system of ventilating underground mines, one of the problems not adequately solved is the presence of dangerous gases and dust immediately adjacent the working face of the mine. The present ventilating systems do not have the ability of diverting the clean air from the end of the line curtain assemblies to the working face which is continuously advancing as the mining machinery removes the material being mined. It is readily apparent to those knowledgable in the art of mining, that with the modern, fast and continuous mining operations, it has become of paramount importance to provide proper air circulation within the working areas of the mine to insure proper ventilation.

It is an object of the present invention to produce a ventilation control system for use in continuous mining operations which overcomes the aforesaid problems and provides an efficient and economically feasible means for achieving air circulation control immediately adjacent the cutting bits of a mining machine to effectively remove dangerous gases and dust content therein.

### Summary

The above objectives of the invention may be typically achieved by a mine ventilation control system for use in a mine working with an associated mining machine comprising an extended surface web of flexible substantially gas impervious sheet material having a leading and a trailing edge portion; a roller mechanism attached to the trailing edge of the sheet material; means for supporting the roller mechanism in a vertical position within the mine working; and coupling means for connecting the leading edge of the sheet material to the mining machine whereby movement of the machine will effectively cause the sheet material to be pair off from the roll mechanism.

### Brief description of the drawings

Other objects and advantages of the invention will become readily apparent to one skilled in the art from reading the following detailed description of an embodiment of the invention when considered in the light of the accompanying drawings, in which:

FIGURE 1 is a fragmentary perspective view of the invention employed in a mine working with a continuous mining machine;

FIGURE 2 is an enlarged elevational view of the invention showing the flexible sheet material in an almost entirely rolled condition; and

FIGURE 3 is an enlarged fragmentary sectional view of the invention taken along line 3—3 of FIGURE 2.

2

### Description of the preferred embodiment

Referring to the drawings wherein like reference numerals designate similar parts throughout, there is illustrated an underground mine working having a floor 10, a roof 12, and a working face 14. A mining machine 16 having ground engaging track laying treads 18 to provide movement of the machine and an array of cutting bits 20 mounted for rotation at the extended ends of a pair of outwardly extending booms 22 is employed to continuously move toward the material being mined. As the machine 16 advances toward the working face 14 of the mine, the bits 20 are rotated and caused to cut-away at the material being mined, such as coal for example. The bits 20 tend to break the coal from the vein which then drops toward the mine floor where it is typically collected on a moving conveyor 24. The conveyor 24 then transports the coal to a position in the rear of the machine 16 where it may be loaded in shuttle cars and eventually transported out of the mine.

FIGURE 1 clearly illustrates a line curtain 30 which has been previously installed in the mine to aid in the directing of a current of ventilating air through the mine. Typically, the fresh air is directed toward the working face 14 along one side of the curtain 30; while the gas and dust laden air is caused to travel in an opposite direction along the opposite face of the curtain 30. These line curtains are installed in the mine after the mining machinery has advanced some predetermined distance. However, it will be appreciated that it is extremely difficult and time consuming to stop the mining machinery every so many feet of travel to install an additional length of line curtain.

To assure a substantially continuous ventilation control system effective to remove dangerous gases and dust in the region of the working face 14 of the mine, there is provided a web of flexible substantially gas impervious sheet material 32 having a leading edge portion 34 and a trailing edge portion 36. The leading edge portion 34 of the sheet material 32 may be reinforced in any of the well known manners, such as for example, being folded back upon itself and stitched to form a reinforcing hem. Attached to the leading edge portion 34 are a plurality of spaced eyes 38 which are employed to be connected to a cooperating hook or hooks 40 affixed to the mining machinery 16.

The trailing edge portion of the sheet material 32 is connected to a tubular spool or drum 42 by a clamping member 43. The tubular spool 42 is mounted in substantially coaxially relation about a center tube 44 which has its opposite ends fixedly secured to the outer ends of arms 46 and 48 of brackets 50 and 52. The outer tubular spool 42 and the center tube 44 are interconnected by a spiral spring means 54. It will be appreciated that since the center tube 44 is fixed, the outer tube 42 can be rotated relative thereto as the sheet material 32 is caused to be paid off therefrom. As the relative rotational movement occurs between the outer tube 42 and the center tube 44, the spring means 54 is placed under tension or loaded tending at all time to rewind the sheet material 32.

The brackets 50 and 52 are rotatably mounted on a vertically disposed supporting column which includes a lower tubular member 56 and a cooperating upper tubular member 58 which is adapted to slide therewithin. The total over-all length of the supporting column may be varied by causing the tubular member 58 to slide within the tubular member 56. The desired length may be fixed by aligning one of the holes 60 of the tubular member 58 with a hole in the upper portion of the tubular member 56 so that a pin 62 may be inserted therein to militate against any relative movement therebetween.

The uppermost end of the upper member 58 is provided with a pad 64 which is adapted to be placed into snug contact with the roof 12 of the mine; while the lowermost end of the tubular member 56 is provided with spike-like extension 66 which is adapted to be inserted into the floor 10 of the mine. Clearly, the pin 62 is removed when the supporting column is to be installed in a mine; tubular members 56 and 58 are typically extended in such a fashion that the pad 64 snugly contacts the roof 12 and the spike-like extension 66 penetrates a portion of the floor 10; and the pin 62 is reinserted. In this manner, the roll of web material 32 is adequately supported in a vertical position within the interior of the mine working.

Projecting radially outwardly of the brackets 50 and 52 are arms 68 and 70, respectively, which support the innermost end of a stationary line curtain 30 as illustrated in FIGURE 1.

Since the brackets 50 and 52 are free floating, the arms 46 and 48 may be moved forward when the drum mechanism 42 is positioned in front of the point of suspension and may be moved rearwardly when the drum mechanism 42 is positioned in the rear of the point of suspension.

In the normal mining operations, the line curtain 30 is typically terminated approximately six feet from the face of the mine. The mining machinery 16 will then progress into the mine toward the face 14 to a point which is not beyond the overhead roof supports which are typically installed as the mining operation progresses. As the mining machinery progresses in toward the working face, the web of sheet material 32 which is hooked to the mining machinery 16 will progress therewith. As the mining operation advances into what is referred to as a box cut or a full face, the web of sheet material 32 advances along with the mining machinery 16 and automatically effects an extension of the line curtain 30.

While the sheet material 32 may be formed of a large number of plastic sheet film materials, whether made of polymerizates, condensation products, or cellulosic derivatives, it is considered preferable to use sheets of fire-resistant or fire-retardant materials, such as those containing chlorine in their composition, for example, vinyl chloride polymers and copolymers, polyvinylidene chloride, vinyl chloride-vinylidene chloride copolymers and the like, or those containing fire-retardant components, such as tricresyl phosphate or chlorinated compounds, because of the greater safety provided by such materials.

The diameter of the roll containing the sheet material 32 will vary according to the desired length of line curtain and the size of the suspension mechanism employed. Of course, the width or height of the sheet material 32 will depend primarily on the height of the mine, which in coal mining operations is a function of the height of the coal bed or vein.

It will be appreciated that the manner of connecting the leading edge portion 34 of the sheet material 32 to the mining machinery 16 may vary considerably. The manner in which the connection is made and the exact point of connection on the machinery will be determined by the specific type of mining machinery being used.

While the illustrated embodiment of the invention discloses the roll containing the sheet material 32 as being mounted in a stationary position within the mine and the leading edge 34 being attached to the mining machine 16, it will be appreciated that the structure could be reversed. The roller mechanism for the sheet material could be mounted on the mining machine 16 and the leading edge 34 could be anchored adjacent the innermost edge of the curtain 30.



After the particular face 14 has become idle and the mining operation has relocated, it may be necessary to bleed off gaseous emmissions, such as methane gas, and this may be accomplished by fixedly supporting the leading edge portion 34 of the sheet material 32 a few feet from the working in a somewhat permanent disposition thereof to achieve the desired ventilating air flow through the mine.

What I claim is:

1. A mine ventilation control system for use in a mine working with an associated mining machine comprising:
   - an extended surface web of flexible substantially gas impervious sheet material having a leading and a trailing edge portion;
   - a roller mechanism attached to the trailing edge of said sheet material;
   - means for supporting said roller mechanism and said sheet material in a vertical position within the mine working;
   - coupling means for connecting the leading edge of said sheet material to the mining machine whereby movement of the machine will effectively cause said sheet material to be paid off from said roller mechanism; and
   - spring means associated with said roller mechanism normally maintaining said web of sheet material rolled on said roller mechanism.

2. The invention defined in claim 1 wherein said means for supporting said roller mechanism consists of a telescoping columnar member adapted to extend between the floor and the roof of a mine.

3. The invention defined in claim 1 wherein said means for supporting said roller mechanism includes an extensible columnar member extending between the roof and the floor of the mine working.

4. The invention defined in claim 3 wherein said means for supporting said roller mechanism includes a pair of spaced brackets for supporting said roller mechanism.

