

A Minerals Research contract report  
September 1980

U.S. DEPARTMENT OF LABOR MSHA



00031779

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**CABLE HANDLING  
IN  
SURFACE MINES**

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**BUREAU OF MINES ★ UNITED STATES DEPARTMENT OF THE INTERIOR**  
Minerals Health and Safety Technology

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## REPORT DOCUMENTATION PAGE

1. Report No.	2.	3. Recipient's Accession No.	
4. Title and Subtitle CABLE HANDLING IN SURFACE MINES		5. Report Date September 19, 1980	6.
7. Author(s) R. Marshall, C. Mertian, R. Winkle		8. Performing Organization Report No.	
9. Performing Organization Name and Address Pincock, Allen & Holt, Inc. 4370 S. Fremont Avenue Tucson, Arizona 85714		10. Project/Task/Work Unit No.	
		11. Contract or Grant No. JO395088	
12. Sponsoring Organization Name and Address U. S. Bureau of Mines Pittsburgh/Bruceton Administrative Office Section of Procurement 4800 Forbes Avenue, Pittsburgh, PA 15213		13. Type of Report Task Completion Report	
		14.	
15. Supplementary Notes			
16. Abstract <p>Electrical trailing cable handling techniques and practices used in metal and non-metal surface mines were investigated by obtaining information through actual visits to the mine properties located in a variety of geological areas and climatic conditions.</p> <p>An analysis was made of all accidents related to cable handling which are cataloged by HSAC* for the period from 1978 through June 1980. Information was also collected from mine operators concerning near accidents and non-reported accidents.</p> <p>The results of this investigation were presented to the U.S. Bureau of Mines in an effort to outline recommended practices for cable handling in surface mines and to recommend additions and/or changes in the present regulations now being enforced by MSHA** field inspectors. These recommendations are also intended to assist the U.S. Bureau of Mines in evaluating the need for assisting the mine operators in the areas of training and distribution of information related to material handling of trailing cable.</p> <p>* Health Safety Analysis Center ** Mine Safety &amp; Health Administration</p>			
17. Originator's Key Words		18. Availability Statement	
19. U.S. Security Classif. of the Report	20. U.S. Security Classif. of This Page	21. No. of Pages	22. Price

CABLE HANDLING IN SURFACE MINES

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR  
BUREAU OF MINES

by

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Task Completion Report  
Contract No. J0395088  
Cable Handling in Surface Mines

September 19, 1980

## 1.0 FOREWORD

This report was prepared by Pincock, Allen & Holt, Inc., under USBM Contract Number J0395088. The Contract was initiated under the M/NM/Health and Safety Program. It was administered under the technical direction of the Pittsburg Mining and Safety Research Center with Mr. George J. Conroy acting as Technical Project Officer. Mr. William R. Mundorf was the Contract Administrator for the Bureau of Mines. This report is a summary of the work recently completed as a part of this Contract during the period 19 September 1979 to 19 September 1980. This report was submitted by the authors on 18 September 1980.

## 2.0 ACKNOWLEDGMENTS

The authors would like to express their gratitude and appreciation to the following people who were directly involved with providing guidance and assistance in completing this project:

Mr. George J. Conroy, Technical Representative  
of the Contracting Officer, Bruceton, PA

Mr. James Greenaway, HSAC Liaison Officer,  
Bureau of Mines, Denver, CO

Mr. Merle L. Venters, Chief of the Mine  
Electrical System Branch, MSHA Technical  
Support Center, Denver, CO

All MSHA District Managers for suggesting the  
mines within their jurisdiction suitable for this project.

Special thanks are in order to the many people in the open pit mining industry for answering countless questions and permitting on-site visits to their mines and facilities. A list of all mining companies, cable repair facilities and cable manufacturers who participated in the project can be found in Section 12.0, References, of this report.

TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
1.0	FORWARD . . . . .	3
2.0	LIST OF FIGURES . . . . .	6
3.0	INTRODUCTION. . . . .	7
	General . . . . .	7
	Project Requirements. . . . .	7
	Project Conditions. . . . .	7
4.0	CABLE HANDLING PRACTICES. . . . .	9
	Manual Handling . . . . .	9
	Lifting and Pulling . . . . .	11
	Loading and Unloading . . . . .	11
	Mechanical Reels. . . . .	12
	Hoisting Towers . . . . .	12
	Lockout Procedures. . . . .	12
5.0	HANDLING AND TRANSPORT	16
	Mechanized Equipment. . . . .	16
	Sleds and Boats . . . . .	16
	Dragging by Motorized Vehicle . . . . .	19
6.0	STORAGE . . . . .	20
7.0	PHYSICAL PROTECTION . . . . .	22
	Cable Towers. . . . .	22
	Cable Bridges . . . . .	22
	Cable Crossovers. . . . .	25
	Non-Metal . . . . .	25
	Metal . . . . .	25
	Split Pipes . . . . .	25
	Culvert Pipe and Direct Burying . . . . .	25
	Grounding . . . . .	27
8.0	CABLE REPAIRS . . . . .	28
	Commercial Shops. . . . .	28
	Mine Site Shops . . . . .	28
	Field Repair. . . . .	28
9.0	CABLE MANUFACTURERS . . . . .	29
10.0	CONCLUSIONS . . . . .	30
11.0	RECOMMENDATIONS . . . . .	33

TABLE OF CONTENTS (cont)

<u>Section</u>		<u>Page</u>
12.0	SUMMARY OF RECOMMENDED HANDLING PROCEDURES .	37
13.0	REFERENCES . . . . .	40

APPENDICES

<u>Number</u>	
I	Mine Site Visits Summary of Data
II	Accident Statistics

## 2.0 LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Cable Handling Tools . . . . .	10
2. Cable Reel on Rotary Drill . . . . .	13
3. Suspension Tower with "D" Ring . . . . .	14
4. Cable Reel Truck General Arrangement . . . . .	17
5. Cable Sled . . . . .	18
6. Cable Storage Yard Crane . . . . .	21
7. Cable Tower. . . . .	23
8. Shovel Cable Bridge. . . . .	24
9. Cable Crossing Mat . . . . .	26

### 3.0 INTRODUCTION

#### 3.1 General

Electrical trailing cable, which supplies power to surface mining equipment, is heavy and cumbersome and presents unique handling problems. Aside from material handling, the cable may also present an electrical shock hazard to personnel coming in contact with the cable. The degree of this hazard is directly related to the distribution system design and the proper maintenance of the system components.

Mine operators are becoming more aware of the cable handling problems due to the increased cost of trailing cable, the costly downtime related to cable failure and the high indirect cost resulting from personnel absence due to material handling accidents.

#### 3.2 Project Requirements

The purpose of this research project, as intended by the U. S. Bureau of Mines, is to document all of the hazards associated with the handling of trailing cable in all types of surface mines throughout all geographical areas of the United States. The results are to be evaluated and utilized to determine the nature of the future work to be developed by the Bureau of Mines which would be most effective for assisting mine operators in the reduction of safety hazards. The research project was to result in recommended standards for handling procedures or protection equipment that would be directly applicable without further development work.

#### 3.3 Project Conditions

The project information was collected by an on-site survey of selected mine properties throughout the United States. Preliminary selection of potential mine sites for visitation was made by the MSHA District Managers. Coal and metal/non-metal surface mines were visited.

All visits consisted of interviews with mine operations and maintenance personnel directly involved with the handling and repairing of trailing cable. The interview ranged through several levels from mine managers to laborers in the cable handling crews. When possible, site visits consisted of actual observations of cable handling procedures and electrical distribution equipment.

Various cable manufacturers and cable repair facilities were also visited in order to procure information pertinent for this project.

## 4.0 CABLE HANDLING PRACTICES

### 4.1 Manual Handling

When energized cables are handled manually, insulated hooks or tongs should be used whenever there is any uncertainty about the condition of the cable or the integrity of the electrical protection provided. The best hooks and tongs have fiber glass handles similar to linemen's hot sticks. Wood handles are acceptable if they are varnished or otherwise protected from moisture. Cable tongs should be made to fit the size of cable in use; otherwise, they may slip off causing the person to fall. Figure 1 illustrates the most common types of tongs or hooks.

The use of insulated ropes or slings have one major drawback: the cable must first be lifted to slide the rope or sling under it. If it is lifted barehanded, there may be momentary lack of protection.

Linemen's gloves may provide excellent protection but they have several serious disadvantages.

- 1) They must be kept clean and in a good state of repair (dirt, grease or pinholes negate the protection).
- 2) There is a sanitation problem when they are shared by different persons.
- 3) Persons tend to allow the cable to touch other parts of their body or clothing when holding the cable with gloved hands. In particular, they commonly hoist the cable across their shoulder, chest or hip.
- 4) Linemen's gloves are expensive and should be tested for dielectric strength at least monthly. This testing is also expensive. They should be given a roll test with fine powder before use on each shift. They should be stored in well made boxes in such a way as to keep them clean and protected from damage. (Not lying in the back of a pickup among the dirt and sharp tools, etc.)
- 5) They are hot and uncomfortable when worn in warm climates.

