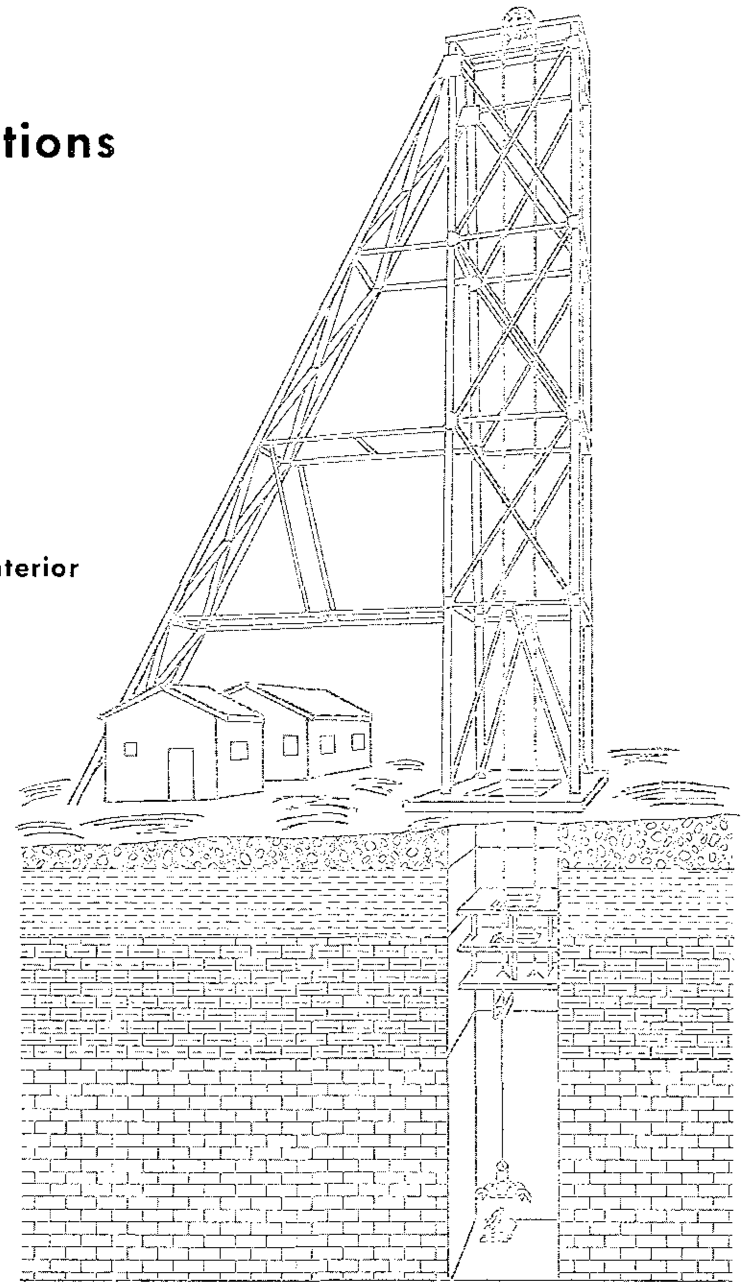
BuMines OFR 45-78

Safety Analysis of United States Shaft-Sinking Operations



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by
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The safety analysis of shaft-sinking operations included a review of accident reports from coal and metal-nonmetallic mine shaft-sinking projects in the United States, a review of foreign and domestic shaft laws, and discussions with shaft contractors and Federal mine inspectors. Accident data were studied to identify the most common and the most severe types of shaft accidents and to determine their immediate and contributing causes. Additional factors such as worker training and experience, equipment and sinking procedures, regulations and enforcement practices were also investigated to determine their impact on shaft safety. The results of the study are summarized in recommendations for improved training of shaft miners and clarification of Federal shaft-sinking regulations. A guide to assist mine inspectors in examining shaft-sinking projects is also included.

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FOREWORD

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This report is a summary of the work recently completed as part of this contract during the period June 1975 to April 1977. This report was submitted by the authors in June 1977.

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SAFETY ANALYSIS OF
UNITED STATES
SHAFT-SINKING OPERATIONS

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

by

DAMES & MOORE
PARK RIDGE, ILLINOIS

FINAL REPORT

on

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AUGUST 1977

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Page II-14. 1st Paragraph - Change Hughes Tool Company to Reed Tool Company.

Page IV-4, Last Paragraph - Change 57, 19-56 to 57, 19-76.

INTRODUCTION

The demands for development of America's mineral resources, particularly the recent increased demand for coal and uranium, have led to the development of new mines and the expansion of existing mines. With the expansion of the mines has come the need for more shafts for access, mineral hoisting, and ventilation. The increase has been particularly evident in the Eastern and Midwestern coal fields where more and deeper shafts are being developed to reach deeper seams and to develop areas not previously mined. It was recently predicted (Dahl, 1976) that the United States coal industry alone will require 160 new shafts each year for the next 10 years.

Problems will come with this increase in shaft-sinking activity. New and inexperienced contractors and operators will enter the industry, and there will be an even greater shortage of skilled shaft miners and supervisors. There will be an increase in the number of shafts sunk by raise drilling or blind drilling, and additional efforts will be made to develop shafts and slopes with downhole machines and tunnel boring machines. The result will be an increase in the number of accidents, many from as yet unidentified safety problems. The actions needed to prevent these accidents must begin now.

Traditionally, the shaft-sinking industry has not been regulated. Existing laws are in part ambiguous and are often enforced by inspectors and other regulatory personnel who lack the personal shaft-sinking experience necessary to apply laws to changing conditions. Shaft sinking is a mixture of mining and heavy construction and must be regulated as such. Several federal agencies are concerned with shaft safety. The Occupational Safety and Health Administration (OSHA) is responsible for enforcement of safety standards on shafts sunk for civil construction projects. The Mining Enforcement and Safety Administration (MESA) regulates the mining industry including the associated shaft sinking and mine development. Since the vast majority of recent shafts have been related to mining, this report will deal only with this phase of the shaft industry.

Many of the problems associated with shaft-sinking safety have been recognized, but satisfactory solutions to all problems have not been reached. In an attempt to identify specific problem areas, the United States Bureau of Mines contracted a safety analysis of shaft-sinking operations. The objective of this analysis was to survey and review shaft-sinking operations for the purpose of identifying specific hazards associated with particular equipment or techniques. The project included a review of the various methods and equipment used in shaft sinking, a study of mining laws in the United States and major foreign mining countries, and an analysis of shaft accident reports. The preliminary results of these studies were discussed in meetings with MESA District Managers, inspectors and shaft contractors and were revised and extended as necessary. Observations made during numerous shaft site visits were included.

Research into the safety situation in the shaft-sinking industry was conducted over a period of approximately 16 months. During that time published information describing the various shaft-sinking methods, equipment, and regulations affecting the industry was collected and reviewed. Much time was spent reviewing the federal mining regulations found in Title 30 Code of Federal Regulations to determine their effectiveness in improving shaft safety. Accident records were obtained and studied to identify common factors in shaft accidents. The study concentrated on shafts sunk for mines in the United States but included data from other nations as well.

It was originally intended that detailed statistical analyses of the variables identified during the reduction of data gathered on shaft descriptions, sinking procedures and accident records would be conducted. However, due to incomplete data and the general lack of sufficient detail on the available information, this became impractical. For example, because of the lack of detail, it was not possible to compare the relative safety records of specific equipment items. Some basic statistical analyses, however, were conducted using the available information and these analyses are presented in this report.

Also, in the original concept of this investigation the use of the detailed statistical analyses in the development of recommendations was to be emphasized. However, due to the inherent limitations of the available data, as described above, this was not feasible. Although some basic statistical analyses were possible, to achieve the objective of this study, emphasis had to be placed on information gathered from the visits to shaft-sinking sites and the interviews and discussions with MESA inspectors and officials, shaft-sinking contractors, and other individuals familiar with the safety aspects of shaft-sinking operations. Although much of the information obtained in this manner was subjective in nature, it brought out many problem areas that would not have been apparent from numerical data alone. It is felt, therefore, that the recommendations presented in this report are more comprehensive and more realistic than would have been possible with an emphasis solely on statistical analyses.

It should be noted that this investigation has placed heavy reliance on information input from MESA, since this agency has enforcement authority for employee safety in all shaft-sinking activity related to mining. The Occupational Safety and Health Administration (OSHA) has enforcement authority over shaft-sinking activity not related to mining and for certain other activities at mine facilities beyond mining and milling processes. (The division of responsibility between MESA and OSHA was clarified in the "Memorandum of Understanding between MESA and OSHA" published in the Federal Register, vol. 39, no. 145, on July 26, 1974.) Since shafts for nonmining projects are generally much shallower than shafts for mines, the safety problems encountered would not be representative of those encountered in the deeper mine shafts which generally require more elaborate equipment and techniques. It was, therefore, decided early in this investigation to concentrate the data gathering effort toward MESA sources and mine shaft-sinking contractors.

The review of accident data and contractors' Employment and Production reports indicate that shaft-sinking work is significantly more dangerous than underground mining. Accident frequency rates for coal mine shaft projects are approximately 131.6 per million man-hours worked compared to a frequency rate of 66.06 for all underground coal mining. On metal and nonmetal mine projects, the accident frequency rate is 157.8 per million man-hours worked compared to a rate of 38.6 for underground metal and nonmetal mining. Average injury severity per accident expressed as the number of days lost per accident including fatalities is 96.6 days for coal shaft projects and 231.1 days for metal and nonmetal shafts.

The accident data indicated that the leading causes of accidents were machinery, materials handling and falls of persons. While the accident records gave a measure of the magnitude of the shaft safety problems, meetings with MESA and shaft-sinking personnel provided an understanding as to the causes.

This report is a summary of the research performed and conclusions reached in the study. It includes recommendations for revisions to the existing mining laws applicable to shaft sinking, an inventory of recent shaft projects, and a guide for inspectors.

I. DATA SOURCES

In order to accomplish the objectives of this study, it was necessary to obtain the following information:

1. descriptive material on shaft-sinking procedures and equipment;

2. quantitative data on shaft-sinking activity in recent years;

3. descriptive and quantitative data on shaft-sinking accidents;

4. existing safety regulations pertaining to shaft-sinking activity; and

5. existing safety inspection procedures.

The above information has been obtained from published documents, MESA file records, interviews and discussions with MESA officials, shaft-sinking contractors, the United Mine Workers of America, and from observation at shaft-sinking sites.

Published documents which have been collected and reviewed for this investigation include articles from both United States and foreign literature, copies of state, federal and foreign safety regulations, and equipment manufacturers' data. The literature also included articles on shaft projects published in a variety of journals worldwide, and reports on specific projects, equipment and technique descriptions. Emphasis was placed on obtaining details on variations in conventional excavation methods used to bore shafts, special techniques such as pregrouting and freezing, equipment specifications and descriptions of safety problems occurring from equipment operation.

Existing federal, state and foreign safety regulations comprised another type of published information collected and reviewed. Federal regulations implementing the Metal and Nonmetal Mine Health and Safety Act and Coal Mine Health and Safety Act are published in Title 30 Code of Federal Regulation, Chapter 1, and are periodically revised. It was learned that an extensive revision of the coal mine regulations, including shaft-sinking provisions, was in progress. Copies of the proposed revisions were provided by the Department of the Interior and were reviewed in light of existing regulations and industry conditions.

State mining regulatory agencies were contacted to determine their activities in shaft safety. Applicable laws currently in effect in Arizona, Alabama, Colorado, Kentucky, Pennsylvania, Illinois, Tennessee, Virginia, Wyoming, Nevada, Idaho, West Virginia, New Mexico, and Utah were studied.

Regulatory offices in foreign countries were contacted to obtain copies of national and provincial mining laws from their regions. Contacts with government officials in these countries provided details on methods of enforcement and local government policy regarding shafts and mine development. Included in this report are reviews of mining laws from Australia including the states of South Australia, New South Wales, Queensland, West Australia, and Tasmania; Canada including the provinces of British Columbia, Manitoba, New Brunswick, Nova Scotia, and Ontario; the Republic of South Africa; and the United Kingdom.

Published equipment manufacturers' data which included specifications, descriptions and photographs were also collected and reviewed.

Quantitative data on shaft-sinking activities in recent years were collected from the Mining Enforcement and Safety Administration (MESA) file records. These data consisted of accident and production records in the files of MESA's Health and Safety Analysis Center (HSAC) in Denver, Colorado; shaft-sinking plans on file at the various MESA Coal Mine Health and Safety district offices; and MESA inspectors' reports of fatal or other serious accidents on file in MESA district offices throughout the country.

Although some of the production data were obtained from published sources, the majority was obtained from Monthly or Quarterly Employment and Production Reports provided by MESA's Health and Safety Analysis Center. The data included mine identification number, date of report, number of underground workers, number of man-hours worked underground, number of surface workers, number of man-hours worked at the surface, and the number of accidents reported during the record period. These data were collected in an attempt to calculate accident frequency rates for shafts sunk by various methods or equipment. The information was, however, found to be incomplete. Significant numbers of production reports were missing and errors were discovered. The most common error being the number of accidents reported on the quarterly or monthly production report and the actual number of accident reports found for that period.

The accident data were obtained from MESA inspectors' reports of fatal or other serious accidents and from accident reports filed by the mine operator with the Health and Safety Analysis Center. Data recorded included mine identification number, document number, accident type, date and time of accident, shift time, victim's age, total mining experience, total experience at the mine in which the injury occurred, part of body injured, cause, location, equipment involved, degree of injury, and days disabled. The information for coal-shaft accidents was supplied as a data printout by the Health and Safety Analysis Center. These data were cross referenced to the report documents to obtain additional details. Information for accidents in metal and nonmetallic mine shafts was obtained directly from the accident reports.

Interviews and discussions with government and industry personnel familiar with the safety aspects of shaft-sinking operations provided information for this study. These interviews and discussions were held with MESA inspectors and officials, shaft-sinking contractors' representatives, and representatives of the United Mine Workers of America. The purpose of these interviews and discussions was to obtain firsthand information from those individuals most familiar with existing shaft-sinking procedures and equipment, and the safety problems associated with shaft development. Although much of the information gathered in this manner was in the form of subjective comments and opinions, it served to complement the previously gathered published documents and MESA file records. Since information was solicited from both industry and government regulatory personnel, it is felt that a suitable balance in viewpoints was achieved. This approach has also placed the practicality of existing regulations and inspection procedures into better perspective.

Visits to actual shaft-sinking sites provided further information for this study. These site visits allowed firsthand observation of work procedures and shaft-sinking equipment, and evaluations of problems associated with the enforcement of existing safety regulations.

As part of the data gathering process for this investigation, an inventory of recent shaft-sinking projects was prepared. This inventory, which includes both domestic and foreign shafts, contains information such as location, mine name, owner, contractor, dimensions, site geology, method of construction and year completed. Since much of these data were obtained from published sources, some discrepancies were found. For example, information such as brief announcements of an operator's award of a contract for a shaft or of a mine recently opened were commonly generalized or did not give the shaft name or specific location. In tabulating this information, some projects may have been omitted or incorrect names applied. It was therefore decided to abbreviate this data group when preparing the final inventory of shafts which appears as Appendix B to this report.

Since the scope of work for this investigation included an in-depth literature search of foreign as well as U.S. sources, data similar to those listed above were gathered from several foreign countries. Personnel in Canada, the United Kingdom, the Republic of South Africa, Australia, and Japan were contacted to obtain pertinent articles from the foreign literature and copies of applicable safety regulations. Also, foreign mine operators and shaft-sinking contractors were contacted to prepare an inventory of recent and current foreign shaft-sinking projects. The data gathered by the foreign offices were transmitted to Chicago where the data was compiled and reviewed. The gathering of all U.S. data was accomplished by personnel in the central Chicago office.

II. SHAFT-SINKING PROCEDURES

INTRODUCTION

Shafts and slopes may be sunk utilizing two basic methods, conventional excavation or drilling. Conventional excavation consists of three basic steps, drilling, blasting, and mucking, and a fourth step, lining, which is also commonly used. This method of shaft sinking has been used to develop the majority of shafts in existence today. It involves the use of a variety of equipment and requires that men work in the shaft. Conventional excavation is relatively slow. Average sinking rates in North America are approximately 45 feet per month in coal shafts (Dahl, 1976; Wilson, 1976) and 200 feet per month in metal mine shafts (Wilson, 1976). In South Africa, conventional excavation has been developed to a high degree and a sinking rate of 1,160 feet per month has been recorded (Hammond, 1975) but required an underground crew of 450 men.

In response to increasing costs of labor and materials and a greater emphasis on worker safety, efforts are being made to increase shaft-sinking efficiency by increased mechanization. Shaft drilling is simpler than conventional excavation and may be accomplished by either raise or blind drilling methods. In raise drilling, a drilling machine bores a small diameter pilot hole from the surface to a level in an existing mine. A large diameter bit is taken into the mine and attached to the drill stem. The drilling machine then pulls the drill bit to the surface widening the shaft to full diameter. Cuttings and broken rock fall to the bottom and are removed. To date, shafts excavated by raise drilling have been limited to circular shafts up to 16 feet in diameter.

In blind drilling, machines drill large diameter holes downward from the surface with the cuttings being removed up the shaft to the surface. To date, blind drilled shafts have been limited to approximately 12 feet in diameter.

Due to the increased costs and low production of conventional methods and advances in shaft drilling equipment and procedures, the shaft industry is in a state of transition. The following sections outline current practices in shaft-sinking work and present information describing the recent trend to bored shafts. The descriptions are based on published reports and observations made during visits to 16 shaft projects which included 25 shafts, 8 slopes, and 2 tunnels.

GENERAL OPERATIONS AND SITE PREPARATION

Regardless of the method used to sink the shaft, several initial steps are standard. In most shaft projects the owner's responsibility consists of preparing the site and providing electric power, including transformers, at the shaft site. The mine owner will usually contract for the shaft development. The contracts vary in extent but are usually limited to the sinking of the shaft with only limited development work at stations. A few mine owners sink their own shafts or slopes. This is done when men and equipment are available and time is not a major consideration. Several qualified sources have stated they believe that shafts sunk by owners are generally safer projects than those sunk by contractors. This view is held chiefly because the owner has the time available and he is not pressed by contract requirements for early completion.

Generally, shaft site preparation and construction of final surface facilities are handled either by the mine owner or a general contractor. The initial steps in site preparation may be used regardless of the methods used to sink the shaft. Preparation of the proposed shaft site is conducted as any earthwork project. In areas where ground water or highly fractured rock may be a problem, the mine owner or a contractor will pregrout or freeze the site area in an effort to stabilize conditions.

Grouting is the injection of a cementing agent under pressure into an area of unsuitable ground to increase its stability or reduce the rate of ground water flow. Several types of grout are available. The most common consists of Portland cement either alone or with a filler such as sand or bentonite. Chemical grouts are also available for use where cement grout is unsuitable. These agents consist of two or more substances which react to form an insoluble precipitate or silica gel. The precipitate fills small voids and seals ground water flow. Grouting work is conducted prior to shaft sinking. The entire depth of the shaft may be pregrouted or grouting may occur in stages as the sinking progresses. Grout injection holes are drilled around the shaft, often at a variety of angles. This practice insures that all potential fractures are found and grouted. The liquid grout is pumped into the injection holes under pressure and allowed to solidify before sinking continues. Care must be taken during sinking, particularly during blasting, to insure that overbreak is kept to a minimum and that no unnecessary fractures are created which will destroy the grouting effect.

Several sites visited in the course of this study had been grouted. Grouting had been only partially successful and the shaft contractor was faced with handling a certain volume of water. In other cases, the site was not pre-grouted either because water was not a problem or because the owner wished to avoid the expense. If ground water was in fact a problem, the shaft contractor was forced to solve it before real progress could be made.

In areas of saturated soil or similar saturated flowing ground, freezing may be employed to form an impervious ice barrier through which the shaft may be sunk. The ice barrier must be firmly anchored into an impervious stratum below the saturated zone. In addition, the rate of ground water flow must be relatively low.

The first step in the freezing process is the drilling of the freeze holes. These are usually arranged in a circle concentric with the proposed shaft centerline. It is important that these holes not allow gaps to exist between the freezing pipes at depth and prevent formation of the ice barrier. Next the refrigerant circulation system is installed. This system consists of refrigeration units, pumps, and circulation pipes. The refrigerant is usually a brine such as a calcium chloride solution. The refrigerant is circulated in the ground through a system of concentric pipes. The fluid is pumped down through the inner pipe and returns through the outer.

The time necessary to form the ice wall varies with the type and temperature of the ground water and with the concentration of dissolved minerals. The ice barrier begins to form as a frozen zone around each refrigerant pipe and grows until the zones from adjacent pipes merge. When the ice barrier closes the remaining unfrozen water at the shaft center is forced upward. An observation well installed on the proposed shaft centerline is used to monitor the ground water level as an indication of freezing progess. Once the entire area is frozen, shaft sinking can begin. Extreme care must be taken to prevent damage to the ice wall and circulation system during blasting. Placement of concrete lining is usually not seriously affected by the frozen ground. Upon completion of the shaft the refrigerating system is disconnected and the ground is thawed naturally or artificially by circulating warm fluids.

CONVENTIONAL EXCAVATION

Once the site is prepared, shaft sinking can begin. The most common method used in the United States has been conventional excavation, wherein men enter the shaft to drill, blast and muck (remove) the broken rock. The work begins with initial excavation which includes removal of overburden to firm bedrock or other predetermined depths. At that time the sinking headframe and hoist are installed and the shaft collar is placed. The shaft is then sunk by the drilling, blasting, mucking and lining sequence. The following sections describe these operations in more detail.

Initial Excavation

Generally, the initial shaft excavation is begun by excavating to firm bedrock. This is commonly done with a backhoe or a crane and clamshell. Once the overburden is excavated and supported, the shaft will be sunk by drilling and blasting to a depth sufficient to allow installation of a work deck, if desired, or the construction of a sinking headframe. This material may be mucked with the crane and clamshell or a shaft-mucking machine may be lowered and used. The depth to which the initial excavation is carried varies according to the contractor's procedure and MESA's enforcement policy in the various districts. The shaft must be deep enough to protect the headframe and work deck against blast damage during deeper shaft-sinking operations. Safety requirements for man hoisting, however, require a substantial hoisting system and shaft guides. In one MESA district the policy may require that the sinking headframe and hoist be installed when the shaft depth reaches 50 feet. In other districts initial excavation may be carried to 100 feet.

At the conclusion of the initial phase, the concrete lining is placed to the depth sunk and the shaft collar is poured, the sinking headframe and hoist are installed, and the work deck is constructed. Ventilation is established if not already installed.

Drilling and Blasting

Following completion of the initial excavation, deeper shaft sinking is accomplished by drilling holes for charges in the shaft according to a pattern, blasting the charges, and removing the debris. The cycle repeats, thus deepening the shaft after each series.

<u>Drilling</u> - Drilling of holes for blasting is done with pneumatic percussion drills, either by hand held sinker drills or mounted on a shaft drill jumbo. Before drilling begins the rock surface is blown clean with water and air to locate any misfired charges left from the previous blast.

When hand held sinker drills are used, an equipment rack containing the drills, drill bits and supplies is lowered to the shaft bottom. Commonly, four or five miners are needed to drill the round. This has the advantage of speed in setting up but creates congestion on the shaft bottom.

Shaft drill jumbos, frames upon which several drills may be mounted, offer several important advantages over hand held drills. The jumbo provides greater control of the drills and allows the use of a single length of drill steel to drill each hole. With the use of a shaft drill jumbo one miner may operate several drills, thereby reducing congestion and the likelihood of accidents. The jumbos also allow greater control of the shape and depth of the pattern but require a longer period to set up in the shaft.