5. The invention defined in claim 4 wherein said brackets are rotatably mounted on said columnar member.

6. A mine ventilation control system for use in a mine working with an associated mobile mining machine comprising:
   - an extended surface web of flexible substantially gas impervious sheet material having a first and a second edge portion;
   - roller means including spring means normally containing said sheet material in rolled condition thereon;
   - means for maintaining one of the edge of said sheet material at a fixed position in the mine working; and
   - means for coupling the other of the edge portions of said sheet material to the mobile mining machine whereby said sheet material is disposed in a vertical plane and forward movement of the machine will effectively cause said sheet material to be paid off from said roller means.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ERNEST R. PURSER, Primary Examiner

U.S. Cl. X.R.

98—50; 299—12

# APPENDIX J

## REPRODUCTION OF U.S. PATENT #3,715,969

## "MINE VENTILATION CONTROL SYSTEM"

# United States Patent [19]

**Burgess, Jr.**

[11] **3,715,969**

[45] **Feb. 13, 1973**


[54] **MINE VENTILATION CONTROL SYSTEM**


[76] Inventor: **James V. Burgess, Jr.**, P. O. Box 385, Madison, W. Va. 25130



[22] Filed: **Feb. 26, 1971**

[21] Appl. No.: **119,270**

[52] **U.S. Cl.** ..........................**98/50**, 160/330, 299/12

[51] **Int. Cl.** ..............................**E21f 1/00**, E21f 3/00

[58] **Field of Search**.............160/DIG. 9, 330; 98/50; 299/12



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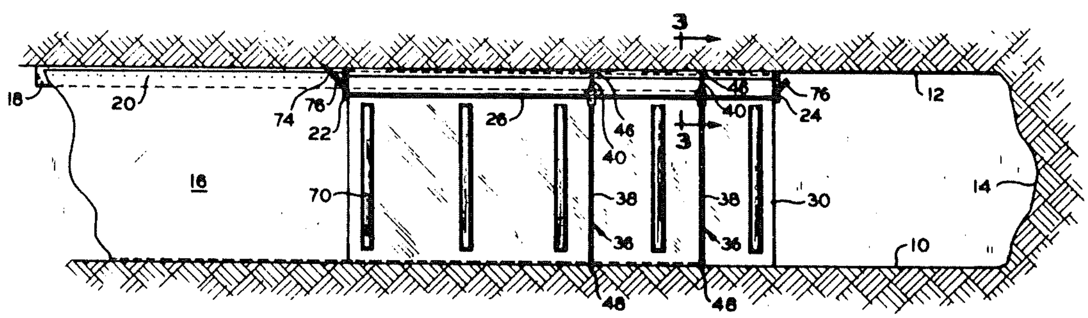
[57] **ABSTRACT**

A mine ventilation control system for directing air flow in the immediate region of the working face of a mine, including an extensible curtain assembly which can be readily mounted adjacent the end of a line curtain and advanced toward the working face of the mine at a rate commensurate with the removal of the material being mined.


**10 Claims, 5 Drawing Figures**



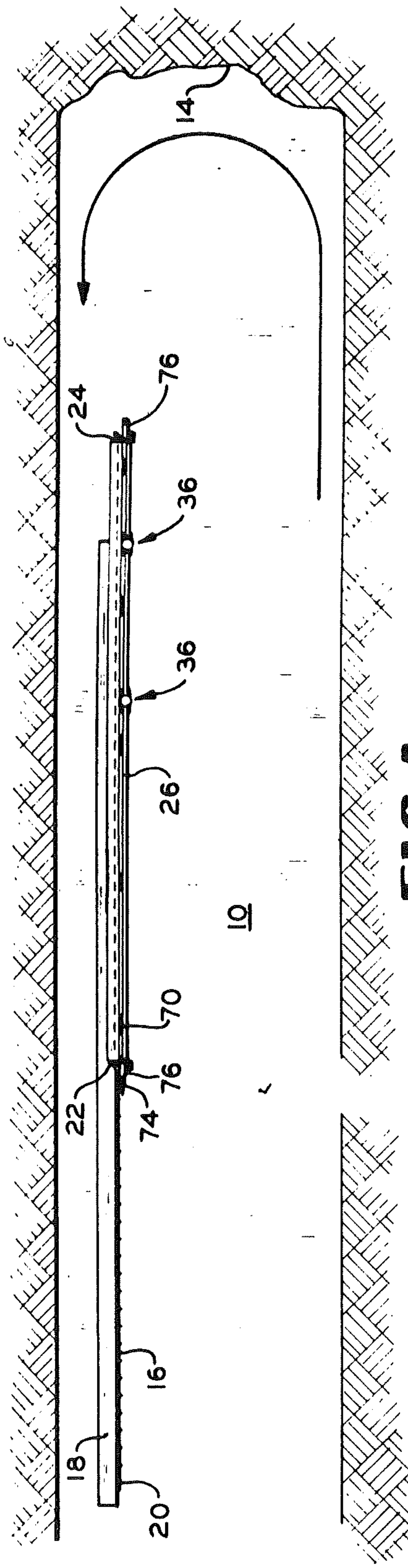


FIG. 1

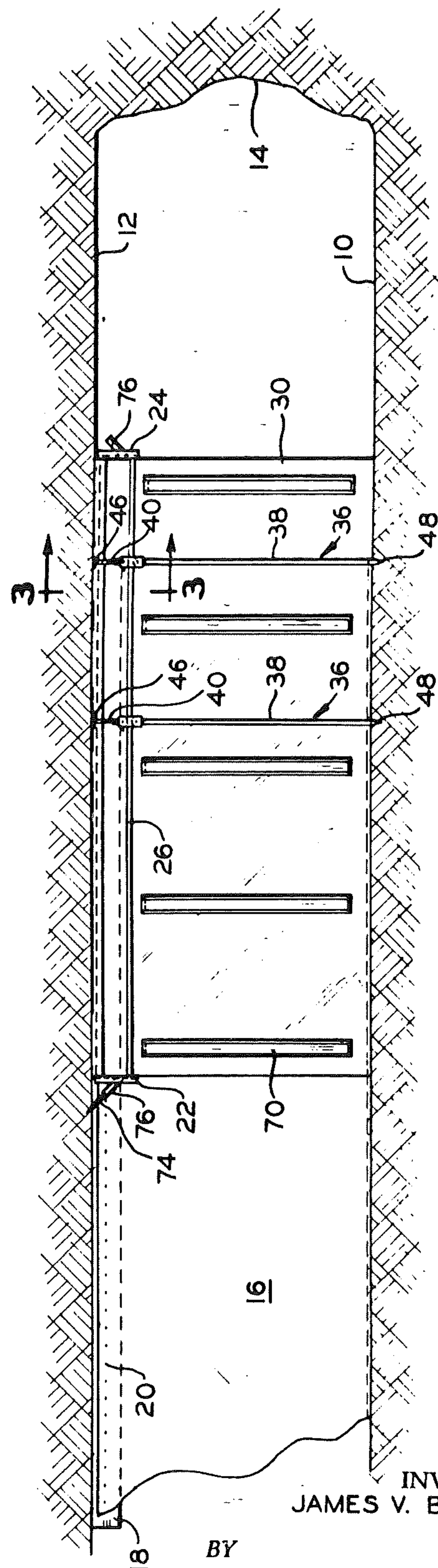


FIG. 2

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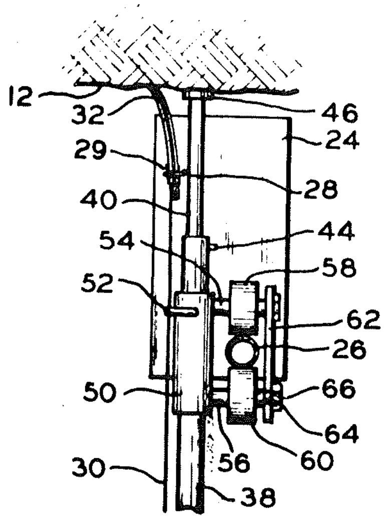