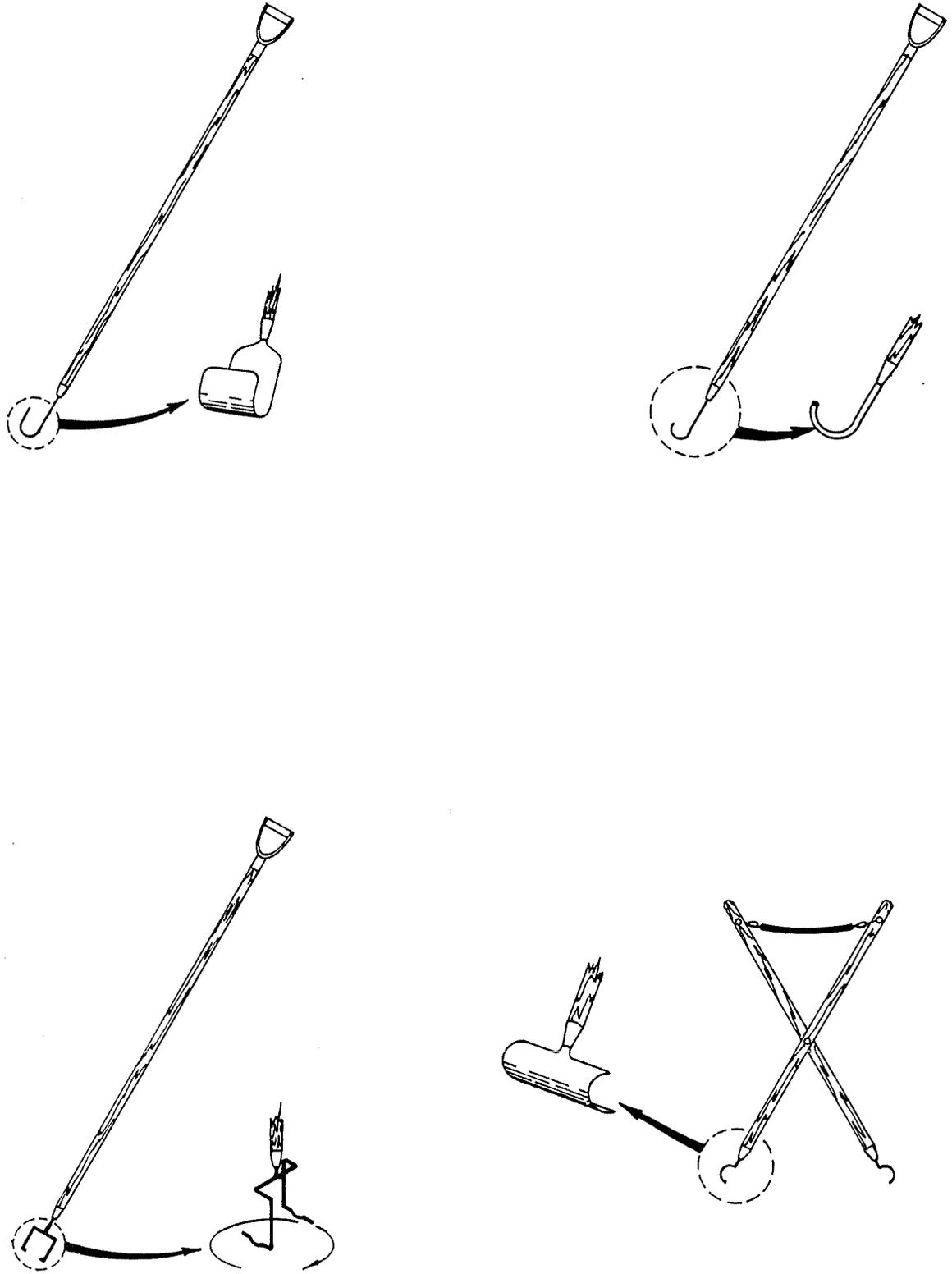


Figure 1: Cable handling tools

The safety of energized cable handling is dependent upon the following conditions:

- 1) high confidence in the electrical protective devices;
- 2) high quality cable construction, including shielded phase conductors and assured ground continuity;
- 3) excellent condition of the cable jacket; and
- 4) high quality splices which assure continuity of all components and excellent bonding of all conductors with the jacket.

#### 4.2 Lifting and Pulling

When lifting or pulling cable by hand, sufficient personnel should be used to divide the load equally to prevent muscle strain. This is one of those obvious precautions which is frequently overlooked. High voltage trailing cable is heavy, stiff and awkward to handle. This, together with the poor footing conditions often found in surface mines, constitutes most of the inherent danger in the handling of trailing cable.

Persons should avoid standing inside a loop of cable when the cable is being pulled taut. All members of the cable handling crew should be alerted to stand outside the loops whenever slack cable is being pulled up.

#### 4.3 Loading and Unloading

When cable is loaded on sleds, truck beds, or piled on the ground, it is usually piled in "figure eights". It can then be pulled straight out without kinking. However, persons should exercise care when pulling cable out of a "figure eight" pile so that they are not struck by a loop of cable which suddenly flips over.

Care should be exercised in loading cable onto truck beds or other high decks. If enough personnel are not used, the cable can flop uncontrollably and strike persons standing on or along side of the deck. Piling too much cable on one load can be dangerous. It may be unsafe for persons to ride on a truckload of cable; judgment has to be used in each case.

#### 4.4 Mechanical Reels

Powered take-up reels as shown in Figure 2 can be attached to the mining equipment to play out cable as the equipment moves forward or take up slack as it retreats. Use of these reels can reduce manual handling of the cable and, thus reduce accidents. These reels are most commonly used on large electric shovels, draglines and blasthole drills. There is a trade-off between cost and accident prevention; however, some mine operators claim a pay out for the reels through savings in cable cost. They claim that use of the reels saves on cable wear sufficiently to pay for the reels in a relatively short period of time.

#### 4.5 Hoisting Towers

Care should be exercised when hoisting cable up on suspension towers. Accidents common to this operation are persons falling, cable falling on persons and muscle strains. Most cable is heavy enough to justify the mounting of a geared hand winch at the base of the tower. The cable is hoisted into place with a small diameter wire rope attached to the winch. A "D" ring or cradle, which retains the minimum radius of the cable, should be lashed to the cable and attached to the wire rope for hoisting. After hoisting, the winch is locked and the wire rope and "D" ring are left in place to support the cable at the top of the suspension tower. This system, shown as Figure 3, alleviates four problems:

- 1) the need for anyone to climb the tower,
- 2) muscle strain from direct pulling,
- 3) sharp radius stress bends in the cable, and
- 4) the accidental dropping of cable during or after hoisting.

#### 4.6 Lockout Procedure

Every mine operation should have a written, step-by-step lockout procedure for the prevention of the coupling or uncoupling of trailing cable while energized. One universal procedure for all mines is impractical. Each should have a procedure designed specifically for its individual set of operating conditions. However, there are certain elements which should be a part of any such lockout procedure.

- 1) There should be a means of assuring that all mining equipment powered by the cable is at rest in a stable position before its feeder cable is either energized or de-energized.



Figure 2: Cable Reel on Rotary Drill

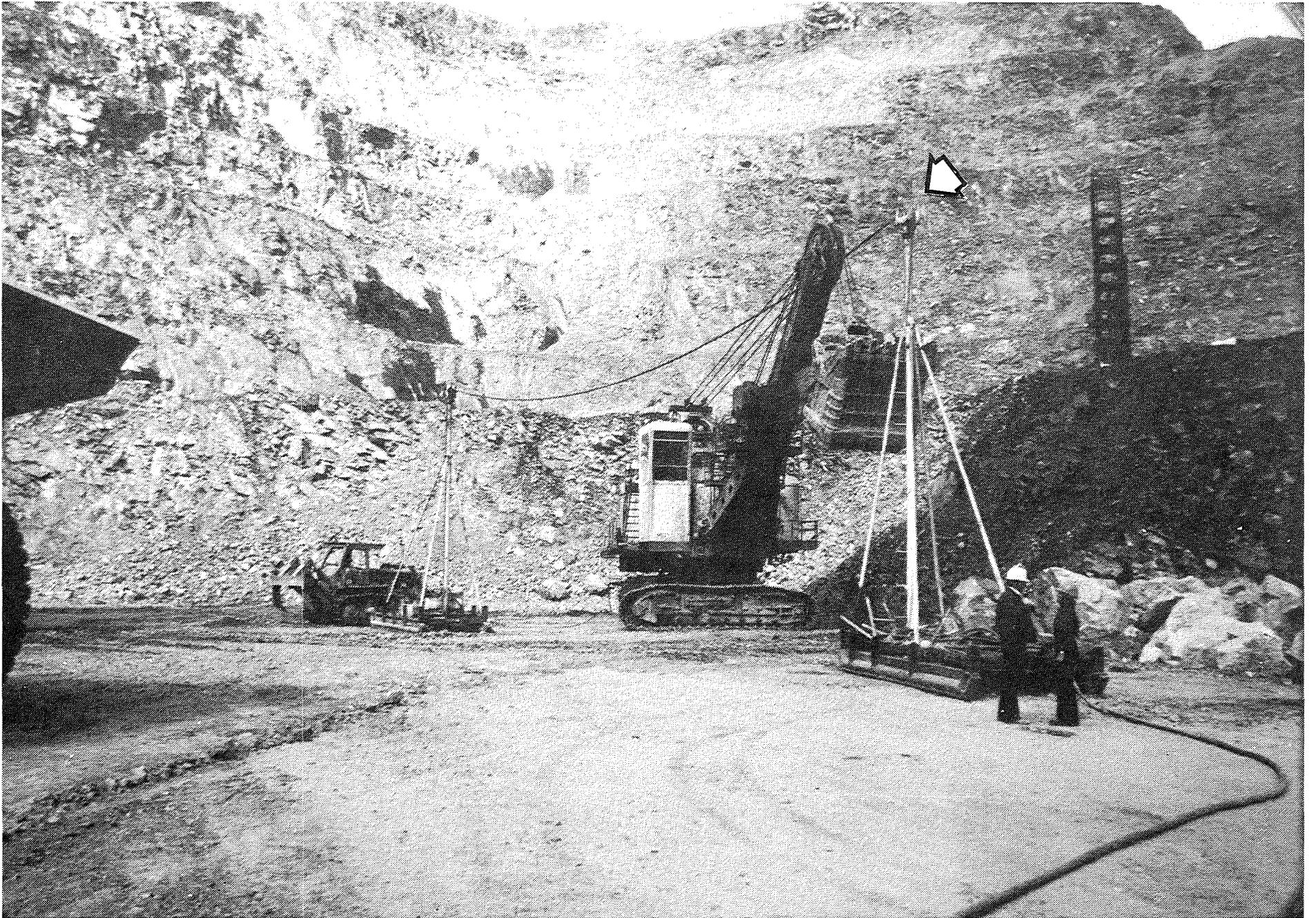


Figure 3: Suspension Tower with "D" Ring

- 2) One responsible person, such as an electrician or operations foreman, should be clearly in charge of the cable change and be the person who opens, locks and tags or guards the circuit switch during the cable change. The operation can be even more secure if every individual who will handle the cable during coupling or uncoupling puts his own lock and tag on the open switch, although this procedure will be cumbersome and may be impractical for some operations.
  
- 3) All concerned equipment operating and cable handling personnel must be clearly informed of the impending "power off" or "power on" condition by the responsible person in charge. In turn, he must receive a clear response indicating their awareness of the status of the circuit switch.

## 5.0 HANDLING AND TRANSPORT

### 5.1 Mechanized Equipment

The pickup and transport of de-energized power cable can be mechanized to a fairly high degree. In general, the more mechanized, the safer the operation. A vehicle mounted take-up reel, shown as Figure 4, can eliminate a great deal of manual handling in gathering up or laying out cable. It can be especially useful in certain difficult locations such as over the sides of a pit wall. Vehicles that are commonly mounted with take-up reels are trucks, wheel loaders (with the reel mounted in place of the bucket) and trailers. The vehicle is usually dedicated for this purpose and may have a powered or manually operated take-up reel and a device for lifting the reel on and off the machine. The best ones take interchangeable reels so the cable can also be stored or run through the repair shops using the same reels. Typical costs for these vehicles are from a few thousand dollars for a simple, trailer-mounted, manually operated reel to over \$100,000 for a self-contained, high capacity, electrically powered reel on a large, sturdy truck. Operations that use only a few lengths of cable at one time may justify the lower cost trailers which can be towed with pickup trucks. Operations which have tens of thousands of feet of cable in use at one time can justify the more expensive units. In both cases, these justifications can usually be made on economic grounds based on the savings in wear and tear of the cable and in the manpower required to handle the cable. The additional safety of handling is a bonus.

### 5.2 Sleds and Boats

A less mechanized system for transporting and storing cables uses skid-mounted boats or sleds, as illustrated in Figure 5. The sleds have the advantage of being good locations in which to store slack cable while it is in or out of use. They also eliminate the cable abuse caused by dragging the cable around on the ground. Their major disadvantages are the additional cable handling required and the fact that the sleds themselves are often hazardous. It is generally safer to pick up cable with a vehicle mounted take-up reel than it is to manually "figure eight" it onto a sled for transport. Manually loading cable onto a truck bed or a sled is one of the most awkward and hazardous operations in cable handling. This is especially true in wet, muddy or icy conditions. It is generally safer for persons, but much harder on the cable, to drag it around on the ground in large loops behind a powered vehicle.