Blasting - The shape and depth of the blast pattern are extremely important factors in the excavation cycle. The shape of the pattern is determined by the ground condition and by the type of mucking equipment being used. The two basic patterns are the full face and bench (Fig. 1). With the full face pattern the entire bottom of the shaft is drilled and blasted in a single lift. This method is generally preferred when using mechanical mucking equipment and results in a higher advance rate (Stevens, 1973). Under extremely wet conditions or in areas of high rock pressures the bench pattern may be preferred. In the bench pattern half of the face is drilled and blasted in each shot. In this way, the muck is confined to one area and a sump is provided to allow pumping of excess water. When high rock stresses are present the use of the full face pattern may result in continued bursting of the bottom and produce a concave bottom which is difficult to drill and muck. This problem is reduced with the bench patterns (Radpath, 1971). The attached figure illustrates the various patterns used.

The depth of the pattern is particularly important in achieving the maximum rate of advance. It is, however, limited by the size of the shaft, ground conditions, and overbreak produced.

After drilling the desired pattern, the rock must be blasted and removed. Selection of the proper explosive to be used is made based upon several factors. Commonly a 40- or 60-percent gelatine explosive is used. The agent used should be unaffected by water. Drill water or ground water may collect on the shaft bottom and, unless the proper agent is used, misfires may result.

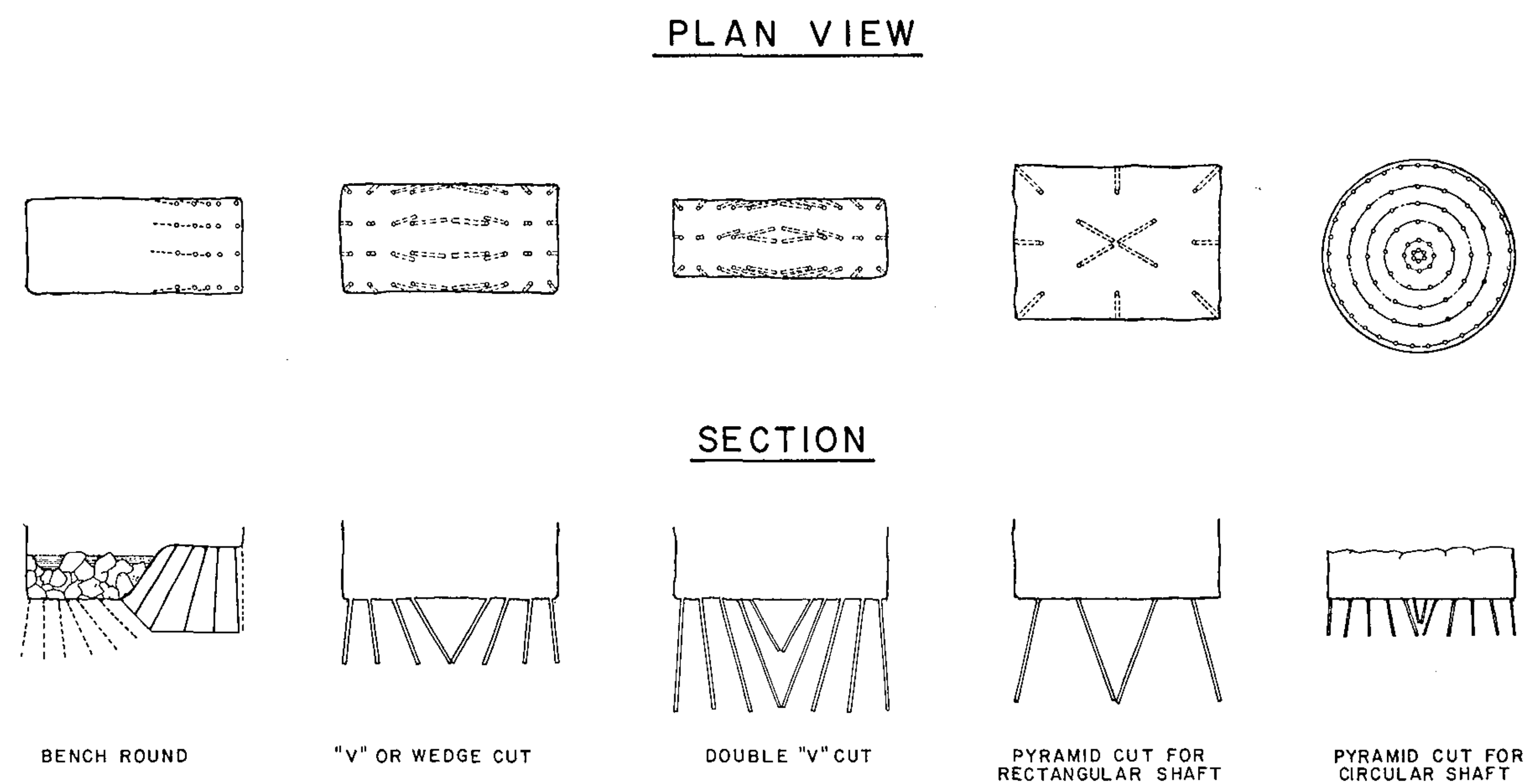


FIGURE 1
BLASTING PATTERNS

AFTER STEVENS, V.L., SHAFT SINKING AND RAISING BY CONVENTIONAL METHODS; SME-ME HANDBOOK, AIME, 1973.

Nearly all of the shaft sites visited used a blasting machine to fire the charges. One contractor, however, uses a separate blasting circuit encased in an armored cable. This circuit is kept de-energized and locked until ready for use. The cable is stored on a reel at the shaft collar and is connected in the hoist house.

Additional safety procedures required for blasting in all underground mining are also followed. These procedures are defined in Title 30 CFR Subchapter N Part 57 for Metal and Nonmetal Mines and Subchapter O Part 75 for Coal Mines.

Following the blast, time is allowed for the ventilation system to remove the dust and fumes. Miners then enter the shaft and carefully examine it for air quality and stability of the walls. Loose material is scaled down and preparations initiated for mucking.

Mucking

Following the post-blasting inspection, the mucking or debris-removing machine is lowered to the shaft bottom. Commonly three or four miners work on or near the bottom during mucking. When the Eimco 630 (Section III) machine is used, three men work on the bottom. This crew consists of an operator, helper, and one miner to position the muck buckets. When the Cryderman, cactus grab or backhoe are used only one or two men are needed on the bottom to position the buckets, since the mucker operator works from a control panel on the stage or mounted on the shaft wall. One contractor visited during this project uses a small clamshell bucket for mucking. This method uses four men on the bottom. The mucker operator controls the clamshell with a button box. Two miners swing the clamshell using taglines attached to opposite sides of the device. The fourth miner positions the muck buckets.

Once the broken rock is loaded into buckets, it is hoisted to the surface. It is common practice to raise the bucket off the bottom and steady it prior to hoisting. At that time loose material which may be stuck to the bucket is removed to prevent it from falling during hoisting.

Commonly, two or more buckets are used, with one bucket being hoisted and dumped while the second is being loaded, to speed the mucking cycle. The loaded buckets are hoisted to the surface and dumped. If a fixed headframe is used, the buckets are raised into the headframe and a dump chute is moved over the shaft collar beneath the bucket.

The bucket is lowered onto the chute and dumped. The bucket is tipped by engaging a short chain into steel projections fitted on the chute floor. When the stiff leg derrick or crane is used the loaded bucket is swung away from the collar for dumping.

Ventilation

Ventilation in shafts and slopes is essential for safe shaft operation. Common ventilation methods on United States shaft projects use a 40- to 100-horsepower electric fan with 24- to 36-inch diameter vent tubing. The fan is offset at least 15 feet from the shaft collar as prescribed by law and is installed to 24- to 36-inch diameter steel or fiberglass ventilation tubing. The tubing extends into the shaft and is kept 30 to 70 feet from the bottom at all times. To prevent damage to the steel tubing during blasting, a section of flexible tubing is used on the lower end of the system. The fans are reversible and may be set to blow air into the shaft or exhaust air from the shaft. Most commonly the fan blows air into the shaft through the tubing with the air being returned up the shaft. The ventilation system commonly produces a volume of 9,000 to 10,000 cubic feet of air per minute at the end of the tubing.

Lining

Nearly all modern shafts are concrete lined to provide support, to seal out excess water, and to protect the wall rock from deterioration. Thickness of the lining may vary but is commonly 1 foot thick. Placement of the lining may be done in stages either following shaft sinking or concurrent or alternating with excavation.

Shallow-to-medium depth shafts in competent rock can be lined after excavation to finished depth after sinking. This practice allows rapid sinking of the shaft since lining work does not interfere. Lining operations also progress rapidly as slipforms may be used starting at the bottom. There is, however, the danger of wall deterioration and falling rock and the potential for problems encountering zones of fractured rock or high water flow.

Lining may also be done concurrently with sinking operations. Two work crews are required, one sinking the shaft while the other places the lining. This method is common in the Republic of South Africa and is fast but becomes costly since a large workforce and complex equipment arrangements are required. Close supervision and careful planning are essential. Safety problems may develop if sinking progresses faster than the lining. In this case the sinking crew works far below the work platform and is exposed to hazards of falling rock and other materials. Other problems arise from the increased amount of hoisting required to simultaneously handle muck removal and concrete haulage.

The most common procedure in the United States and Canada is the method of alternating sinking and lining. This method is particularly well suited to deep shafts or areas of unstable ground. In this method one work crew is required for each shift. Sinking progresses a predetermined distance, then lining is placed. The amount of wall, or rib, exposed prior to lining is established by local regulation or by ground conditions.

Temporary support may consist of rock bolts, bolts and wire mesh, or gunite. The exact type of support should be determined by ground conditions. When rock bolts are used they are commonly 5 feet long and placed on centers of 4 and 5 feet. The bolts may be the expansive shell type installed to a specified amount of torque or they may be resin grouted into the rock. In areas of particularly bad ground wire mesh may be used in conjunction with the rock bolts. The mesh is anchored to the bolts and aids in retaining base blocks which might otherwise fall into the shaft. Gunite or shotcrete is also commonly used as a means of support. The gunite may be applied directly to the rock or it may be used in conjunction with rock bolts and wire mesh for additional strength.

Placement of the finished concrete lining begins when the sinking operation has exposed a desired length of rib. At that time one additional round is drilled and blasted. The muck from this round is left in place until the lining is installed. Reinforcing steel is assembled and placed into position around the rib. The steel forms are then lowered into position at the bottom of the interval to be lined. These forms are comprised of several sections and often incorporate bunton boxes which will provide for anchoring of steel sets in the finished shaft.

A ring of forms is completed by the insertion of a keyway. Each ring of forms is commonly 5 to 10 feet high.

Concrete for the lining is batched on the surface. The mix is commonly a high early strength design and may contain accelerators to speed setting. The concrete is transported to the shaft form by bucket or slickline. When buckets are used the concrete is placed into the forms through an "elephant's trunk". The slickline is a system in which the concrete is dropped down a pipe anchored into the shaft wall. Provision may be made on the work deck to remix the concrete prior to placing in the forms. Remixing prevents segregation of the concrete after dropping through the slickline.

After the concrete in the forms has set, the short keyway section of the forms is removed and the form segments are stripped. The work deck is raised and the forms are positioned for the next segment of lining. The process is then repeated until the entire segment of lining is complete. When sinking resumes, the muck is first removed from the last round blasted. The new lining is then left above the shaft bottom and is protected from damage during the blasting.

In shafts where excessive ground water is a problem, water rings are constructed in the lining. Water rings (Fig. 2) are recessed areas in the lining in which excess water is collected and channeled to a sump for pumping. The water rings may be drained through pipes inside the shaft leading to a sump or, as seen at shaft sites visited, a well is used. With this method a borehole is drilled outside the perimeter of the shaft and other connecting drains are drilled from the water rings to the borehole. An electric submersible pump is then placed in the borehole and the water is pumped to the surface. In this way the water is handled outside of the shaft and does not interfere with shaft sinking.

In some shafts shotcrete or gunite may be used instead of concrete to form a full shaft lining. Gunite and shotcrete are mixtures of cement, water and aggregate that are applied by spraying. The only difference between them is aggregate size, with shotcrete containing the larger material. A shotcrete or gunite lining several inches thick may be applied rapidly without the need for forms. This type of lining is commonly placed over a wire mesh anchored with rock bolts.

SHAFT DRILLING PROCEDURES

Procedures used to drill shafts, whether by raise or blind drilling, are simpler than those of conventional excavation. Presently, raise drilling has developed further than blind drilling and is more widely used. Blind drilling is slightly more complex and is still not fully applicable to shaft construction. Raise and blind drilling are explained in more detail in the following sections.

Raise Drilling

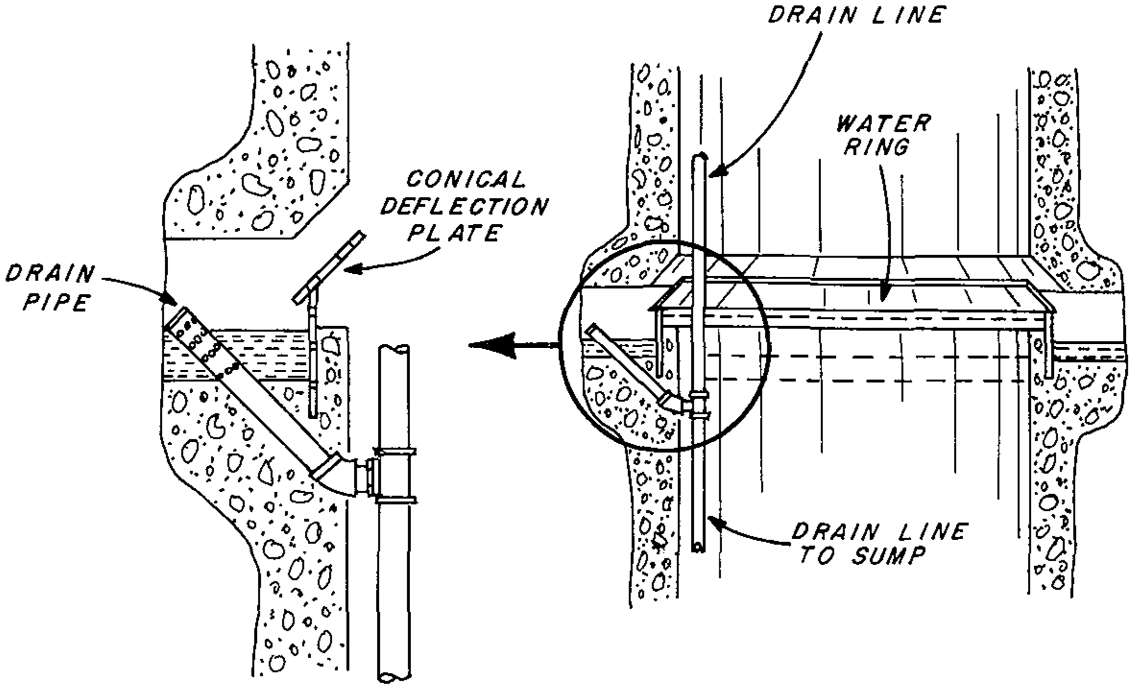
Raise boring or drilling the shaft up from an existing mine level to the surface is relatively simple. The shaft site is prepared as described in the GENERAL OPERATIONS section.

The presence of large amounts of ground water must be determined. If such conditions exist the shaft zone should be carefully grouted to seal off the potential flow of water. While the water would present little problem to the raise drilling equipment it could be a serious problem for the mucking operation and present problems for the mine's dewatering system.

If the shaft will connect two levels within a mine, the upper level may be enlarged to provide adequate working space. Once the drilling machine is in place on the surface, a pilot hole is drilled. This is generally a 6- to 11-inch hole drilled downward the full depth of the proposed shaft. When the pilot hole reaches the proper level, the cutting head is assembled and attached underground. The shaft is enlarged by pulling upward on the drill stem while the cutting head is rotated. The enlargement of the pilot hole to the final diameter of the shaft may be done with a single pass of the cutter. In larger diameter shafts multiple passes are used. When the final diameter is reached the boring machine is removed and the shaft is completed by lining and the installation of facilities.

The mucking operation and haulage of muck to the surface should be carefully planned. During drilling, the cuttings drop to the bottom of the shaft and must be removed through the existing mine. This is done by the mine owner's load-haul-dump units, loading machines or similar equipment. The muck is removed as general mine waste. This material must be removed efficiently to prevent delays with shaft drilling. It must also not be allowed to interfere with normal haulage and production in the mine.

As men are not working in the shaft being sunk, installation of sustaining ventilation through the shaft is not necessary. During raise drilling operations in coal mines, care must be taken to prevent the accumulation of explosive airborne dust or methane in the shaft between the cutting head and the muck pile. Such accumulations may be prevented by a water spray at the drill bit or by ventilation. Ventilation may be provided by blowing or exhausting through the drill stem. Ventilation for work at the base of the shaft is supplied through hook-up to the existing mine's system.



AFTER STEVENS, V.L., SHAFTING SINKING AND RAISING BY CONVENTIONAL METHODS; SME-ME HANDBOOK, AIME, 1973.

FIGURE 2
DETAILED SECTION OF WATER RING

Although raise boring of shafts is inherently safer than conventional means, there are some problems associated with raise drilling. For example, the pilot holes must be drilled accurately to encounter the desired mine level properly. This must be done through several hundred feet of overburden of various lithologies. The driller must use care to prevent the bit from walking on hard strata and to maintain a straight hole. Also, men in the existing mine below must be cautioned to avoid working under the cutterhead whether or not actual drilling is occurring. This is especially important when the cutterhead is near to breaking out at the surface, where weathered or broken rock may cave into the shaft. The accumulation of potentially explosive dust and gas in the shaft has already been mentioned.

Blind Drilling

Blind drilling is the development of large diameter holes from the surface. The method does not require prior access through an existing mine to the hole bottom. The shaft may be drilled to full diameter with a single pass of the drill tools. If access is available to the shaft bottom through an existing mine, the shaft may be drilled by making successive passes with larger diameter drilling tools. With this method the cuttings are removed from the shaft via the pilot hole and the existing mine's haulage system much like in raise boring.

Blind drilling has not been used extensively in the mining industry due to shaft size limitations. To date, blind drilled shafts have been limited to approximately 12 feet in diameter. This limit has resulted from technical problems associated with cuttings removal, shaft alignment and lining construction.

The equipment and procedures used in blind drilling are basically modifications of oil well drilling techniques. The drilling machines used in blind drilling shafts are commonly standard, oil-well drilling machines. Minor modifications may be made to the platform to handle large cutting heads but the drive motors, derrick and draw work are unchanged. Recently several models of large raise boring machines have been developed which may be converted to blind drilling.

The drilling tools include the equipment used in the shaft to cut the rock and stabilize the hole. Actual cutting is done with bits of the types shown on Figure 22. Depending on the nature of the rock to be cut, the bits may be milled tooth, disc, kerf or tungsten carbide button insert cutters. The bits are mounted on a large circular disk or cutterhead. (Figure 24 shows a type of cutterhead manufactured by the Reed Tool Company.)

The cutterhead is fitted to the end of a large, heavy mandrel which provides weight to aid cutting and stabilize the hole. The mandrel's weight may be increased by the addition of large steel weights. The mandrel assembly is illustrated on Figure 25.

The drill tools are connected to the drilling machine using drill stem pipe. The drill stem is hollow to allow passage of the drilling fluid. The drilling fluid serves the dual functions of cooling the bits and removing the cuttings. The fluid may be water, air, mud, foam, or a water and compressed air mix. The fluid aids removal of cuttings from the bits and transports them to the surface. The removal of the cuttings has been a major obstacle to the development of blind drilling operations. In conventional drilling work, the drill stem is relatively large in comparison to the hole diameter. This allows the drilling fluid to be pumped into the hole through the hollow drill stem and back to the surface through the small annular space between the drill rods and rock wall. The fluid is tightly confined and adequate pressures are maintained to easily lift the cuttings to the surface. In blind drilling, however, the drill stem is small compared to the diameter of the hole and conventional circulation is often inadequate to remove the cuttings. To solve this problem, a system of reverse circulation may be used. With this system the shaft is kept filled with the drilling fluid to a depth sufficient to stabilize the hole. The drilling fluid is then pumped from the hole through the drill stem. In this manner adequate pressure is maintained and cuttings are removed.

Lining

Installation of the shaft lining has presented some problems in both raise and blind drilled shafts. In drilled shafts the lining is installed after completion of the drilling. The lining must be installed in sections and placed in the shaft or men must enter the shaft and construct the lining. Either method requires that the shaft walls be sufficiently stable to allow the hole to stand open throughout the drilling operation. In some shafts a steel lining is used. The steel linings are manufactured in sections. The sections are lowered into the shaft using jacks or the drill's draw works and assembled. This method is limited to small diameter shafts since the weight of the liner requires a very large hoisting system during installation. Once the liner is in place, grout is pumped behind it to seal ground water and to fix the liner in position. This is also a difficult operation since high grout pressures may easily collapse the liner.

Concrete lining may be attempted to avoid some of the problems associated with steel liners. The concrete liner, however, must be placed by men working in the hole. The shaft must first be drilled to its planned depth and the drill tools removed. Suitable hoisting equipment, work decks and forms must be used to construct the liner. An alternative to the concrete lining is the use of shotcrete or gunite. Placement of this type of lining still requires men to enter the shaft although there is less equipment required.

OTHER METHODS

Other attempts to mechanize shaft and slope sinking include the use of tunnel-boring machines to drive a slope for coal mines in Pennsylvania. In these trials a tunnel-boring machine was modified to meet MESA permissibility requirements and was successfully used to bore 17-degree slopes at several western Pennsylvania mines.

Downhole machines function in vertical shafts much as a tunnel-boring machine does in a horizontal opening. The machines advance the shaft by drilling and provide a platform from which the lining may be constructed.

Downhole machines consist of a steel frame which may be secured against the shaft walls by hydraulic jacks. The frame provides support and contains the motors used to power the cutting head. The head containing the cutters is rotated by electric motors and forced against the rock by hydraulic pistons.

Several modified designs of downhole machines have been developed. An early design (Cobbs & Reeder, 1973) developed in 1954 advanced the shaft by cutting a 4-inch-wide kerf around the perimeter of the shaft. This produced a section of rock core up to 3-3/4 feet long which had to be removed. The initial design had a hydraulic thrust of 100,000 pounds and a capacity to drill a 76-inch diameter shaft. The machine was modified to drill a 12-foot diameter shaft by cutting the full face at once. The modification used a pilot hole to remove muck by dropping it to the mine below, much like a raise drill system.

Another full face downhole machine was developed by Dravo Corporation's Zeni-McKinney-Williams Corporation. This machine employed a full shaft diameter face sharply angled to allow cutting to fall in the center. Muck was removed through a 10-inch diameter discharge line. A shaft 17 feet 4 inches in diameter was attempted with partial success with this machine.

III. SHAFT-SINKING EQUIPMENT

INTRODUCTION

As discussed in the previous section shafts may be sunk by conventional excavation or they may be drilled using either raise drilling or blind drilling techniques. When conventional excavation methods are used, men enter the shaft to drill, blast and load, or muck, the broken rock. This method includes the use of a wide variety of machines, many of which present safety hazards to the miners especially when used in the confines of a shaft. Drilling methods are being used with greater frequency to sink shafts because they do not require men to work in the shaft, are generally faster, and are more economical than the conventional techniques.

The following discussion describes the various types of equipment used in shaft-sinking work. The first section will deal with that equipment used in conventional excavation. The later sections will briefly outline the machines used in shaft drilling.