**FIG. 3**

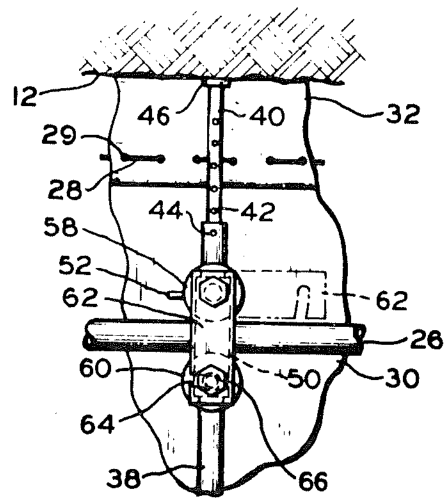


**FIG. 4**

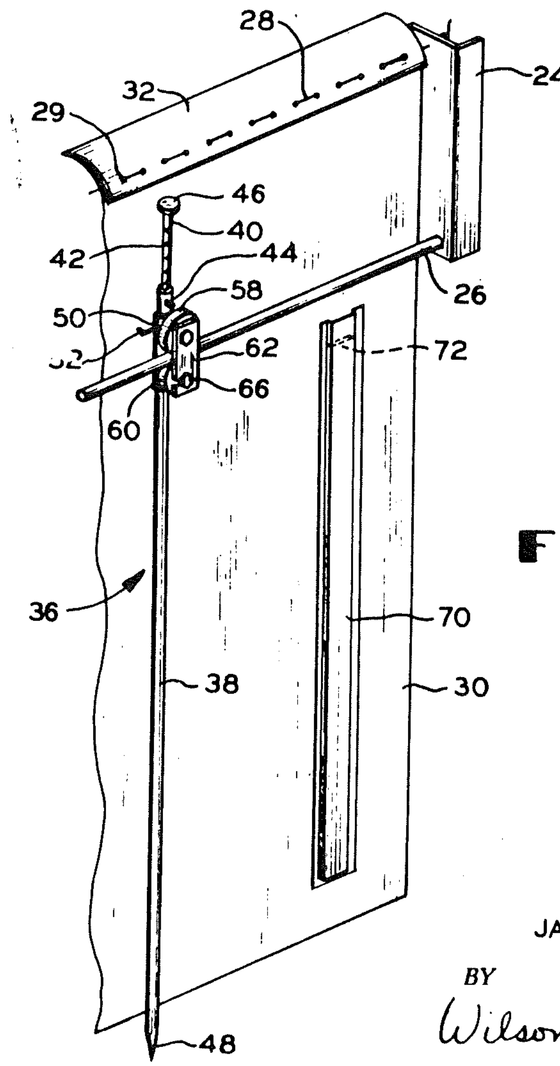


**FIG. 5**

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## MINE VENTILATION CONTROL SYSTEM

### BACKGROUND OF THE INVENTION

In the present systems of ventilating underground mines, one of the problems not adequately solved is the presence of dangerous gas and dust immediately adjacent the working face of the mine. The present ventilating systems do not have the inherent ability of continuously diverting the clean air from the end of the line curtain assemblies to the working face which is continuously advancing as the mining machinery and operation removes the material being mined. It is readily apparent to those knowledgeable in the art of mining operations that with the modern, fast, and continuous mining operations, it has become of paramount importance to provide adequate air circulation at the working face area of the mine to continuously remove dangerous gases and dust to thereby insure proper ventilation for the safety of those working underground.

Presently, to attempt to provide the desired ventilation within the working areas of the mine, line curtains are employed along the length of the mine working to, in effect, provide an inlet conduit for clean air and an outlet conduit for the exhaust of dangerous gases which are typically laden with a high degree of dust particles. Clearly, the gases and dust contamination is injurious to the respiratory system of the miners, as well as the principle cause of explosions within the mines. As the mining operation continuously advances away from the end of the line curtain, the flow of ventilating air at the working face becomes less and less effective. Accordingly, the actual mining operations must be periodically stopped and an additional length or section of line curtain must be erected.

It is an object of the present invention to produce a ventilation control system for use in mining operations which overcomes the aforesaid problems and provides an efficient and economically feasible means for achieving air circulation control immediately adjacent the working face of the mines to effectively remove the dangerous gases and dust content therein as the mining operation continues.

### SUMMARY

The above objectives of the invention may typically be achieved by a mine ventilation control system for use in a mine working having a roof and a floor in association with line curtain comprising an extended surface web of flexible substantially gas impervious sheet material having a leading, a trailing, an upper, and a lower edge portion; a first support means for supporting the upper edge portion of the sheet material; a second support means supporting the first support means to position the upper and lower edge portions of the sheet material adjacent the roof and the floor of the mine working respectively in adjacent substantially parallel relation with the line curtain; and means providing longitudinal movement of the first support means and the associated sheet material relative to the second support means whereby the leading edge portion of the sheet material may be advanced toward the working face of the mine working and the trailing edge portion of the sheet material advanced toward the end of the line curtain most adjacent the working face.



### BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become readily apparent to those skilled in the art from reading the following detailed description of an embodiment of the invention when considered in the light of the accompanying drawings, in which:

FIG. 1 is a fragmentary top plan view of a mine working provided with a ventilation control system incorporating the features of the invention;

FIG. 2 is an elevational view of the system disclosed and illustrated in FIG. 1;

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is a fragmentary elevational view of the roller mechanism interconnecting the supporting elements of the invention; and

FIG. 5 is a fragmentary perspective view of the first and second supporting elements of the invention and the associated extended surface web of flexible gas impervious sheet material.

### DESCRIPTION OF PREFERRED EMBODIMENT

Referring to the drawings wherein like reference numerals designate similar parts throughout, there is illustrated an underground mine working having a floor 10, a roof 12, and a working face 14. A line curtain 16 typically formed of an extended sheet of flexible substantially gas impervious material, is suspended within the mine from a header member 18 which is secured to the roof 12 of the mine and extends longitudinally along the mine toward the working face 14. The upper edge portion of the line curtain 16 is provided with a series of spaced apart grommets 20 through which suitable fastening means are employed to adequately secure the line curtain 16 in place. It will be observed that the lower edge portion of the line curtain 16 is in intimate contact with the mine floor 10, while the upper edge portion is in sealing relationship with the roof 12 of the mine through the header 18 to thereby provide an elongate seal extending along the mine terminating short of the working face 14. Thus, the structure assumes a substantially continuous ventilation control system to effectively remove dangerous gases and dust in the region of the working face 14 of the mine and create an air flow in the direction of the arrow in FIG. 1. It will be understood, that the fresh air is directed along one side of the line curtain, while the undesired gases and dust laden air is caused to travel in an opposite direction along the opposite face of the curtain 16. The line curtain 16 is installed in the mine after the mining operation has advanced a predetermined distance. In order to assure proper ventilation and therefore the safety of the miners, it is necessary to constantly be certain that the leading edge of the line curtain 16 is within approximately 10 feet of the working face 14. It will be appreciated that it is extremely difficult and time consuming to stop the mining operation and mining machinery every so many feet of travel to install additional lengths of line curtain.

To assure an effective continuous ventilation control system to remove the dangerous gases and dust in the region of the working face 14 of the mine, the present invention provides a cooperating longitudinally extending line curtain assembly which comprises a first supporting frame including a pair of spaced apart end brackets 22 and 24. The lower portions of the brackets 22 and 24 are coupled together by a generally horizontally extending rod member 26. The opposite ends of the rod member 26 may be secured to the respective brackets by any of the known manners such as for example by welding, threaded fasteners, or the like. The upper portions of the brackets 22 and 24 are typically provided with apertures to receive opposite ends of a cable 28 which is woven through spaced apart grommets 29 of an extensible line curtain 30. In order to impart a certain additional strength and rigidity to the upper edge portion of the line curtain 30, the material forming a line curtain 30 is folded upon itself to produce an upper mine roof engaging heading 32. It has been found desirable in certain instances to cause the cable 28 to be drawn tightly to prestress the rod 26 and produce a slight bow therein which when mounted in the operative position illustrated in the drawings is caused to return to its normal substantially straight form by the load imposed thereon by the weight of the curtain material 30. The curtain 30, as well as the line curtain 16, may be formed of a large number of plastic sheet film materials whether made of polymerizates, condensation products, or cellulosic derivatives. However, it is considered preferable to use sheets of fire resistant or fire retardant material such as those containing chlorine in their composition, for example, vinyl chloride polymers and copolymers, polyvinylidene chloride, vinyl chloride-vinylidene chloride polymers, and the like, or those containing fire-retardant compounds, such as tricresyl phosphate or chlorinated compounds, because of the greater safety provided by such materials. In many instances, it may be found desirable to also provide an integral reinforcing material, in a woven or non-woven condition, to impart greater strength thereto without adding a considerable weight factor.

After the cable 28 has been threaded through the grommets 29 in the heading 32 of the line curtain 30 and drawn tight, the ends thereof are suitably secured to the upper portion of the brackets 22 and 24 by any of the known manners.

Next, a second supporting assembly is positioned within the mine. The second supporting assembly illustrated in the drawings consists of a pair of spaced apart supporting columns 36. Since each of the columns 36 is of the same structure, only a single one will be explained in detail. The supporting columns 36 include a main supporting tubular member 38 and a cooperating upper tubular member 40 which is adapted to slide therewithin. The total overall length of the supporting columns 36 may be varied by causing the tubular member 40 to slide within the tubular member 38. The desired length may be fixed by aligning one of the holes 42 of the tubular member 40 within a hole in the upper portion of the tubular member 36 so that a pin 44 may be inserted therein to militate against any relative movement therebetween.

The uppermost end of the upper tubular member 40 is provided with a mine roof engaging pad 46 adapted to be placed into snug engagement with the roof 12 of the mine; while the lowermost end of the tubular member 38 is provided with a spike-like extension 48 which is adapted to be inserted into the floor 10 of the mine. Clearly, the pin 44 is removed when the supporting column 36 is to be installed in a mine. When the pin 44 is removed the tubular members 38 and 40 are positioned relative to one another such that the pad 46 snugly contacts the roof 12 of the mine and the spike-like extension 48 penetrates the floor 10 of the mine and then the pin 44 is reinserted.

