

## **Two Decades of Mobile Roof Support Applications**

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### **ABSTRACT**

Second, or retreat mining with Mobile Roof Supports (MRS) has now been part of coal mining in the United States and Australia for two decades. Their utilization has evolved into mining applications which vary in seam heights from 890mm to 5.5m, and overburden depths from outcrop to beyond 600m. This paper will detail the pillar plans, lift sequences, and machinery utilized in these operations and the rationale for the plans. A comparison of the current productivities achieved will be outlined.

### **INTRODUCTION**

The utilization of Mobile Roof Supports in pillar extraction has now been a part of coal production in the United States for twenty years. At this writing, approximately 290 Mobile Roof Supports are in service in coal mining regions of the United States, Australia, and South Africa. This is a result of the safety, productivity, and economic gains that can be realized with the automation of the timbering cycle of retreat or second mining.

Retreat mining or pillar extraction can be one of the more productive mining methods, but because of the nature of roof caving, it can be unpredictable and risky for both personnel and equipment. Mobile Roof Supports are utilized in place of the wing, roadway, and, in some cases the breaker posts. They provide protection for the mine personnel and the face equipment while pillar extraction takes place. Timber setting in the production cycle is eliminated. When utilized in conjunction with remotely controlled face equipment, they allow the pillars to be extracted without the slow cycle of splitting the pillar. The addition of 1450 tonnes of support on the pillar line can greatly reduce the probability that the continuous miner will be caught by a roof fall. Mobile Roof Supports have also been operated as walking shields for the recovery of shields during longwall moves.

## HISTORY

The first prototype of a Mobile Roof Support (MRS) was developed through the guidance of the Spokane Group of what was then the U. S. Bureau of Mines. This unit was a modified roof bolter chassis with two cylinders for roof support mounted within the chassis and two additional cylinders. These cylinders were attached to arms, which could be jettisoned from the chassis (figure 1). The roof support cylinders lowered to the mine floor and raised the rubber tired chassis off the floor. A pod was attached to the top of the cylinders which spread the contact area against the mine roof. This first generation unit was tested in 1979 at Inland Steel, Sesser, Illinois with unsatisfactory results.

The second generation system was modified to a crawler drive and the three point contact pods on the chassis roof cylinders were replaced by rails. Each cylinder on the support was rated at 50 tons capacity. This system was tested with much more favorable results at Southern Utah Fuel Co., near Salina, Utah, from April to November in 1984. A single support was set in the entry, and one in the pillar split. These two supports replaced all but two of the wing and roadway posts.

The concept evolved into a machine with a smooth canopy, similar to a longwall shield. This design direction was followed by several mining equipment manufacturers. Prototype units, constructed by Voest Alpine Mining and Tunneling, were observed in operation in 1987 at the Middlebult Colliery at the SASOL mining complex near Secunda in the Republic of South Africa. These supports, referred to as "Breaker Line Supports" are utilized in pairs, with two supports set in each entry. Structurally, the BLS are a crawler driven chassis with a flat, lemniscate guided canopy supported by four cylinders. This support was rated at a total capacity of 600 tons. The first commercial application of the BLS in the U. S. was in early 1988 at the Donaldson operation of The Valley Camp Coal Co. near Charleston, West Virginia. In 1988, J. H. Fletcher & Co. began production of a set of 600 ton supports that were installed later in that year, in the mines of Martin County Coal, near Inez, Kentucky. This mobile support was the result of design and prototype evaluation conducted by J.H. Fletcher since 1984.

The application of MRS to retreat mining in Australia began in 1987 and has continued successfully to date with many systems in use. However, the details of their use in Australia will only be briefly covered in this paper.

## APPLICATION/OPERATION

Mobile roof supports are set in the entry and crosscut around the pillar to be extracted. They are utilized in pairs and generally positioned with one slightly ahead of the other in an arc, similar to that

described by wing timbers (figure 2). The continuous miner extracts the wing to the right. After the lift is completely mined, the gob, or goaf side MRS is retracted a few inches from the roof and trammed forward approximately one-half the length of the support, or 1.8 to 2.1m. The roof plate is then reset. The adjacent MRS is lowered and trammed forward a similar distance, then reset against the roof. This process continues until the supports are positioned for the next lift. This cycle time should require one to four minutes and can usually be accomplished while the continuous miner is repositioned and its cable slack pulled back. This method, where a pillar is extracted only from one side or entry, is referred to as the outside lift, or one sided lift approach. This lifting sequence is applied generally in seams with 180 m of overburden or less, although its use has been observed in some areas with very strong coal and competent immediate strata at depths well over 300 m.

Mining of the lifts continues until the pillar has been completely extracted from the entry. The MRS in the entry are then positioned at the intersection. The outby end of the pillar is then mined with the other pair of MRS (figure 3). The final stump or pushout is extracted with four supports set in close proximity in the crosscut and intersection (figure 3). After the pushout is completed, the four supports are moved together and set against the roof in the intersection for their protection, and as they are removed from the intersection, they are trammed to the same positions to start mining in the next pillar.

Mobile Roof Supports are also used to extract the pillars by mining lifts to the left and right out of the same entry or breakthrough. This is referred to by a variety of different terminology's, such as twining, left and right, Christmas treeing, tree topping, and other appellations too numerous to relate. This plan is the most commonly applied technique for MRS, being utilized on approximately 65 to 70% of the sections.

Twining requires that the lifts be kept to the proper width dimension as mining takes place in the entry. If this is not done, the operators will be working with an unsupported, open lift to their backs. Coordinating the continuous miner operator's moves and those of the MRS operator can alleviate this problem.

Move time for the MRS is shorter per lift when twinning, and fewer moves are required per ton mined than in the outside lift plans. Because this method is applied in deeper seams, or higher grind, lower strength coal beds, the pillars are generally larger and several lifts must be mined from the back, or breakthrough side of the pillar (figure 4). In twining, the two MRS positioned in the crosscut play a more important, and in some seams, a critical role in the protection of men and equipment. Figure 5 shows the positioning of the supports while the mining of the final stump, or pushout takes place.

The broad spectrum of mining plans that have been written and applied are variations of the outside lift and twinning lift sequences. These plans have been altered and expanded to adapt them to specific mining conditions, the face equipment in use, and the concerns of management, the workforce, and the regulatory authorities in the various mining regions.

MRS's have also been utilized in thicker seams that have been bench mined. The upper portion of the seam is extracted as the panel is driven and supplemental side-wall support is installed during this development. When the pillars are retreated, bottom coal is extracted for a distance of one to two rows of pillars and a row of pillars is extracted with high seam MRS by either the outside or twinning lift sequence.

Pillar extraction has been performed with Mobile Roof Supports both above and beneath mined out longwall panels and areas that had been previously retreated with timber.

#### BENEFITS OF MRS UTILIZATION

The MRS's provide an upward, active force on the immediate roof strata. When two supports are positioned and set in an entry, there is a total active force of at least 300 to 400 tons applied to the roof. This results in the normal cave line of the roof being pushed back into the goaf by several meters. The difference in the cave line of the roof with timber and the cave line with MRS is also shown in figures 2 & 5.

The control of the roof in the immediate area of the pillar extraction provided by the Mobile Roof Supports can yield substantial benefits in a broad range of areas that are critically important to mine operators. These include safety, productivity, and mine cost. The positive aspects resulting from the application of Mobile Roof Supports are summarized as follows.