CONVENTIONAL EXCAVATION

Conventional excavation requires a large initial investment in skilled workers and equipment including the extensive surface operation of hoists, headgear, shaft conveyances and ventilation equipment. Additional underground equipment including drills, excavators, forms and work platforms are also needed. All of the equipment must meet requirements of state and federal mine safety laws.

The following sections describe the various types of equipment used in conventional excavation shaft-sinking.

Hoisting Systems

The hoisting system is perhaps the most critical component in conventional shaft excavation. In vertical shafts or steeply inclined slopes, the hoisting system is the sole means of access.

Men and materials are raised and lowered by means of the hoist. The hoist is used to raise the broken rock to the surface for disposal. This vital system must be properly installed and maintained to protect the lives of the miners and to speed progress of the work.

The hoisting system is composed of a number of related machines, the hoist, controllers, rope and sheaves, headgear, and conveyances. Each component is vital to the performance of the system. Other equipment related to the hoisting systems include work decks and winches.

The various types of equipment used in hoisting systems are described in detail in the following sections.

Hoists - Hoists are mechanically driven drums which raise or lower a load by winding in or playing out a length of wire rope.

There are two basic types of hoists in use today -- the friction, or koepe, hoist and the drum hoist. The friction hoist operates by passing a rope around a moving drum, while the drum hoist winds the rope onto a drum where it is stored. The drum-type hoist, driven by an electric motor, is the hoist most commonly found on shaft projects. Power is transferred from the motors through a set of reduction gears and clutch to the hoist drum. The hoist is stopped with a hydraulic brake system acting on the hoist drum. Figure 3 illustrates these two principal types of hoist brakes.

Drums of various diameters are used. Projects visited as part of this study used hoist drums ranging from 26 inches to approximately 8 feet in diameter. In all cases the hoists were substantially mounted on concrete footings and enclosed in temporary shelters for protection.

Controllers - In hoist operations, equipment failure or human error may cause the hoist to raise or lower its load accidentally with excessive speed or to pull the conveyance beyond its landings at the shaft bottom or surface. To prevent such accidents nearly all hoists are fitted with limit controls to protect against overspeed and overwinding. Automatic stop or deadman controls are provided as a protection against failure by the hoistman. The most common types of overspeed/overwind controls used today are the Lilly and Simplex controls manufactured by the Logan Actuator Company of Chicago (Fig. 4). These devices are mounted on the hoist and are gear driven from the hoist drum.

Overspeed controls consist of a fly ball governor and are commonly set to activate when movement of the conveyance exceeds a predetermined speed. In coal mine shafts the maximum speed is set at 575 feet per minute or 15 percent above the maximum man-hoisting speed of 500 feet per minute. In metal and nonmetal mines the controllers are set to 115 percent of an arbitrarily selected speed. When this speed is exceeded, the controller automatically cuts power to the hoist and applies the brakes.

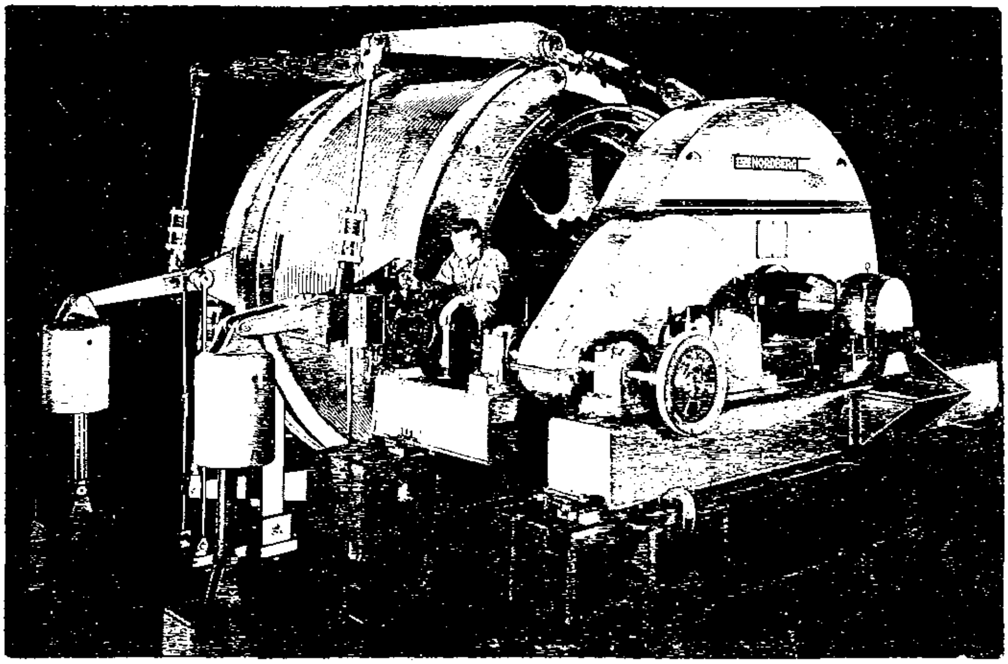
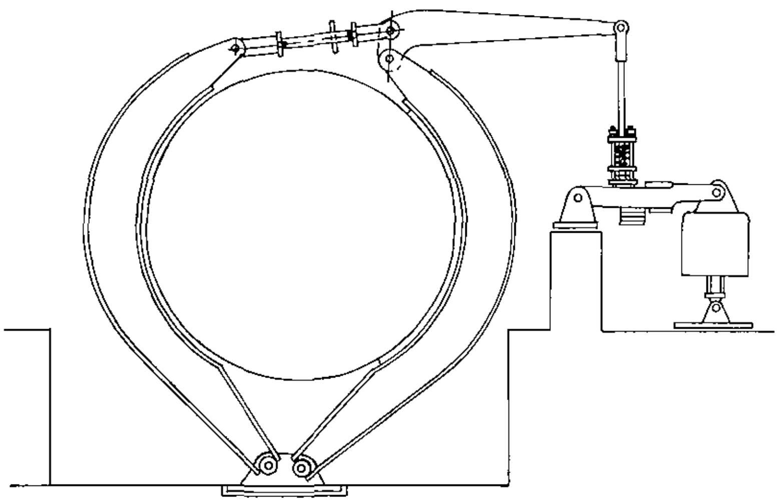
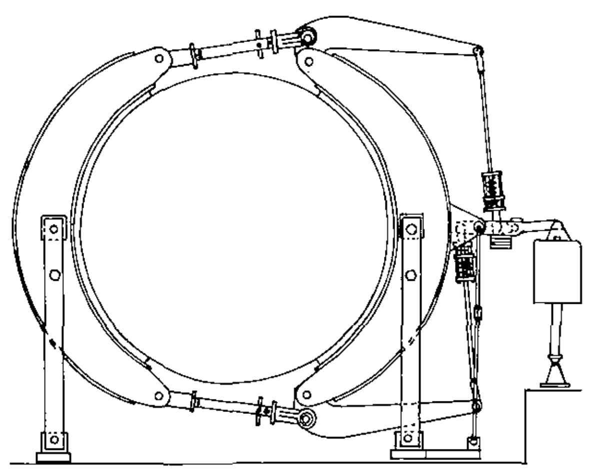


FIGURE 3A
SINGLE DRUM
HOIST



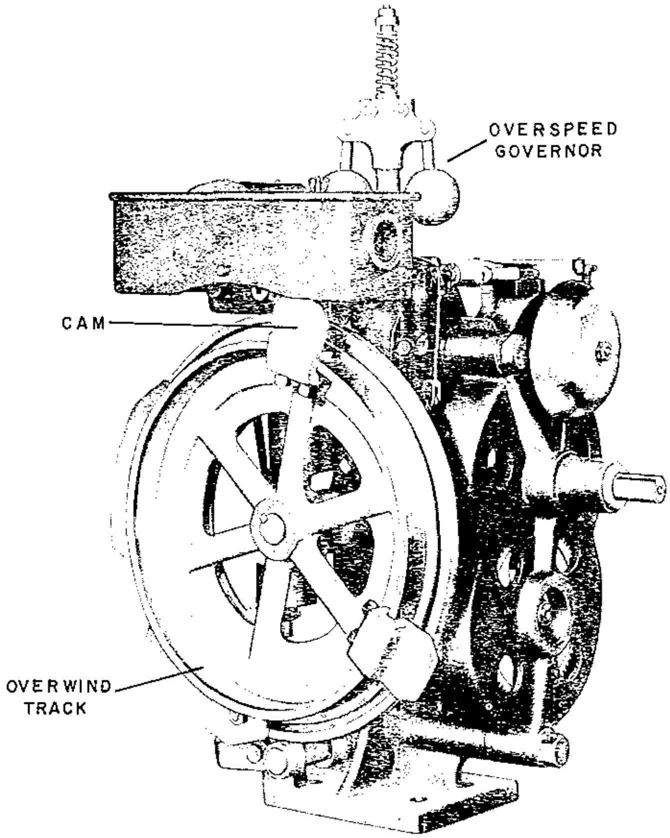
NORDBERG UNIFORM PRESSURE
JAW BRAKE

FIGURE 3B
HOIST BRAKE SYSTEMS

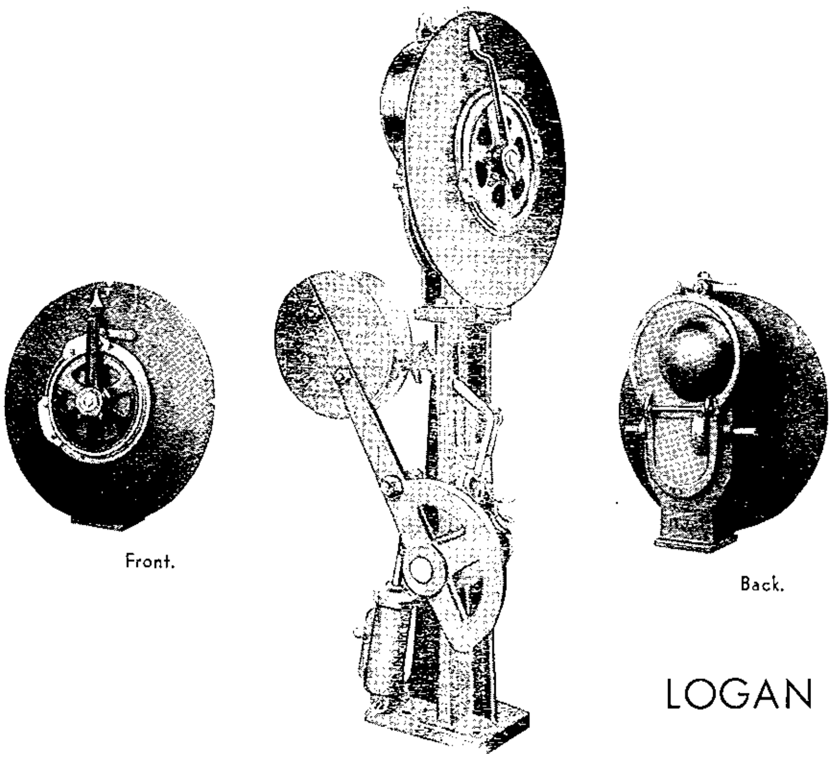


NORDBERG PARALLEL MOTION BRAKE

COURTESY OF NORDBERG MACHINERY GROUP
REXNORD, INC.



LOGAN - LILLY MODEL D
HOIST CONTROLLER



LOGAN SIMPLEX CONTROLLER

COURTESY OF LOGAN ACTUATOR COMPANY

FIGURE 4

Overwind and underwind controls are designed to prevent the conveyance from being moved vertically in the shaft beyond preset upper or lower limits. In shaft-sinking work the underwind or bottom limit is usually omitted since the shaft depth changes often and would require frequent control adjustments. Safety under these conditions depends on the alert operator and an accurate depth indicator. The overwind or upper limit control is nearly always used.

The wind controllers consist of a moveable circular metal track and fixed contact. A wedge-shaped cam is fitted on the circular track at a point which coincides with the desired upper limit of hoist travel. As the conveyance is raised, the circular track rotates beneath the fixed contact point. When the conveyance nears the desired stopping point, the track's rotation moves the cam under the contact point causing the contact to rise. Movement of the contact halts the hoist drum by cutting power and applying the brakes (Fig. 4).

The controller is not used routinely to stop the hoist, rather, it is designed as an automatic system to stop the conveyance should the hoistman exceed normal speeds or limits of travel.

<u>Rope</u> - Wire rope, connecting the hoist and conveyance, is the critical component of the hoisting system. Proper selection, installation and maintenance of the rope is essential if it is to perform satisfactorily and safely. The following terms are used to describe the component parts of a rope and are necessary to an understanding of rope construction and performance:

Wire - The basic element of a wire rope is a single metallic wire. It may be either round or shaped.

Center - The center is the axial member of a strand about which the wires are laid. It may be cotton or polypropylene fiber or one or more wires.

Strand - A strand is a plurality of round or shaped wires helically laid around a center in one or more layers.

Core - The core of a wire rope is the axial member around which the strands are laid to form a wire rope. It may be either steel, natural fibers, or polypropylene.

Rope - A number of strands laid helically around a core form a rope.

Figure 5 illustrates the construction of a typical wire rope.

Standards for the installation and use of wire rope are established by American National Standards Institute (ANSI) Specification M11.1-1960, "Specifications for Use of Wire Rope in Mines". This publication is cited in current federal regulations as the accepted standard for use of wire rope. Among the factors which must be considered with respect to rope construction and diameter is the diameter of the hoist drum and sheaves, the fleet angle, and the factor of safety. ANSI standards specify the proper ratio of rope diameter to sheave and drum diameter for most common types of wire rope. This ratio is important since it determines the amount of bending imposed on the rope when it is wound on the hoist drum or when passing over the sheaves. Excessive bending damages the rope core and wires, and leads to early rope failure.

The fleet angle is the angle between the position of the rope at the extreme end wraps on the drum, and a line drawn perpendicular to the axis of the drum through the center of the nearest fixed sheave (Fig. 6). This angle is extremely important as it has a direct bearing on the way the rope winds on the drum. Improper winding of the rope leads to excessive wear and early failure.

The factor of safety is perhaps the most important consideration in the selection of rope for a specific purpose. The following table lists the required factors of safety for ropes in mine hoisting.

	Factors of Safety	
Mine Shafts	Minimum for New Rope	Minimum Allowed Rope Must Be Retired
Depths to 500 feet	8	6.4
Depths of 500-1000 feet	7	5.8
Depths of 1000-2000 feet	6	5.0
Depths of 2000-3000 feet	5	4.3
Depths of 3000 feet or more	4	3.6

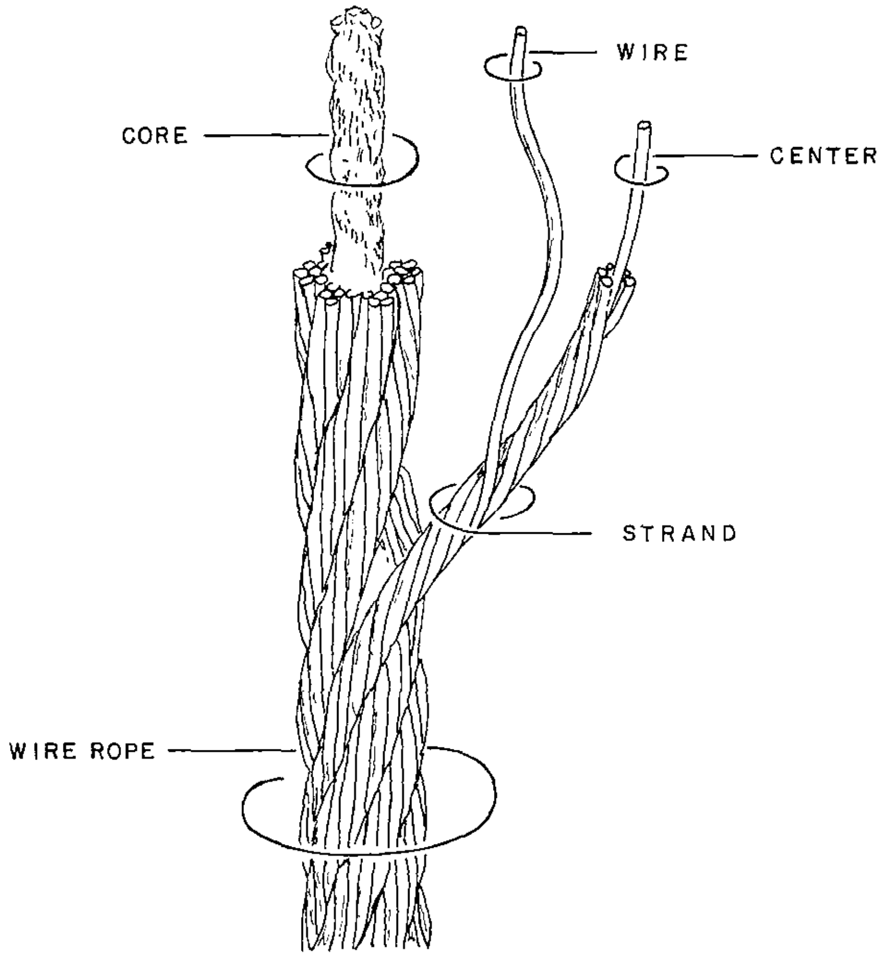


FIGURE 5
WIRE ROPE CONSTRUCTION

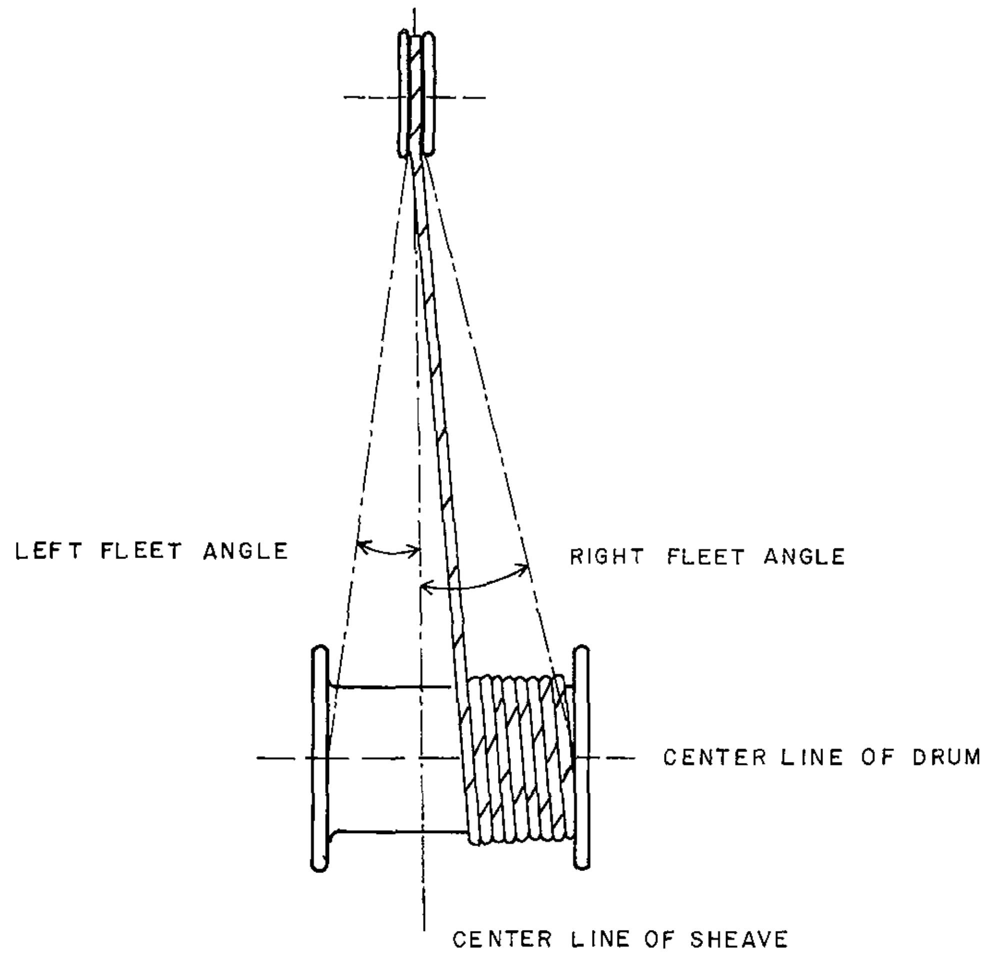


FIGURE 6
FLEET ANGLE

The factor of safety is calculated using the formula:

$$\text{Factor of Safety}^* = \frac{\text{Nominal Breaking Strength of Rope}}{\text{Maximum Weight of Conveyance} + \text{Maximum Weight of Suspended Rope}}$$

Headgear - The headframe (Fig. 7) supports the main sheave for the hoist rope and may be used to support other ropes for winches or form hoists. The headframe may also contain a dump chute into which muck buckets are emptied. On most United States shaft projects a temporary headframe is used while the shaft is being sunk. This temporary headframe is replaced with a permanent headframe upon completion of the project, and is moved to other job sites as needed. The temporary sinking headframe is a steel structure of varying size. Sinking headframes in use at the sites visited in this study ranged from approximately 50 to 80 feet in height. There are several designs of sinking headframes. One type is designed to be erected directly over the shaft collar allowing the hoist rope to pass through the center of the headframe. Another type is designed to be erected adjacent to the shaft with the main sheave mounted as a cantilevered beam over the shaft.

Other types of headgear may be used in the hoisting system in addition to sinking headframes. During initial stages of shaft excavation, truck-mounted cranes may be used for mucking and access. These cranes are moved away from the collar to prevent damage from fly rock when blasting. The cranes may be used solely for mucking when no men are in the shaft. If they are used to transport men they must be fitted with overspeed and overwind safety devices.

Several contractors or mine operators sink shafts using stiff leg derricks or tower cranes as headgear. These devices may be used alone or in conjunction with a headframe. The stiff leg derrick is used in conjunction with a conventional drum hoist placed in a hoist house behind the derrick and fitted with suitable brakes and limit controls. The tower crane is the type commonly used on civil construction projects. It is also fitted with safety devices including an automatic control to cut the hoist power if the operator attempts to lift a load greater than a preselected limit.

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*Source: ANSI Specification M11.1-1960, page 31.

Both the stiff leg derrick and tower cranes have the ability to swing their loads away from the shaft collar. In this way it is not necessary to load men or materials or dump muck over the shaft collar.

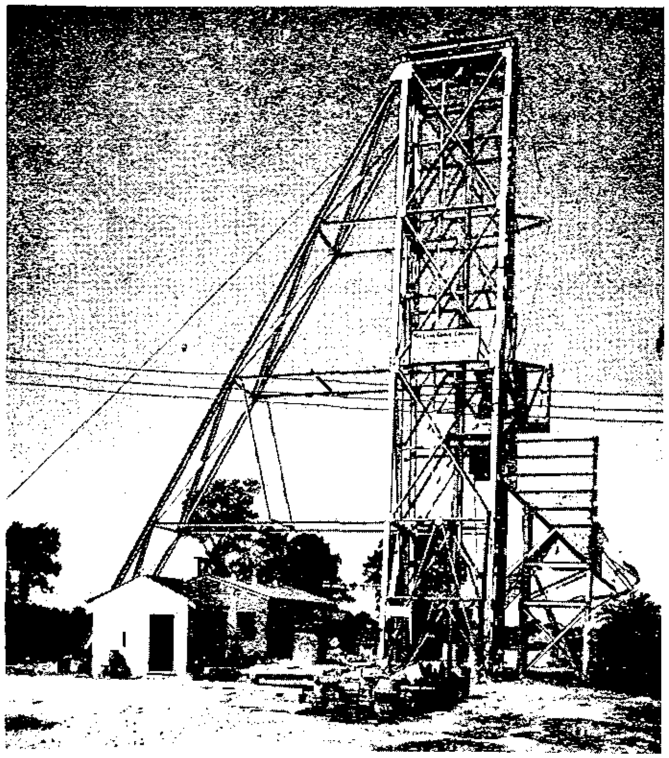
Platforms - Platforms, work decks, or Galloway stages of various types are commonly used in shaft projects to provide an area for construction of the shaft lining or while installing service lines.