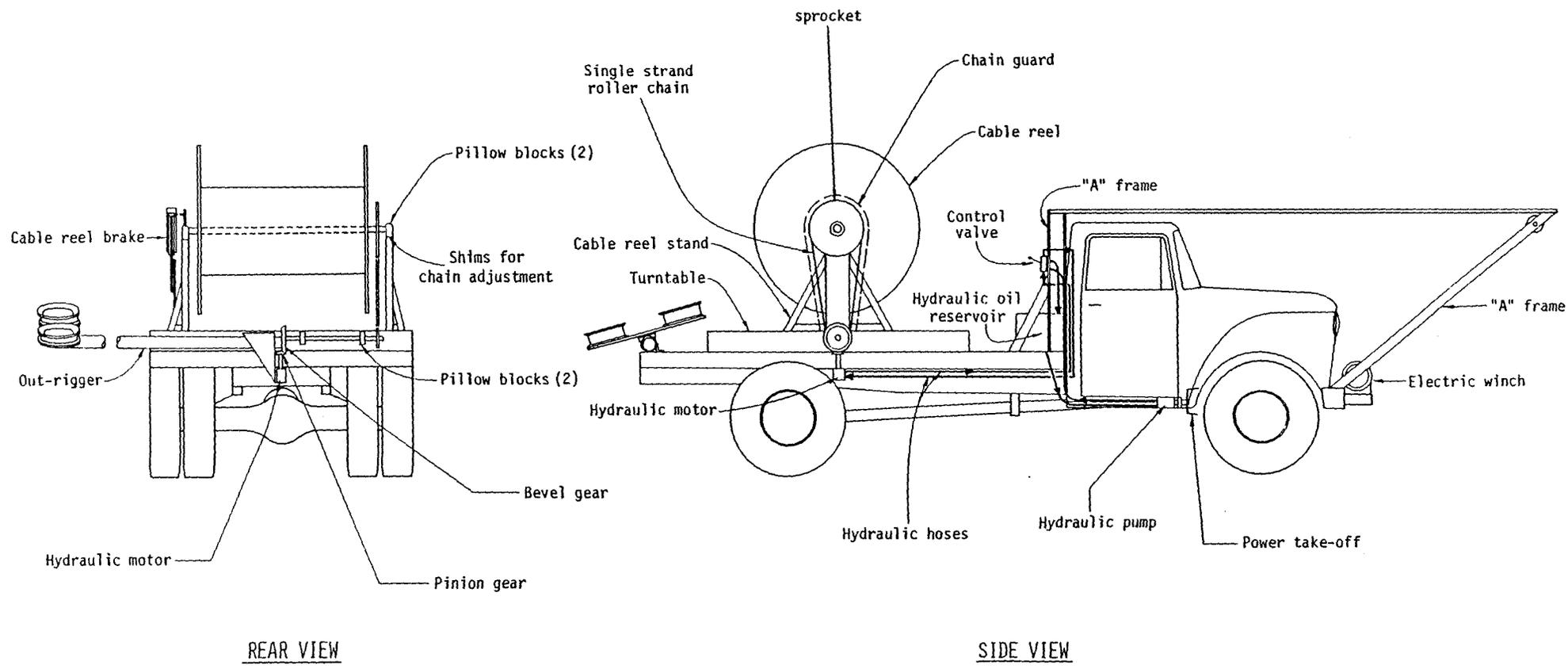
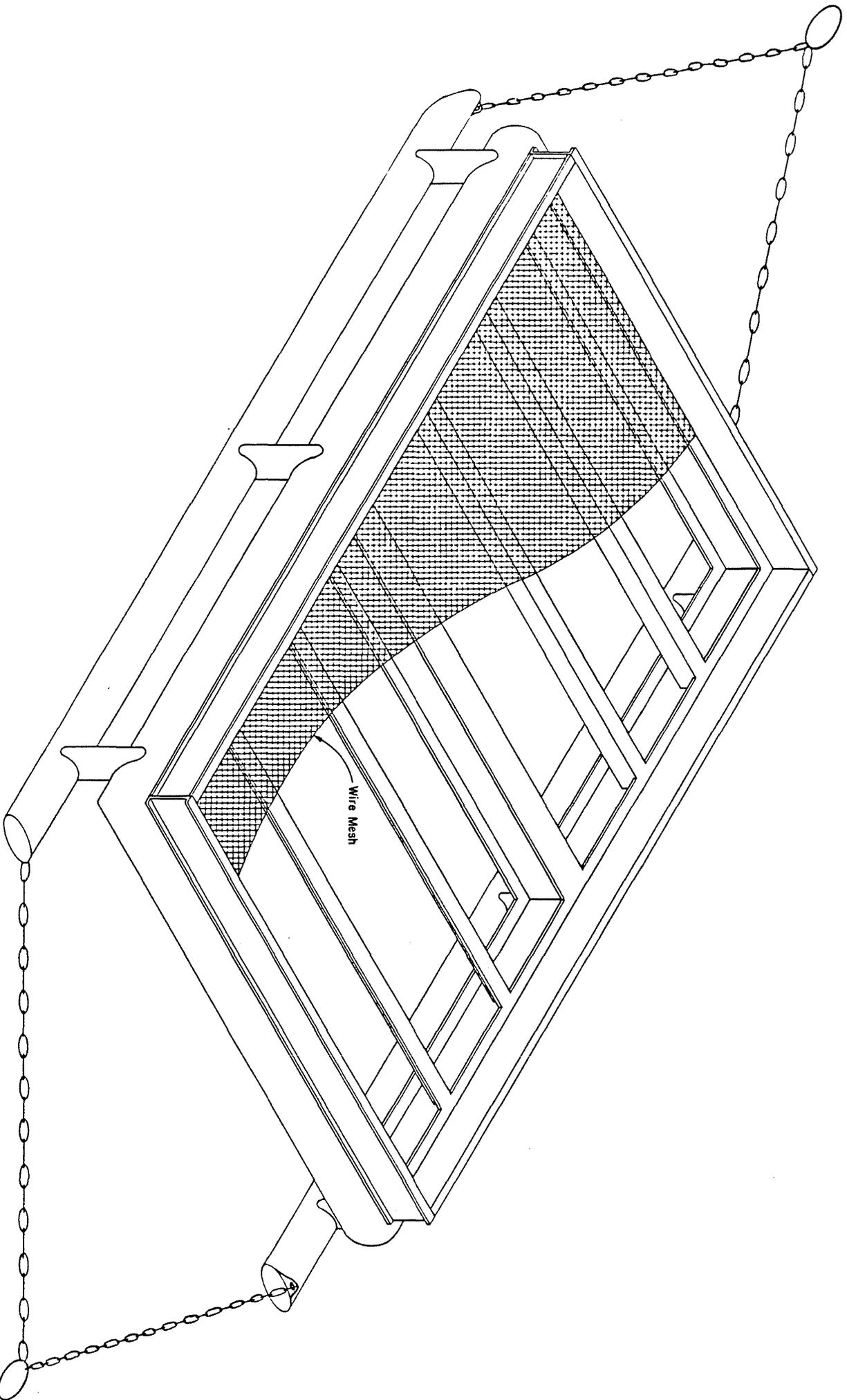


Figure 4: Cable reel truck general arrangement

Figure 5: Cable sled



### 5.3 Dragging by Motorized Vehicle

The least mechanized transport system is the dragging of cable on the ground behind a truck, loader, dozer or other powered vehicles. Although this is generally safer for persons than the use of sleds, it is not as safe as using vehicle mounted take-up reels for pickup and transport. If a long length of cable is to be dragged, abuse of the cable can be reduced by pulling on large radius "D" rings lashed to the heads of the loops of cable. If, for example, three loops are being pulled, a "D" ring should be lashed to the cable at the head of each loop with each of the three "D" rings tied to the pulling vehicle. The end couplers of the cable should be carried in a cradle on the vehicle for special protection. Some operations keep most of their cable in long loops with "D" rings already lashed to the cable at the heads of the loops so they are always ready for pulling.