- Forcing the cave line further into the gob allows for a wide or thicker fender to be mined on retreat. When radio controlled continuous miners are utilized, "fenders" as thick as 12.2 m have been mined on retreat. This eliminates the costly and relatively unproductive cycle of splitting the pillar and the supporting the pillar split.
- A higher percentage of the reserve can be mined on retreat. Production is derived without the roof support material and the infrastructure costs that accompany mine development and receding faces. Dramatically lower overall cost of production is realized.

- The exposure of workers that is associated with setting turn posts, and in some regions, breaker timber, is eliminated. Radio remote control of the MRS and the proper installation of cable hangers that can break away from the roof can ensure this. Where breaker posts are set, an MRS can be utilized to protect those setting these posts. It is the opinion of many mine personnel that the benefits of breaker posts are not offset by the hazard and expense of installing them. An increase in the overall level of safety may be achieved by not setting this support and keeping the workforce out of the area; as is the case in Southwestern Virginia. However, in those seams where overrunning caves are a factor, breaker posts should be maintained.
  
- The continuous miner produces at a higher average rate. With older, timber retreat plans, coal fenders were only 4.6 to 5.5m wide and the continuous miner spent a large portion of its production cycle turning into the lift, with the cutter drum only partially engaged. The thin fenders were then mined through quickly. The miner operators spent the majority of the shift in the unproductive cycle of turning the miner into the coal rib. With MRS's, the continuous miner is able to mine a large volume of coal without tramping to another place. Accordingly, the efficiency of the haulage setup becomes even more critical. Those mines with very efficient haulage layouts, especially continuous haulage, can produce substantially higher output on retreat, as compared to development.
  
- Operating the supports realizes a dramatic reduction in the usage of timber and the accidents that are often associated with timber handling. This includes the cost of the posts and the labour to supply and set the prop. The operation of MRS's eliminates the need for roadway, wing, and in some regions, breaker posts.
  
- Less time is required to set up for a lift with MRS's than when setting wing posts. Especially when mining lifts both left and right, the MRS's can be advanced before the miner is ready to turn the next lift. Depending on the mining cycle utilized, the repositioning of Mobile Roof Supports is 4 to 5 times faster than timber setting.
  
- MRS's allow for higher reserve recovery. A higher percentage of the coal in the pillar is recovered safely with MRS's than with timber. A larger pillar can be safely and more completely extracted. Fewer stumps are left remaining and those that are left are smaller. Many operations profess to achieve a high pillar extraction rate without supplemental support. Observation of the mining in these sections utilizing timber, or no support, indicates that large amounts of resource are left behind. In some situations, this incomplete recovery causes severe strata instability as a direct resulting from incomplete caving of the roof. Total reserve recovery can be realized as high as 85% when utilizing the roof supports. When compared to the recovery of 45 to 60% for

developing rooms only, this can be significant addition to mine life. Actual in-pillar recovery can be above 90%. However, pillars must be left in bleeder entries and sub mains development. This reduces overall reserve recovery.

- Complete pillar recovery and the ability to mine a larger pillar results in a more stable pillar line. Generally, the sections utilizing mobile roof supports do not have rides, squeezes, and pressures overriding the immediate face. This can add a substantial factor of safety for the work force, and smooth production from the pillar line. Observations of pillar extraction on the same section before the use of the roof supports , and after the utilization of them, has shown a dramatic reduction in roof and floor heave problems and sharply higher stability of side walls. All this occurs in areas that mine personnel must spend their working shift.
- Fewer personnel are required on a crew retreating with MRS's than on a developing panel, or on a retreat panel with timber.
- Due to the more complete recovery associated with the operation of roof supports and the larger pillar size, caving becomes more regular and somewhat predictable. The hazards associated with unexpected or premature caving are substantially reduced. However, no guarantees are made or implied in this matter. Caving patterns are, by nature, individual to each mine and can vary according to the strata present at any given location. Variations in the mine roof must be noted by crews and supervision with in-mine experience.
- When unexpected caving does occur, the fall is stopped with a very high degree of reliability by the MRS's. Roof falls which would have caught the continuous miner and required two days to a week to recover, are reduced to no delay or less than two hours for recovery. The recovery process with MRS's is also much safer than with posts and cribs. MRS's have often been used as auxiliary support in these situations, both to increase the level of safety and to speed the recovery process.
- Daily production can be mined at a higher yield on retreat. The support provided by the MRS's, combined with a more stable pillar line contributes to less deflection in the roof, minimizing the contamination of the product by out of seam contamination. A more stable pillar line can decrease floor heave and minimize the need to load floor material.

The operation of Mobile Roof Supports represents a very different mining situation to many mine managers and equipment operators. There are several factors which should be recognized, accepted, and dealt with for reliable and safe operation of the pillar line while utilizing Mobile Roof Supports.

- Always position the MRS's as close to the continuous miner for maximum protection of the equipment and personnel. Do not try to mine more than one lift without advancing the pair of MRS's. However, allow adequate space for the miner operator to rapidly exit the lift and ensure that the miner is not "wedged" by rib sloughage. Do not use them separately. Work the MRS's in pairs only.
- Retraction of the roof plate (canopy) can trigger a fall. Do not lower more than one MRS roof plate at a time when advancing the machine to another lift. If this occurs, or caving begins while advancing the support, reset the roof plate immediately and let the support "ride out" the fall.
- The lack of timber (breaker posts are knocked out when the MRS's are first positioned in the entry) does not allow the warning that is given in a full timber plan by timber failure. This circumstance can create discomfort among those accustomed to using wood.
- Since a very high percentage of the pillar is recovered with MRS's, it is sometimes advisable to leave a small stump, "peg", or fender of coal to give a warning or protect the equipment, especially while moving out of the pushout area. These must be sized to crush out later. Each mine represents a different situation regarding the size and placement of these protective stumps.

There is no substitute for training and experience in full retreat mining. This is especially true when the initial break of the main roof occurs on the panels. Do not become over confident with the operation of any roof support. The MRS provides support of the immediate roof only, and cannot "hold up the entire mountain" as is sometimes commented.

#### MINING PLANS FOR MOBILE ROOF SUPPORTS

The first full retreat pillar plan utilizing Mobile Roof Supports in the U. S. was issued to Donaldson Mine Co. in late 1987. It required line timbers to be set and although figure 6 does not show it, a staggered face was required to be maintained. The line timbers were removed as a requirement as long as three rows of bolts, two feet longer than the normal anchorage length were installed in the intersection. Only the outside lift method was allowed (no twinning or left/right lifts) and lifting off the barrier was not permitted.

A modified rib pillar of extraction, first observed in South Africa in early 1987, was utilized to pillar a barrier up to 60m thick between the five entry panels, (figure 7). Overburden depth varied from outcrop to 170m. The entries were spaced on 30m centers, and breakthrough centers were 15m. Pillar extraction proceeded from left to right across the last open break. This orientation of the pillar has been referred to as “laid down”. There is very little time required to move and set the MRS’s up in the next pillar and haulage was augmented by a permissible feeder that kept the haul distance short. This plan, with some variations, is still in use in West Virginia.

Today, Mobile Roof Supports have been utilized in many different seams varying in depth from outcrop (mountaintop mine) to over 600m of overburden. They have recently been applied in seam heights from 890mm to 5.0m. At one operation, 600mm roof plate extensions were used to increase the operation height of the 5.0m supports to 5.6m. Twinning is the most widely practiced lift sequence (figure 4). There are many plans that achieve similar goals as the rib pillar. They mine by lifting off the barrier pillar or driving short rooms into the barrier and recovering the fenders/pillars in those rooms. These minimize the haulage distance. Note haulage distance is the major limitation to the rib pillar type of plan (figure 8). The majority of pillar orientations are with a short distance between entries and longer breakthrough distances, or with the pillars “standing up”. This can allow the crosscuts to be driven through in one cut on development with a remotely controlled miner, and also requires fewer stoppings (figure 9).