Single-deck platforms are commonly used as a temporary stage while placing concrete. This type of deck consists of several sections of wood or steel mats which are jacked against the concrete forms. Once the concrete is placed, these platforms are freed and pulled from the shaft.

More elaborate multi-deck Galloway stages remain in the shaft during the entire sinking operation (Fig. 8). In the United States the most common type of stage consists of one to three decks. Since the platforms remain in the shaft they are fitted with wells to allow passage of muck buckets and supplies. The platforms are suspended by ropes mounted on hoists at the surface. Commonly, two hoists and ropes are used. The rope may be rigged as a single-part line, in which each rope extends to the bridle chains supporting the stage. Other stages are suspended using a two-part line system. In this case each support rope extends from the hoist through a sheave at the shaft collar or headframe, over two sheaves on opposite ends of the work deck, and back to a deadend connection on the shaft collar. Although some types of mucking machines may be suspended from the stage, this practice is not common in the United States. It is common, however, to use the stage to free and transport steel lining forms.

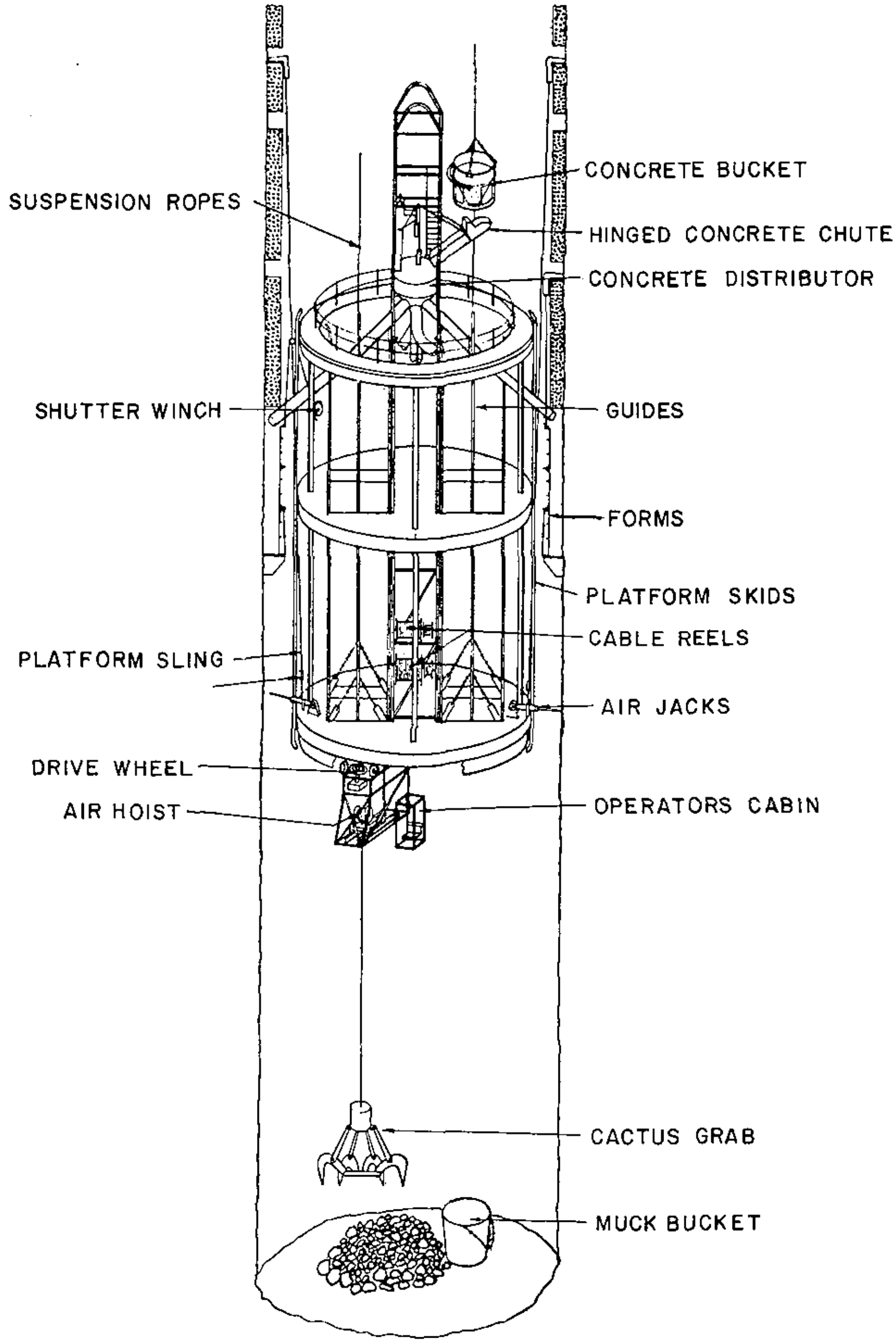
In sinking the extremely large and deep shafts in South Africa large Galloway stages are commonly used. The top deck provides overhead protection for the workmen. Intermediate decks are used to install concrete forms, pour concrete, and/or install service lines. The bottom deck may be used to suspend a cactus grab or similar mechanical mucking device. These large stages may be more than 70 feet high and weigh more than 70 tons (Rood & Upton, 1968).

Buckets - In shaft-sinking operations the muck bucket (Fig. 9) is the all-purpose conveyance for handling debris, supplies and men. The buckets may range in capacity from approximately 2 to 8 cubic yards. They are hung from the main hoist rope in either of two basic methods. They may be attached by a system of three bridle chains located at 120-degree intervals around the bucket rim, or they may be suspended by a bail which is mounted on the bucket sides or bottom and allows the bucket to be tipped to dump muck.



COURTESY OF ELGOOD MAYO CORP.

FIGURE 7
SINKING HEADFRAME



AFTER JAMIESON, PEARSE, AND PLUMSTEAD, 1961

FIGURE 8
MULTI-DECK STAGE

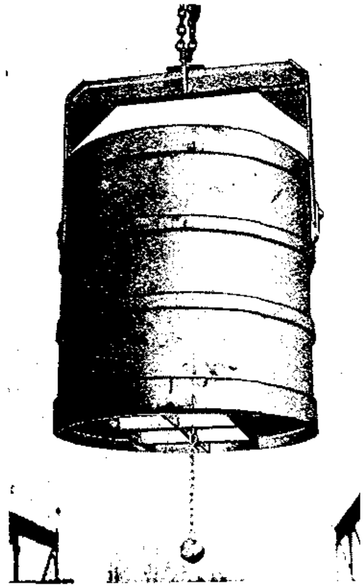


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FIGURE 9
MUCK BUCKET

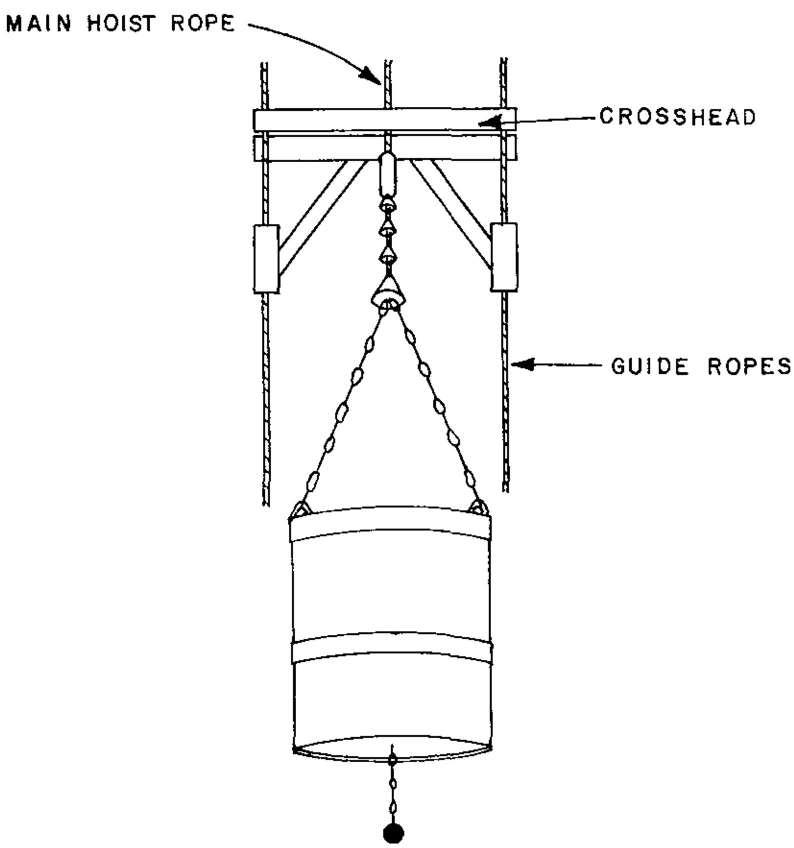


FIGURE 10
CROSSHEAD

When men are transported in the bucket, an additional system of safety chains is required. These chains must be securely fastened to the hoist rope at least 3 feet above the bucket attachment.

Crossheads, Safety Catches, and Guides - Crossheads are commonly used in conjunction with rope guides to prevent buckets from swinging or spinning while being hoisted. The crossheads are steel structures that ride on platform suspension ropes and are designed to lock onto the main hoist rope at the bucket attachment to provide stability for the bucket (Fig. 10).

Included in crossheads are safety catches which are designed to engage and halt the bucket in the event the main rope becomes slack or fails. Such safety catches are not required by current federal regulations on buckets used in shaft-sinking work. They are, however, regularly used on cages and skips at producing mines. In producing mines the conveyance rides on a wooden or steel guide which provides a satisfactory medium for engaging the safety catches. In shaft-sinking work fixed guides are not used and the crossheads must ride on rope guides.

Several contractors use a temporary line as a shaft guide. These operators do not use a work deck and do not have guide ropes available. Their system consists of a weight, generally a 5-gallon bucket filled with concrete, hung from a small diameter rope on a tugger hoist. This weight is lowered to the shaft bottom and serves as a guide rope. Men in the bucket secure a rope sling around the guide rope and either secure the sling to the bucket or hold it by hand.

Winches - In addition to the main hoist and work deck hoists, small air winches (tuggers) are commonly used. These winches are used for a variety of tasks, including as an emergency escape system if power to the main hoist fails. They are also employed to lower concrete slicklines, remix chambers, and handle concrete forms and steel ventilation tubing. One contractor employs a set of four tugger winches at the collar to move his sliding steel shaft cover and to move a clamshell mucker on the shaft bottom.

Drilling Equipment

Drilling of holes for blasting is done with pneumatic percussion drills, either hand-held sinker drills or mounted on a shaft drill jumbo.

Sinker Drills - The hand-held jackhammers or sinker drills (Fig. 11) range in size and weight from approximately 25 to 80 pounds. The drills operate on an air pressure of approximately 100 pounds per square inch and use between 100 and 200 cubic feet per minute (Morrell and Unger, 1973). Hand-held drills require the successive use of multiple lengths of drill steel, generally a sequence of 2-, 4-, 6-, 8-, and 10-foot lengths to achieve the desired depth. In drilling the 80 to 100 holes used in each blasting round, four or five miners are required to work on the bottom at once.

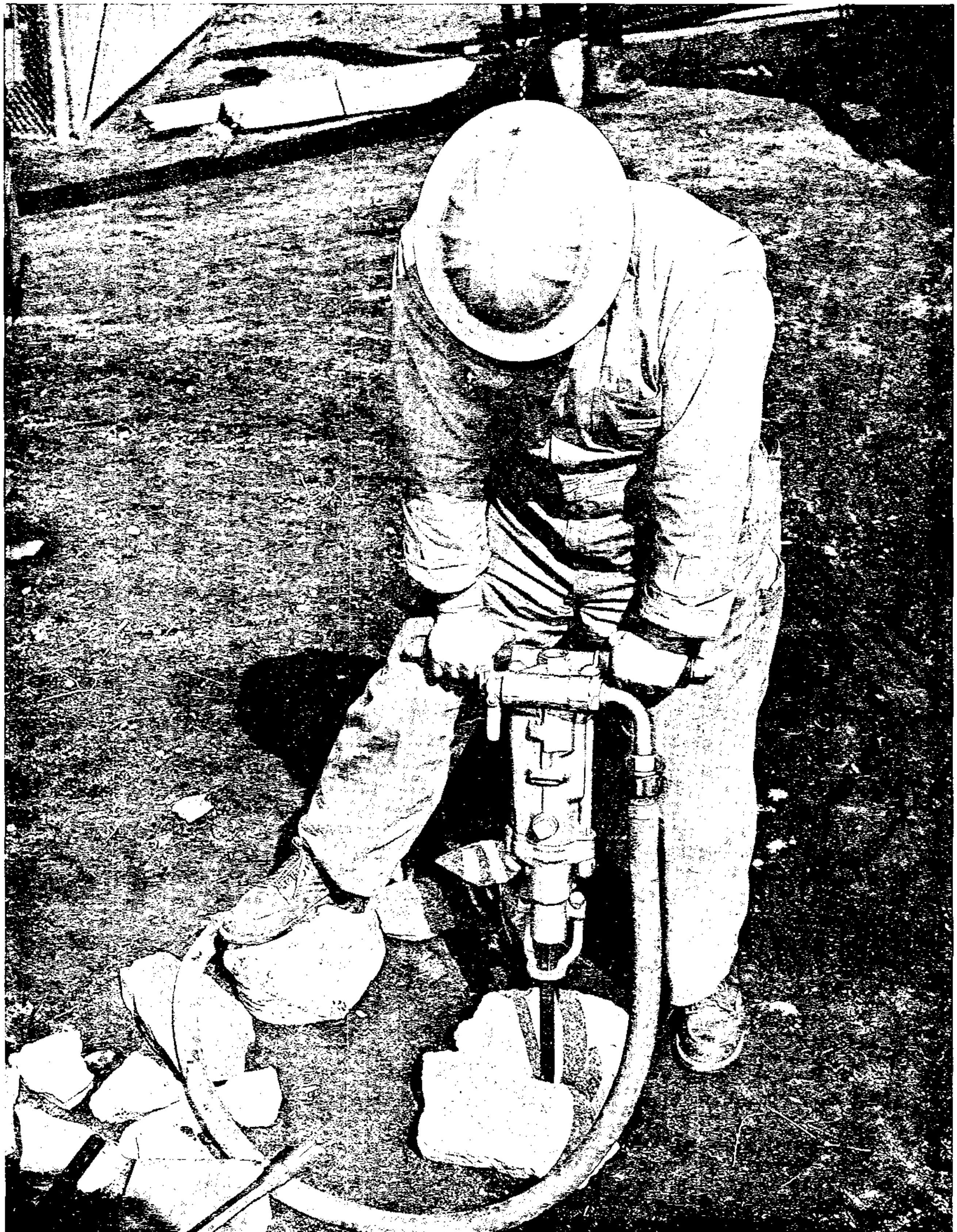
Drill Jumbo - Jumbos are frames upon which several drills may be mounted (Fig. 12). The drills are mounted on hydraulically or pneumatically operated arms which may be positioned as needed to drill various patterns. Shaft drill jumbos offer several important advantages over hand-held drills. The frames provide greater control of the drills and allow the use of a single length of drill steel to drill each hole, and the jumbo mount allows the use of longer drills than the hand-held (Fig. 13). These drills operate at approximately 100 pounds per square inch pressure but require a greater volume of air than the sinker drills.

In addition, one miner can operate several drills when using the shaft drill jumbo. This reduces congestion and the likelihood of accidents. The jumbos also allow greater control on the shape and depth of the pattern but require a longer period to set up in the shaft.

Mucking Equipment

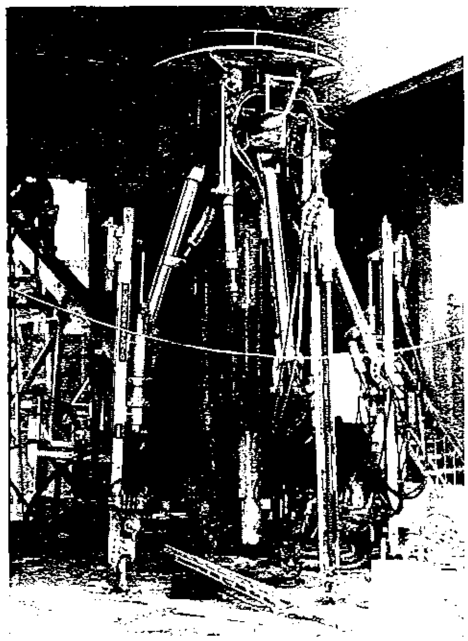
Mucking, or the removal of broken rock, is entirely mechanized in the United States and Canada. Some hand mucking is still found in South Africa where a large supply of cheap, unskilled labor is available. Mechanical mucking equipment is commonly hydraulic or pneumatic. Generally, the machines being used are either a form of clamshell suspended from the working platform or set into the wall, or are crawler-track, bucket loader machines which move on the muck pile itself. Some of the more popular machines are discussed in the following paragraphs.

Eimco 630 - The Eimco 630 is a small, air-operated, crawler-track bucket loader manufactured by the Eimco Mining and Tunneling Machinery Division of the Envirotech Corporation (Fig. 14). The machine is approximately 5 feet 8 inches wide, 4 feet 11 inches high, and 9 feet 5 inches long. The length and height may vary with different bucket sizes and bucket positions. The complete machine weighs 10,000 pounds.



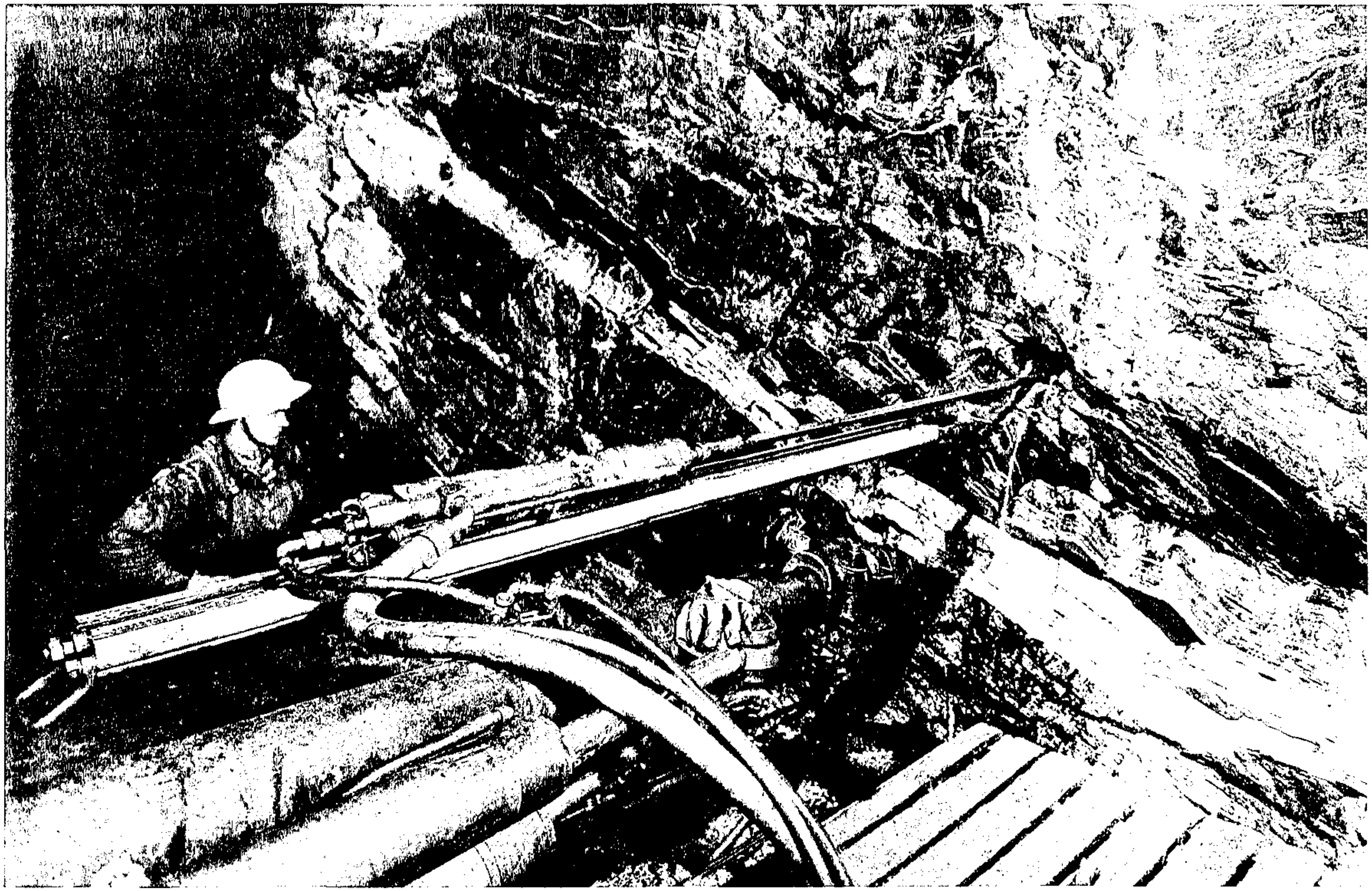
COURTESY OF GARDNER-DENVER COMPANY

FIGURE 11
SINKER DRILL



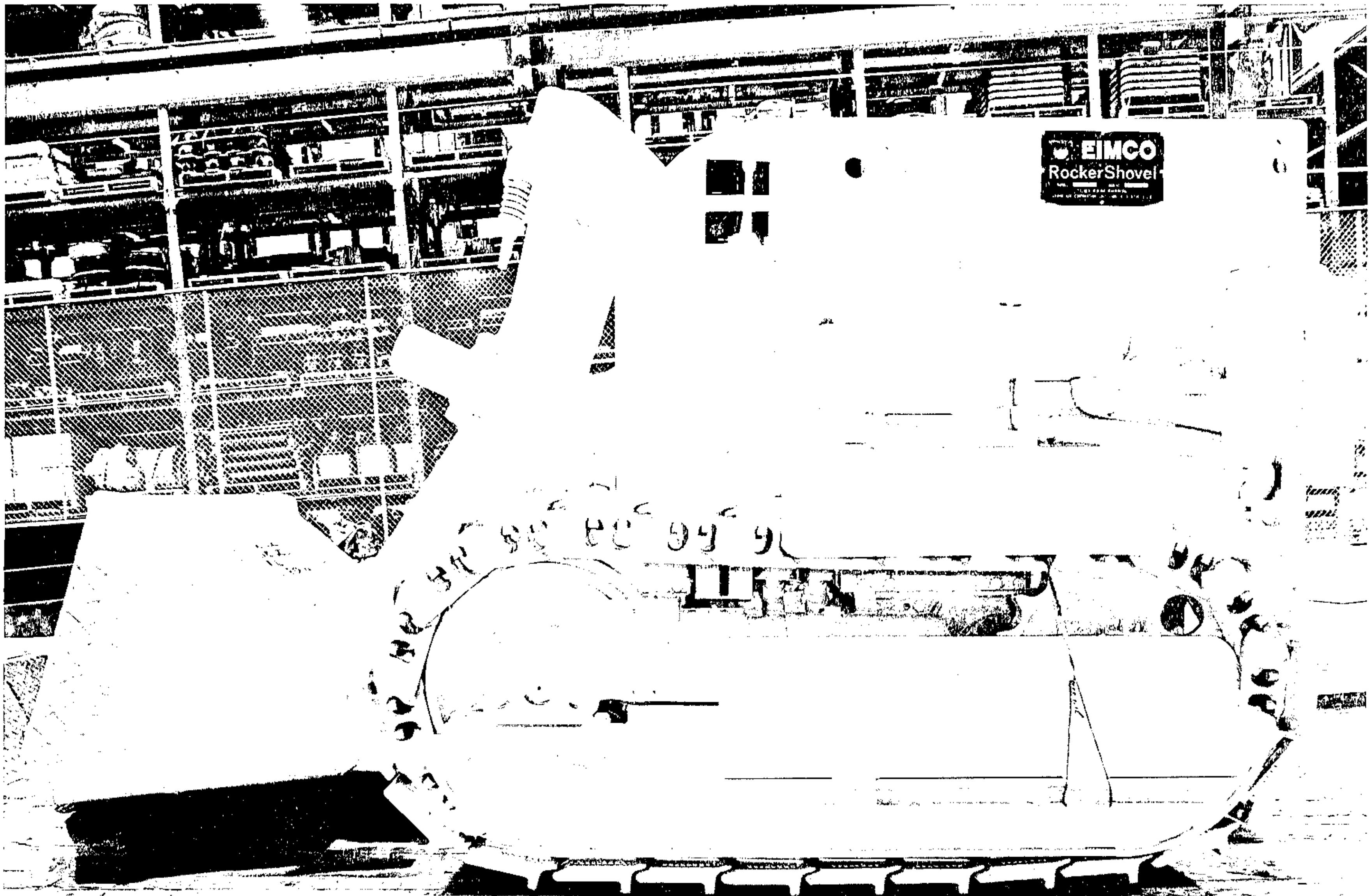
COURTESY OF MITSUI CONSTRUCTION COMPANY

FIGURE 12
SHAFT DRILL JUMBO



COURTESY OF GARDNER-DENVER COMPANY

FIGURE 13
GARDNER DENVER MODEL C-260 JUMBO MOUNTED DRILL



COURTESY OF THE EIMCO MINING AND TUNNELING MACHINERY DIVISION, ENVIROTECH CORP.