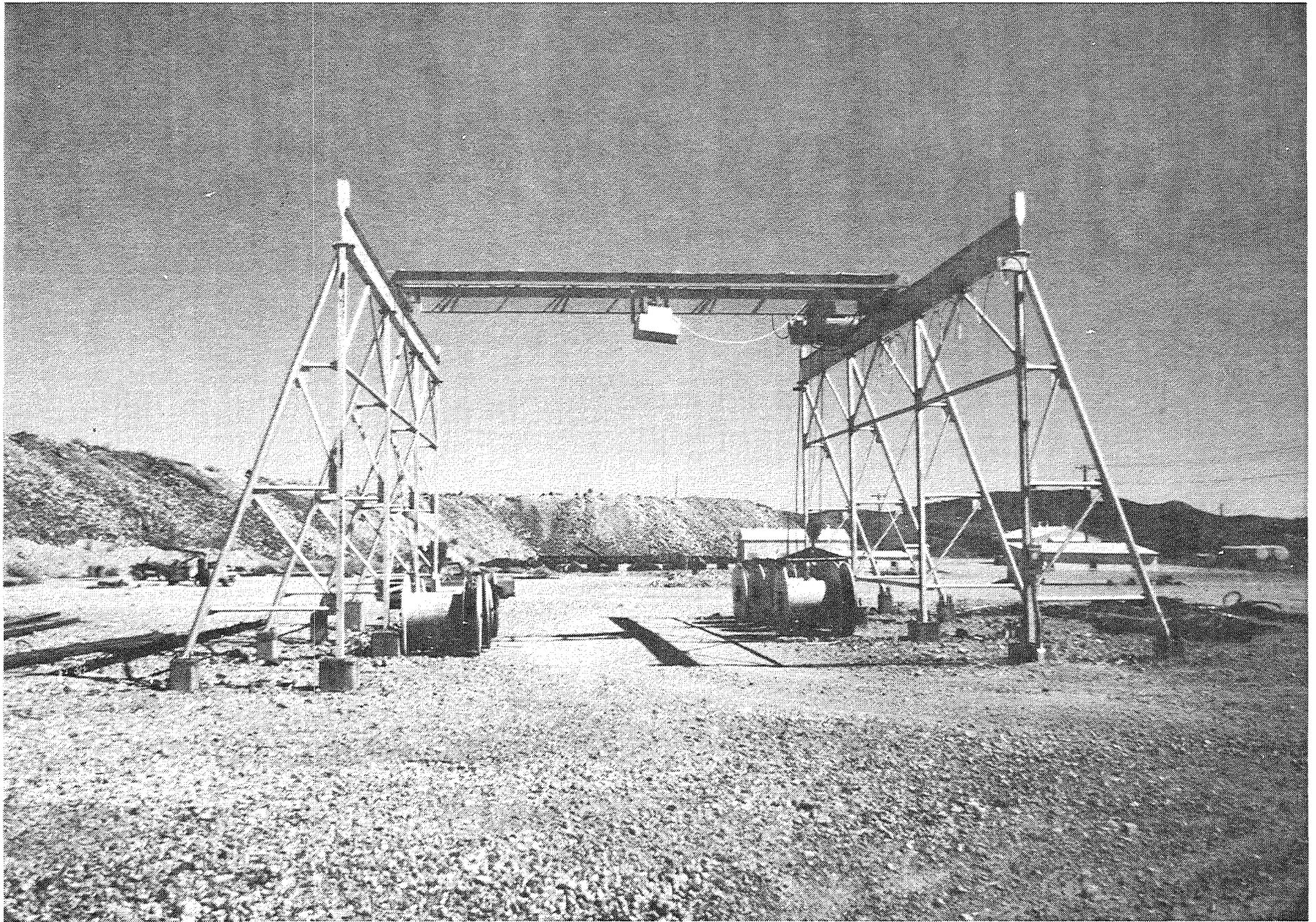


Figure 6: Cable Storage Yard Crane

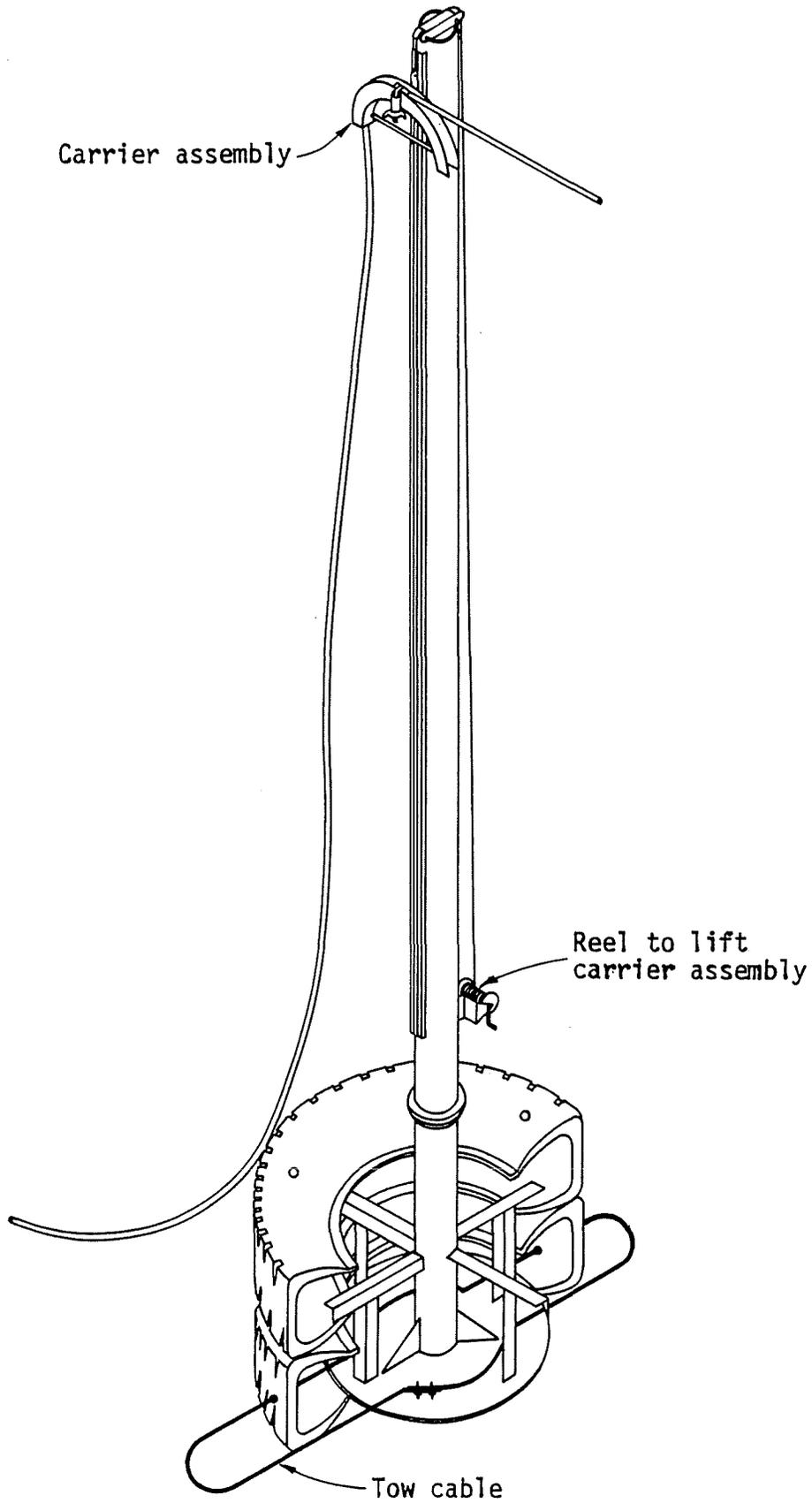


Figure 7: Cable tower

## 6.0 STORAGE

Cable is usually stored at designated yards in the pit, outside the pit, or along side the cable repair shop. It can be, but need not be, stored under roof in most climates.

The most hazardous operation in storing cable is loading it on or off the transporting vehicle. This has already been thoroughly discussed in preceding sections. However, at storage yards that are permanently located, stationary lifting equipment can be installed to load and unload cable reels.

One good system is to have a traveling crane on an overhead rail which encircles the outside of the cable repair shop. It can be arranged so that a reel of B.O. cable can be lifted off the truck and placed on a stand to one side of the shop. The end of the cable can then be pulled through the shop to a powered take-up reel on the other side with cable repairs being made while it is being pulled through the shop. With the crane rail continuous around the shop, the traveling crane can then be brought around to the other side of the shop to lift the repaired cable on this take-up reel (one of the interchangeable reels) onto a truck for transport to a storage yard. This system is ideal in that it eliminates all manhandling, thus reducing accidents from that source. Similar overhead cranes can be set up at the storage yards, as shown in Figure 6. Certain cable reel trucks were fixed with boom hoists which eliminated the need for stationary cranes at the repair shops or storage yards.

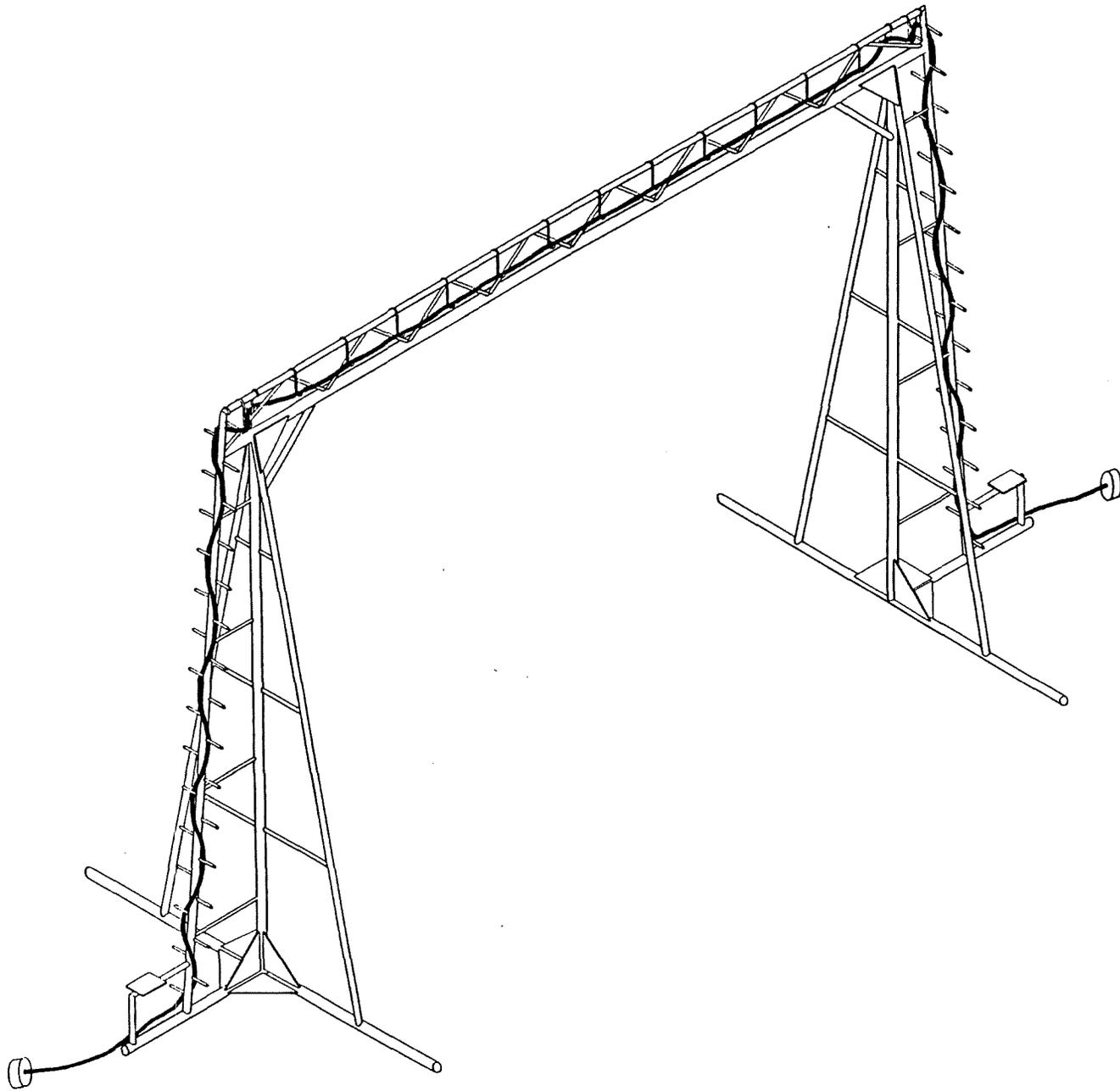


Figure 8: Shovel cable bridge

The material handling of cable when using the tower consists of physically lifting and stringing the cable on the elevated tower. This task is compounded in cold and inclement weather. To solve this problem, mine operators have equipped the tower with a short piece of cable having a coupler attached to each end. Some operators use a mobile crane to lay the tower on its side when replacing the cable.

### 7.3 Cable Crossovers

In the area of service roads where vehicle traffic is less frequent, and of a lighter weight, power cable is generally laid across the roadway and protected by a suitable crossover.

#### Non-Metal, Rubber

The most widely used crossover is basically of rubber construction using a double tapered mat with a recessed groove located in the center of the thickest part of the mat. The cable lays in this recess and is protected from direct contact with the vehicle tires by using a strip insert to cover the cable. This device may be purchased commercially, but may also be built at the mine site by using old conveyor belts and other salvaged materials. The cable crossing mat is illustrated in Figure 9.

#### Metal

This same basic concept of using a rubber mat has resulted in the development of tapered steel crossovers, but due to the weight and handling problems, there are few of these units in service. The unit also has a tendency to bend upwards at the ends after prolonged use.

#### Split Pipes

Split pipes are also used in some specific locations where there is only light traffic with infrequent crossings. They tend to move or roll over when being crossed by a vehicle. In some instances, the pipe was slightly buried in the roadway to prevent movement.

#### Culvert Pipe and Direct Burying

Two methods being used by various mines provide semi-permanent crossovers which consist of burying metal culverts under the roadways or directly burying the power cable in the soil under the roadways. Both methods work well in specific applications and climatic conditions. The cable should be of a type suitable for burial and installed at a minimum depth to assure mechanical protection.