Generally, a complete set of Mobile Roof Supports is comprised of four machines. There are several plans which require only two MRS’s. The two MRS plans are approved for thinner and more shallow seams. These plans have usually not allowed mining on the back side of the pillar. However, several plans have recently been approved which combine timber (set for the mining of the lift from the breakthrough) and MRS (see figure 10). Operating with four MRS provides greater safety and allows for greater protection when unexpected caving causes problems. In these situations, four supports can provide much more coverage and support than two.

The various retreat lift patterns have been used with all types of haulage, including shuttle cars, battery haulers, and continuous haulage. The continuous haulage plans (figures 11, 12 & 13) generally require pulling the pillars from the outside entries to the center conveyor entry. In some seams this can result in stress concentrations in this belt entry as the pillars or fenders remaining there are extracted. This situation can be moderated by modifying the type of bolts installed on development, altering the timing of the belt back, and leaving strategic stumps that will later crush out. Other plans are being utilized for recovering barrier pillars in the outcrop of mountaintop mines, where surface mining has previously occurred (figure 14).

MRS's have been operated on super sections with two continuous miners and two sets of MRS's working the face simultaneously. Other super sections operate with one set of MRS's. The continuous miners are not operated at the same time, and one develops fenders for retreat in the barrier. The second miner retreats the face pillars and the barrier fenders as they occur in the sequence (figure 15).

After observing the operation of MRS's on numerous retreat panels at a variety of operations, the following trends in output rates have been noted. Whereas the comparisons can not always be directly made due to the wide range of scheduling options, equipment selection, mining conditions and worker motivation; some generalizations can be made. Retreat productivity with continuous haulage has been observed to peak at approximately 274m of advance per shift and can average between 210m and 240m per shift. In lower seams, a single continuous miner with shuttle car haulage, 890mm of working height, and an 8 ½ hour shift has produced around 91m per shift.

Retreat with MRS's has taken place in several seams with previous second or longwall mining in adjacent seams both above and below the active works. Pillaring is currently taking place in seams that were judged too difficult or hazardous to retreat with timber plans.

The applications of Mobile Roof Supports has expanded to their use as walking shields in the recovery of longwall shields. This has been done at several mines across the United States, the first being the Eagle Energy Mine, near Van, West Virginia.

#### APPLICATIONS-AUSTRALIA & ELSEWHERE

MRS have also gained wide acceptance in Australia. However, the usage has declined there as production methods have shifted to longwall operations versus room and pillar. In many Australian applications, a set consists of three supports (figure 16). Lifting of the pillar begins with two MRS's. After the first lift has been extracted, the continuous miner is set to the side of the entry, or backed out of the place, and a third MRS is positioned next to the other two. This common extraction sequence utilized in Australia is referred to as the "Wongawilli". It was first utilized on the Wollongong area at Coal Cliffs Colliery.

One set is in operation in South Africa at Anglo American's Goedehoop Colliery. It is a 5.0m set and operates in the #2 Seam. It began operation in 2003.

The use of MRS's is currently being evaluated in several countries besides the U. S. and Australia for coal and mineral mines. These include Mexico, New Zealand, Canada, and Norway.

## PILLAR DESIGN

Sections that apply the technology of Mobile Roof Supports experience higher productivity and substantially improved strata control when the pillars are sized and developed specifically for the retreat process with MRS's. Proper design can ensure that development and retreat productivity and production are balanced according to the overall roof support costs at a particular mine. Most operators are now finding that, in most seams, retreat productivity can substantially exceed that obtained while in development. Retreat tonnage is placed in an even more favorable cost perspective if the overall considerations of yield, supply cost savings, and increased economic life of the reserve are factored into the equation. Proper pillar design is an essential for achieving a safe and productive pillar line.

## THE INTERESTING DAY

No discussion of Mobile Roof Support application should be complete without addressing the problems that can occur when premature caving locks the support in place. This problem can occur with inexperienced crews and, with much less regularity, the fully initiated.

It can be stated that, depending on the specific conditions and the training of the crews, getting an MRS "caught" is an infrequent problem. A Fletcher MRS has a powerful tram drive system that enables it to tram out, without assistance from a large majority of these problems. In approximately 10% of these occurrences assistance is required in the form of a pull from the continuous miner. Generally, a 30mm wire rope, or a short piece of longwall chain is used. A retriever should be available within an hour from the section. All MRS applications should include a reliable equipment retriever.

In all but two occurrences during the last three years by the author, proper and safe extraction of the support has required less than 20 minutes.

## CYLINDER PRESSURES

Set pressures on the roof plate vary between 25% and 50% of initial yield pressure. If set pressures are too high, fracturing of the immediate roof can occur in fragile roof areas. A set pressure too low can result in the support settling into the floor, or roof strata while mining takes place, with a resulting loss of pressure and a decrease in the active support applied to the immediate roof. If the pressures are reduced due to the relaxation of soft material in the mine floor, the support must be

reset. These machines are not equipped with hydraulic circuits that maintain constant set pressure. In fact, all MRS are shut down after they are positioned

Large, 150mm gauges are connected to the front and rear pairs of the roof plate cylinders. These are accurate until the bottom stage of the cylinder is fully extended. However, the pressure gauge readings cannot be inferred to reflect or indicate the full range of status of the roof. In many mines, the roof plate builds pressure, often near completion of a pillar or prior to a fall. In many others, the gauges show little increase, if any, during the mining cycle. Increasing pressure recorded by the gauges is sometimes a warning of an impending fall. However, no change in pressure should not be taken as a sign that all is entirely well. Pressure gauge readings have also decreased just prior to a fall.

A load monitor is now incorporated in all newly manufactured Mobile Roof Supports. It provides a visible alarm at several increments of increasing roof plate load.

## CURRENT DESIGN STATUS

The earliest supports were intended to replace the rows of breaker posts, both in design and function. The post (cylinder only) type support had obvious problems when the immediate roof was broken or caved upon the retraction of the cylinders. Advancing a single machine with no adjacent support in place proved risky all too often. This design was replaced early on most drawing boards by the smooth canopy type of design that is seen today with the MRS's utilized in pairs for additional support while advancing the MRS.

A Mobile Roof Support consists of (figure 17) a roof support plate (canopy), lemniscate linkage with a caving shield incorporated into it, support cylinders, chassis, side curtains, and plow, which contains the cable reel, electrical controller & motor, and hydraulic power system.

Some of the early supports trammed slowly and were frequently stopped by debris left in front of the machine. Spillage from the CM shovel can leave large volumes of material in front of the roof supports. Each MRS must tram through this debris at some point in the mining cycle.

Caving often damaged side protection. Cable reels were not included in earlier designs, and the cable, which had to be “figure eighted” on the plow, was bulky, hard to control, and sometimes damaged. Gauges to read cylinder pressure were nonexistent or small and difficult to read. Hydraulic

systems were sometimes difficult to keep on stroke and components were hard to access, especially in poor rib conditions.

Machine size and the expected benefits of the concept were thought to limited applications to working heights of approximately seven feet or less. Currently, there is strong interest in MRS applications in working heights as low as 890mm.