The aforementioned second supporting assembly is employed to support the first supporting assembly is such fashion that the curtain 30 may be moved longitudinally toward the working face of the mine and provide, in effect, an operable extension of the line curtain 16 while not requiring the stopping or cessation of the mining operations and, at all times, provide adequate ventilation in the region of the working face 14 of the mine. To accomplish these objectives, a tubular sleeve 50 surrounds the tubular member 38 of column 36 and may be vertically positioned thereon and secured at the desired position by a set screw having an operating handle 52. Projecting radially outwardly of the sleeve 50 are a pair of vertically spaced apart shafts 54 and 56 for rotatingly supporting rollers 58 and 60, respectively. The rollers 58 and 60 may be provided with suitable bearing means such as ball bearings to enable them to roll freely under specified load requirements.

Pivotally mounted at the outermost end of the upper shaft 54 is a locking plate 62 having a notch 64 formed in the opposite end adapted to receive the outer end of the lower shaft 56. The locking plate 62 may be locked in the position shown in full lines in FIG. 3, 4 and 5 by an internally threaded nut 66. By loosening the nut 66, the locking plate 62 may be swung upwardly about the shaft 54 to the dotted line position illustrated in FIG. 4 to enable the roller assembly to receive the rod 26 of the first supporting assembly. After the rod 26 is thus inserted into the space between the rollers 58 and 60, the locking plates 62 are swung downwardly and locked in position by tightening the fasteners 66.

The curtain 30 may be rigidized by the addition of spaced vertically extending batten pockets 70 adapted to receive suitably formed batten strips 72. In typical installations, the batten pockets 70 are positioned at approximately four foot centers and commence just below the vertical height of the rod 26 and terminate approximately one foot from the mine floor 10. The typical height of the curtain 30 is slightly more than the distance from the floor 10 to the roof 12 so that the stiffened upper heading 32 will be slightly bent over in the installed operative position to form a sealing relation with the roof 12 of the mine while the lower edge of the curtain 30 would be in contact with the floor 10, again for the purpose of providing a seal therebetween.

When the assembly is in the assembled position illustrated in the drawings, the curtain 30 may be manually advanced toward the working face 14 of the mine as the mining operations progress constantly maintaining the desired interval between the leading edge of the curtain 30 and the working face 14 to, at all times, maintain effective mine ventilation control without having to close down or impair the mining operation.

To militate against any retrograde movement of the first supporting assembly and the associated curtain 30, there is provided an angularly extending spike 74 adapted to be received within a tubular socket 76 secured to the brackets 22 and 24 at a substantially 45

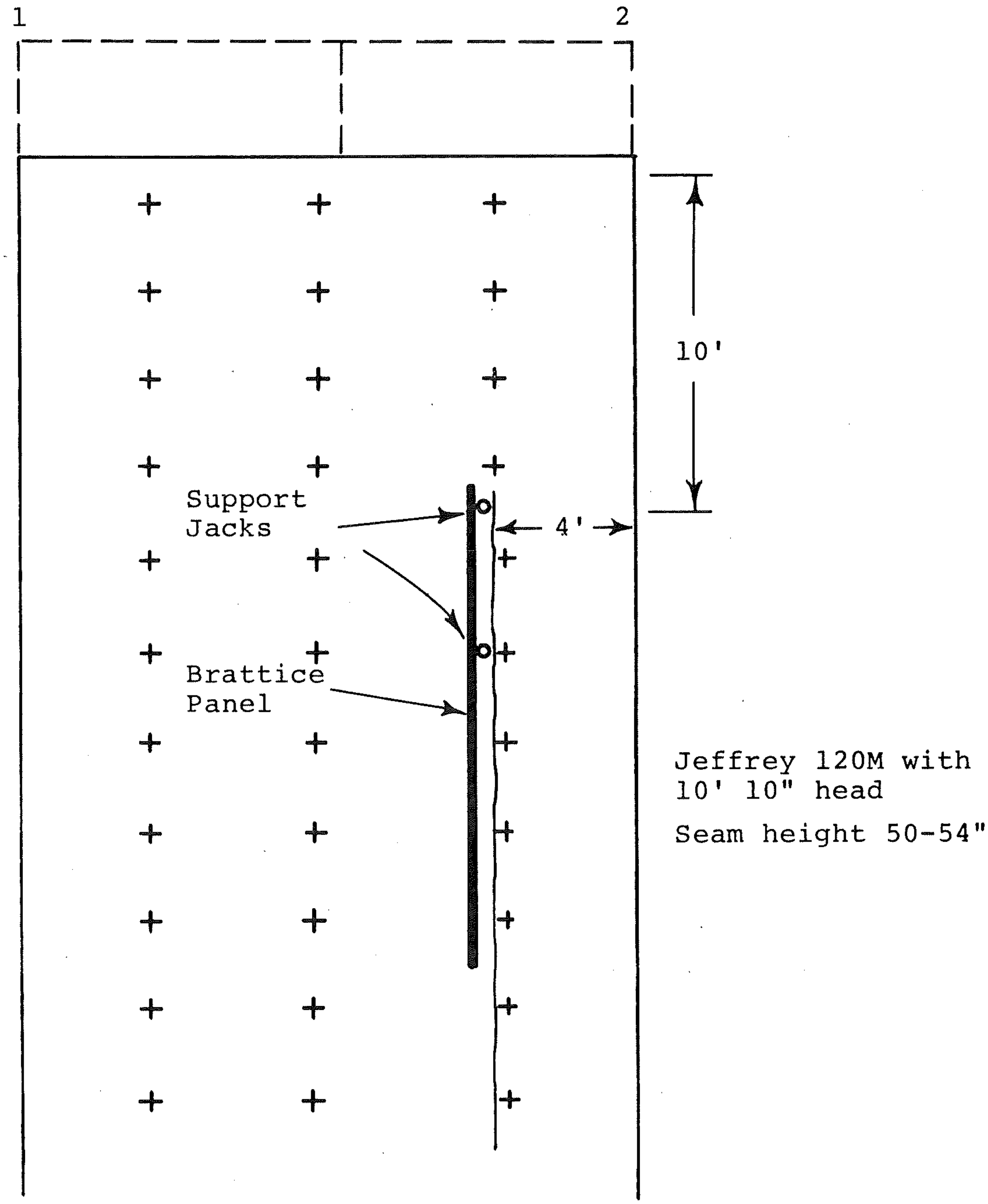


Figure K-1 - Extensible Brattice at Keystone No. 5

(1) vent curtain at least four feet from rib

(2) narrowest available cutting head--overhangs machine only one foot on each side

(3) preoccupation for smooth rib precluded "angling-in" the machine beyond the curtain.

In other operations observed, narrower space behind the brattice, wider heads and an "angling-in" technique practiced by the miner operator permit the vent curtain to remain close to the face even while cutting on the brattice side.

2. Keystone No. 1 Mine

In November of 1975, the extensible brattice panel was introduced into EACC's Keystone No. 1 Mine. It was used for two days by the men on 6 Left 1 North under the supervision of Mr. Ted Lewtas of Foster-Miller Associates and Mr. William Desieghart of EACC. The test section employed a Lee-Norse hardhead miner to cut a 60-inch seam. Exhaust ventilation brattice on the left side was used, as shown in Figure K-2. Five headings were being driven but only three rooms were worked on any one shift. No. 5 heading was the intake and No. 1 the return airway.

The extensible panel was set up inside the static brattice in No. 5 cut. The brattice panel worked well and, because a notchy rib was satisfactory, the jacks were not moved during the actual mining. After the miner left the place, however, the panel and the brattice curtain were removed from the vicinity of the face to permit cleaning along the rib. Two men are required at this stage to remove and then replace the extensible panel. Altogether the extensible brattice was utilized in three complete mining cycles at Keystone No. 1.