FIGURE 14
EIMCO MODEL 630 EXCAVATOR

Several bucket sizes are available, from 5-1/2 to 9 cubic feet. The machine operates on an air pressure of 90 pounds per square inch obtained through a 2-inch bull hose. This machine requires an operator and a helper to tend the bull hose. While its production rate is slightly lower than that of grab devices it has the advantage of being able to crowd into the muck pile for efficient loading and is capable of cleaning even minor amounts of muck at the end of a loading cycle. This machine has presented a safety hazard when improperly used. To simplify operation, miners have removed the track control centering spring. This increases the chance of injury if the operator is thrown from the control step. Multiple control levers are being replaced on newer models with single "wobble stick" control.

Clamshell - Clamshells may be used from a surface-mounted crane or adapted for use at the bottom of the shaft. One contractor uses a small clamshell operated by two air winches (tuggers) mounted on the surface. The clamshell is operated from the shaft bottom by a miner using a button box control. The clam is swung by two other miners using tag lines. This system is reported to be fast and eliminates the problem of a mucker riding on the muck pile. However, the clam's suspension ropes are easily damaged, and the system is reported to present a hazard when the ropes become worn.

Backhoes - Backhoes (Fig. 15) in several forms have been used on United States shaft projects with limited success -- their main disadvantage being a relatively low production rate. For several current projects, backhoes have been modified from hydraulic to air operations to meet permissibility requirements. The machines are either hung from the surface or a work deck, or are mounted on the rib. They remove the operator from the bottom and provide better visibility.

Cryderman Muckers - This air-operated machine has a positive, opening-and-closing, clamshell-type bucket (Fig. 16). The machine weighs approximately 5 tons and may be more than 40 feet long. It may be either hung vertically in a shaft or mounted on small rail cars in slopes. The operator works from a control panel on the working stage. This machine has the advantage of positive closing allowing it to dig into the muck for better loading. It can also be used near the end of the mucking cycle when little material remains in the shaft. The machine is somewhat difficult to control and requires an experienced operator.

Cactus Grab - The cactus grab or orange-peel is a multi-leaved clamshell-type machine suspended from either a centrally pivoted boom hung below the work stage or on hydraulic booms mounted on inserts placed into the shaft lining (Fig. 17). The operator controls the machine from a cage suspended from the work stage or from a remote control box at the shaft bottom. The cactus grab works well in circular or elliptical shafts. It has a high production rate and has been used with much success in South Africa. Since the machine is swung or cast to load, there is some hazard for miners working on the bottom.

Riddell Mucker - This machine is similar to a cactus grab and consists of a small clamshell bucket hung from a bridge below the work stage. Figure 18 illustrates the Riddell Mucker.

Load-Haul-Dump (LHD) Tractors, Front End Loaders - Diesel-powered, rubber-tired equipment has been used successfully in several United States slope projects. The equipment is self-propelled, thus eliminating the need for track, air hoses or power cables (Fig. 19). The machines are equipped with buckets with capacities ranging from approximately 2 to 8 cubic yards.

The use of diesel equipment presents a ventilation problem. Air quantities must be increased to remove toxic or objectionable exhaust fumes. The permissibility certificate granted each piece of diesel equipment specifies the quantity of air required. The total quantity of air required when using multiple pieces of diesel equipment is the sum of the ventilation requirements of each machine (30 CFR Sections 31.9 and 32.9).

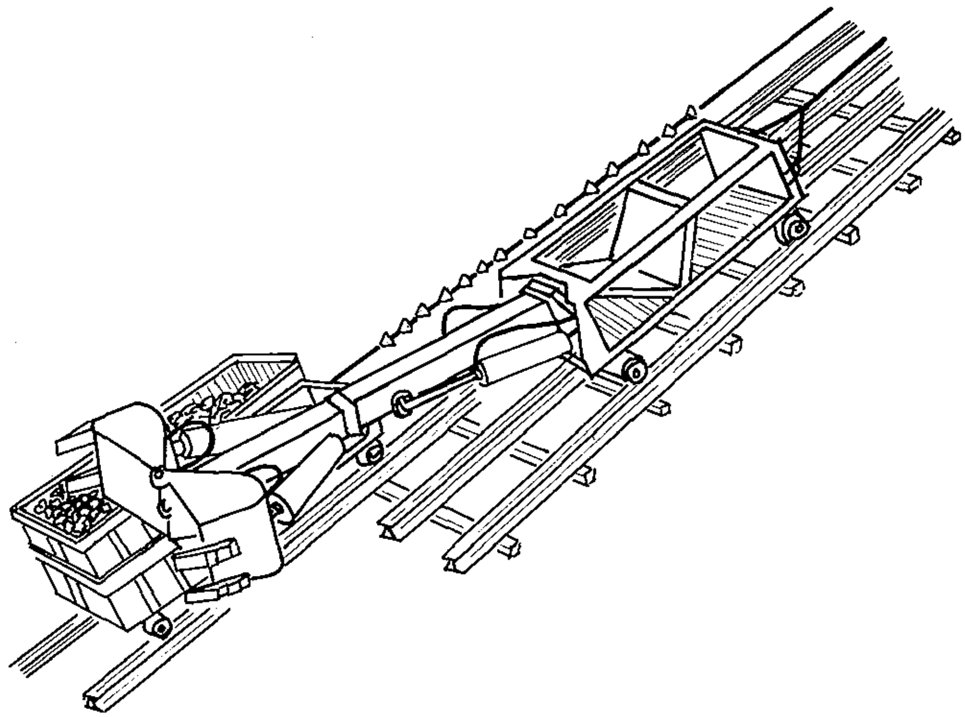
Other disadvantages to the use of diesel equipment are a limited tram distance and the need for an assist hoist for pulling the tractor up slopes steeper than approximately 12 to 15 degrees. The assist hoist, however, need not have a certified hoistman nor meet man-hoisting requirements. Safety controls are provided by having the tractor operator ride the machine and apply the brakes as needed.

Fans

Ventilation in the shafts is provided by surface-mounted fans. The most common type seen during the project were Joy Axivane fans with 24- to 36-inch diameters. The fans are electrically powered and are mounted in 24- to 36-inch-diameter steel tubing. As required by federal regulations, the fans are offset at least 15 feet from the shaft collar. The fans produce approximately 6,000 to 10,000 cubic feet per minute of air at the end of the tubing, depending on motor size and length of tubing.

COURTESY RAISE EQUIPMENT COMPANY

FIGURE 15
BACKHOE

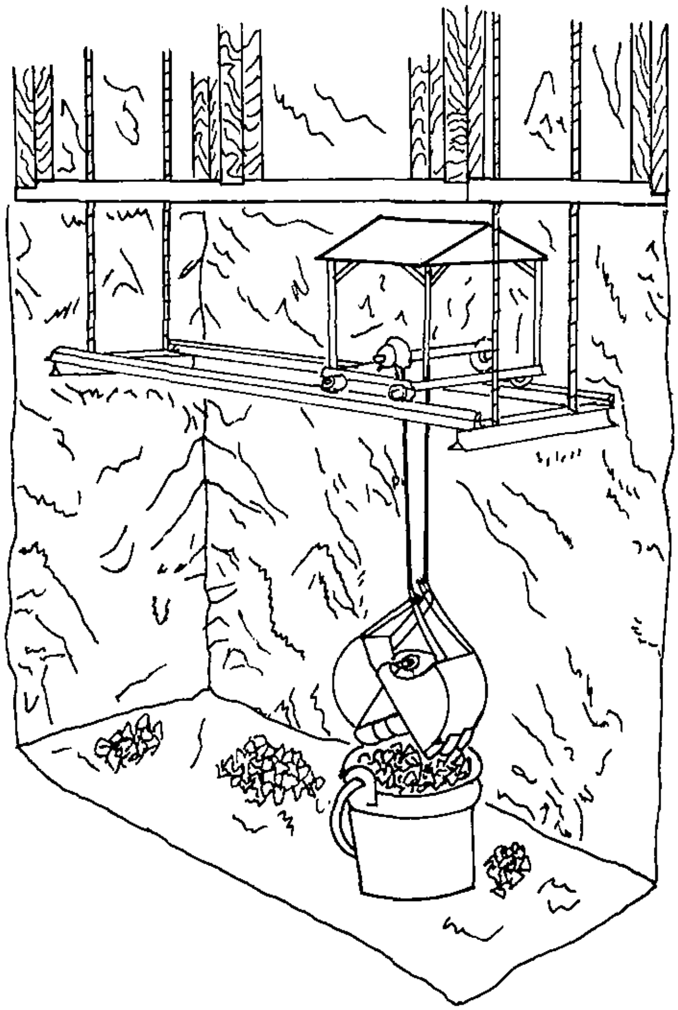


AFTER STEVENS, V.L., SHAFTING SINKING AND RAISING BY CONVENTIONAL METHODS; SME-ME HANDBOOK, AIME, 1973.

FIGURE 16
CRYDERMAN MUCKER

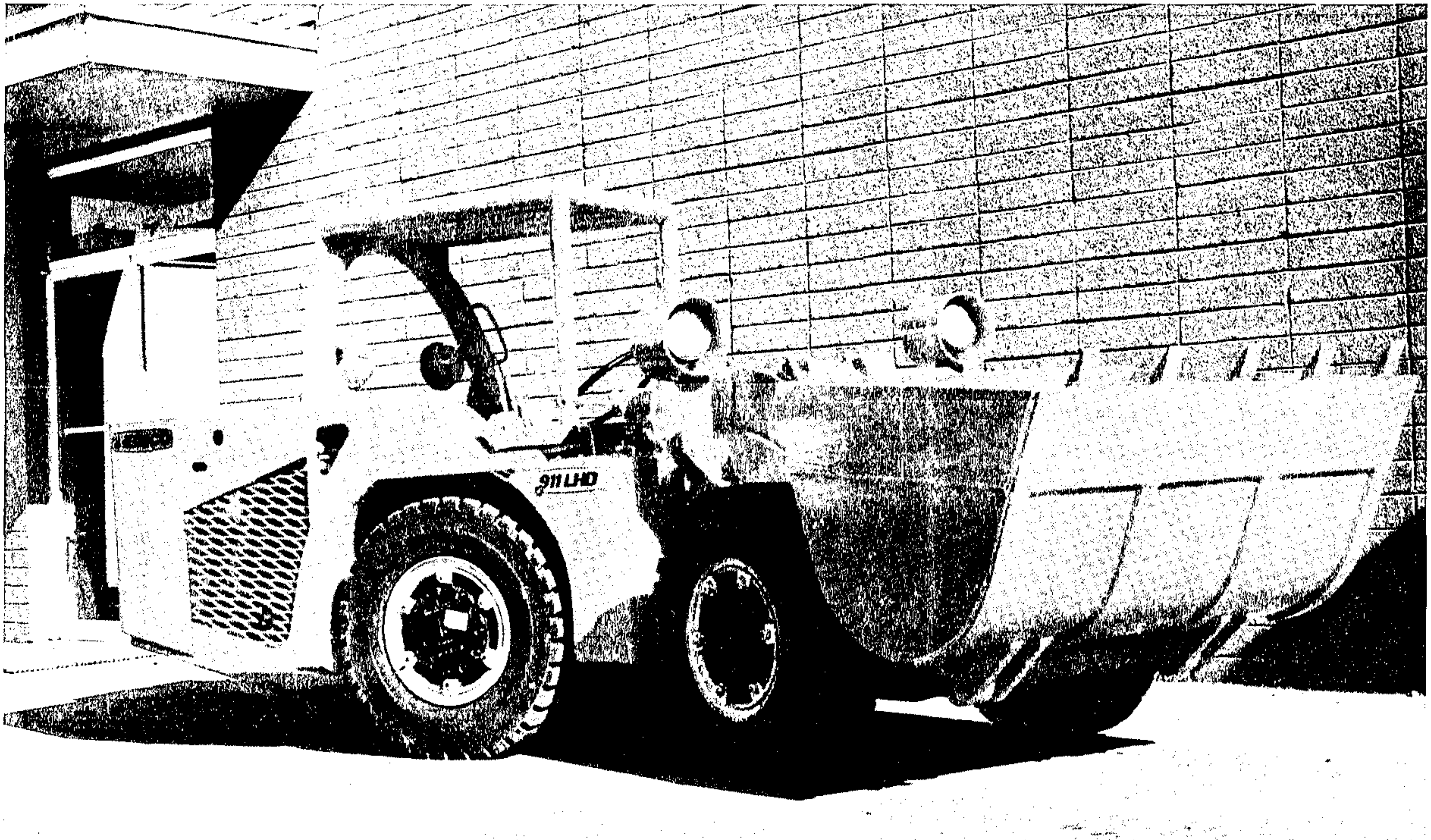
COURTESY OF MITSUI CONSTRUCTION COMPANY

FIGURE 17
CACTUS GRAB



AFTER STEVENS, V.L., SHAFTING SINKING AND RAISING BY CONVENTIONAL METHODS; SME-ME HANDBOOK, AIME, 1973.

FIGURE 18
RIDDELL MUCKER



COURTESY OF THE EIMCO MINING AND TUNNELING MACHINERY DIVISION, ENVIROTECH CORP.

FIGURE 19
LOAD-HAUL-DUMP (LHD) EXCAVATOR

DRILLED SHAFTS

The current trend in shaft-sinking technology is toward increased use of drilling machines to bore shafts. The following sections describe the various types of equipment used in drilling shafts.

Raise Drilling

Raise drilling is currently the most common method for drilling shafts. It is fast and requires relatively few men and equipment. Equipment used in raise drilling is relatively simple and may be broken down into components designed for easy handling.

Raise Drills - The drilling machine (Fig. 20) consists of an electric motor to turn the drill stem and a hydraulically operated frame to raise or lower the bit. Several manufacturers, among them the Robbins Company, Subterranean Tools, Inc. and Hughes Tool Company, make raise drills in a variety of sizes. Smaller machines are capable of drilling 2- to 3-foot-diameter raises 500 feet long, larger units are capable of shafts 18 feet in diameter more than 2500 feet long according to the manufacturers' specifications. The equipment is relatively simple to install and may be operated by one man.

Drill Stem - The drill stem consists of hollow steel pipe which transfers the vertical and rotational motion of the drill to the bit. The drill stem is commonly comprised of 5-foot long sections of hollow pipe, 11 to 13 inches in diameter.

Bit - The bit (Fig. 21) is a multi-layered steel assembly fitted with multiple cutters. The bit or head may be built-up as needed by the addition of sections to increase its diameter.

Cutters - The actual cutting of the rock is accomplished with roller-type cutters as illustrated in Figure 22. Differing designs are used, depending on the rock hardness. The most common types are the milled tooth, disk, kerf, and carbon insert button cutters.

Blind Drilling

Blind drilling is the development of large diameter holes from the surface. The method does not require prior access through an existing mine to the shaft bottom.

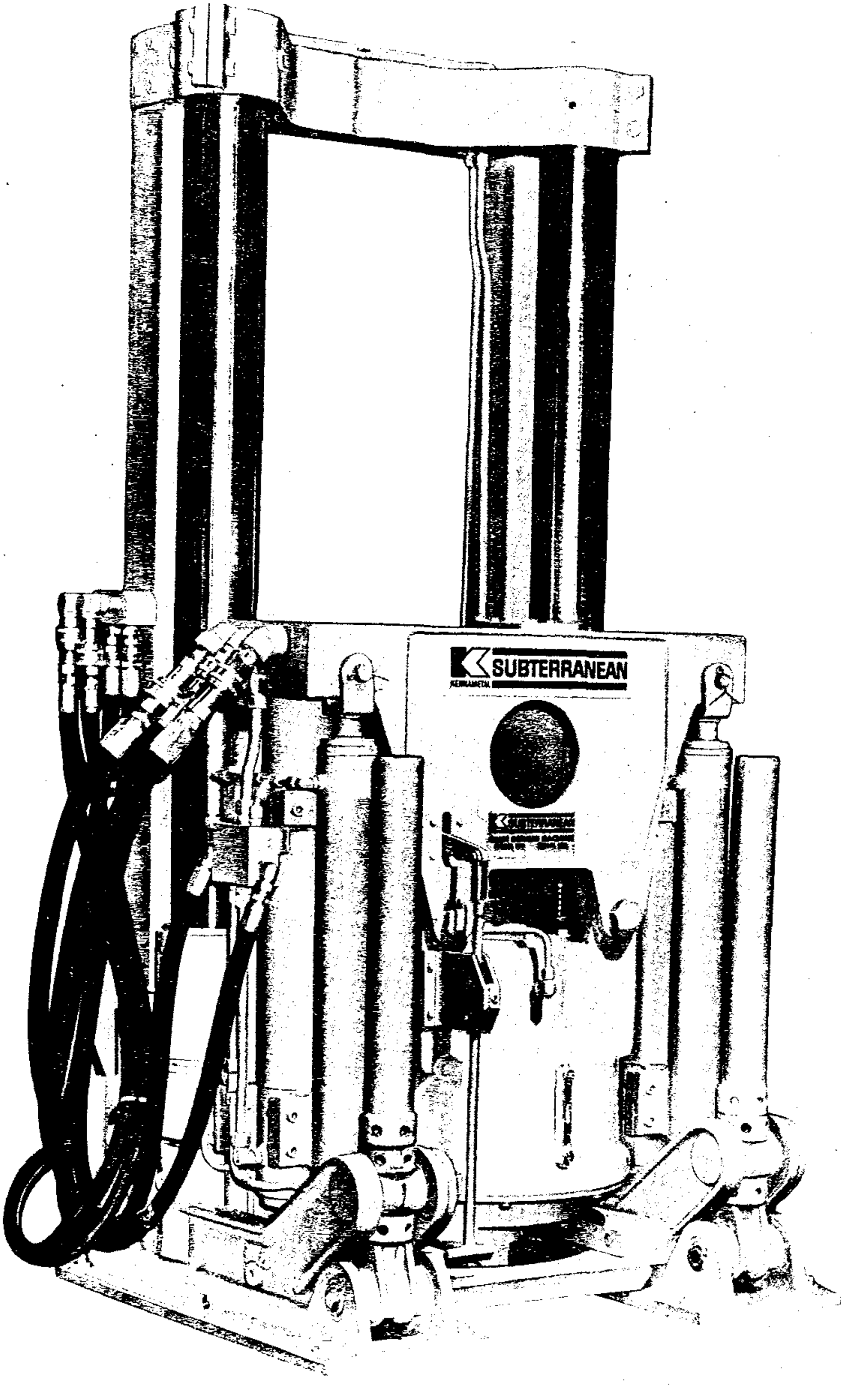
Drilling Machine - The equipment and procedures used in blind drilling are basically modifications of oil well drilling techniques. The drilling machines used in blind drilling shafts are commonly standard oil well drilling machines. Minor modifications may be made to the platform to handle large cutting heads but the drive motors, derrick and draw work are unchanged. Recently, several models of large raise boring machines have been developed which may be converted to blind drilling (Fig. 23).

Bit - The drilling tools include the equipment used in the shaft to cut the rock and stabilize the hole. Actual cutting is done with cutters of the types shown on Figure 22. Depending on the nature of the rock to be drilled the cutters may be milled tooth, disk, kerf or tungsten carbide button insert types. The cutters are mounted on a large circular bit or head. Figure 24 shows a type of shaft drilling head or bit.

Mandrel - The bit is fitted to the end of a large, heavy mandrel (Fig. 25) which provides weight to aid cutting. A stabilizer (Fig. 26) aids in centering the drill stem in the shaft. The mandrel's weight may be increased by the addition of large steel weights.

Drill Stem - The drill tools are connected to the drilling machine using drill stem pipe. The drill stem is hollow to allow passage of the drilling fluid. The drilling fluid serves the dual functions of cooling the cutters and removing the cuttings. The fluid may be water, air, mud, foam or a water and compressed air mix. The fluid aids removal of cuttings from the bits and transports them to the surface.

The removal of the cuttings has been a major obstacle to the development of blind drilling operations. In conventional drilling work the drill stem is relatively large in comparison to the hole diameter. This allows the drilling fluid to be pumped into the hole through the hollow drill stem and back to the surface through the small annular space between the drill rods and rock wall. The fluid is tightly confined and adequate pressures are maintained to easily lift the cuttings to the surface. In blind drilling, however, the drill stem is small compared to the diameter of the hole and conventional circulation is often inadequate to remove the cuttings. To solve this problem a system of reverse circulation is used. With this system the shaft is kept filled with the drilling fluid to a depth sufficient to stabilize the hole. The drilling fluid is then pumped from the hole through the drill stem. In this manner adequate pressure is maintained and cuttings are removed.



COURTESY OF KENNAMETAL, INC.