Reliability is a critical requirement for an MRS system. A bulky, unpredictable support can mean more than just lost production on the pillar line. A mobile support is subjected to severe duty and must be capable of surviving the repeated abuse dealt in this environment. The mobile roof support manufactured today is an electro-hydraulic unit with a 37 or 55 kW motor driving a piston hydraulic pump. All functions are hydraulically operated and controlled by radio remote. The unit has hydraulic tram motors equipped with variable torque/speed control. These motors are equipped with valve blocks that reduce tram speed from a normal speed of 23 mpm if impediments such as debris or hills are encountered, and automatically increases the available torque to handle such obstructions. This is especially valuable in situations where caving has flushed loose rock around the support or the continuous miner has left a deep pile of coal in front of the MRS.

J.H. Fletcher & Co. previously manufactured supports with a capacity of 544 tonnes. At present, only 727 tonne capacity supports are manufactured. The higher capacity MRS's have a greater reliability for a variety of reasons, including cylinder design and lemniscates strength.

The MRS's were utilized with two radio transmitters and two umbilical, hard wired controls. Due to a need to ensure greater operator safety, the umbilical controls have been eliminated, and four radio transmitters, one per MRS, are supplied with each set.

The plow contains the electrical enclosure, cable reel, and hydraulic valve chest. The location of all controls in the plow makes troubleshooting safer and easier. It is raised and lowered by cylinders capable of raising the crawlers off the ground. High strength steel linkage connects the plow to the chassis and is designed to allow the use of up to a 140 tonne retrieval system.

Control of the support is through a radio transmitter/receiver whose outputs are directly connected via intrinsically safe circuitry to the valve bank and its pulsar type solenoids. This eliminates interface relaying and enhances reliability. The transmitter can operate up to eight MRS and the pendant can control any machine to which it is connected. Various safeguards are in place to make sure that each support can be operated by only one remote at any time.

Roof plate cylinders are available in two or three stage versions, with the three stage preferred because of the wider operating range that it affords. Cylinder capacity is 181 tonnes yielding a total support capacity of 727 tonnes. Each cylinder contains a low volume yield valve and a high volume atmospheric relief, or rock burst valve to protect the MRS in case of heavy or sudden loading. It should be noted that the MRS has gone through several design evolutions and is comprised of high strength steel. Compromising the strength of the steel during repairs and maintenance can dramatically affect the durability and reliability of the support.

As each mine has individual characteristics, a wide variety of height ranges are manufactured. In thin seams, a 812mm (collapsed height), 600 ton support (figure 18) is utilized. The lowest MRS built to date in the 800 ton (727 tonne) size has been a 1100mm collapsed height machine. However, a 975mm collapsed height support is currently being designed.

At the other end of the spectrum, 544 and 727 tonne MRS's have been manufactured which ranged up to 5.0m (figure 19). The higher systems can also have a tilt frame incorporated into the structure. This allows the controlled tilting of the canopy in higher seam applications and ensures that the roof plates of adjacent supports do not collide if the MRS is trammed over uneven ground or loose debris (figures 20 & 21). The higher MRS's have been utilized in thicker seams that were mined all in one pass, as in the South African mines, or in benches, or separate levels on development versus retreat.

An additional feature that can be incorporated into the support is the ability to alter the height of the support by changing cylinders, and/or lemniscate linkage. This allows the MRS to be utilized in multiple seam applications with a fraction of the capital required for several sets of supports. Canopy and cylinder extensions are also available for minor or localized increases in working height.

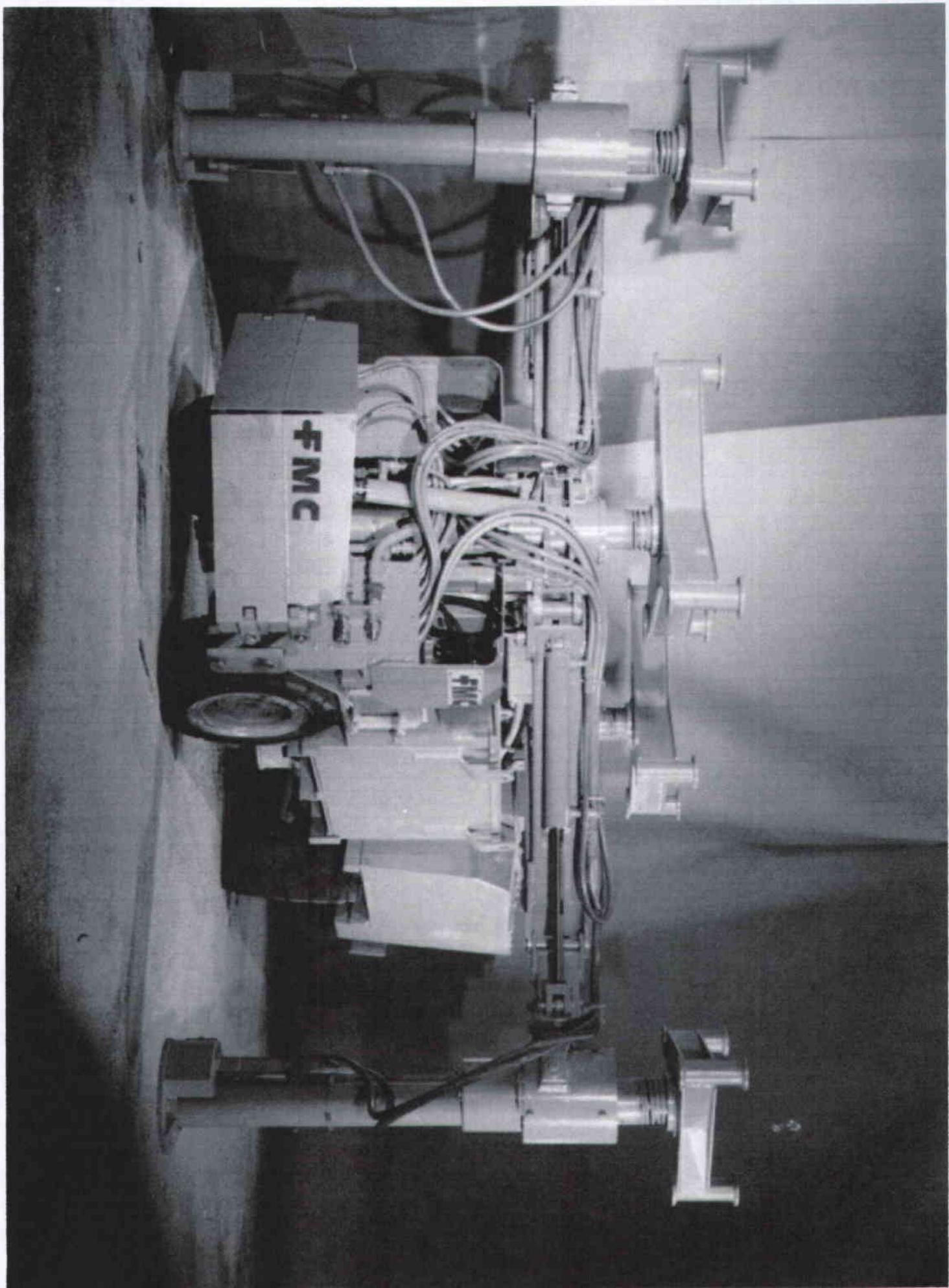
The roof support plate (canopy) is constructed of the highest strength steel (T1) and is a total of 350mm thick. This provides a rigid canopy that does not deflect under the roof load, and ensures a smooth surface for the MRS to slide from under caved roof. The ability to independently tram from caved areas is a major advantage of a Mobile Roof Support. The caving shield, incorporated onto the lemniscate linkage, translates the vertical loading of the gob or goaf into a horizontal direction and assists in bringing the support out of the gob. This has been referred to as a "squirter" by operators utilizing the support. The powerful tram system, the rigid canopy, and the caving shield all work to ensure that the support exits the gob under its own power.