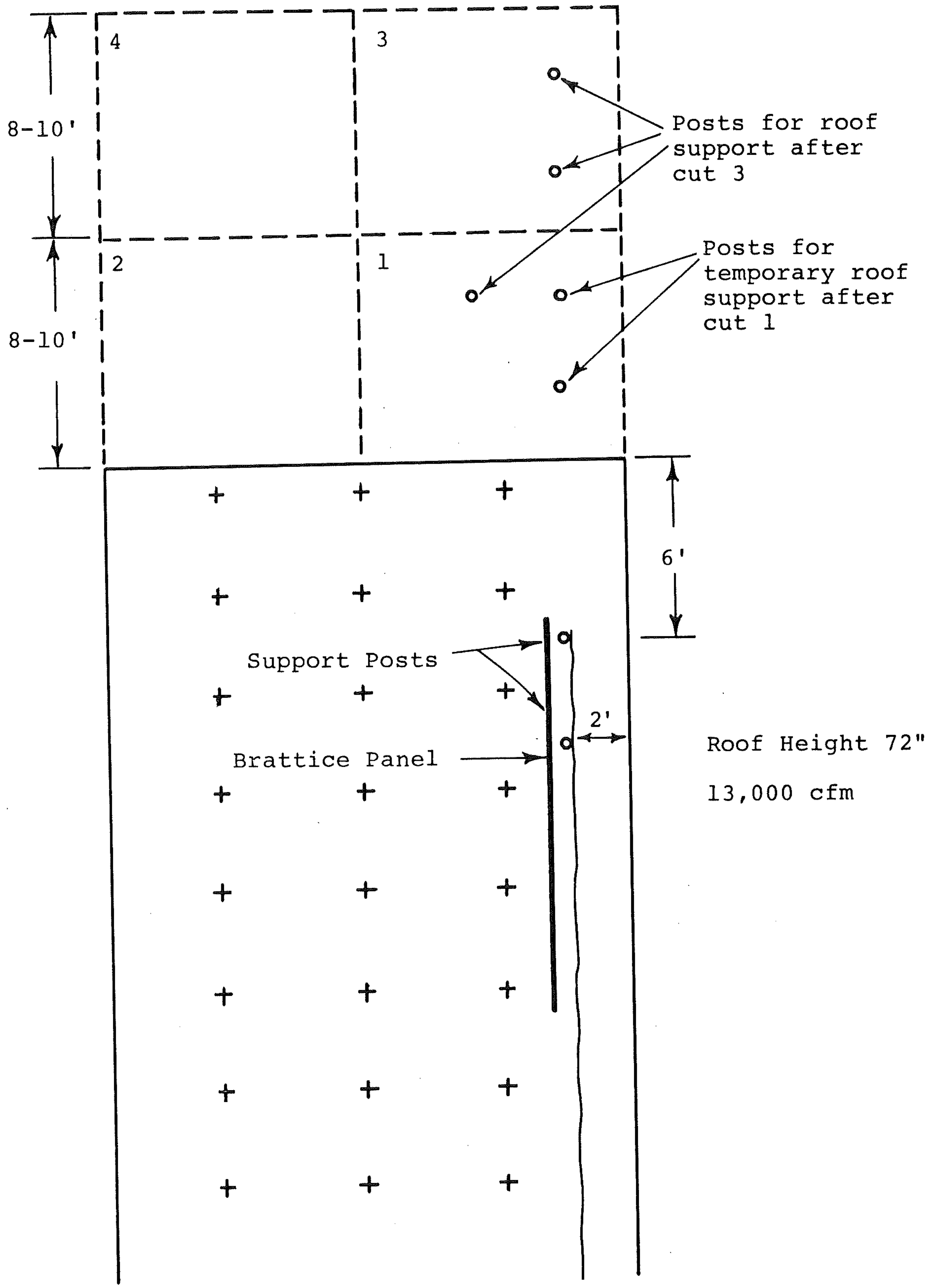


Figure K-3 - Extensible Panel at Dilworth Mine

Because of the above conflict in goals, the panel was not well suited to this mine--or the district. The demonstration was extremely valuable in identifying certain shortcomings of the present design and modifications that would increase the probability of acceptance on any section. The limitations of the present design include:

- o the support jacks positioned along the brattice line are vulnerable to damage from the miner.
- o pulley alignment requirements demand accurate alignment of jacks for smooth advance of panel.
- o accurate direction of the brattice advance demands careful positioning of the jacks.
- o the length of the frame and rigidity of the positioned jacks permits no minor correction for roof or rib irregularity
- o at extremely high ventilation flows the panel is drawn toward the rib reducing available flow area.

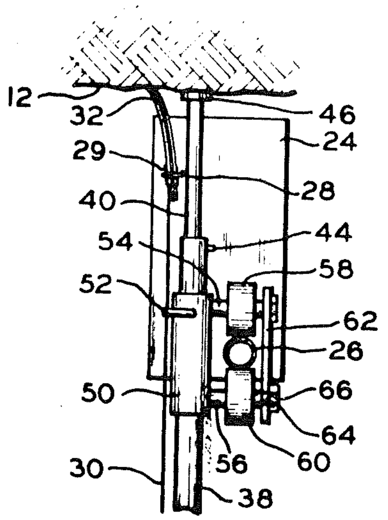


FIG. 3

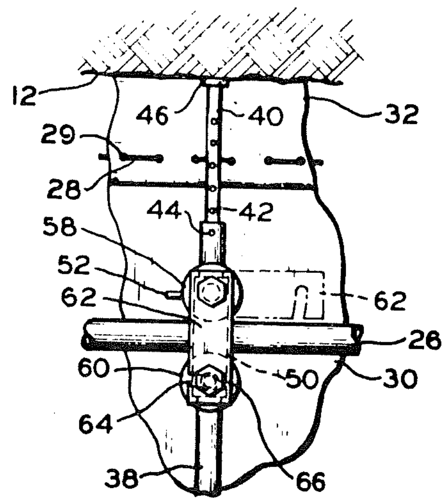


FIG. 4

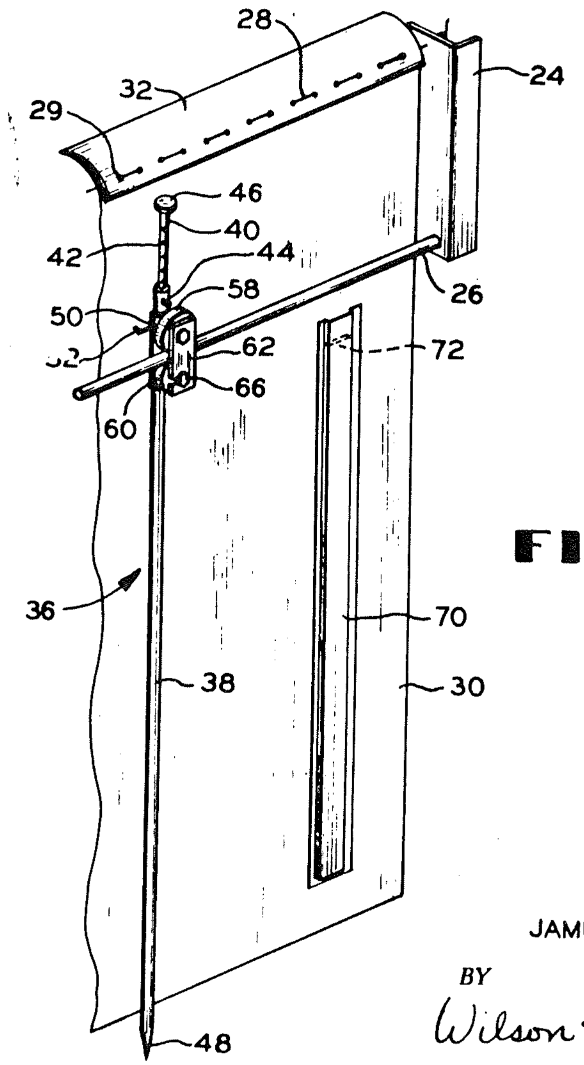


FIG. 5

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# MINE VENTILATION CONTROL SYSTEM

## BACKGROUND OF THE INVENTION

In the present systems of ventilating underground mines, one of the problems not adequately solved is the presence of dangerous gas and dust immediately adjacent the working face of the mine. The present ventilating systems do not have the inherent ability of continuously diverting the clean air from the end of the line curtain assemblies to the working face which is continuously advancing as the mining machinery and operation removes the material being mined. It is readily apparent to those knowledgeable in the art of mining operations that with the modern, fast, and continuous mining operations, it has become of paramount importance to provide adequate air circulation at the working face area of the mine to continuously remove dangerous gases and dust to thereby insure proper ventilation for the safety of those working underground.

Presently, to attempt to provide the desired ventilation within the working areas of the mine, line curtains are employed along the length of the mine working to, in effect, provide an inlet conduit for clean air and an outlet conduit for the exhaust of dangerous gases which are typically laden with a high degree of dust particles. Clearly, the gases and dust contamination is injurious to the respiratory system of the miners, as well as the principle cause of explosions within the mines. As the mining operation continuously advances away from the end of the line curtain, the flow of ventilating air at the working face becomes less and less effective. Accordingly, the actual mining operations must be periodically stopped and an additional length or section of line curtain must be erected.

It is an object of the present invention to produce a ventilation control system for use in mining operations which overcomes the aforesaid problems and provides an efficient and economically feasible means for achieving air circulation control immediately adjacent the working face of the mines to effectively remove the dangerous gases and dust content therein as the mining operation continues.

## SUMMARY

The above objectives of the invention may typically be achieved by a mine ventilation control system for use in a mine working having a roof and a floor in association with line curtain comprising an extended surface web of flexible substantially gas impervious sheet material having a leading, a trailing, an upper, and a lower edge portion; a first support means for supporting the upper edge portion of the sheet material; a second support means supporting the first support means to position the upper and lower edge portions of the sheet material adjacent the roof and the floor of the mine working respectively in adjacent substantially parallel relation with the line curtain; and means providing longitudinal movement of the first support means and the associated sheet material relative to the second support means whereby the leading edge portion of the sheet material may be advanced toward the working face of the mine working and the trailing edge portion of the sheet material advanced toward the end of the line curtain most adjacent the working face.



## BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become readily apparent to those skilled in the art from reading the following detailed description of an embodiment of the invention when considered in the light of the accompanying drawings, in which:

FIG. 1 is a fragmentary top plan view of a mine working provided with a ventilation control system incorporating the features of the invention;

FIG. 2 is an elevational view of the system disclosed and illustrated in FIG. 1;

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is a fragmentary elevational view of the roller mechanism interconnecting the supporting elements of the invention; and

FIG. 5 is a fragmentary perspective view of the first and second supporting elements of the invention and the associated extended surface web of flexible gas impervious sheet material.

## DESCRIPTION OF PREFERRED EMBODIMENT

Referring to the drawings wherein like reference numerals designate similar parts throughout, there is illustrated an underground mine working having a floor 10, a roof 12, and a working face 14. A line curtain 16 typically formed of an extended sheet of flexible substantially gas impervious material, is suspended within the mine from a header member 18 which is secured to the roof 12 of the mine and extends longitudinally along the mine toward the working face 14. The upper edge portion of the line curtain 16 is provided with a series of spaced apart grommets 20 through which suitable fastening means are employed to adequately secure the line curtain 16 in place. It will be observed that the lower edge portion of the line curtain 16 is in intimate contact with the mine floor 10, while the upper edge portion is in sealing relationship with the roof 12 of the mine through the header 18 to thereby provide an elongate seal extending along the mine terminating short of the working face 14. Thus, the structure assumes a substantially continuous ventilation control system to effectively remove dangerous gases and dust in the region of the working face 14 of the mine and create an air flow in the direction of the arrow in FIG. 1. It will be understood, that the fresh air is directed along one side of the line curtain, while the undesired gases and dust laden air is caused to travel in an opposite direction along the opposite face of the curtain 16. The line curtain 16 is installed in the mine after the mining operation has advanced a predetermined distance. In order to assure proper ventilation and therefore the safety of the miners, it is necessary to constantly be certain that the leading edge of the line curtain 16 is within approximately 10 feet of the working face 14. It will be appreciated that it is extremely difficult and time consuming to stop the mining operation and mining machinery every so many feet of travel to install additional lengths of line curtain.

To assure an effective continuous ventilation control system to remove the dangerous gases and dust in the region of the working face 14 of the mine, the present invention provides a cooperating longitudinally extending line curtain assembly which comprises a first supporting frame including a pair of spaced apart end brackets 22 and 24. The lower portions of the brackets 22 and 24 are coupled together by a generally horizontally extending rod member 26. The opposite ends of the rod member 26 may be secured to the respective brackets by any of the known manners such as for example by welding, threaded fasteners, or the like. The upper portions of the brackets 22 and 24 are typically provided with apertures to receive opposite ends of a cable 28 which is woven through spaced apart grommets 29 of an extensible line curtain 30. In order to impart a certain additional strength and rigidity to the upper edge portion of the line curtain 30, the material forming a line curtain 30 is folded upon itself to produce an upper mine roof engaging heading 32. It has been found desirable in certain instances to cause the cable 28 to be drawn tightly to prestress the rod 26 and produce a slight bow therein which when mounted in the operative position illustrated in the drawings is caused to return to its normal substantially straight form by the load imposed thereon by the weight of the curtain material 30. The curtain 30, as well as the line curtain 16, may be formed of a large number of plastic sheet film materials whether made of polymerizates, condensation products, or cellulosic derivatives. However, it is considered preferable to use sheets of fire resistant or fire retardant material such as those containing chlorine in their composition, for example, vinyl chloride polymers and copolymers, polyvinylidene chloride, vinyl chloride-vinylidene chloride polymers, and the like, or those containing fire-retardant compounds, such as tricresyl phosphate or chlorinated compounds, because of the greater safety provided by such materials. In many instances, it may be found desirable to also provide an integral reinforcing material, in a woven or non-woven condition, to impart greater strength thereto without adding a considerable weight factor.

After the cable 28 has been threaded through the grommets 29 in the heading 32 of the line curtain 30 and drawn tight, the ends thereof are suitably secured to the upper portion of the brackets 22 and 24 by any of the known manners.

Next, a second supporting assembly is positioned within the mine. The second supporting assembly illustrated in the drawings consists of a pair of spaced apart supporting columns 36. Since each of the columns 36 is of the same structure, only a single one will be explained in detail. The supporting columns 36 include a main supporting tubular member 38 and a cooperating upper tubular member 40 which is adapted to slide therewithin. The total overall length of the supporting columns 36 may be varied by causing the tubular member 40 to slide within the tubular member 38. The desired length may be fixed by aligning one of the holes 42 of the tubular member 40 within a hole in the upper portion of the tubular member 36 so that a pin 44 may be inserted therein to militate against any relative movement therebetween.

The uppermost end of the upper tubular member 40 is provided with a mine roof engaging pad 46 adapted to be placed into snug engagement with the roof 12 of the mine; while the lowermost end of the tubular member 38 is provided with a spike-like extension 48 which is adapted to be inserted into the floor 10 of the mine. Clearly, the pin 44 is removed when the supporting column 36 is to be installed in a mine. When the pin 44 is removed the tubular members 38 and 40 are positioned relative to one another such that the pad 46 snugly contacts the roof 12 of the mine and the spike-like extension 48 penetrates the floor 10 of the mine and then the pin 44 is reinserted.

The aforementioned second supporting assembly is employed to support the first supporting assembly in such fashion that the curtain 30 may be moved longitudinally toward the working face of the mine and provide, in effect, an operable extension of the line curtain 16 while not requiring the stopping or cessation of the mining operations and, at all times, provide adequate ventilation in the region of the working face 14 of the mine. To accomplish these objectives, a tubular sleeve 50 surrounds the tubular member 38 of column 36 and may be vertically positioned thereon and secured at the desired position by a set screw having an operating handle 52. Projecting radially outwardly of the sleeve 50 are a pair of vertically spaced apart shafts 54 and 56 for rotatingly supporting rollers 58 and 60, respectively. The rollers 58 and 60 may be provided with suitable bearing means such as ball bearings to enable them to roll freely under specified load requirements.

Pivotally mounted at the outermost end of the upper shaft 54 is a locking plate 62 having a notch 64 formed in the opposite end adapted to receive the outer end of the lower shaft 56. The locking plate 62 may be locked in the position shown in full lines in FIG. 3, 4 and 5 by an internally threaded nut 66. By loosening the nut 66, the locking plate 62 may be swung upwardly about the shaft 54 to the dotted line position illustrated in FIG. 4 to enable the roller assembly to receive the rod 26 of the first supporting assembly. After the rod 26 is thus inserted into the space between the rollers 58 and 60, the locking plates 62 are swung downwardly and locked in position by tightening the fasteners 66.

The curtain 30 may be rigidized by the addition of spaced vertically extending batten pockets 70 adapted to receive suitably formed batten strips 72. In typical installations, the batten pockets 70 are positioned at approximately four foot centers and commence just below the vertical height of the rod 26 and terminate approximately one foot from the mine floor 10. The typical height of the curtain 30 is slightly more than the distance from the floor 10 to the roof 12 so that the stiffened upper heading 32 will be slightly bent over in the installed operative position to form a sealing relation with the roof 12 of the mine while the lower edge of the curtain 30 would be in contact with the floor 10, again for the purpose of providing a seal therebetween.

When the assembly is in the assembled position illustrated in the drawings, the curtain 30 may be manually advanced toward the working face 14 of the mine as the mining operations progress constantly maintaining the desired interval between the leading edge of the curtain 30 and the working face 14 to, at all times, maintain effective mine ventilation control without having to close down or impair the mining operation.

To militate against any retrograde movement of the first supporting assembly and the associated curtain 30, there is provided an angularly extending spike 74 adapted to be received within a tubular socket 76 secured to the brackets 22 and 24 at a substantially 45 degree inclination. As the rod 26 of the first supporting assembly is moved between the rollers 58 and 60 in the direction of the working face 14 of the mine, the spike 74 inserted in the socket 76 as illustrated in FIGS. 1 and 2 will slide along the roof 12; however, any reverse movement of the first supporting assembly is substantially prevented.

In accordance with the provisions of the patent statutes, I have explained the principle and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that the invention may be practiced otherwise than as specifically illustrated and described without departing from its spirit or scope.

I claim:

1. In a mine ventilation control system for use in a mine working having a roof and a floor in association with an air directing curtain comprising:
   - an extended surface web of flexible substantially gas impervious sheet material having a leading, a trailing, an upper, and a lower edge portion;
   - a first support means supporting said sheet material near the upper edge portion thereof;
   - a second support means supporting said first support means to position the upper and lower edge portions of said sheet material adjacent the roof and the floor of the mine working respectively in adjacent substantially parallel relation with the air directing curtain; and
   - means providing movement of said first support means and said sheet material relative to said second support means whereby the leading edge portion of said sheet material may be advanced toward the working face of the mine working and the trailing edge of said sheet material will be advanced toward the end of the air directing curtain most proximate said working face.