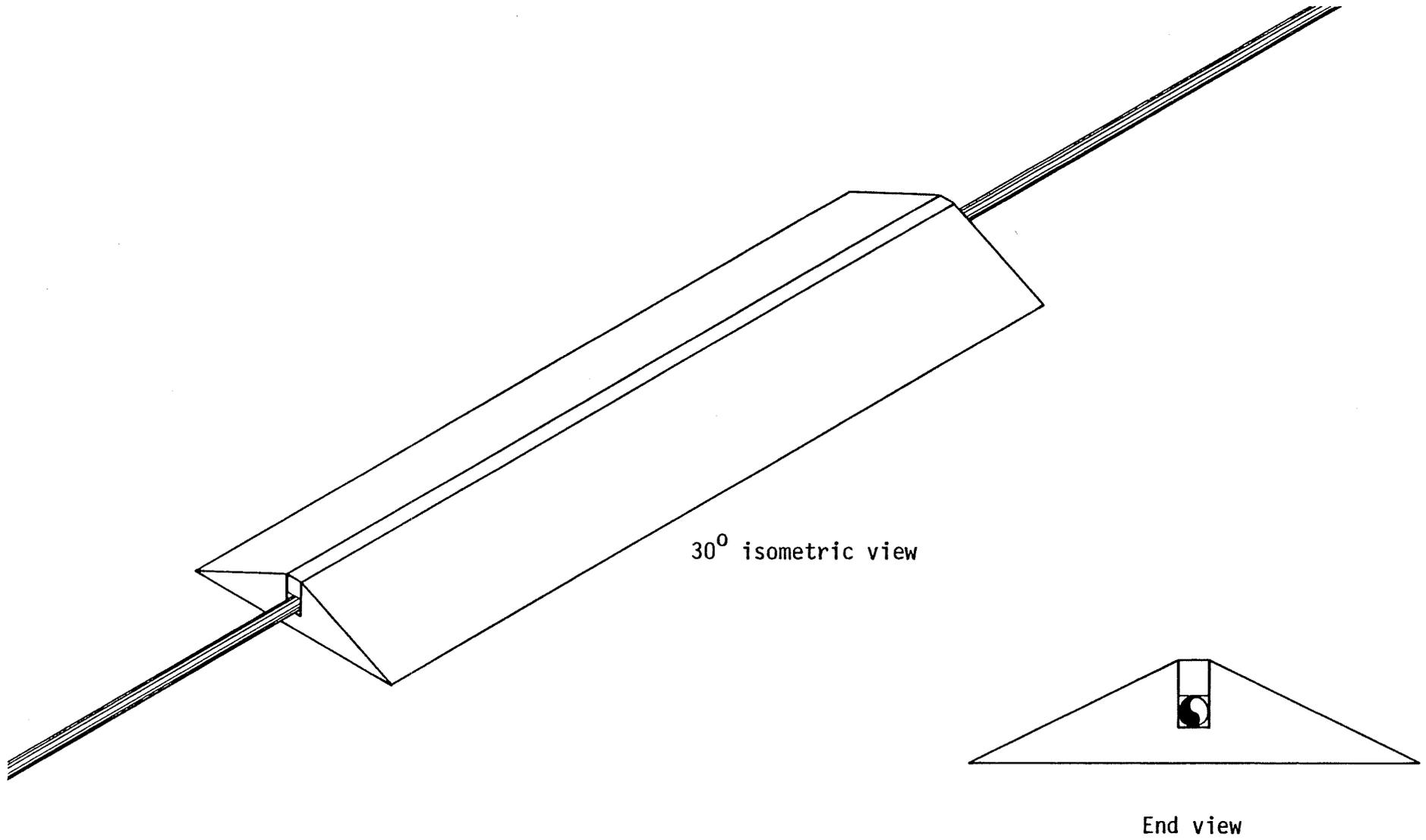


Figure 9: Cable crossing mat

The culverts are large enough to provide for passage of the cable couplers and are placed in such a position so as not to fill up with water. The locations where cable was found to be successfully buried in the soil was in sandy areas and where the soil does not freeze during winter months.

### Grounding

Several incidents were cited where the cable was buried directly in the earth to eliminate the requirement for grounding the culvert. Subsequent removal and re-location of the cable from the frozen earth resulted in its destruction.

## 8.0 CABLE REPAIRS

### 8.1 Commercial Shops

Certain operators in the mining industry utilize commercial cable repair shops exclusively to provide all of their cable repairs and splicing requirements. These shops have established a timely and dependable relationship with the mine operators and function to pick up, repair and deliver cable to the mine site on a moment's notice from the mine operator. This style of repair service eliminates expenditures for the equipment and personnel required strictly for the purpose of cable repairs.

The general success of this style of cable repair depends on the proximity of the repair shop to a group of mines located within a given area. The cost of transporting cable and the turn-around time become the most important factors when considering the economics of this style of cable repairs.

The majority of the cable repairs are made using vulcanized splices with a few minor repairs being made with custom repair kits.

### 8.2 Mine Site Shops

The vast majority of all cable repairs and splices are performed at the mine sites using personnel specifically trained for this purpose. Larger mines utilize sophisticated shops with mechanized cable handling equipment which provides a means of repairing and inspecting the entire length of cable without manual handling.

Vulcanizing remains the most widely used method of cable repair. Most shops have devised splicing tables and splicing techniques which prepare a splice equal to the sizes and configuration of the original cable. The splicing techniques observed were generally of high quality with special emphasis on continuity and grounding of cable shield with restoration of the conductor insulation to the original cable specifications. In general, mine operators feel that the vulcanized splice is more flexible and performs much better than custom kits, especially so in cold climates.

### 8.3 Field Repair

Custom repair kits are becoming more prevalent throughout the mining industry. With the development of new materials, splice kits can be readily used for quick infield splices and repairs. Many of the operators use these kits for temporary repairs until the cable can be taken out of service and removed to the shop for a permanent vulcanized splice. The degree of splice integrity and appearance depends on the proficiency of the personnel utilizing the kit. Most complaints from MSHA field inspectors have been the result of a poorly made custom kit splice.

## 9.0 CABLE MANUFACTURERS

Visits were made to various major mine trail cable manufacturing plants for the purpose of discussing cable developments, testing and general cable construction. All of the manufacturers visited were actively engaged in research for new materials, new methods, and evaluating destructive testing of their mine power cable. It was generally stated that in the foreseeable future there will probably not be any great breakthrough as to changes in the present power cable construction.

The majority of all mine power cable presently being purchased by the surface mining industry is of the SHD-GC type. This cable is constructed using individually shielded phase conductors, ground conductors and a ground check conductor.

Most mine operators expressed dissatisfaction with the durability of the ground check conductor. Contrary to the mine operators' opinions, through destructive testing and analyzing of cable failure in the field, the manufacturers have determined that the ground check conductor is the most durable conductor in the cable bundle.

The major comments made by mine operators pertaining to cable development are presented in descending order:

- 1) Improve the flexibility of the cable without sacrifice to abrasive resistance.
- 2) Improve shielding of conductors so as to assure reliability for handling bare-handed.
- 3) Improve ground check wire insulation for flexibility and ease of splicing.
- 4) Improve jacket/conductor layer separation for ease of stripping and splicing.
- 5) Improve jacket and insulation design resulting in weight reduction for ease of handling.

- c) Field inspectors for MSHA, in a few instances, are interpreting regulations in such a way as to require additional unnecessary protection; i.e., insulation of the already insulated, shielded and jacketed trailing cable from metal objects such as support towers, sleds, vehicles, etc.
- 5) Several mines have long practiced the handling of energized cable barehanded and have had no electrical shock injuries from trailing cable. Many other mines have been lax in their enforcement of the use of personal protection for the handling of energized cable. Many mines who use linemen's gloves in handling energized cable do not adequately care for or inspect the gloves. Even so, as stated before, surface mines have an extremely low incidence of electrical shocks from handling trailing cable. Therefore, any regulations for personal protection apparatus for the handling of energized cable should be advisory and not mandatory. The use of linemen's gloves should not be considered the best of these methods.
- 6) Regulations 55.12-39 and 56.12-39, which require that surplus trailing cables connected to machines should be stored in cable boats or on reels, should be revised. Trailing cable which is stored on boats or sleds raises the same handling problems as when stored out of the way on the ground. Slack or moving cable is present in both cases. The option to use or not use boats or sleds should remain with the individual operators. Properly trained personnel being alert to the dangers of moving cable is the key safety factor in this area.
- 7) There is extensive confusion throughout the mining industry with regard as to what constitutes "electrical work" as stated in Regulation 77.501. Certain MSHA field inspectors contend that operating mine substation circuit breakers, withdrawing cable couplers, moving energized cables, etc., are considered electrical work. This regulation should be revised to clarify its intent or it should be eliminated.
- 8) It is felt that the low incidence of electrical shocks from trailing cable in all surface mines is due, in part, to the prevalence of shielded cable and resistance-grounded systems. These two factors should be strongly considered in promulgating future regulations for all surface mines.

- 9) Incidents or accidents which were reported involving electrical shock from trailing cable have commonly been the result of a poorly designed or poorly enforced lockout procedure. In most cases, there existed a lack of communications between the involved personnel or the lack of a responsible individual to coordinate the planned electrical changes.

Two fatal accidents involving electrical shock which are listed in the "Accident Summary" were the result of contacting an energized circuit, one being an overhead powerline and the other in a mine knife switchhouse. Although neither accident was related to cable handling, both accidents would have been avoided by following established lockout procedures.

## 11.0 RECOMMENDATIONS

As with the limited number of conclusions drawn from this study because of the similarity of operator practice and resultant accident types, recommendations have been limited and are listed below.

- 1) The U.S. Bureau of Mines should encourage surface mines to increase the mechanization in the handling of trailing cable. This is the surest and most direct way to reduce accidents associated with this work. The Bureau of Mines could provide this encouragement by publishing a collection of general specifications, including drawings or photographs, of mechanized equipment such as powered take-up reels, reel trucks and trailers, reel lifting and loading equipment, cable handling apparatus for repair shops, cable sleds, vehicular cable pulling apparatus, hooks and tongs, support towers, etc. Many variations of this equipment are currently in use in surface mines around the country. Many are available commercially, but most are home-built, one-of-a-kind models. It is believed most mines would do well to share specifications on their home-built equipment with others. For the most part, this equipment is mechanically simple, although ingenious in concept, and the home-builts would not be considered highly proprietary by most mining companies. For some equipment, the Bureau of Mines could incorporate their own design.
- 2) The Bureau of Mines should publish a training manual and/or film on the correct cable handling techniques to prevent muscle strains and sprains, slips and falls, and being struck-by type of accidents. These are by far the most prevalent type accidents associated with cable handling work.
- 3) The following Title 30 regulations should be eliminated:
  - a) 55.12-39
  - b) 56.12-39

There is no basis to assume that cable paying out from a boat is safer than payout from an orderly pile on the ground. The hazard of slack and moving cable is the same.

  - c) 77.803, 803-1, 803-2
  - d) 77.805 (a) (4)

## e) 77.902, 902-1, 902-2

There were no recorded accidents in metal/non-metal mines which can be attributed to the absence of ground continuity circuits; therefore, the coal industry working with identical equipment and conditions are burdened by the extra regulation.