FIGURE 20A
RAISE DRILL MACHINE

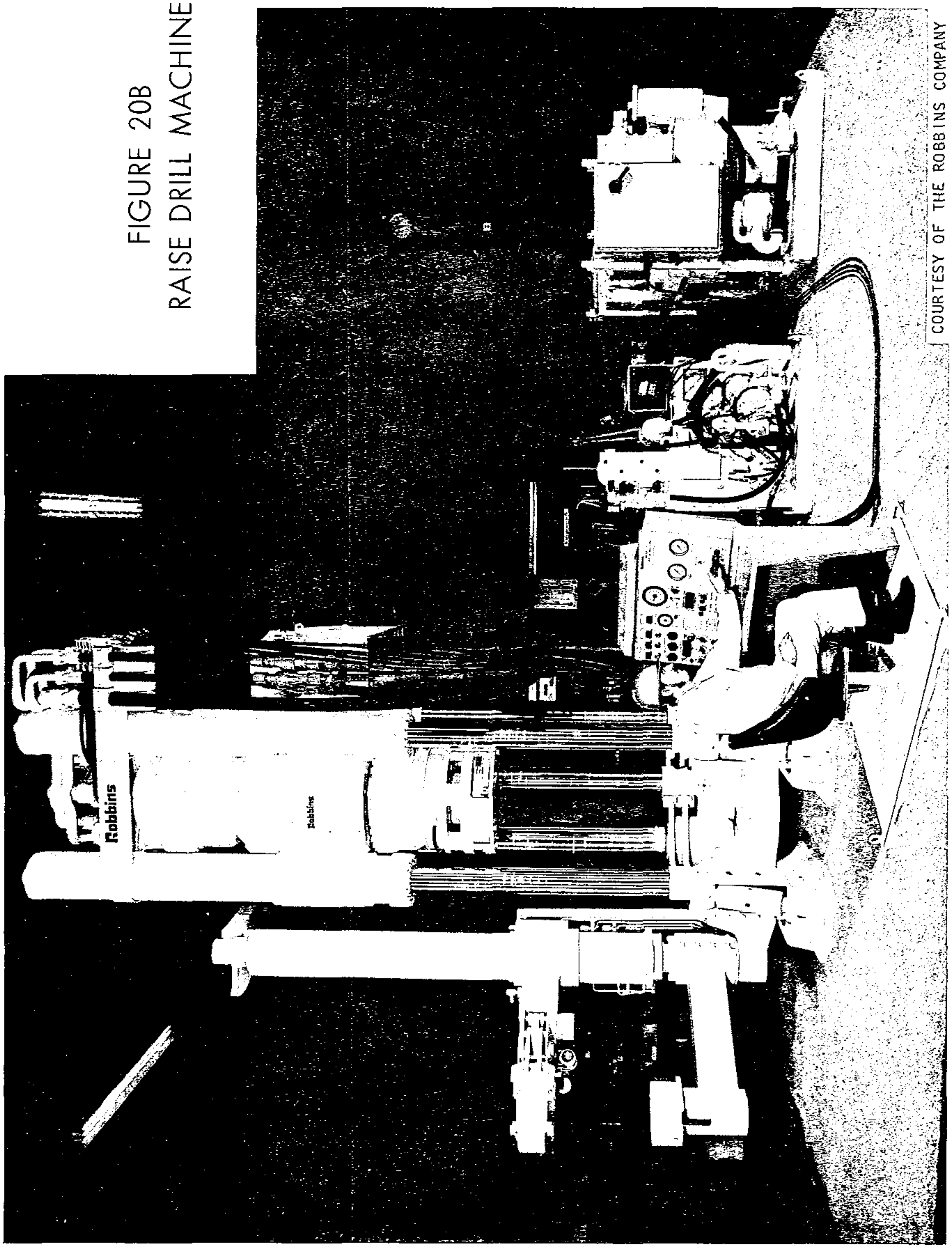
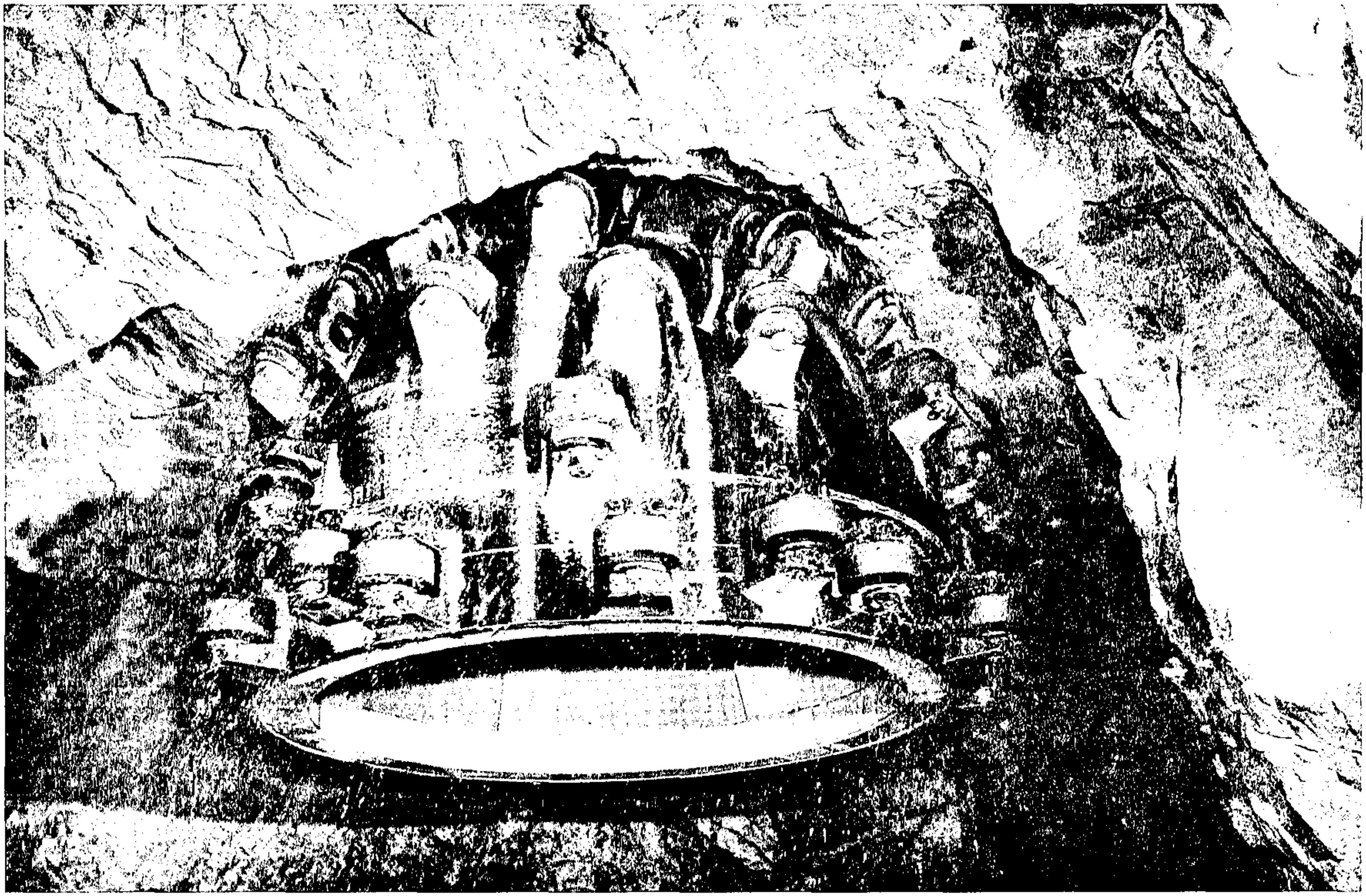