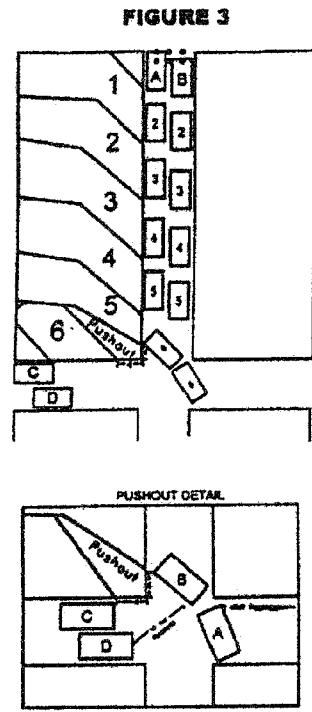
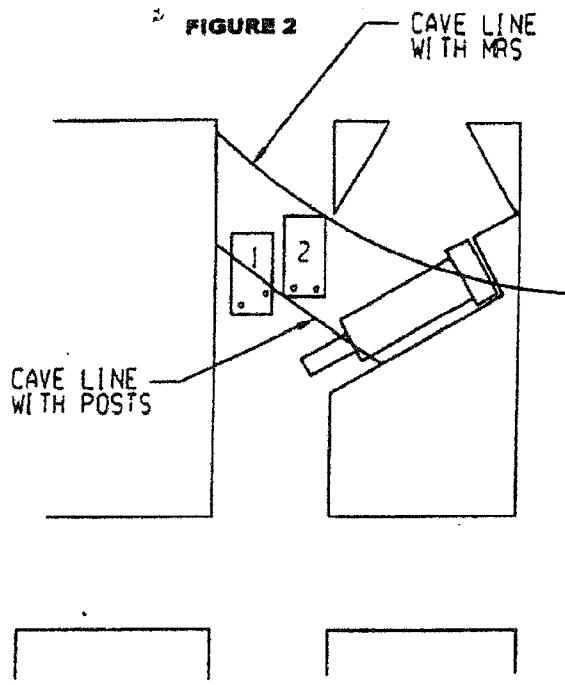
## SUMMARY

The use of Mobile Roof Supports continues to expand rapidly for both retreat mining and longwall shield recovery. As reserve depletion forces the mining of thinner seams in deeper strata, and in more adverse roof conditions, the need for productive second mining alternatives will increase. The most significant change to note in the last ten years is that pillar extraction has been safely applied in seam conditions as high as 5.5m. The use of the supports has continued to expand, especially in the United States. Very few Mobile Roof Supports are available on the used equipment market.

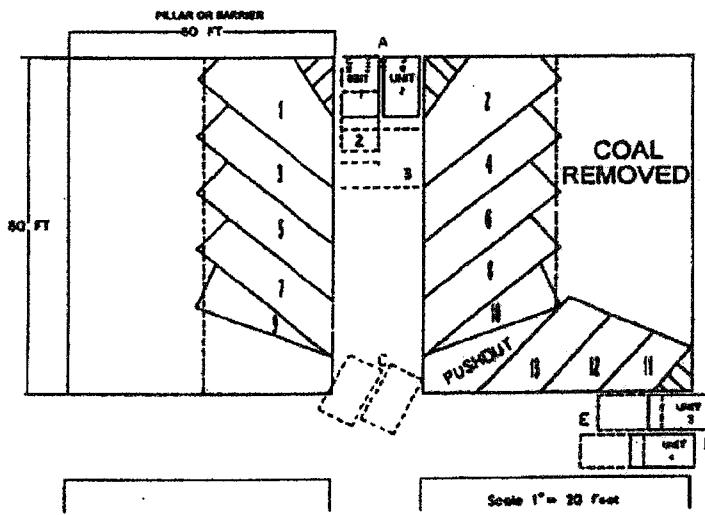
Mobile Roof Supports, when properly applied, can allow the economic recovery of reserves in bedded strata with a substantially higher degree of safety and improved productivity. J. H. Fletcher & Co. plans to play a primary and integral role in this field by providing a Mobile Roof Support that is custom designed to meet the needs of the mining industry.

**Figure 1: First Prototype Mobile Roof Support**





#### PILLAR EXTRACTION USING THE XMAS TREE METHOD



**FIGURE 4**

FIGURE 5

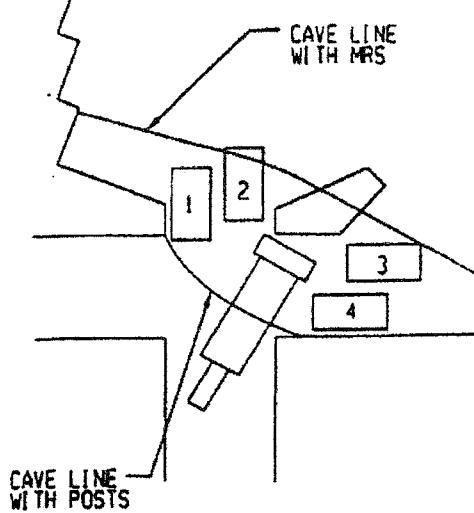


FIGURE 6

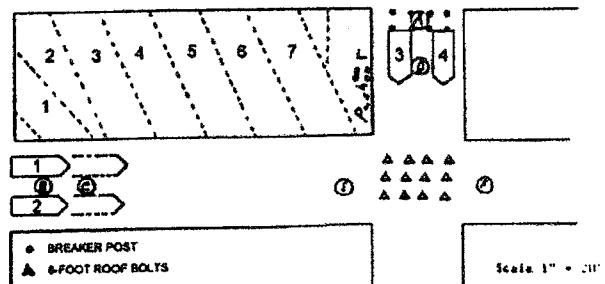
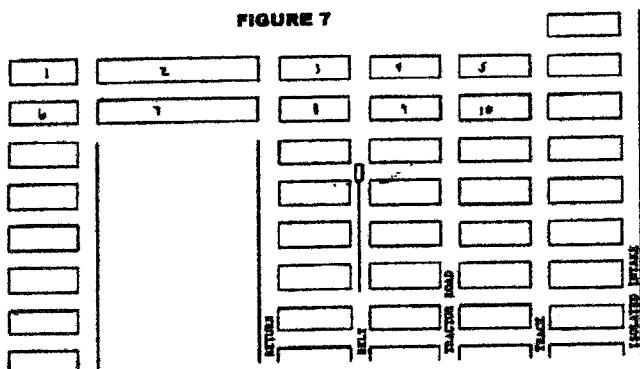