## 4) The following Title 30 regulations should be revised or added as shown:

- 77.804 (revised to read as follows)

55.12-72 (added as a mandatory regulation)

56.12-72 (added as a mandatory regulation)

(a) High voltage trailing cable shall be equipped with metallic shields around each power conductor. There shall be one or more continuous ground conductors have a combined cross sectional area of at least one-half that of the power conductor.

(b) All such high voltage trailing cable shall be adequate for the intended current and voltage. Splices made in such cables shall provide continuity of all components.

## - 77.606 (revised to be a non-mandatory regulation)

56.12-14 (revised to be a non-mandatory regulation)

55.12-14 (revised to be a non-mandatory regulation)

(a) When energized high voltage trailing cables are handled manually, insulated hooks, tongs, ropes, or sling should be used unless suitable protection for persons is provided by other no-less-effective means. The cable should be held so as not to contact parts of the body or clothing not so protected.

(b) Linemen's gloves should not be considered suitable protection unless rigorously inspected for cleanliness and physical condition before each use. They should be tested and certified for dielectric strength at least monthly. When not in use, gloves should be stored in such a manner as to keep them clean and protected from damage.

- 77.607 (added as a new mandatory regulation)
  - 56.12-73 (added as a new mandatory regulation)
  - 55.12-73 (added as a new mandatory regulation)

When a high voltage trailing cable is in use, its ground conductors shall be solidly connected to the grounding conductor of a resistance-grounded system, extended to a low resistance-ground field.

- 77.608 (added as a new mandatory regulation)
  - 56.12-74 (added as a new mandatory regulation)
  - 55.12-74 (added as a new mandatory regulation)

Immediately after the repair or coupling of any part of a string of high voltage trailing cables, the string shall be tested for continuity of the ground conductors throughout its entire length from its connection at its supply terminal to the equipment frame at its load terminal.

- 77.609 (added as a new mandatory regulation)
  - 56.12-7 (revised to read as follows)
  - 55.12-7 (revised to read as follows)

- (a) The terminal or coupling connections of a trailing cable shall not be made or broken under load.
- (b) Before such connections are made or broken, one responsible person, who is trained in the safe operation of the switchgear, shall first insure that all equipment powered by the cable is at rest in a safe and stable position before the cable is de-energized. The responsible person shall then insure that the switch controlling that cable is open and the cable is de-energized before any connection is made or broken and remains de-energized until the completed cable string is tested for ground continuity as per Regulation 55.12-74.

- (c) As a minimum precaution, the responsible person shall either guard or lock and tag the open switch. This does not preclude the use of multiple lock and tag procedures.
  - (d) Whatever procedure is devised to accomplish this purpose shall be standardized and written in detail for the purpose of indoctrinating each participant in the proposed procedure.
- 77.501 (revised adding section (b) to read as follows)
- (b) Exceptions: Examples of duties that are not considered to be "electrical work" and would not be required to be performed by a "qualified person" or under the direct supervision of a "qualified person" are the following: operation of electrical equipment; transportation of equipment and cables; operation of control switches, circuit breakers, or switchboxes, provided that no energized parts are exposed; changing cutting bits; lubrication work; moving of energized trailing cables; or inserting or withdrawing proper couplers into or from their receptacles. These tasks are considered to be part of the normal routine operation of electrical equipment; therefore, are not considered to be "electrical work."

## 12.0 SUMMARY OF RECOMMENDED CABLE HANDLING PROCEDURES

Electrical trailing cable used to supply power for surface mining equipment presents unique handling problems for mine operators. The material handling encompasses two distinct areas requiring specific techniques depending on whether the cable is in an energized or de-energized state. When the cable is energized, additional precautions beyond material handling techniques should be observed to minimize the electrical shock hazard for handling personnel. In actual practice, it was determined that the incidence of shock accidents when handling trailing cable are minimal. Therefore, efforts to reduce injuries should emphasize the materials-handling type techniques rather than additional electrical protection.

In the area of material handling, there exists a high potential for injury of handling personnel. The inherent nature of handling heavy and cumbersome trail cable in adverse weather conditions readily promotes an accident prone environment conducive to strain and sprain injuries resulting from slipping or lifting while in the act of moving cable. The accident patterns naturally do vary because of the diversity and variety of climatic conditions associated with surface mining, but in general, all serious accidents were muscle strain while pulling, sprains from falling and contusions or bruises from being struck by the cable or associated hardware.

Obviously, in view of the accident statistics, it would appear that if a mine operator would eliminate manual handling of trail cable by using mechanized equipment with reels, etc., the handling problems would cease to exist. While this idea is not entirely feasible, the fact remains that the extent of mechanical equipment available for cable handling has a direct bearing on the accident frequency related to cable handling. The degree of mechanized equipment also relates directly to the number of cable failures caused by wear and tear from dragging over rough work areas. The size and resulting costs of cable handling crews are also drastically reduced by using mechanized equipment.

Mine operators should become more aware of cable handling problems and the associated high costs of cable repairs and replacements, equipment downtime due to cable failure, and indirect costs from personnel absence due to cable handling accidents. In view of these factors, re-assessment of the cable handling techniques should be made to determine the affordability of mechanical equipment based

on the amount of cable in service and the relative success of the existing cable handling procedures.

Not all cable handling problems can be solved with mechanical methods, nor can all manual handling be eliminated, so therefore, it is also important to develop proper handling procedures both from an electrical and materials handling viewpoint.

Increased personnel safety and cable life can be realized by practicing acceptable cable handling procedures.

### Recommended Procedures - Cable Handling

#### Training

- 1) Cable handling personnel should be systematically trained in cable handling techniques with frequent re-training in the proper way to lift, pull or load cable using proper tools, equipment and methods as developed by the mine operator.

The training should be comparable to other safety training used for accident prevention. Very few operators presently place any special emphasis on training cable handling personnel.

- 2) Cable handling personnel and other personnel responsible for making changes in the trail cable system should be thoroughly trained in the use of a safe and dependable lockout procedure. Enforcement of the prescribed procedure should be mandatory.

The few incidents, whether officially reported or not, involving the possibility of electrical shock were the result of a poorly conceived or improperly enforced lockout procedure in effect when making or breaking a cable connection.

#### Preventive Cable Damage

- 3) Develop a system to mark the presence of cable along roadways and in pit areas so as to prevent physical damage by mine equipment vehicular traffic. This is especially necessary in locations where mud, snow and ice may obscure cable from view.
- 4) Provide suitable cable crossovers to prevent damage from mobile equipment. In the areas of heavy traffic, cable bridges or cable towers should be used to elevate the cable above the roadways. In areas of light traffic, cable crossovers may be used when they provide sufficient protection and are properly aligned to prevent

direct cable contact with the vehicle tires. Burying the cable in light soil at a proper depth is also acceptable in mild climates.

- 5) The dragging of cable over rough terrain and for extended distances should be avoided. Dragging causes excess wear to the jacket, rock cuts and possible kinks in the cable. Cable should be loaded on sleds, skids, reels, etc., for transport.
- 6) Cable should be supported, suspended, and pulled using a device having sufficient radius to prevent internal damage to the conductors and shielding. At most mine sites, cable damage is prevalent due to handling cable with nylon rope or small radius equipment.
- 7) When cable is attached to switchhouse or machines, it should be supported by a device which will prevent strain on the coupling and will not in itself damage the cable. Rope or wire cable, used as support, should be avoided as it will provide a short radius and cut into the trail cable.

#### Manual Handling

- 8) The use of linemen's gloves should not be considered the most suitable method of protection for handling cable. At most mine sites, the physical care and poor condition of the gloves would not meet a minimum safe standard. Personnel using the gloves also tend to place the cable across their body negating any protection offered by the usage of gloves.
- 9) Cable tools used for cable handling should be kept clean and in a good state of repair in order to provide personnel protection. The shape of the tool should be such that the cable cannot slip out when the cable is being pulled. The handle should also be insulative to provide shock protection.

## 13.0 REFERENCES

The below list identifies the mining companies, cable repair facilities and cable manufacturers who participated in this cable handling study.

Agrico Chemical Co.  
Aloe Coal Co.  
Amax Coal Co.  
Anaconda Wire & Cable Division  
Anamax Mining Co.  
Anixter Bros., Inc.  
Asarco Inc.  
Atlantic Cement  
Bluestone Coal Co.  
C & K Coal Co.  
Carbon Coal Co.  
Carter Mining Co.  
Cities Service Co.  
Cyprus Bagdad Copper Co.  
Cyprus Pima Mining Co.  
Duval (Sierrita)  
E. R. Jahna  
Essex Power Conductor Division  
Hatfield Wire & Cable  
Hibbing Taconite Co.  
Inland Steel Co.  
Inspiration Consolidated Copper Co.  
International Mineral & Chemical Co.  
K & J Coal Co.  
Kaiser Steel Corp.  
Kennecott Minerals Corp.  
Kerr-McGee Coal Co.  
Marquette Cement  
Midway Coal Co.  
Molycorp, Inc.  
New York Trap Rock Corp.  
Northern Coal Co.  
Pennweir Construction Co.  
Perry Brothers Coal Co.  
Phelps Dodge Corp.  
Rebel Coal Co.  
Reserve Mining Co.  
Silver Sand Co.  
Sunedco Coal Co.  
The Okonite Co.  
The Pittsburg & Midway Coal Mining Co.  
U. S. Steel Corp.  
Utah International  
Vermont Asbestos Group, Inc.  
Western Coal Co.

APPENDIX I

## Mine Site Visits

Summary of Data

	<u>Coal</u>	<u>Metal &amp; Non-Metal</u>	<u>Sand &amp; Gravel</u>
1.0 TOTAL MINES SURVEYED	19	29	2
2.0 TRAILING CABLE TYPE			
2.1 Type G		1	
2.2 SHD-G		3	1
2.3 SHD-GC	19	27	1
2.4 External Pilot Wire	1		
3.0 OPERATING VOLTAGE (APPROX.)			
3.1 2400		1	2
3.2 4160V	10	26	
3.3 5500V		1	
3.4 7200V	12	3	
3.5 22900V	1		
4.0 CABLE HANDLING, ENERGIZED			
4.1 Powered Take-Up Reel on Equipment	6	5	
4.2 Linemen's Gloves	19	19	
4.3 Insulated Tongs, Hooks	13	22	
4.4 Rope Slings	15	12	
4.5 Barehanded		4	
4.6 Other		2	
5.0 CABLE HANDLING, DE-ENERGIZED			
5.1 Self-Propelled, Powered Reel Trucks	8	17	
5.2 Reel Trailers & Carts	2	3	
5.3 Sleds, Skids, Boats	7	16	
5.4 Other	4	4	2
6.0 PROCEDURE FOR CABLE REPLACEMENT			
6.1 Responsible Person, Minimum Level			
6.11 Electrical Foreman	4	8	
6.12 Qualified Electrician	12	6	
6.13 Operations Foreman	2	15	1
6.14 Other	1		1