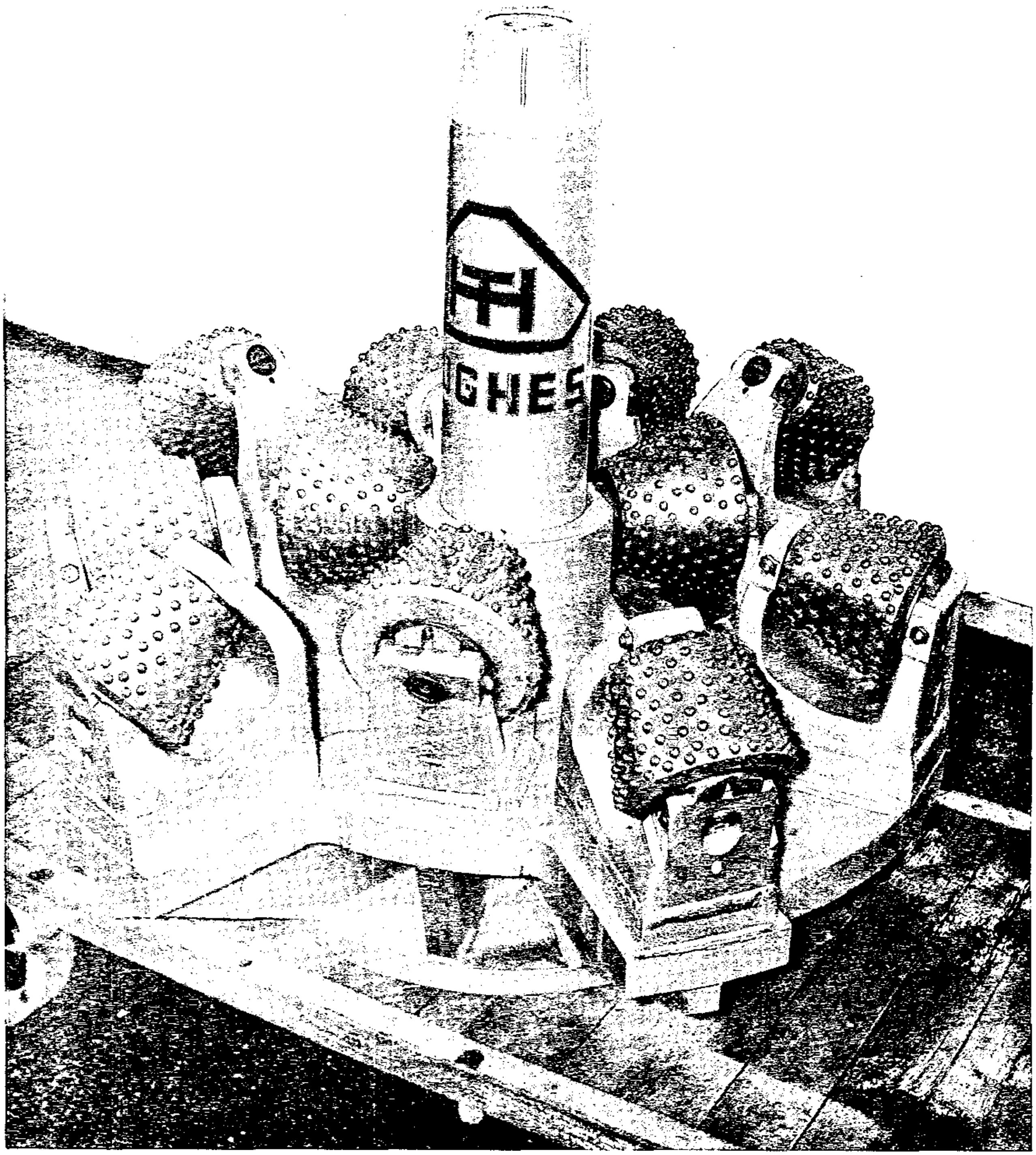
FIGURE 20B
RAISE DRILL MACHINE

COURTESY OF THE ROBBINS COMPANY



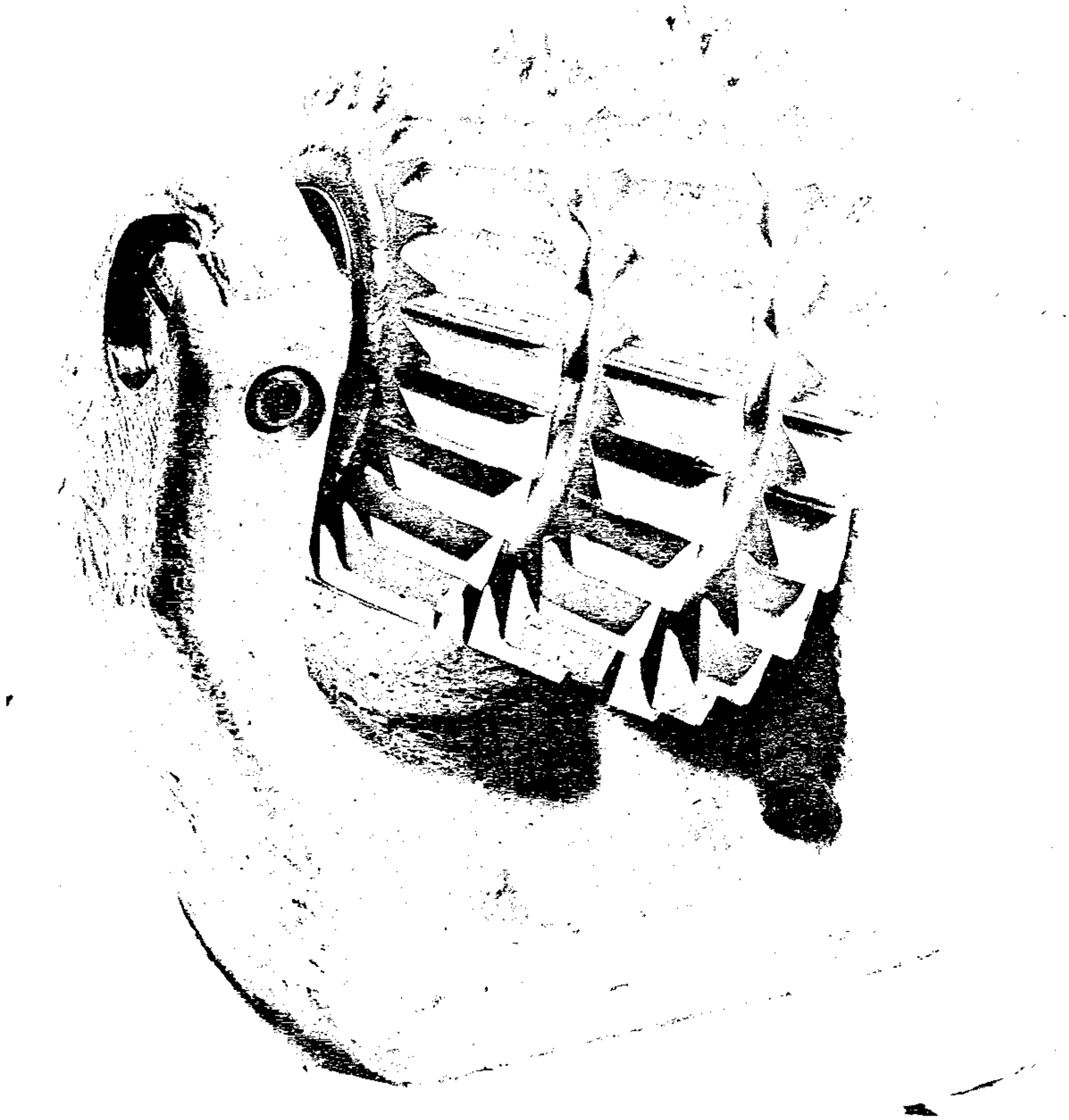
COURTESY OF THE ROBBINS COMPANY

FIGURE 21A
RAISE DRILL BIT



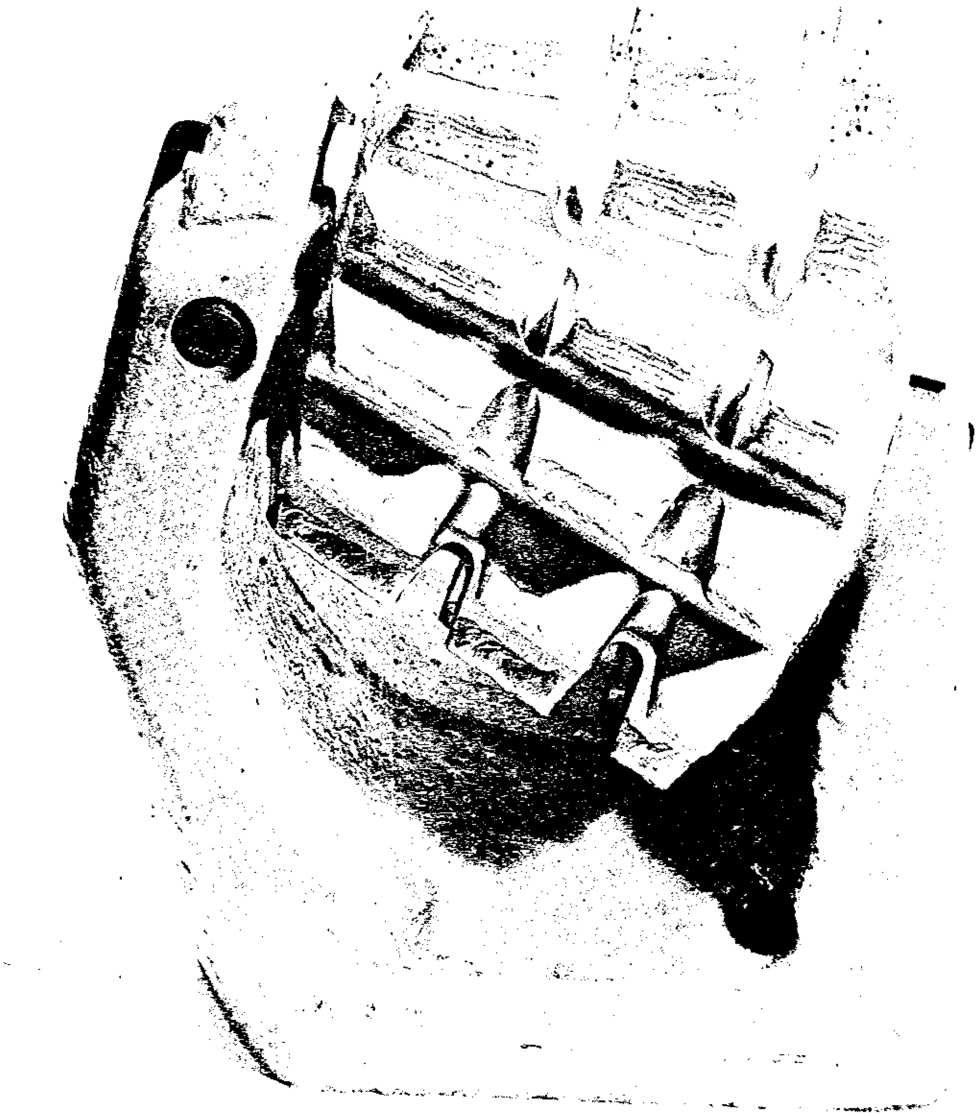
COURTESY OF HUGHES TOOL COMPANY

FIGURE 21B
RAISE DRILL BIT



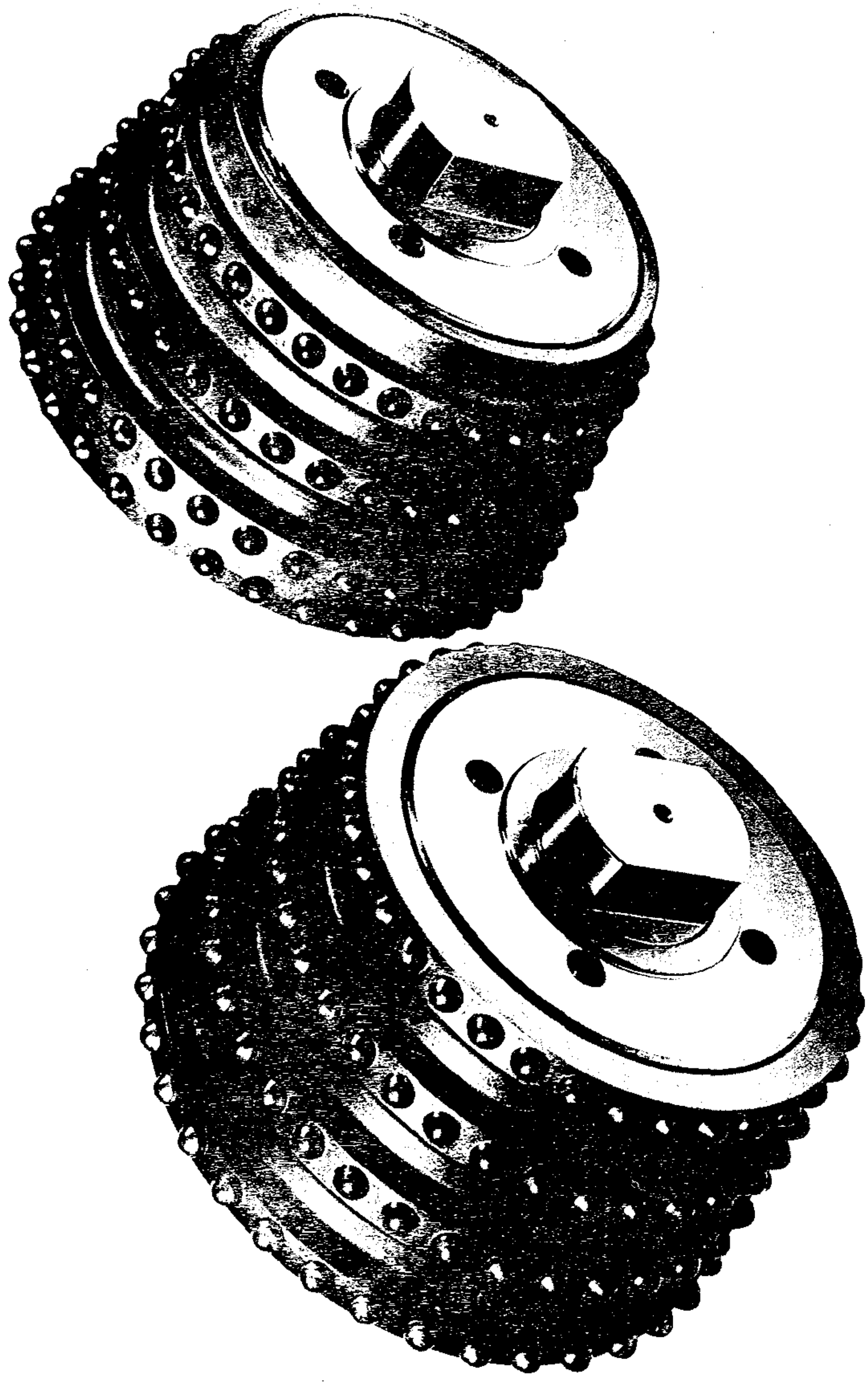
COURTESY OF REED TOOL COMPANY

FIGURE 22A
MILLED STEEL TOOTH CUTTER



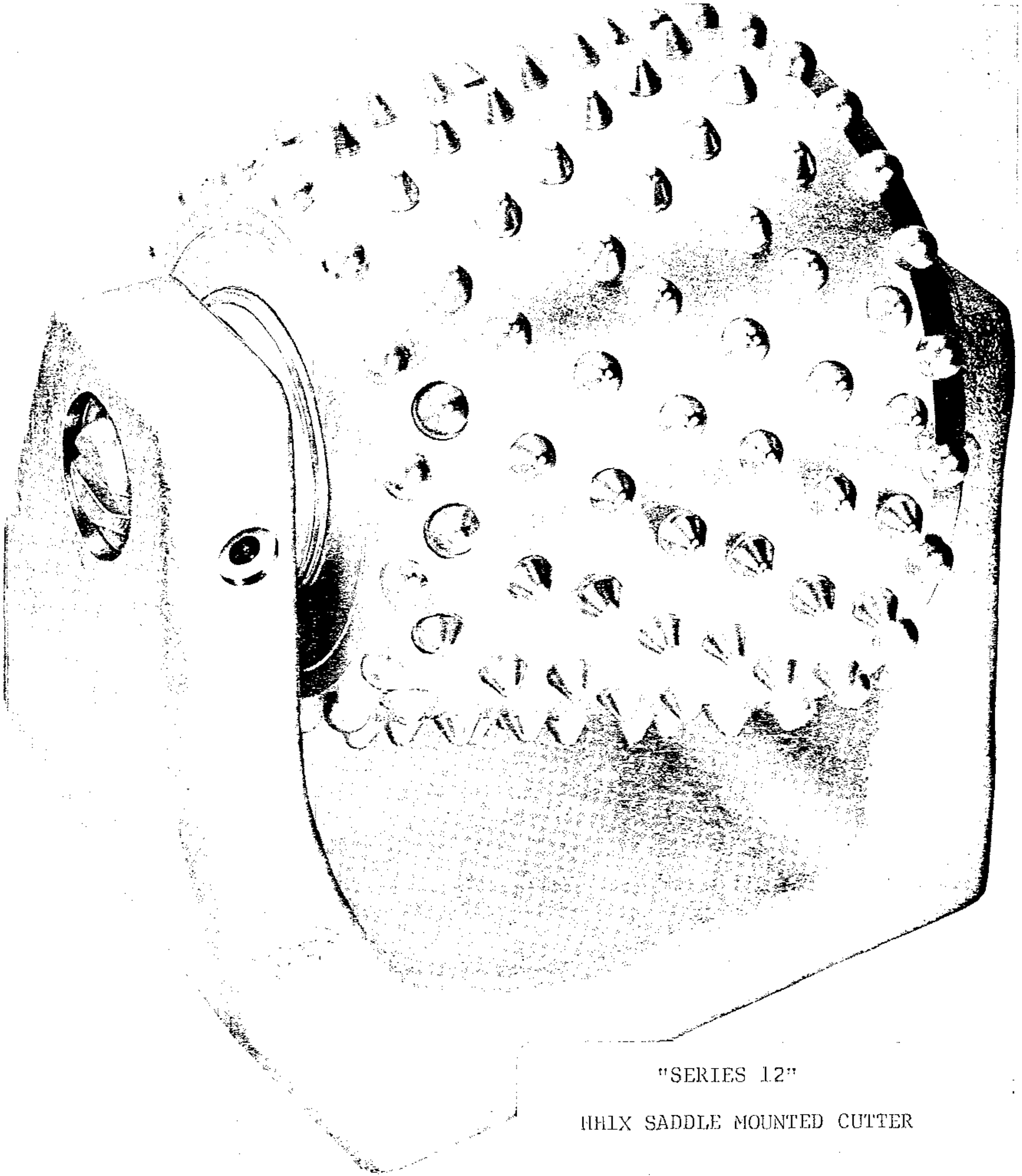
COURTESY OF REED TOOL COMPANY

FIGURE 22B
MILLED STEEL TOOTH CUTTER



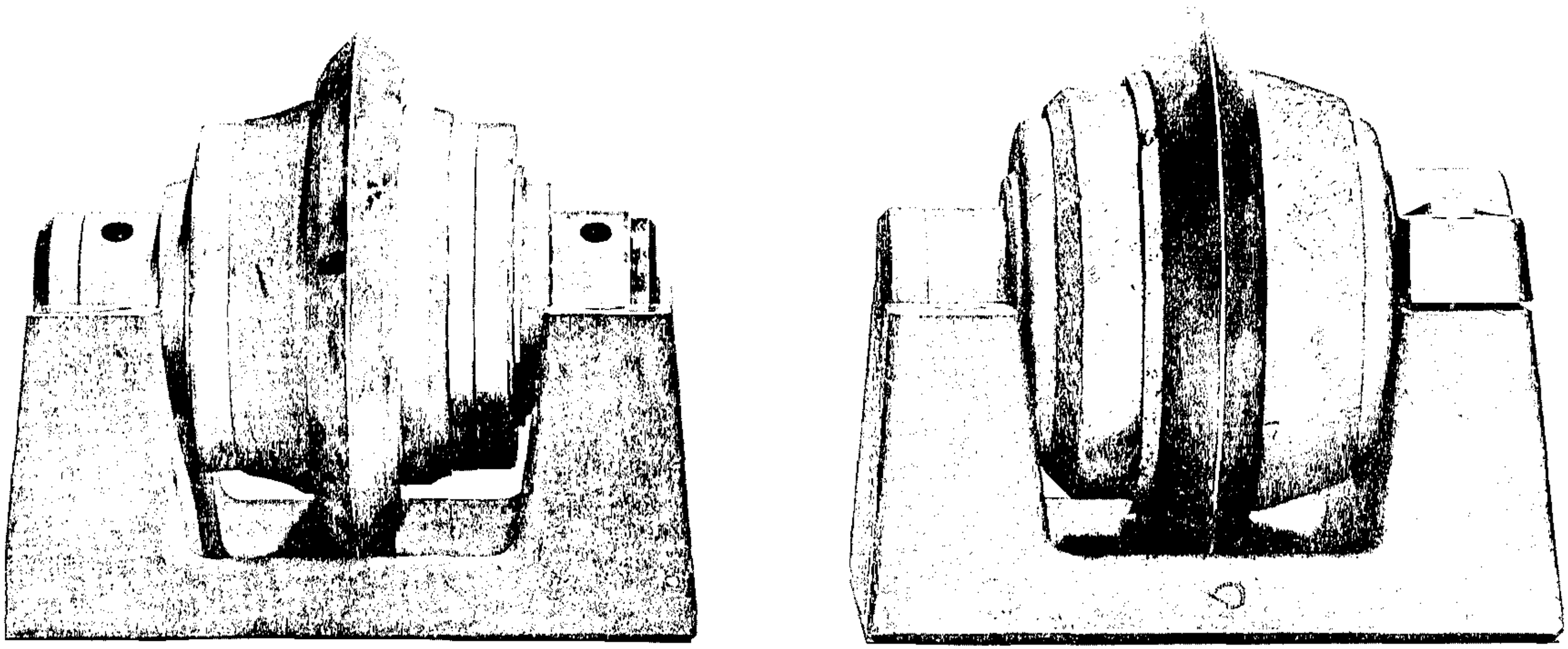
COURTESY OF KENNAMETAL, INC.

FIGURE 22C
CARBIDE INSERT CUTTER



COURTESY OF HUGHES TOOL COMPANY

FIGURE 22D
CARBIDE INSERT CUTTER

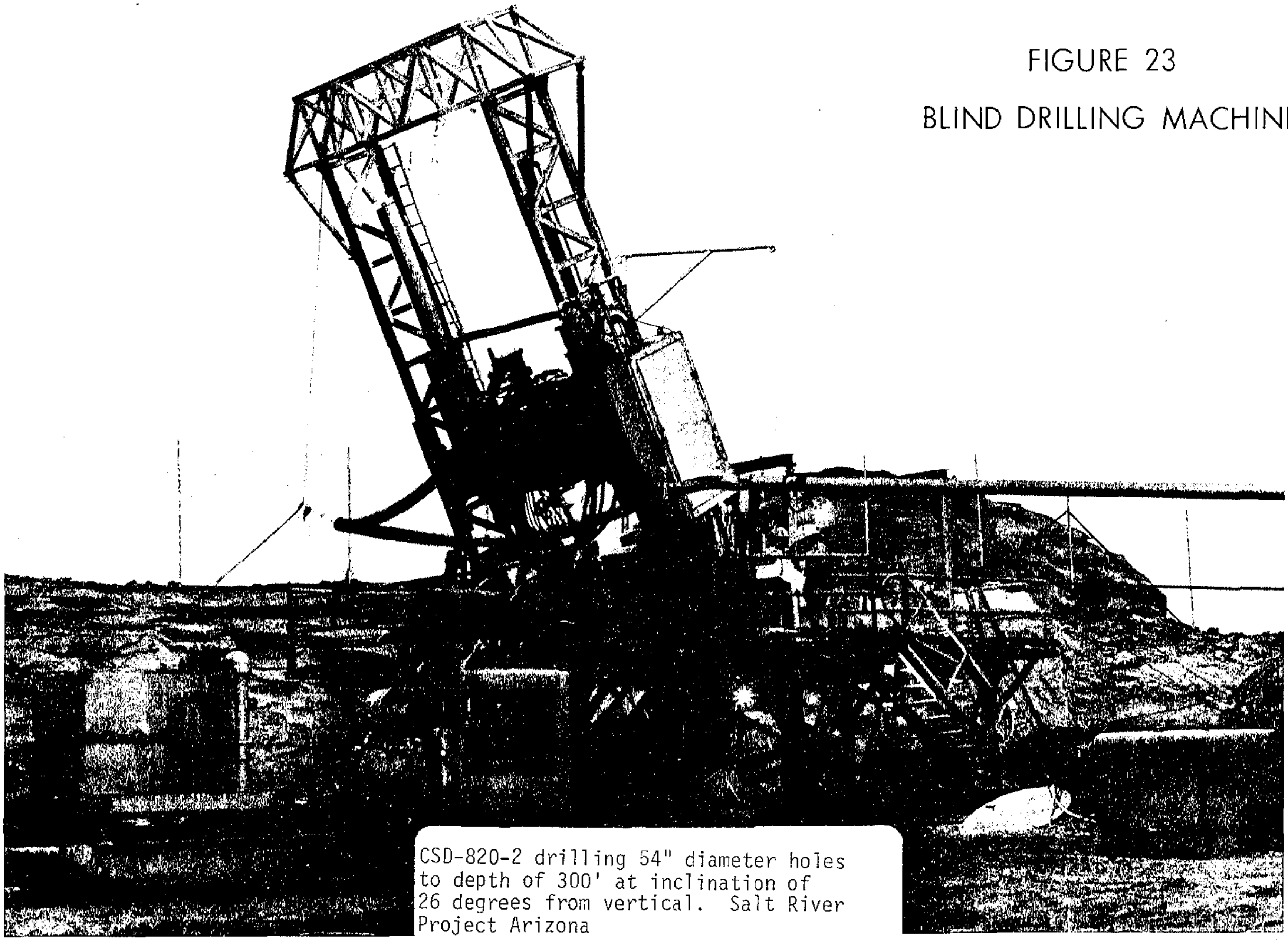


COURTESY OF THE ROBBINS COMPANY

FIGURE 22E
DISK CUTTERS

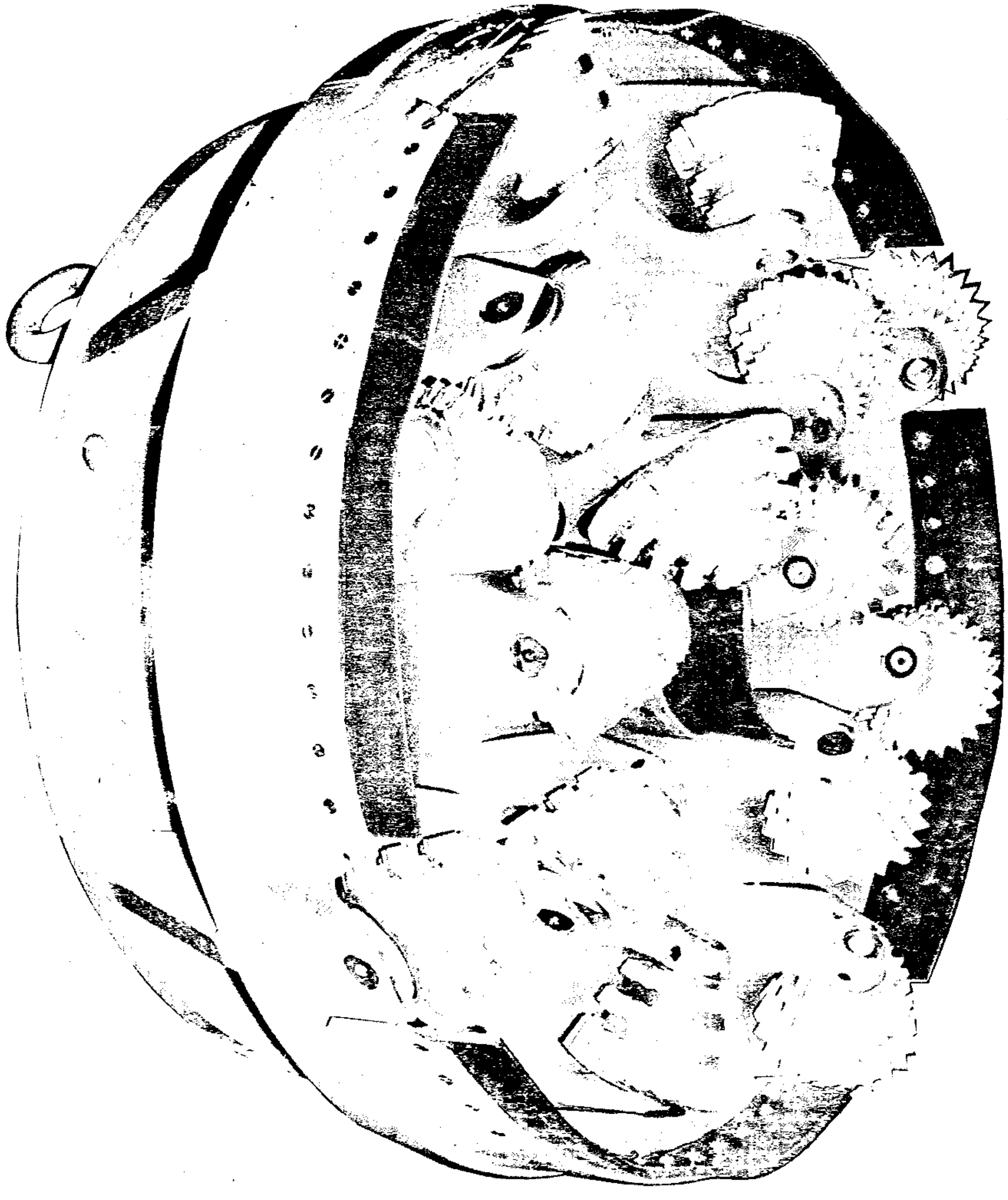
FIGURE 23

BLIND DRILLING MACHINE



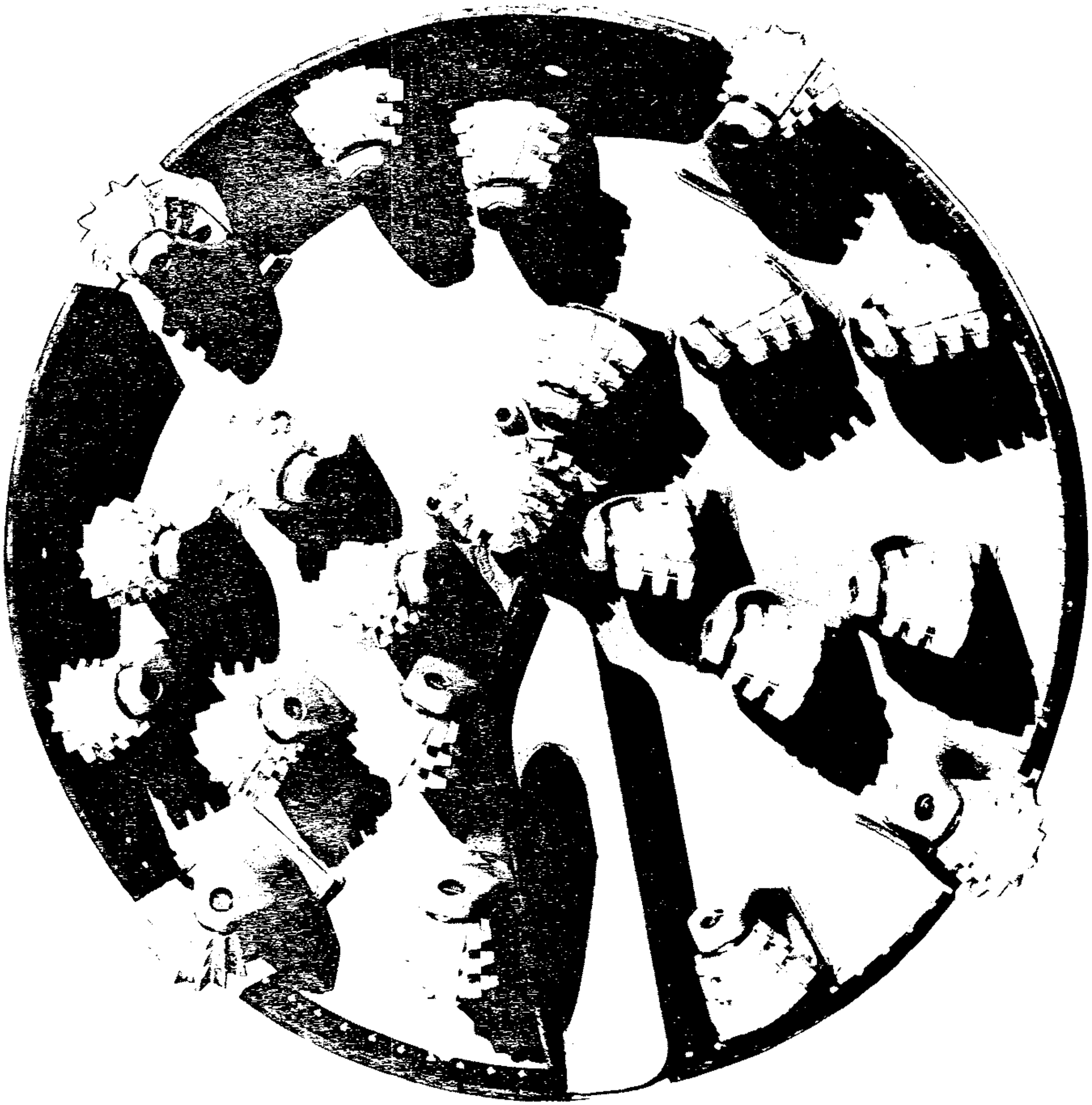
CSD-820-2 drilling 54" diameter holes to depth of 300' at inclination of 26 degrees from vertical. Salt River Project Arizona

COURTESY OF HUGHES TOOL COMPANY



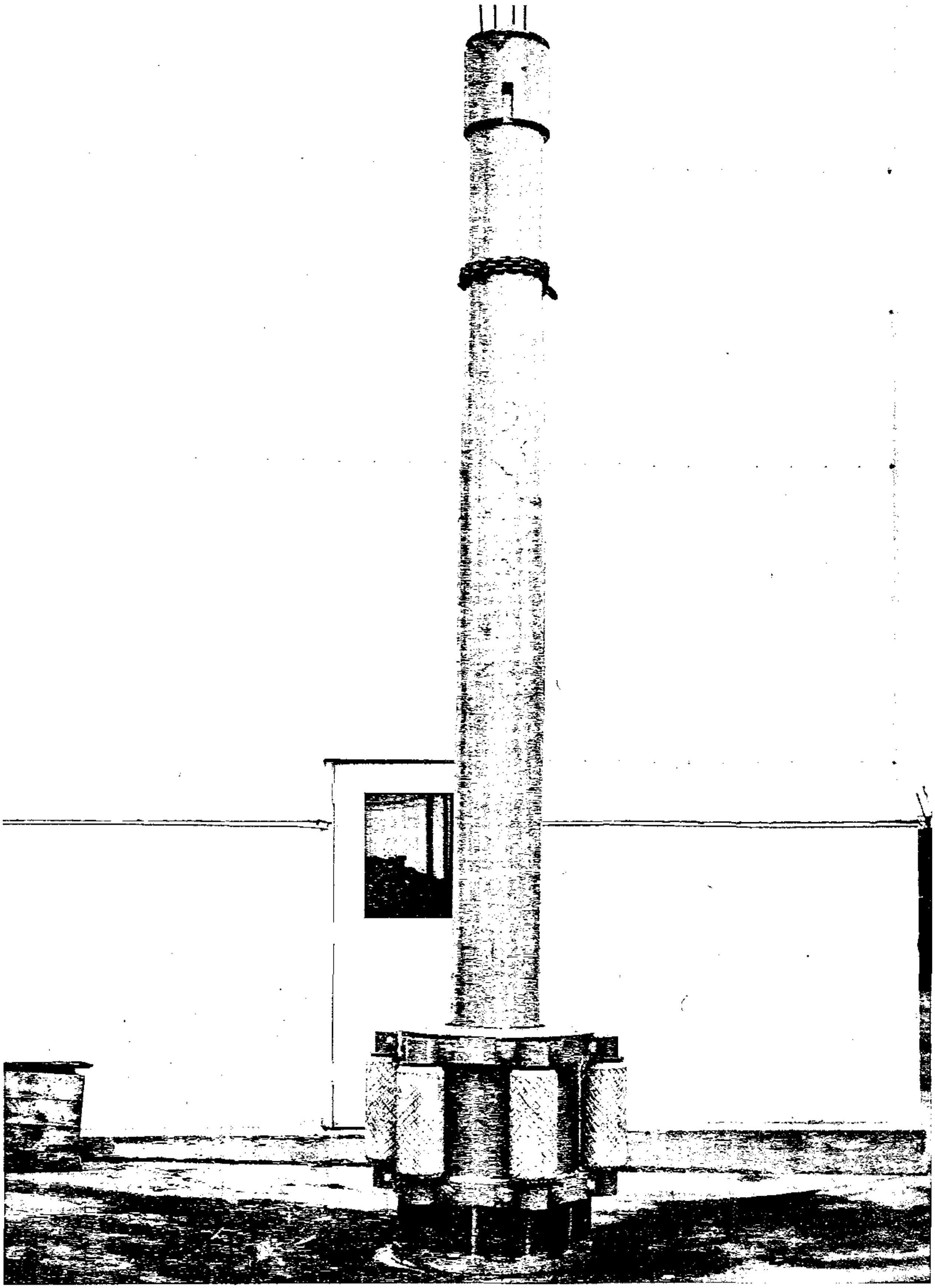
COURTESY OF REED TOOL COMPANY

FIGURE 24A
SHAFT DRILLING HEAD



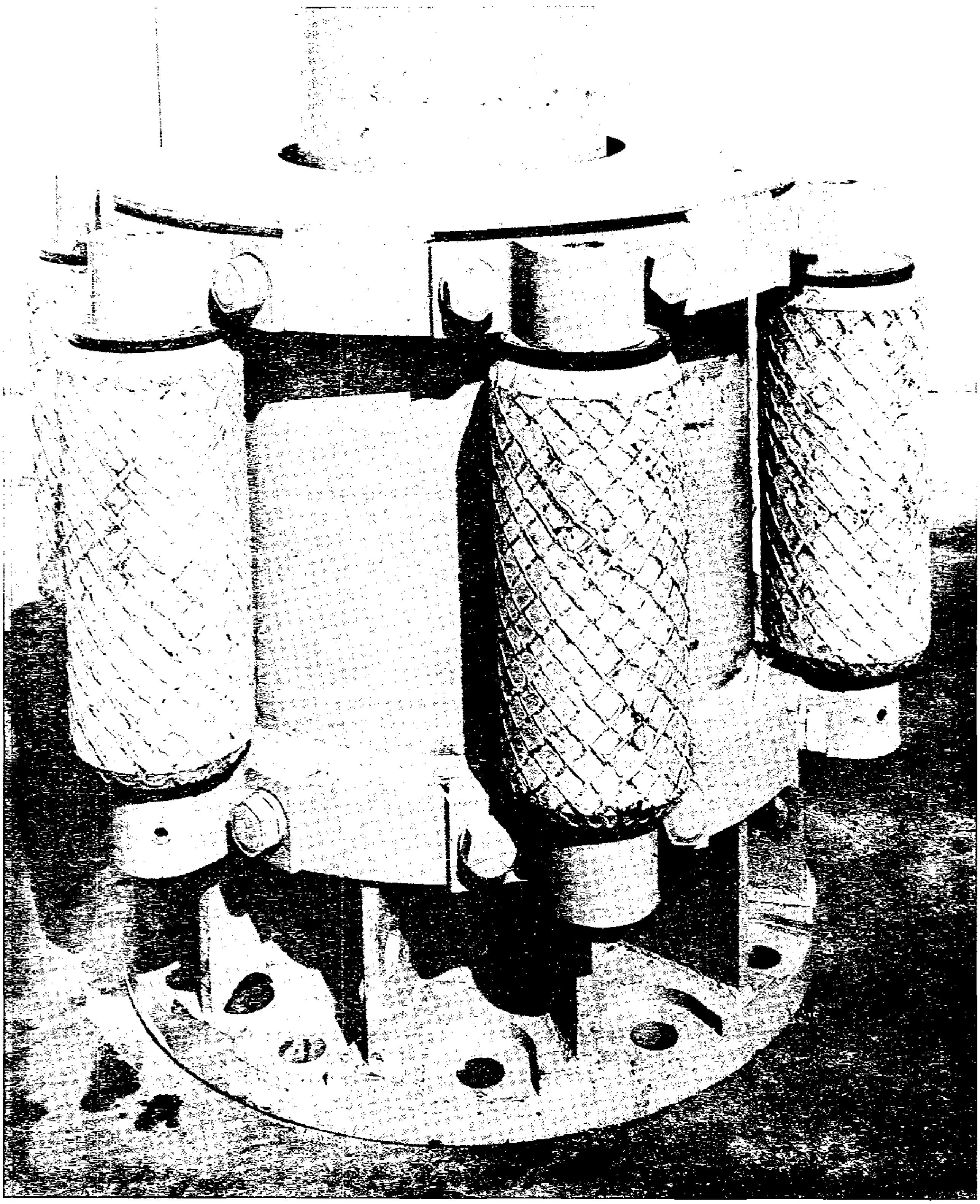
COURTESY OF REED TOOL COMPANY

FIGURE 24B
SHAFT DRILLING HEAD



COURTESY OF HUGHES TOOL COMPANY

FIGURE 25
MANDREL



COURTESY OF HUGHES TOOL COMPANY

FIGURE 26
STABILIZER

IV. SHAFT-SINKING LAWS

INTRODUCTION

Shaft-sinking projects have not, until recently, been extensively regulated, and enforcement of existing regulations has caused criticism from many sources. The laws in many cases are statements of existing operating procedures, while, in other instances, enactment of laws forces revisions in procedure to improve safety. Although temporarily inconvenient to mining operations, such laws eventually become accepted operating procedures. In an effort to clarify the safety practices in shaft sinking for this study, present regulations governing shaft operations were reviewed. The review included current federal regulations as well as laws of selected states. Laws from major mining nations around the world were also reviewed to determine their application to shaft-sinking work.