FIGURE 7



RETRIEVE MINE PLAN FOR PANEL

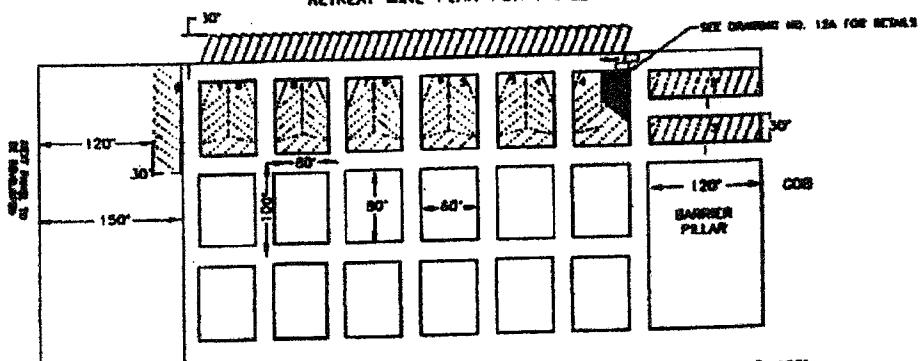


FIGURE 8

SCALE 1" = 100'

FIGURE 5

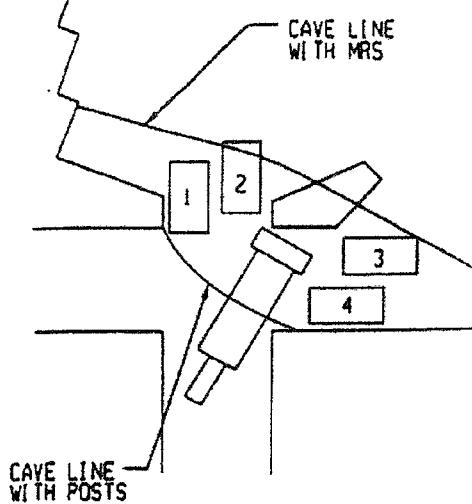


FIGURE 6

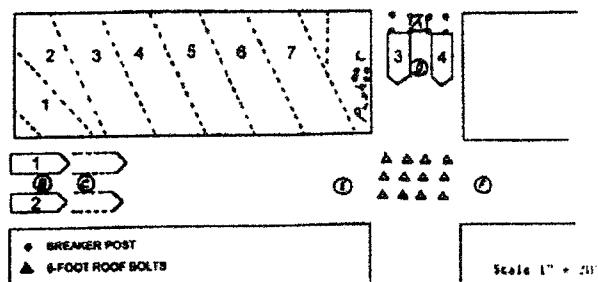
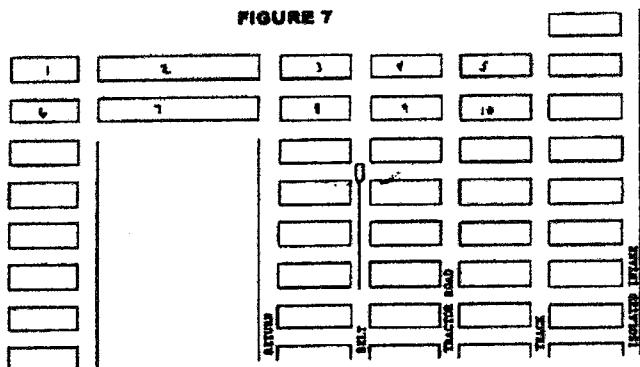


FIGURE 7



RETREAT MINE PLAN FOR PANEL

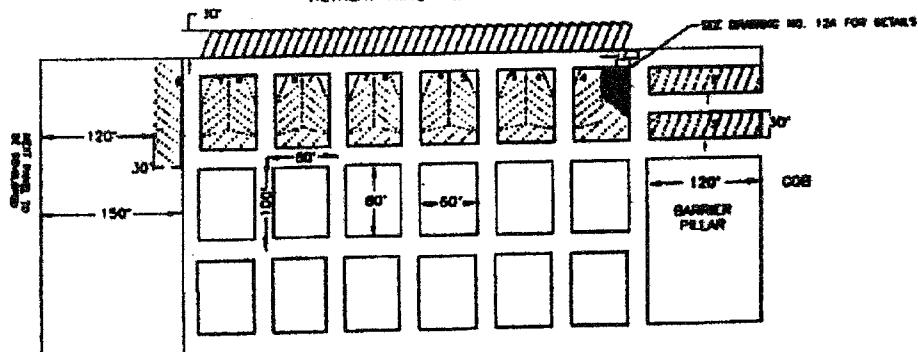
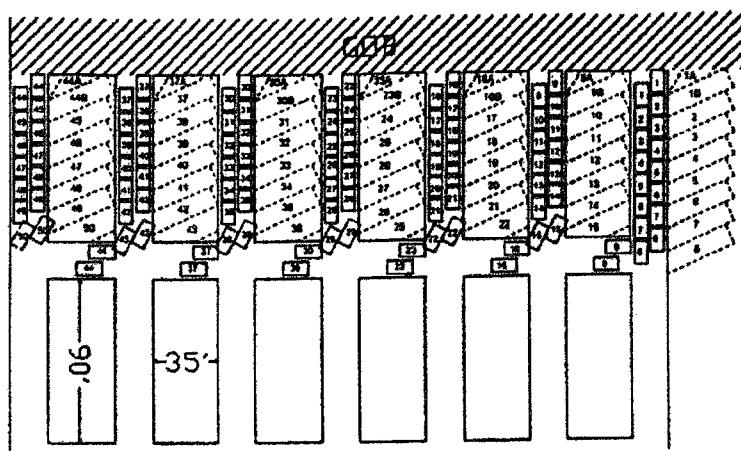
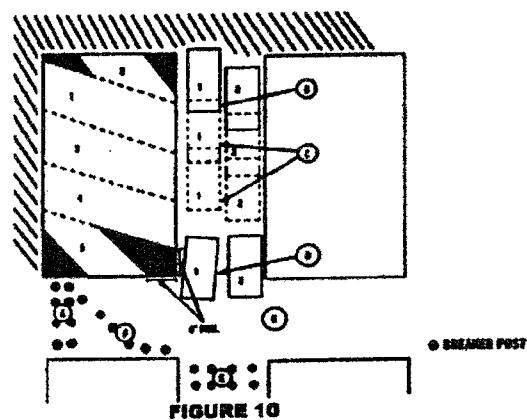


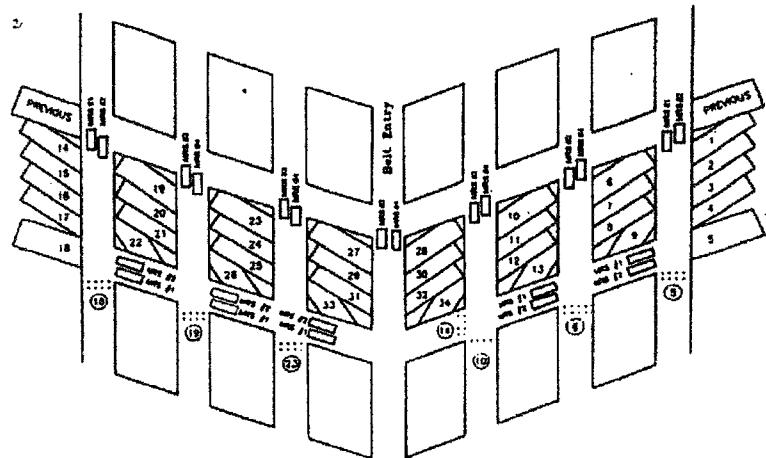
FIGURE 8



**FIGURE 9**



**FIGURE 10**



**Legend**

- MRS (Mobile Roof Support)
- 18 CUT SEQUENCE
- (1) INDICATES POST TO BE SET PRIOR TO MAKING CUT INDICATED
- ::::: TIMBERS

FIGURE 11

PILLAR RECOVERY PLAN  
DEEP-CUT USING MOBILE ROOF SUPPORTS  
SCALE: 1 IN. = 20 ft.