2. The invention defined in claim 1 wherein the upper edge portion of said sheet material is in intimate contact with the roof of the mine working.

3. The invention defined in claim 2 wherein said upper edge portion of said sheet material is folded upon itself to form a stiffened heading therefor.

4. The invention defined in claim 1 wherein said first support means includes a cable interwoven through suitable apertures in the upper edge portion of said sheet material.

5. The invention defined in claim 4 wherein said first support means includes a substantially horizontally extending rod and a pair of brackets spaced on said rod and connected to spaced sections of said cable.

6. The invention defined in claim 5 wherein said rod is prestressed by the tension of said cable between said brackets.

7. The invention defined in claim 1 wherein said second support means includes roller means for supporting said first support means.

8. The invention defined in claim 5 wherein said second support means includes roller means for supporting said rod of said first support means.

9. The invention defined in claim 5 wherein said second support means includes spaced apart vertically extending columns.

10. The invention defined in claim 9 wherein said second supporting means includes roller means for supporting said rod of said first supporting means and means for selectively adjusting the vertical position of said roller means.

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# APPENDIX K

## FIELD TESTS OF EXTENSIBLE BRATTICE PANEL

### 1. Keystone No. 5 Mine

In October of 1975, the extensible brattice panel was introduced into the Keystone No. 5 Mine in Sophia, W. Va. The system was demonstrated to the assistant superintendent and the men on the section by Mr. Ted Lewtas and Mr. Wilhelm Euler of Foster-Miller Associates and Mr. William Desieghart of EACC's Research Group. A summary of the attempted installation is presented in the following paragraphs.

On the section observed, ventilation curtain was run on the right-hand side four feet or more from the rib, as shown in Figure K-1. At the beginning of a cycle the roof is bolted up to the face and the vent curtain extended to within 10 feet of the face. A Jeffrey 120 M with a 10' 10" cutting head is used in a two-step operation cutting first on the left and then on the right side.

The left-hand cut is made to a depth of approximately four feet and then the machine moves to the right cutting the same depth to a smooth face. These cuts are kept shallow because of gas problems experienced because of poor face ventilation on deeper cuts. Prior to the cut on the right-hand side the vent curtain is removed from the vicinity of the machine to a distance about twenty feet back from the face. This requires removal of the jacks which support the extensible brattice, the foremost of which must be placed at the end of the original brattice line. This is done to permit the machine to hug the rib producing a smooth rib with no saw tooth pattern. The curtain is not moved back to the face for several cycles at least.

This mining cycle and face ventilation procedure is not compatible with the extensible brattice panel. In an attempt to produce a smooth rib, face ventilation can suffer. Several features of this cycle contributed to the conflict between face ventilation and a smooth rib. These include:

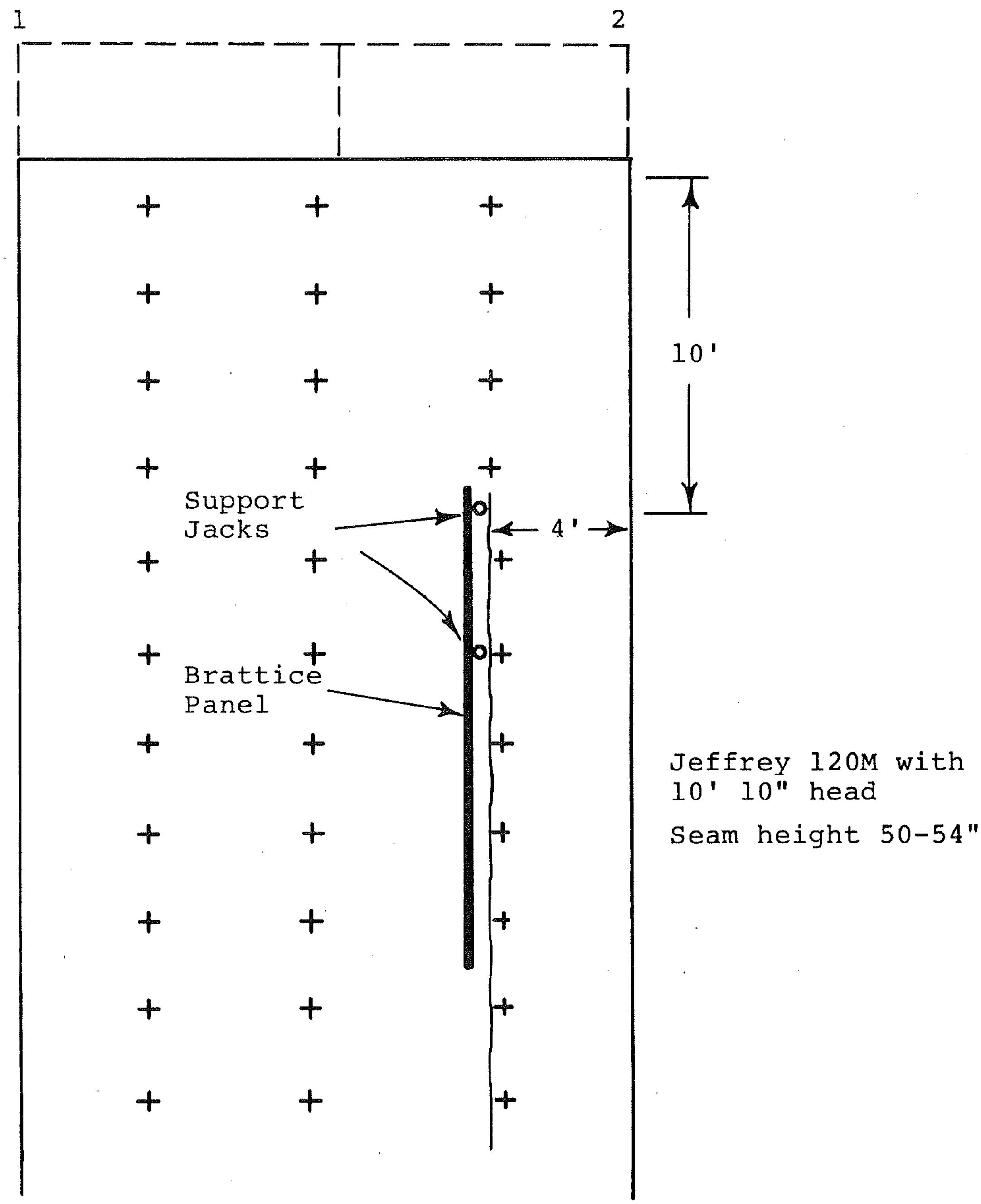


Figure K-1 - Extensible Brattice at Keystone No. 5

(1) vent curtain at least four feet from rib

(2) narrowest available cutting head--overhangs machine only one foot on each side

(3) preoccupation for smooth rib precluded "angling-in" the machine beyond the curtain.

In other operations observed, narrower space behind the brattice, wider heads and an "angling-in" technique practiced by the miner operator permit the vent curtain to remain close to the face even while cutting on the brattice side.

2. <u>Keystone No. 1 Mine</u>

In November of 1975, the extensible brattice panel was introduced into EACC's Keystone No. 1 Mine. It was used for two days by the men on 6 Left 1 North under the supervision of Mr. Ted Lewtas of Foster-Miller Associates and Mr. William Desieghart of EACC. The test section employed a Lee-Norse hardhead miner to cut a 60-inch seam. Exhaust ventilation brattice on the left side was used, as shown in Figure K-2. Five headings were being driven but only three rooms were worked on any one shift. No. 5 heading was the intake and No. 1 the return airway.

The extensible panel was set up inside the static brattice in No. 5 cut. The brattice panel worked well and, because a notchy rib was satisfactory, the jacks were not moved during the actual mining. After the miner left the place, however, the panel and the brattice curtain were removed from the vicinity of the face to permit cleaning along the rib. Two men are required at this stage to remove and then replace the extensible panel. Altogether the extensible brattice was utilized in three complete mining cycles at Keystone No. 1.