	<u>Coal</u>	<u>Metal &amp; Non-Metal</u>	<u>Sand &amp; Gravel</u>
6.2 Protection for Persons Handling Cable			
6.21 Open CB Guarded By Responsible Person		2	
6.22 Single Lock on Open CB	19	22	2
6.23 Single Tag on Open CB	6	10	
6.24 Multiple Lock on Open CB		2	
6.25 Multiple Tag on Open CB		1	
7.0 CONSTRUCTION OF SWITCH CABINET			
7.1 Insulated Mat or Grounded Platform at Switch Location	10	13	1
8.0 PHYSICAL PROTECTION OF CABLE			
8.1 Cable Towers	11	17	
8.2 Cable Bridges	3	5	
8.3 Vehicle Crossovers			
8.31 Metal	1	3	
8.32 Non-Metal	9	13	
8.33 Split Pipe	6		
8.34 Culvert Pipe	6	7	
8.35 Buried	2	8	
8.36 Other	1		1
9.0 CABLE STRAIN PROTECTION			
9.1 Insulated Clamps	9	9	2
9.2 Non-Insulated Clamps	3	13	1
9.3 Kelms Grips	14	12	
9.4 Rope	11	10	
9.5 Raychem Grips	1	5	2
9.6 Other	4	3	

	<u>Coal</u>	<u>Metal &amp; Non-Metal</u>	<u>Sand &amp; Gravel</u>
10.0 ELECTRICAL PROTECTION FOR CABLE			
10.1 Overload/Short Circuit			
10.11 Fuses	17	27	2
10.12 Overcurrent Relays	19	29	2
10.13 Auto Circuit Breaker	19	29	2
10.2 Ground System			
10.21 Type			
10.211 Solid		4	
10.212 Resis- tance	19	25	2
10.31 Protection			
10.311 Relays	19	29	2
10.41 Ground System Connections			
10.411 Cable Bridges	2	2	
10.412 Cable Towers	1		
10.413 Cable Couplers	10	11	
10.414 Cable Junction Boxes	11	10	
10.415 Equipment Frame	19	29	2
10.51 Ground Contin- uity Check Sys- tem <u>In Use</u>			
10.511 Pilot Wire Loop	19	10	

	<u>Coal</u>	<u>Metal &amp; Non-Metal</u>	<u>Sand &amp; Gravel</u>
11.0 CABLE REPAIRS			
11.1 Repairs by Commercial Shop	7	5	2
11.2 Repairs Made on Site	16	29	
11.3 Types of Repairs			
11.31 Vulcanized	11	15	1
11.32 Custom Repair Kits	12	25	1
12.0 PERIODIC INSPECTIONS WITH RECORDS			
12.1 Linemen's Gloves, Dielectric Strength			
12.11 At Least Monthly	13	1	
12.12 Greater Than Monthly Intervals	3	3	
12.2 All Electrical Protection Devices			
12.21 At Least Monthly	18	2	
12.22 Greater Than Monthly Intervals	1	16	1
13.0 CABLE FAILURES, MAJOR CAUSES			
13.1 Run Over by Mobile Equipment	10	22	1
13.2 Abused in Transport	4	16	1
13.3 Rock Cuts	10	11	
13.4 Other		1	

APPENDIX II

EXHIBIT A

Summary of Accidents, Coal - Open Pit - 1978

1. North Dakota 280330133 1/78 - Fracture thumb - tripped on coiled cable
2. Texas 280550162 2/78 - Sprain shoulder - pulling cable and hit by pipe
3. Missouri 280860093 2/78 - Strain back - lifting a cable splice
4. Indiana 281210152 4/78 - Bruise hand - cable hook broke striking hand
5. Indiana 281320033 4/78 - Hernia - lifting cable over rock
6. Illinois 281350019 4/78 - Strain stomach - pulling cable
7. Kansas 281250116 4/78 - Fractured ankle - struck by moving cable
8. Kentucky 281280147 4/78 - Fractured leg - struck by slack power cable
9. Colorado 281360032 5/78 - Strained back - moving dragline power cable
10. Missouri 281450074 5/78 - Strained back - bent over to pick up cable
11. Alabama 281460104 5/78 - Fractured ankle - caught in slack cable
12. Illinois 281530033 5/78 - Laceration hand - pulling cable with farm tractor & caught hand in hitch
13. Illinois 281590060 5/78 - Sprained ankle - stepped on coal lump moving cable
14. Indiana 281290240 5/78 - Fractured leg - pulling slack cable hit leg
15. Wyoming 281700222 6/78 - Sprained knee - cable loop struck employee
16. Kentucky 281780030 6/78 - Bruised ankle - moving cable struck leg and ankle
17. Indiana 281860047 6/78 - Shock - employee thought he felt shock when moving cable
18. Indiana 282050247 7/78 - Fractured wrist - slack cable being pulled knocked employee down
19. Alabama 281920100 7/78 - Sprained knee - stepped on rocks moving cable

EXHIBIT A (cont)

Summary of Accidents, Coal - Open Pit - 1978

- |     |                           |  |
|-----|---------------------------|--|
| 20. | Ohio<br>282230168         | 8/78 - Crushed hand - moving cable with loader and got hand in track pad                         |
| 21. | Pennsylvania<br>282430008 | 8/78 - Sprained wrist - lifting cable over spool   |
| 22. | Indiana<br>282440070      | 8/78 - Electric shock - repairing a power cable and bolt of lightning struck near the substation |
| 23. | Texas<br>282690011        | 9/78 - Strained back - moving cable hung in coal   |
| 24. | Missouri<br>282840146     | 10/78 - Bruises upper body - winch crank handle slipped while lowering cable from tower          |
| 25. | Wyoming<br>282890137      | 10/78 - Sprained back - lifting cable over dozer   |
| 26. | Indiana<br>283030088      | 10/78 - Sprained back - moving power cable   |
| 27. | Illinois<br>283100062     | 10/78 - Sprained ankle - stepped in rut moving cable   |
| 28. | Texas<br>283170217        | 11/78 - Hernia - moving cable over dirt clods  |
| 29. | Kentucky<br>283170405     | 11/78 - Strained back - lifting cable over rocks   |
| 30. | Pennsylvania<br>283280131 | 11/78 - Strained chest - lifting drill cable   |
| 31. | Illinois<br>283520195     | 11/78 - Bruised foot - foot between farm tractor and cable sled                                  |
| 32. | Wyoming<br>283520509      | 12/78 - Sprained back - fell on slick ground moving cable  |
| 33. | Colorado<br>283550120     | 12/78 - Strained back - pulling cable with hook  |
| 34. | Ohio<br>283600025         | 12/78 - Strained back - slipped on loose coal while pulling cable                                |
| 35. | Kentucky<br>283600441     | 12/78 - Strained pelvis - moving cable   |
| 36. | Illinois<br>290020085     | 12/78 - Strained back - lifting cable on reel drum   |
| 37. | Oklahoma<br>290020298     | 12/78 - Strained back - lifting cable over his head  |

EXHIBIT A (cont)

Summary of Accidents, Coal - Open Pit - 1978

- |     |                           |   |
|-----|---------------------------|---|
| 38. | Wyoming<br>290080065      | 12/78 - Fractured leg - moving cable struck employee in leg |
| 39. | Pennsylvania<br>290150472 | 12/78 - Strained abdomen - pulling cable by hand            |
| 40. | Indiana<br>290220133      | 12/78 - Strained shoulder - pulling slack cable by hand     |

EXHIBIT B

Summary of Accidents, Metals/Nonmetals - Open Pit - 1978

1. Minnesota 280320181 1/78 - Strain chest - handling shovel power cable
2. Minnesota 280340016 1/78 - Bruise breast - handling cable, lost balance & fell
3. Michigan 280340017 1/78 - Amputation foot - moving cable with shovel bucket
4. Minnesota 280340019 1/78 - Bruise forearm - using winch to hoist power cable, glove slipped and handle hit arm
5. Minnesota 280520096 2/78 - Bruise head - lowering cable from tower, cable fell and struck head
6. Arizona 280970042 2/78 - Strain back - pulling cable when tongs slipped
7. Wyoming 280760084 3/78 - Strain back - loading cable in tub and lost footing
8. Minnesota 280820021 3/78 - Bruise side - slipped on ice and fell while moving cable
9. California 281100110 3/78 - Strain abdomen - pulling cable by hand
10. Minnesota 281350231 4/78 - Sprain neck - handling cable, lost balance and fell
11. Arizona 281350462 4/78 - Fracture wrist - pulling cable from truck lost balance & fell backwards
12. Michigan 281140117 4/78 - Fracture ankle - moving drill cable stepped on rocks
13. Minnesota 281160033 4/78 - Strain back - pulling cable slack toward shovel
14. Minnesota 281210169 4/78 - Fracture tailbone - pulling cable, lost balance, fell backward on rock
15. Michigan 281290103 5/78 - Strain back - unloading cable from boom truck

Summary of Accidents, Metals/Nonmetals - Open Pit - 1978 (Cont'd)

16. Minnesota 5/78 - Sprain leg - moving cable over bank and slipped  
281660232
17. Arizona 6/78 - Bruise hip - pulling cable and fell  
281700226
18. Nevada 7/78 - Sprain leg - pulling cable by hand  
281990040
19. Michigan 7/78 - Sprain ankle - moving cable and stepped on loose rock  
290810001
20. Minnesota 7/78 - Sprain knee - cable splice caught on cable truck bed  
282120001 and slack struck employee
21. Minnesota 8/78 - Lacerated finger - pulling cable and cut hand on rock  
282360205
22. Minnesota 8/78 - Sprain knee - pulling cable and slipped in mud  
282370039
23. Arizona 8/78 - Bruise ankle - moving cable by hand  
282480463
24. Minnesota 9/78 - Bruise leg - loading cable on boat when boat struck employee  
282780061
25. Arizona 10/78 - Fracture foot - pot head fell on foot  
282990195
26. Minnesota 10/78 - Sprained back - picking up cable coupler  
283070043
27. Minnesota 11/78 - Bruised hand - placing cable on tripods, caught hand between  
283250054 cable and tripod
28. Arizona 11/78 - Cut hand - caught between mechanical reel and power cable  
28335001
29. Arizona 12/78 - Sprained hip - moving cable and stepped in water filled hole  
290020091

EXHIBIT C

Summary of Accidents, Coal - Open Pit - 1979

1. Illinois 290310053 1/79 - Strain back - injured lifting a pothead
2. Missouri 290310088 1/79 - Cut mouth - pulling ground monitor cable out of frozen ground and struck him in the mouth.
3. Indiana 1/79 - Sprain knee - standing inside the loop when cable caught employee and knocked to ground
4. Indiana 290370029 1/79 - Sprain elbow - moving cable by hand, slipped on ice
5. Wyoming 290430058 1/79 - Strain back - pulling cable over rocks
6. Indiana 290510190 1/79 - Strain back - lifted pothead to throw it over highwall
7. Wyoming 291010080 1/79 - Bruise knee - moving power cable knee gave way and fell
8. Illinois 290510156 2/79 - Strain back - moving power cable by hand
9. Washington 290640374 2/79 - Strain back - pulling power cable by hand
10. Ohio 290670054 2/79 - Sprain knee - moving cable in mud foot slipped.
11. Texas 290670087 2/79 - Strain back - lifting cable when his footing slipped
12. Pennsylvania 290710159 3/79 - Strain back - pulling cable fell forward injuring back
13. Indiana 290680069 3/79 - Strained back - lifting cable onto dozer blade
14. Alabama 290880102 3/79 - Hernia - picking up electrical cable
15. New Mexico 290880135 3/79 - Fractured finger - winding cable into the repair shop when cable pulled his hand into the guide roller
16. Indiana 291140168 4/79 - Strained pelvis - moving cable by hand
17. Kentucky 291210027 4/79 - Strained back - pulling cable over rocks