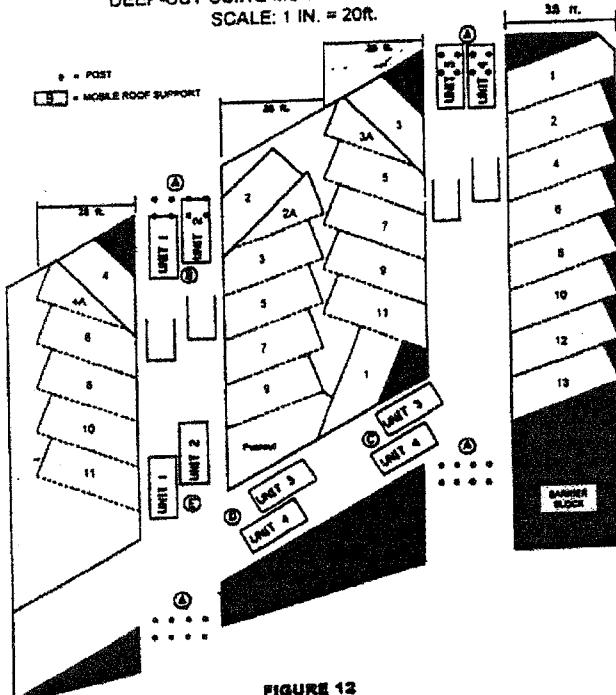


FIGURE 12

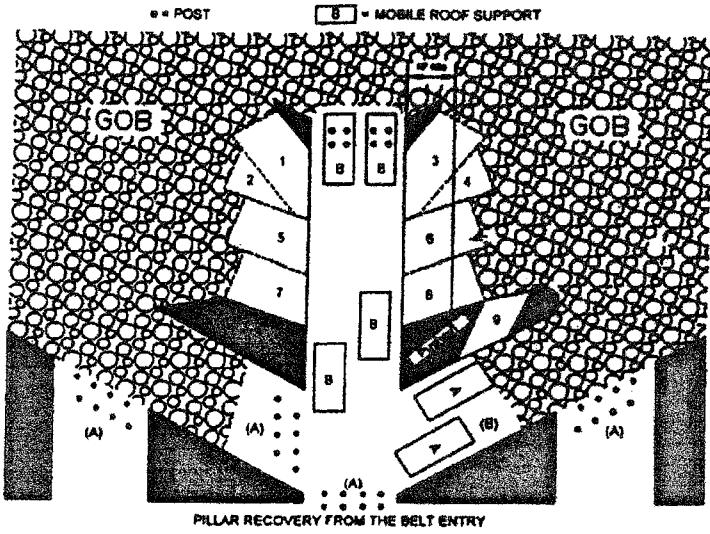


FIGURE 13

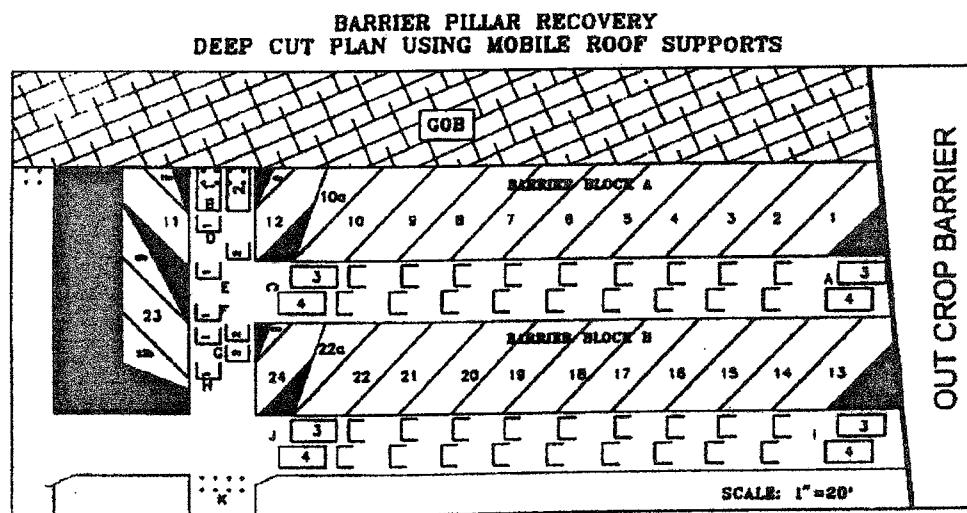


FIGURE 14

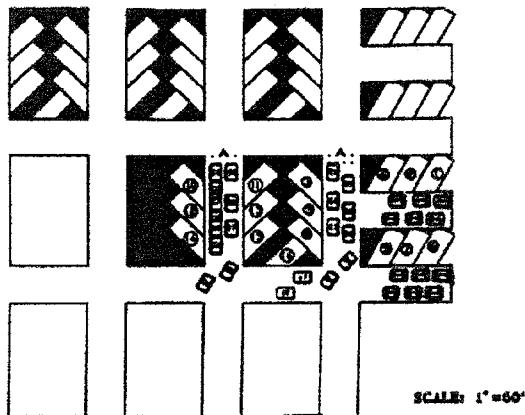


FIGURE 15

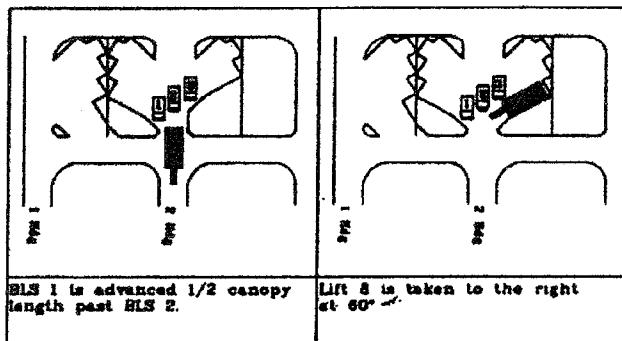


FIGURE 16

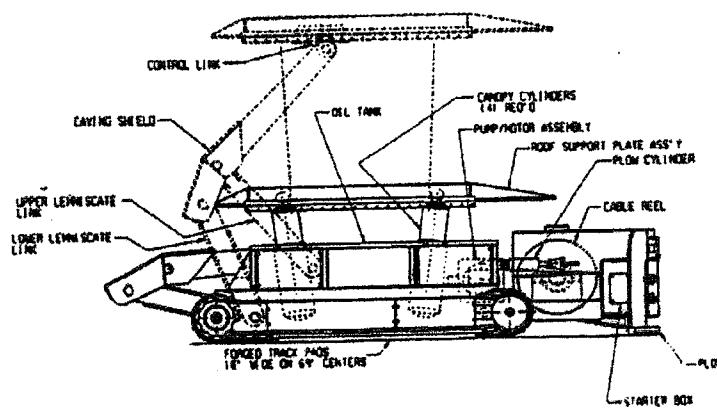