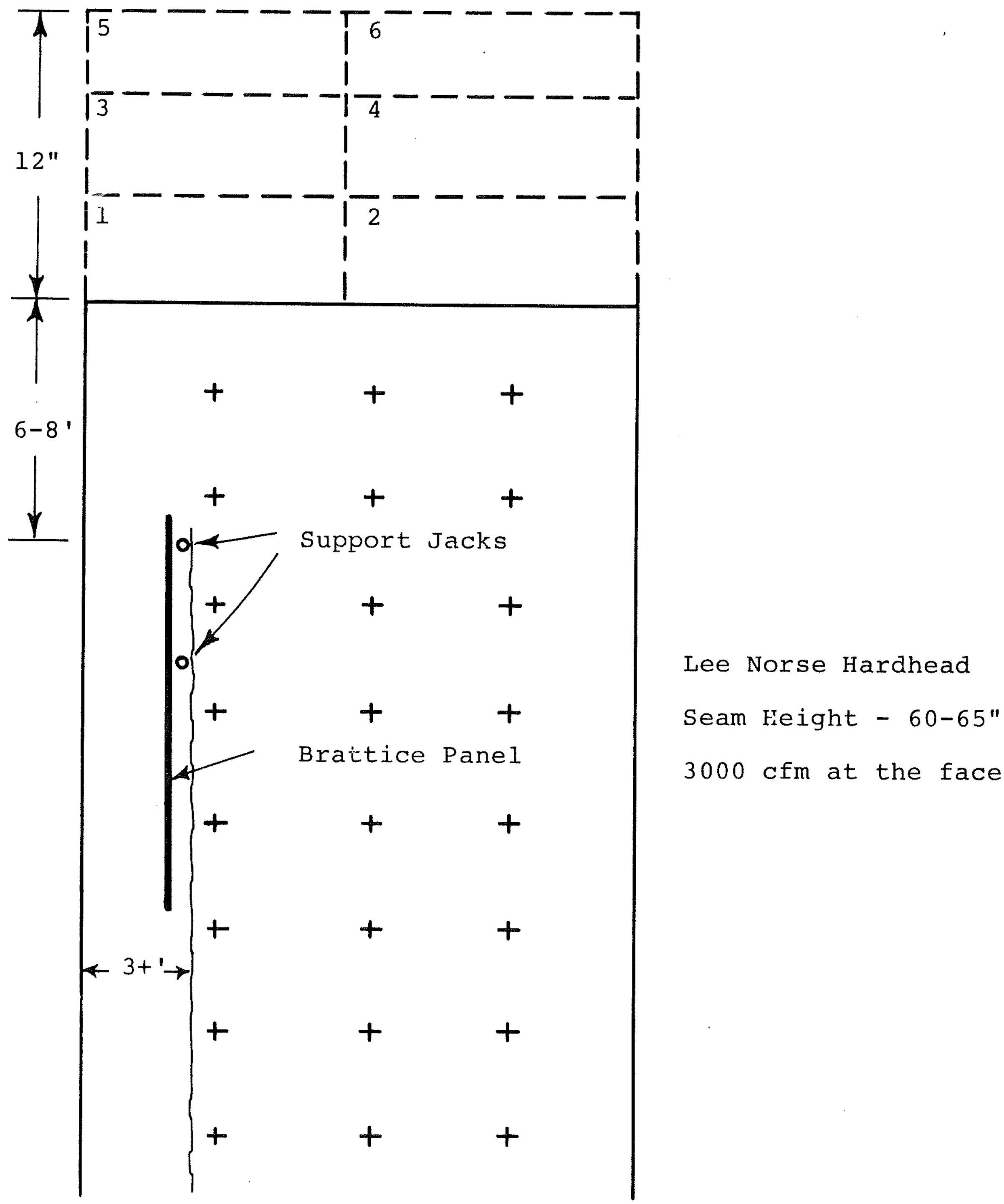


Figure K-2 - Extensible Brattice at Keystone No. 1

It was generally felt that the panel was aiding the face ventilation, but there was no dramatic change in visible dust concentration. The men questioned regarding the extensible panel felt that it was a good idea but not suited to their mining cycle which requires complete removal of the brattice for cleanup after each cycle. An extensible system that can be installed and operated by a single man would be required for their cycle.

3. Dilworth Mine

In December of 1975, the extensible brattice panel was demonstrated at U. S. Steel's Dilworth Mine in Rice's Landing, Pennsylvania. It was used on Bottom Flat section under the direction of Mr. Ted Lewtas and Mr. Dave Monaghan. This particular section provided an excellent opportunity to evaluate the panel under ideal conditions. The entry was 18-feet wide and approximately 72-inches high. Ventilation was excellent with roughly 13,000 cfm passing behind the brattice line placed two feet from the rib. A schematic of entry development is shown in Figure K-3.

The face is advanced in steps eight to ten feet in depth, starting on the side with the brattice. After the first cut, three temporary roof supports are set and the brattice line spadded to the roof roughly 6 feet from the face. This maintains adequate ventilation during the balance of the cycle. It was hoped that the extensible panel would eliminate the need for the temporary supports and the manual hanging of line curtain. The roof supports are required, however, since methane checks are required by the state inspector at the face with a safety lamp.

The men on the section attempted to use the brattice panel and the roof supports--with some inconvenience. If men are required to venture under unbolted roof, they understand and prefer the old techniques employing only line curtain.

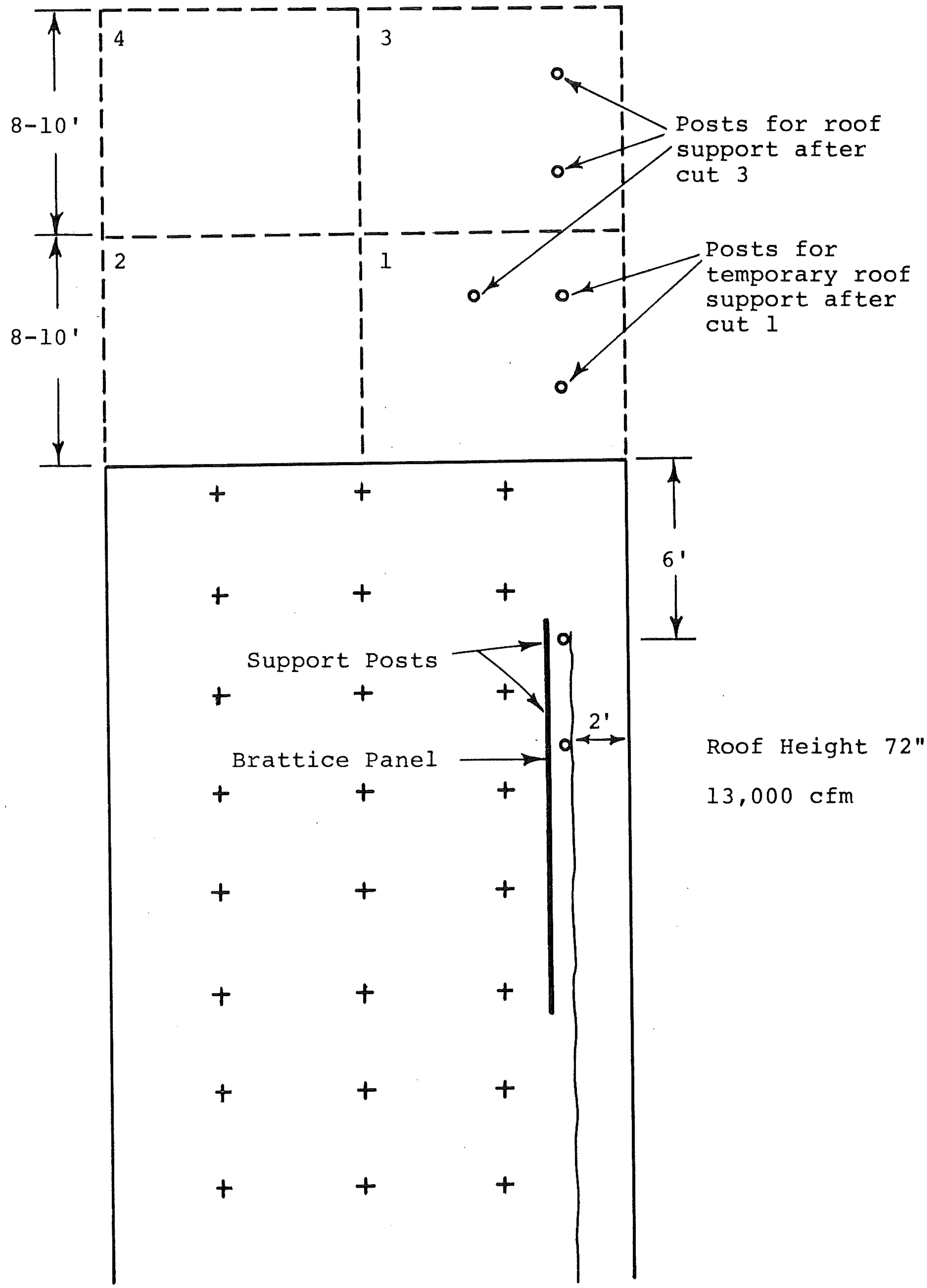


Figure K-3 - Extensible Panel at Dilworth Mine

Because of the above conflict in goals, the panel was not well suited to this mine--or the district. The demonstration was extremely valuable in identifying certain shortcomings of the present design and modifications that would increase the probability of acceptance on any section. The limitations of the present design include:

- o the support jacks positioned along the brattice line are vulnerable to damage from the miner.
- o pulley alignment requirements demand accurate alignment of jacks for smooth advance of panel.
- o accurate direction of the brattice advance demands careful positioning of the jacks.
- o the length of the frame and rigidity of the positioned jacks permits no minor correction for roof or rib irregularity
- o at extremely high ventilation flows the panel is drawn toward the rib reducing available flow area.