Summary of Accidents, Coal - Open Pit - 1979 (cont)

18. Indiana 291220060 4/79 - Strained back - attempting to lift power cable off of cable hooks on 61R drill
19. Ohio 291230018 4/79 - Strained back - attempting to place a rope sling around cable
20. Pennsylvania 291280167 4/79 - Cut arm - taking cable off reel and cable struck his arm
21. Pennsylvania 291440004 5/79 - Strained back - moving shovel power cable
22. Colorado 291510008 5/79 - Bruised knee - moving cable and slipped hitting his knee on a rock
23. New Mexico 291590114 5/79 - Cut finger - pot head struck the hand against a pickup tailgate
24. Kentucky 291630008 5/79 - Crushed finger - moving trail cable and mashed index finger
25. Illinois 292110081 6/79 - Strained back - moving power cable by hand
26. Washington 292140173 7/79 - Strained back - lifting on power cable
27. Alabama 292180096 7/79 - Strained back - picking up piece of drag cable and pulled muscle
28. Indiana 292530441 8/79 - Strained back - attempting to pull power cable from rock slide
29. Ohio 292600175 8/79 - Strained back - pulling drill power cable through mud
30. New Mexico 292570108 9/79 - Multiple Injuries - pulling slack cable when cable came across and hit employee knocking him to the ground
31. Pennsylvania 292670266 9/79 - Sprained knee - pulling shovel cable and slipped
32. Washington 292610017 9/79 - Strained back - moving trailing cable by hand
33. Illinois 293340135 9/79 - Strained back - moving cable to untie a knot in pulling rope
34. Wyoming 293020243 10/79 - Sprained back - moving cable on a berm, slipped and fell backwards on a rock.
35. Indiana 292950218 10/79 - Fractured leg - moving cable when it struck employee on leg
36. Ohio 292980009 10/79 - Cut finger - slack cable struck employee knocking to ground causing a minor cut

Summary of Accidents, Coal - Open Pit - 1979 (cont)

- |     |                           |   |
|-----|---------------------------|---|
| 37. | Kentucky<br>293170383     | 10/79 - Strained back - pulling power cable loose from rocks                              |
| 38. | Wyoming<br>293310153      | 11/79 - Fractured ankle - cable lowered over highwall cable loop<br>struck employee       |
| 39. | Illinois<br>293510347     | 11/79 - Hernia - lifting power cable and feet slipped                                     |
| 40. | Oklahoma<br>293370433     | 11/79 - Strained back - moving cable for dragline by hand                                 |
| 41. | Pennsylvania<br>293470003 | 11/79 - Cut scalp - cable struck him on head while handling cable                         |
| 42. | Illinois<br>293550008     | 12/79 - Strained back - placing power cable in brackets of dragline                       |
| 43. | Indiana<br>293510297      | 12/79 - Sprained ankle - attempting to pull cable from rocks and slipped<br>on loose coal |
| 44. | Illinois<br>200100069     | 12/79 - Hernia - moving cable and connector   |

NOTE: There were two incidents reported by MSHA on 12/79 regarding suspected electrical shock while handling power cable. These incidents are not recorded as accidents as there were no injuries or lost time. Therefore, they do not appear in the HSAC tabulated data. Electrical inspector stated "there was no explainable reason for them to get a shock."

EXHIBIT D

Summary of Accidents, Metal/Non-Metal - Open Pit - 1979

1. Arizona 290290166 1/79 - Sprained ankle - placing cable on tower, dozer jolted tower and employee fell
2. Florida 293200262 1/79 - Sprained back - moving dragline power cable by hand
3. Michigan 290590102 2/79 - Sprained back - handling cable and foot slipped
4. Arizona 291620021 2/79 - Sprained back - pulling power cable over rocks
5. Arizona 290680073 3/79 - Sprained knee - pulling cable over rocks and slipped
6. Minnesota 290710343 3/79 - Bruised hand - slipped and fell pulling drill power cable
7. Texas 290960125 3/79 - Strained groin - pulling cable by hand
8. New York 290990095 3/79 - Hernia - lifting cable into cable boat
9. Wyoming 291130218 3/79 - Strained back - moving cable for shovel move
10. Arizona 291200013 4/79 - Hernia - lifting pothead
11. New Jersey 291200273 4/79 - Strained neck - pulling cable on dredge
12. Colorado 291210170 4/79 - Cut fingers - lifting cable by hand
13. Minnesota 291440103 5/79 - Sprained knee - pulling cable by hand and fell
14. Georgia 291700126 6/79 - Fatal electrical shock - man was standing in dredge pond when the power cable was accidentally pulled from the connection to the dredge creating a short circuit, phase-to-phase condition which energized the dredge and pond. No electrical circuit protection.
15. Kentucky 293600181 7/79 - Strained back - bent over lifting cable
16. Arizona 292070140 7/79 - Strained back - bent over to pick up cable

EXHIBIT D (cont)

Summary of Accidents, Metal/Non-Metal - Open Pit - 1979

17. Minnesota 7/79 - Strained arm - pulling cable by hand  
292110007
18. Utah 7/79 - Electrocution - made contact with energized overhead powerline  
292080125 while relocating cable drop on distribution tower.
19. Indiana 7/79 - Strain back - moving cable between cable boats  
292250176
20. Michigan 8/79 - Strained back - moving cable covered with dirt along ramp  
292390030
21. Minnesota 8/79 - Cut hand - fell moving cable in dark  
292390075
22. Minnesota 9/79 - Strained back - pulling shovel cable by hand  
292640196
23. Minnesota 9/79 - Sprained wrist - pulling shovel cable from mud  
292670473
24. Florida 9/79 - Strained back - moving cable by hand  
292700172
25. Arkansas 9/79 - Fractured toes - moving cable with dozer and set blade on foot  
292760031
26. Florida 9/79 - Electric Shock - opened cable connector box and touched  
292600186 electrical connection with bare hand
27. Vermont 10/79 - Strained back - moving cable and slipped  
292950207
28. Minnesota 10/79 - Sprained fingers - removing power cable from shovel path when  
293200230 backing shovel
29. Iowa 10/79 - Strained back - pulling cable up on dredge floats  
292840086
30. Minnesota 10/79 - Back sprain - lifting drill power cable  
293020376
31. Arizona 11/79 - Sprained ankle - pulling cable over rock and slipped  
293310085
32. Minnesota 11/79 - Strained back - pulling cable by hand  
293400113
33. Arizona 11/79 - Sprained back - pulling cable by hand and slipped  
293540002

EXHIBIT C (cont)

Summary of Accidents, Metal/Non-Metal - Open Pit - 1979

- |     |                           |   |
|-----|---------------------------|---|
| 34. | Wyoming<br>293510241      | 12/79 - Dislocated foot - loading power cable in pickup and slipped<br>on ice |
| 35. | Pennsylvania<br>293520020 | 12/79 - Back sprain - lifting power cable clear of crawler path               |

EXHIBIT E

Summary of Accidents, Coal - Open Pit - 1980

1. Alabama 200350330 1/80 - Back Sprain - moving power cable
2. Ohio 200280164 1/80 - Fracture, forearm, moving power cable and fell
3. Kentucky 200630040 2/80 - Back Sprain - pulling on power cable
4. Ohio 200630296 2/80 - Back Sprain - slipped on rock when pulling cable
5. Illinois 200530185 2/80 - Shoulder Injury - moving cable with tractor
6. Illinois 200910112 3/80 - Cut finger - sharp edge on cable reel
7. Illinois 200730155 3/80 - Back Injury - lifting cable into cable TVB
8. Indiana 200770507 3/80 - Back Sprain - moving cable and slipped
9. Montana 200800084 3/80 - Fracture, foot - caught in cable loop
10. Ohio 201010112 3/80 - Shoulder sprain - relocating cable
11. Colorado 200910124 3/80 - Contusion chest - lifting power cable
12. Kentucky 201190040 4/80 - Bruise ankle - struck by slack cable
13. Ohio 201340223 4/80 - Leg sprain - pulling cable by hand
14. Kentucky 201120249 4/80 - Back sprain - lifting 8 Kv cable over a dozer
15. Colorado 201260111 4/80 - Sprained ankle - caught in cable slack
16. Illinois 201570136 5/80 - Electrocution - removing knife switchhouse supply power cable while energized without lockout procedure or door interlocks.
17. Wyoming 201510030 5/80 - Sprained ankle - stepped into hole while moving cable
18. Montana 5/80 - Shock burns - entered junction box for feeder cable before system was de-energized without regard for lockout procedure
19. Illinois 201570091 5/80 - Hernia, groin - lifting cable into loader bucket
20. Texas 201680156 6/80 - Back sprain - stepped into hole while moving cable

EXHIBIT F

Summary of Accidents, Metal/Non-Metal - Open Pit - 1980

1. Florida 200100092 1/80 - Hernia - moving dragline power cable
2. Florida 200250050 1/80 - Leg sprain - knocked down by moving cable
3. Arizona 200350167 1/80 - Fracture, head - cable tongs slipped, employee fell
4. Oklahoma 301760023 1/80 - Electrical burn - using a hot stick to energize shovel, fell on ice and contacted live circuit
5. Arizona 200800122 2/80 - Multiple injuries to back and head - struck by cable and fell
6. Arizona 200440010 2/80 - Arm sprain - pulling on cable
7. Arizona 200500417 2/80 - Sprained wrist - pulling power cable and slipped
8. Florida 200770345 3/80 - Bruise, groin - struck by power cable
9. Georgia 201090032 3/80 - Bruise, back and hip - cable tool slipped while moving cable
10. Nevada 200980076 3/80 - Back sprain - lost footing while moving cable
11. Arizona 200950150 3/80 - Back sprain - fell when cable tongs broke
12. Arizona 201150020 4/80 - Back sprain - moving power cable up a bank
13. New York 201270071 4/80 - Cut, mouth area - removing cable from reel, end struck employee
14. Texas 201610243 4/80 - Back sprain - lifting cable
15. New York 201160150 4/80 - Fractured wrist - fell backward when moving cable
16. Arizona 201140015 4/80 - Sprained back - lifting power cable
17. Arizona 201610143 5/80 - Sprained elbow - pulling on power cable
18. Colorado 201430091 5/80 - Fractured leg - foot caught between cable and large rock
19. Minnesota 201360131 5/80 - Back sprain - pulling on power cable

Summary of Accidents, Metal/Non-Metal - Open Pit - 1980 (cont)

- 20. Texas                    5/80 - Fractured ankle - cable kink hit employee  
    201570142
- 21. Arizona                6/80 - Sprained back - pulling on power cable  
    201960264
- 22. Arizona                6/80 - Back sprain - loading cable on flatbed truck  
    201920006
- 23. Wyoming               6/80 - Electrical burn - during training secession, employee unplugged  
    201830171                    an energized supply cable to switchhouse, in-  
                                  tended to unplug the de-energized load cable