FIGURE 17

Figure 18: 800mm to 1600mm Mobile Roof Support

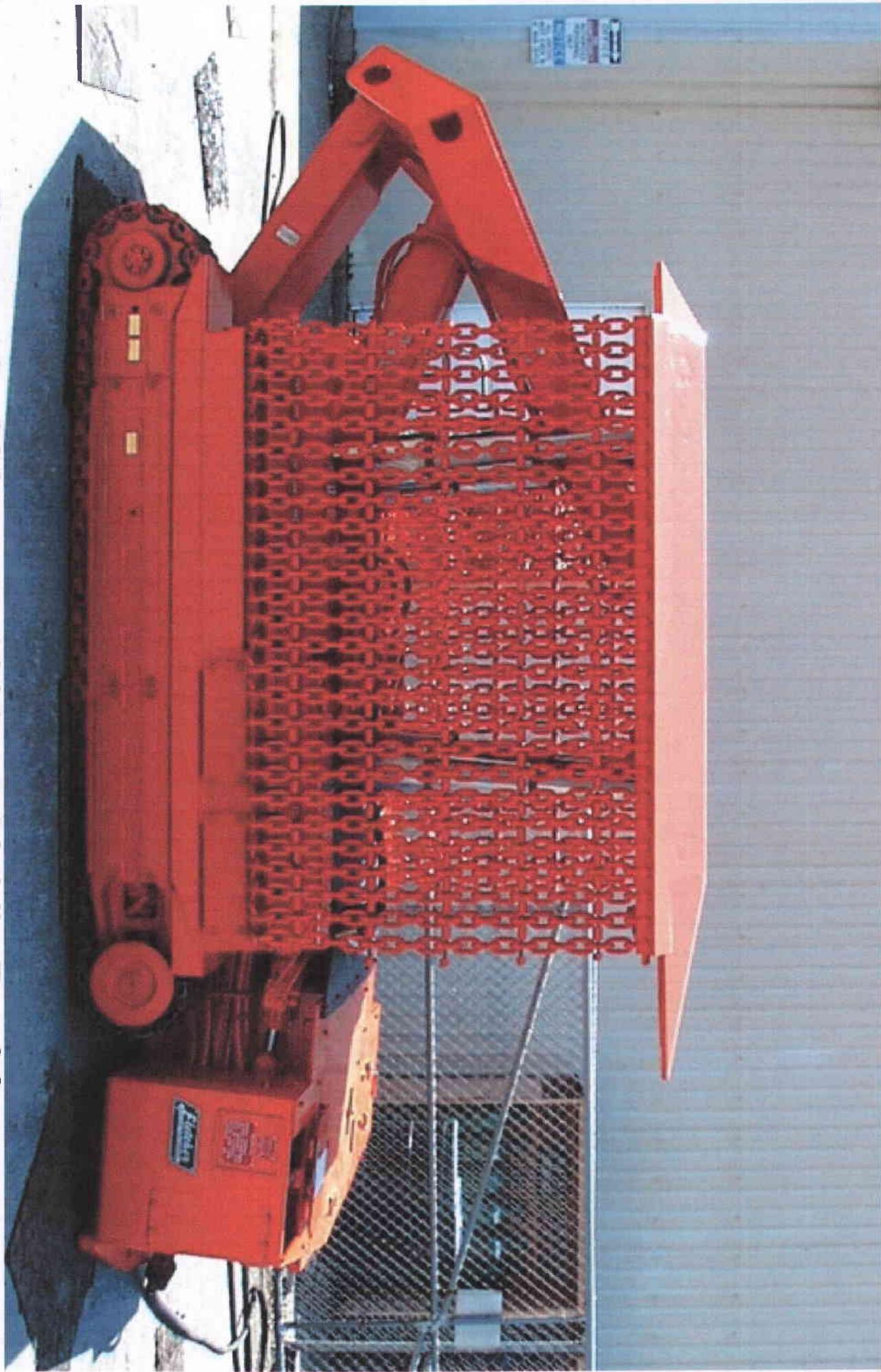




Figure 19: 5.0M Mobile Roof Support

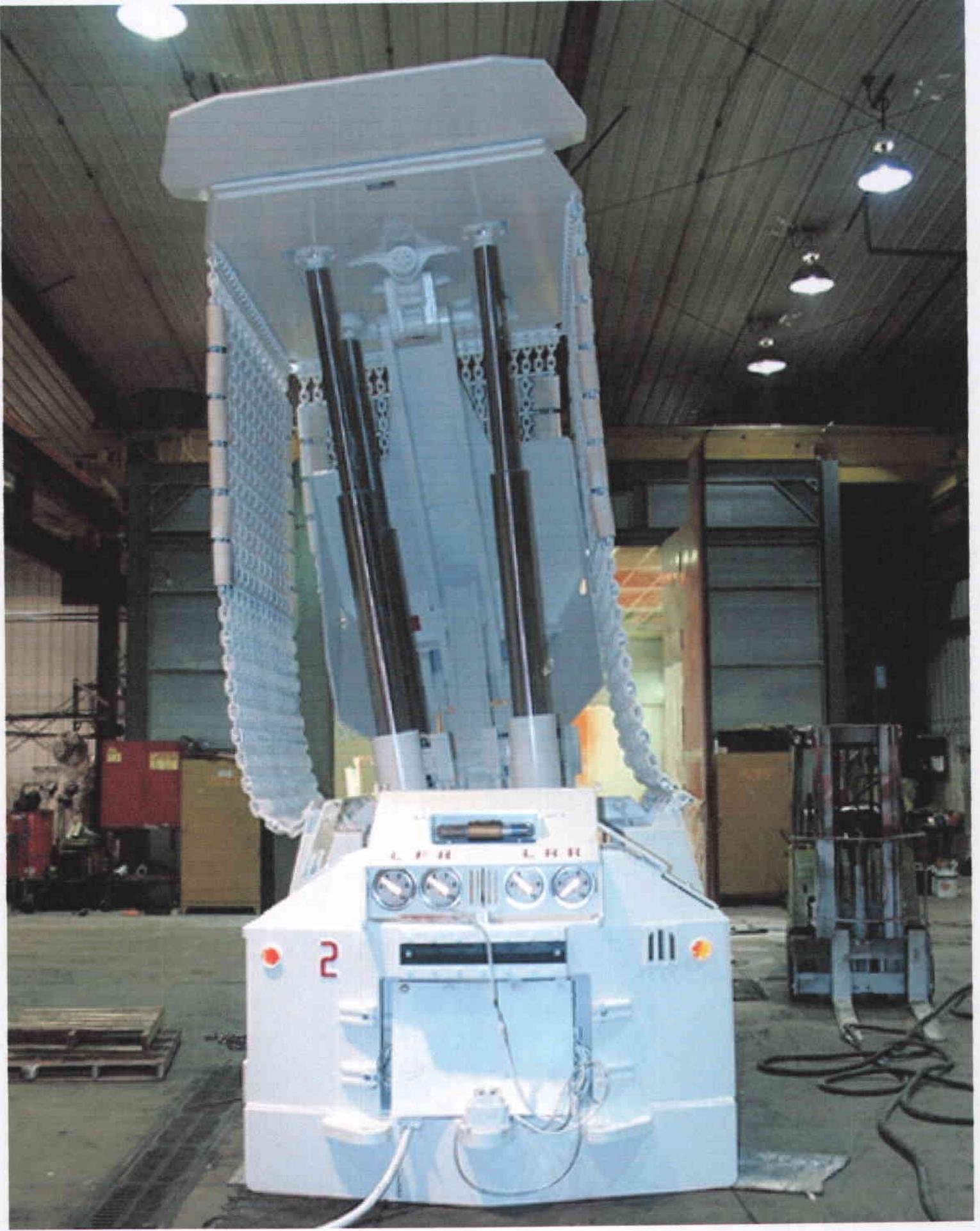


Figure 20: Mobile Roof Support with Tilt Frame

**Figure 2.1: MRS Plowing Through Debris**