The following laws and implementing regulations were reviewed:

Federal: Title 30, Code of Federal Regulations, Chapter 1, Sections 55, 57, 75 and 77.

States: Alabama

Coal Mining Laws of the State of Alabama, as amended, 1960.
Mine Safety Rules of the State of Alabama, 1962.

Arizona

Arizona Code of Rules and Regulations, Title 11, Chapter 1.

Colorado

Colorado Mining Laws with Safety and Health Rules and Regulations, Bulletin 20, 1971.

Idaho

Minimum Safety Standards and Practices for Mining and Mineral Industry, Safety Code 5, 1974.

Illinois

The Coal Mining Act, 1975, revised.

Kentucky

Laws Governing the Mining of Coal and Clay, Kentucky Revised Statutes, Chapters 351-352, amended 1974.

Nevada

State of Nevada, Health and Safety Standards for Underground Metal and Nonmetal Mines, Parts 1 and 7, Title 46, Chapter 512, Nevada Revised Statutes, 1975.

New Mexico

New Mexico Mine Safety Code for All Mines, 1972.

Ohio

Mining Laws of Ohio, 1976.

Pennsylvania

Bituminous Coal Mining Laws of Pennsylvania for Underground Mines, 1961.

Tennessee

Laws and Regulations Governing Mines and Mining, (Title 58).

Utah

General Safety Orders covering Coal Mining Operations in the State of Utah, 1967.
Metal and Nonmetal Health and Safety Standards, Dec. 1973.

Virginia

Rules and Regulations Governing the Mining of Metals and Nonmetallic Minerals, 1974.
Mining Laws (Including Oil and Gas) of Virginia, 1974.

West Virginia

Mining Laws of West Virginia, 1974, revised.

Wyoming

State of Wyoming, Non-Coal Mining Laws, Including Safety Rules and Regulations, March 1971.

Foreign:	Australia	Canada
	New South Wales	British Columbia
	Queensland	Manitoba
	South Australia	New Brunswick
	Tasmania	Nova Scotia
	Victoria	Ontario
	West Australia	

Republic of South Africa

United Kingdom

Shaft-sinking operations in the United States are subject to regulation by both state and federal agencies. The federal government divides its mining regulations into the two areas of metal and nonmetal mining and coal mining. The federal regulations concerning metal and nonmetal mining do not, for the most part, differentiate shaft-sinking operations from other mining activities, whereas in the regulations concerning coal mines, shaft-sinking standards are defined in a subpart separate from the main body of laws. Most state and foreign mining laws are written similar to the United States' federal regulations concerning metal and nonmetal mining -- the shaft-sinking standards are included throughout the main text.

FEDERAL REGULATIONS

Federal regulation is accomplished by the Department of the Interior, Mining Enforcement and Safety Administration (MESA), based upon the Federal Metal and Nonmetallic Mine Safety Act of 1966 and the Federal Coal Mine Health and Safety Act of 1969. Regulations implementing these laws are contained in Title 30, Code of Federal Regulation, Chapter 1. At the present time sections of these regulations governing shafts at coal mines are being revised. The proposed revisions were published in the Federal Register on January 13, 1977. This discussion will consider only the current regulations as published in July 1976 in Title 30 CFR. Adoption of the proposed revisions will occur only after public comments and after changes made in response to those comments.

Metal-Nonmetal Mine Regulations

Federal regulations pertaining to metal and nonmetal mines are found in 30 CFR, Chapter 1, Subchapter N, Parts 57 and 58. Although shaft-sinking regulations are not separated from other mining regulations, and, therefore, all regulations pertain to shaft-sinking, several standards specifically mention shaft-sinking projects and cover conditions unique to such operations. Some of these standards are advisory while others are mandatory.

Standard 57.3-28 is advisory, and states that temporary or permanent ground support should be kept near enough to the bottom of the shaft to prevent falls from the sides. There is no definition as to the type of ground support needed or what is considered a sufficient distance from the bottom; these decisions are the responsibility of the contractor or inspector.

In the area of blasting operations only two standards specifically refer to shaft sinking work. Standard 57.6-124 states that when electric detonators are used in shaft sinking, work shall be suspended and all men withdrawn from the shaft upon the approach of an electrical storm. Standard 57.6-182 requires that blasts be initiated from a safe location outside the shaft.

Several standards apply to hoisting at shaft-sinking sites. Standard 57.19-49 states that buckets shall not be used to hoist men except in shaft sinking, inspection, maintenance or repair. The requirements for the use of buckets to hoist men are stated in mandatory Standard 57.19-50. The bucket must be stabilized by the use of a crosshead the height of which is at least 1-1/2 times its width if wooden guides are used, or a minimum height of 4 feet if rope or steel guides are used. In shafts greater than 50 feet deep, the bucket must have overhead protection for men. The bucket must also be of sufficient depth or have a suitably designed platform to allow men to be transported standing. Buckets which are suspended from a bail mounted on the lower half of the bucket must have a device to prevent accidental dumping while transporting men.

Work decks at shaft projects are commonly suspended from the surface by wire rope. Standard 57.19-53 is a mandatory requirement that such ropes have an approved rating for the load.

Rope guides used to stabilize the crosshead and bucket must be of locked coil construction according to Standard 57.19-54.

Standard 57.19-76 states that when men are hoisted bucket speeds should be limited to 500 feet per minute and 200 feet per minute within 100 feet of a station. This standard is advisory for metal-nonmetal mines but is mandatory for coal shaft projects. This suggested speed is slower than those required by state and foreign regulation agencies.

Standards 57.19-77 and 57.19-78 are closely related and are commonly found in regulations of all mining nations studied. Mandatory Standard 57.19-77 requires that buckets not be lowered directly to the shaft bottom; rather, they must be stopped about 15 feet above the bottom and held until a second signal is given by the bottom crew. Standard 57.19-78 is advisory. It states that the bucket should be raised approximately 3 feet and held to allow the bucket to be stabilized. The bucket should then be raised slowly until the crosshead is engaged before hoisting to the surface.

Another standard which specifically mentions shaft work is 57.19-111. This is an advisory item stating that fixed ladders should be kept as close to the bottom as practical and that chain, rope, or other extension ladders be used to reach from the bottom to the fixed ladder. This item is a requirement in many foreign laws. In these cases the fixed ladders extend from the work deck to the bottom of the shaft.

Coal Mine Regulations

Detailed federal regulation of coal mines, including shaft projects, began with the passage of the Federal Coal Mine Health and Safety Act of 1969. The appropriate standards implementing this act are found in 30 CFR, Chapter 1, Subchapter O, Sections 75 and 77. All standards are mandatory. As can be seen from the following discussion, federal regulations governing shafts at coal mine projects are quite extensive.

Section 75 includes mandatory safety standards for underground coal mines, and Section 77 the mandatory standards for surface coal mines and surface work areas of underground coal mines. Section 77, however, includes Subpart T specifically regulating shaft and slope sinking. The intention is to include shaft sinking in with surface work at underground mines until such time that mining of coal begins. The following is a discussion of Subpart T -- Slope and Shaft Sinking.

Standard 77.1900 requires that each operator is to submit a shaft-sinking plan to the Coal Mine Health and Safety Manager for the district in which the shaft is located. Controversy has developed concerning the definition of operator. Recent court decisions have held that the mine owner is responsible for all work on his property including preparation of the shaft report. This ruling is being appealed by several mine owners who contend that the contractors should be considered operators and therefore responsible for submission of the plan, compliance with the law and payment of fines.

Under present regulations the plan must include:

1. The name and location of the mine, and the Mining Enforcement and Safety Administration mine identification number, if known;

2. The name and address of the mine operator;

3. A description of the construction work and methods to be used in the construction of the slope or shaft, and whether part or all of the work will be performed by a contractor and a description of that part of the work to be performed by a contractor;

4. The elevation, depth, and dimensions of the slope or shaft;

5. The location and elevation of the coal bed;

6. The general characteristics of the strata through which the slope or shaft will be developed;

7. The type of equipment which the operator proposes to use when the work is to be performed by the operator. When work is to be performed by a contractor, the operator shall, as soon as known to him, supplement the plan with a description of the type of equipment to be used by the contractor;

8. The system of ventilation to be used; and

9. Safeguards for the prevention of caving during excavation.

The shaft-sinking plan must be approved by the MESA District Manager before work may begin. Once approved, the plan becomes the statement of health and safety requirements to be followed on the job.

Standards 77.1901 and 77.1901-1 require pre-shift and on-shift inspection of the shaft area and require that the results be recorded.

Drilling and mucking operations are described in Standard 77.1902. This item states that diesel equipment shall be permissible, operated permissibly and maintained in a permissible condition. It is further specified in Standard 77.1902-1 that Bureau of Mines Schedule 31 standards for pPermissibility be applied.

Minimum standards for hoists and hoisting are specified in Standard 77.1903. These standards require that hoists used to transport men and muck shall have valid capacities consistent with the load and recommended safety factor. In addition, each hoist shall be equipped with an accurate and reliable indicator of the position of the conveyance.

Requirements also state the American National Standards Institute (ANSI) Specification M11.1-1960 for the use of wire rope in mines shall be used as a guide in the selection, installation, and maintenance of rope. These standards, developed by rope manufacturers, prescribe factors of safety and criteria for inspecting rope. Although the ANSI specification is referenced in the regulations as a guide in the use of wire rope, it is used by inspectors as the standard for hoists and ropes, therefore key sections will be considered here. Among these key sections are rope safety factors, sheave and drum sizes, and rope inspection criteria.

The static load factor of safety prescribed by ANSI standards is shown in the following table:

Length of Rope in Shaft (Feet)	Minimum Factor of Safety (New Rope)	Minimum Factor of Safety (Remove)
500 or less	8	6.4
501 to 1,000	7	5.8
1,001 to 2,000	6	5.0
2,001 to 3,000	5	4.3
3,001 or more	4	3.6

The Factor of Safety is calculated by dividing the nominal breaking strength of the rope by the calculated total static load. The nominal breaking strength may be obtained for new rope from the manufacturer or from laboratory tests performed on used rope. The total static load is the weight of the loaded conveyance plus the weight of the length of rope extending from the headsheave to the conveyance attachment when the conveyance is at the lowest point in the shaft.

Minimum tread diameters of sheaves and drums are specified in ANSI Specification M11.1-1960 abd are closely observed by MESA inspectors. The following table shows recommended and minimum tread diameters as stated in the ANSI specification.

Rope Construction	Diameter of Sheave and Drum	
	Recommended	Minimum
6 x 7	72 x rope diam.	42 x rope diam.
6 x 19	45 x " "	30 x " "
6 x 37	27 x " "	18 x " "
6 x 25	45 x " "	30 x " "
6 x 27	45 x " "	30 x " "
6 x 30	45 x " "	30 x " "
18 x 7	51 x " "	34 x " "

Criteria for inspection and removal of hoist ropes are discussed in general terms in the ANSI specification. No firm criteria are given to determine when a rope should be removed. The specification states that the factors to be considered in examining a rope are a marked reduction in rope diameter, evidence of excessive abrasion on outer wires, broken outside wires or severe corrosion. In general when corrosion is present, the remaining strength cannot be readily calculated and the rope should be removed. Likewise the condition of the worst rope lay is the governing factor in examining a rope for worn or broken wires. Ultimately, the ANSI specification leaves the decision to remove a rope to the experience abd judgment of the mine officials.

Standard 77.1904 requires two means of communication between hoist operator and shaft bottom. In actual operation a dual system of bells and telephones are used between the hoist operator, shaft bottom and topman at the shaft collar.

General hoist safeguards are required by Standard 77.1905. Currently, these requirements state that the hoist transporting persons shall be equipped with brakes capable of holding a fully loaded conveyance. In addition, the current regulations permit the use of a second qualified hoist operator in lieu of fully automatic controllers.

Standard 77.1906 covers the maintenance and inspection of hoists. The standard requires daily inspection of the hoist, headgear, ropes, connections and chains. A test trip of the conveyance is required before each shift and after all repairs to the hoist. It is required that records of the inspection be kept.

The report of the daily inspections shall be signed by the person making such inspection and the report shall be signed or countersigned by either the mine foreman, mine superintendent, assistant superintendent or other health and safety supervisors.

Hoist construction standards are established in Standard 77.1907. The standard requires that the rope be attached to the drum with a spelter-filled socket, thimble with the proper number of clips, or a wedge socket. Two bridle chains are required to secure the conveyance to the rope. The chains must be attached to the rope at least 3 feet above the last clip. If hooks are used for attaching conveyances, they must be of the self-locking type. The rope must in turn be securely fastened to the hoist drum, except friction hoists, with at least three full turns on the drum at all times. There should be at least one full turn on the drum shaft or spoke of a free drum and the rope securely fastened.

Standard 77.1908 regulates hoist installation and use. The regulation states that when men are hoisted and the shaft is greater than 50 feet deep, the rope must be hung from a substantial hoist installation high enough to provide clearance between the main sheave and bucket.

Standard 77.1908 also requires guides and guide attachments or a no less effective means to prevent the swing of the bucket when hoisting men from a shaft 100 feet or more deep. According to the existing regulation, the guides must be kept no less than 75 feet from the shaft bottom.

Other items in Standard 77.1908 require that buckets be hung no more than 10 feet below the crosshead if a crosshead is used; that a loading platform is required if men enter or leave a bucket over a shaft; and that a ladder or independently powered hoist is required for emergency evacuation of the shaft.

Men are not permitted to ride on the bucket's rim, on loaded buckets, or with tools or equipment other than small hand tools. Man-trips in the bucket should not be crowded and the maximum manload must be posted. Speeds when hoisting men must not exceed 500 feet per minute and must be reduced to 200 feet per minute within 100 feet of a landing.

Additional requirements for hoist operation are:

1. A notice of established speeds shall be posted in clear view of the hoistman.

2. Conveyances being lowered in a shaft in which persons are working shall be stopped at least 15 feet above such persons and shall be lowered further only after the hoistman has received a signal that all persons who may be endangered by the conveyance are in the clear.

3. No conveyance shall be raised or lowered in a slope or shaft until it has been stabilized and trimmed.

4. Measures shall be taken to prevent material from falling back into the shaft while buckets or other conveyances are being unloaded.

5. Properly attached safety belts shall be worn by all persons required to work in or over any shaft where there is a drop of 10 or more feet, unless other acceptable means are provided to prevent such persons from falling into the shaft.

The hoist operator must also be qualified. Standard 77.1908-1 states that hoists shall be under the control of and operated by a qualified hoistman when persons are being transported or when persons are in a slope or shaft.

Standards 77.1909 and 77.1910 concern the types of explosives permitted and establish blasting procedures. Standard 77.1909 requires the use of permissible explosives and blasting machines. However, the MESA District Manager may, upon application, issue permits to use non-permissible explosives and a non-permissible blasting machine.

Standard 77.1910 establishes the following standards for the use of blasting agents.

1. Light and power circuits shall be disconnected or removed from the blasting area before charging and blasting.

2. All explosive materials, detonators, and any other related blasting material employed in the development of any slope or shaft shall be stored, transported, carried, charged, and fired in accordance with the provisions of Subpart N of Section 77. Except as provided below, all shots shall be fired from the surface.

3. Where tests for methane have been conducted and methane has not been found and only permissible blasting units are being employed, shots may be fired from an upper level of the slope or shaft.

4. Except as provided below, all persons shall be removed from the slope or shaft prior to blasting.

5. Blasting areas in slopes or shafts shall be covered with mats or other suitable material when the excavation is too shallow to retain blasted material.

6. Where it is impracticable to prepare primers in the blasting area, only the number of primers needed for one round of shots shall be prepared and remain on the surface in an isolated area prior to use. The primers shall be carried in insulated, covered containers.

7. No other development operation shall be conducted in a shaft or at the face of a slope while holes are being charged and until after all shots have been fired.

8. The slope or shaft shall be examined after each blast, and loose material shall be removed.

9. Loose rock and other material shall be removed from timbers and platforms after each blast before persons are lowered to the shaft bottom.

Shaft and slope ventilation practices are governed by Standard 77.1911. This standard requires that all shafts and slopes be mechanically ventilated. The mechanical ventilation equipment shall be examined before each shift. The quantity of air in the slope or shaft must also be determined by a certified person. The results of these tests must be recorded in a book approved by the Secretary of the Interior.

The ventilation fan must be installed on the surface in a fireproof housing, designed to permit reversal of the air current and located to prevent recirculation of the air or contamination of the air from any source. The fan must be either constantly attended or equipped with an automatic device to signal an alarm in the event the fan slows or stops. In addition, the fan must be offset not less than 15 feet from the shaft or slope and equipped with air ducts which are non-combustible, and maintained to prevent excessive leakage of air. If flexible ducts are used, they must be constructed to permit ventilation by either exhausting or blowing methods and, when metal air ducts are used, they shall be grounded effectively to remove static and other electrical charges. Ventilation ducts shall extend as close to the bottom as necessary to keep the face clear of dangerous and noxious gases. "Face" as used in this subpart means where excavating is progressing or was last done.

Standard 77.1911 requires that each ventilation system be properly maintained by a qualified operator. The fans shall operate continuously when persons are below the surface. The revised regulations include the requirements that the fan shall be operated at least one half-hour prior to entering the underground area of a slope or shaft by any person. In addition, any accidental stoppage or reduction in air flow shall be corrected immediately. If such corrections cannot be made immediately, development work below the surface shall be stopped, and all persons not needed to make necessary corrections to the ventilation system shall be removed to the surface.

Standard 77.1912 requires that substantial stairways or ladders shall be used during the construction of all shafts where no mechanical means are provided for persons to travel. Landings at intervals of not more than 30 feet shall be installed. Shaft ladders shall project 3 feet above the collar of the shaft, and shall be placed at least 6 inches from the side of the shaft.

Standard 77.1913 states that all wood products, with the exception of crossties, which are permanently installed in slopes and shafts, shall be fire-retardant.

Requirements for shaft and slope electrical systems are established in Standard 77.1914. This regulation requires that all electrical equipment used below the collar be permissible. All conductors used underground must be flame resistant. Lighting used underground, lamps and floodlights, shall be permissible under Parts 19 and 20 of 30 CRF Chapter 1.

Standard 77.1915 defines requirements for the storage and handling of combustible materials. Liquefied and nonliquefied compressed gas cylinders, and oil, gasoline and other petroleum products shall not be stored within 100 feet of any slope or shaft opening. Combustible material and supplies, other than those specified above, shall not be stored within 25 feet of any slope or shaft opening.

Pyritic slates, bony coal, culm or other material capable of spontaneous combustion shall not be used for fill or as surfacing material within 100 feet of any slope or shaft opening.

Areas surrounding the opening of each slope or shaft shall be constructed to insure the drainage of flammable liquids away from the slope or shaft in the event of spillage. Oily rags, waste, waste paper, and other combustible waste material disposed of within or in the vicinity of any slope or shaft opening shall be stored in closed containers until removed from the area.

Standards for welding, cutting, soldering and fire protection are included in Standard 77.1916. At least one portable fire extinguisher shall be provided where welding, cutting, or soldering with arc or flame is performed. Welding, cutting or soldering with arc or flame in any slope or shaft, or within the vicinity thereof, except where such operations are performed in fireproof enclosures, shall be done under the supervision of a qualified person who shall make a diligent search within or in the vicinity of the slope or shaft for fire during and after such operations. Before welding, cutting or soldering is performed in any slope or shaft, an examination for methane shall be made by a qualified person with a device approved by the Secretary for detecting methane. Examination for methane shall be made immediately before and periodically during welding, cutting or soldering, and such work shall not be permitted to commence or continue in air which contains 1.0 volume per centum or more of methane.

Noncombustible barriers shall be installed below welding, cutting or soldering operations in or over a shaft.

STATE SHAFT-SINKING LAWS

The state regulations reviewed for this study contained fewer items applicable to shaft projects than the existing federal laws and regulations. The state laws considered either did not discuss shaft sinking or were more general than comparable federal regulations. States generally do not emphasize inspection of shaft-sinking work. With the exception of Pennsylvania's Department of Environmental Resources, none of the states had records covering shaft projects. Research revealed that state inspectors visit shaft sites much less frequently, usually quarterly, and spend less time at each shaft site than do federal inspectors.

Generally, state regulations treat shaft-sinking as mining work. Regulations applicable to shaft-sinking are found in the general body of mining law and applied as necessary.

Ohio, however, has a specific section relating to shaft work. Figure 27 is a copy of Section 4153.12 relating to shaft sinking. The items listed in that section cover the major provisions of federal law but are less detailed. A unique feature of Ohio's law is found in the next to last paragraph: "Other than this section, Chapters 4151, 4153, 4155, 4157 and 4159 of the Revised Code do not apply to the opening of a mine until such opening reaches the seam, and the entry or landing is extended beyond a break-through, or other place driven at right angles thereto." This is the only law reviewed that specifically exempts shaft work from other sections of mining law.

The regulations of several other states (Idaho, Virginia and Nevada) are patterned closely after the federal model. These states cite the federal standard number from Title 30 CFR after their own regulation. In many cases the state regulation is an abbreviated version of the equivalent federal standard.

Many of the state laws had common provision with respect to shaft sinking. In nearly all cases, mention of shaft sinking was made as an exception to general mining law. Most states require that men be hoisted in cages and establishes criteria for such cages. The laws then make the exception of allowing men to be hoisted in buckets only during shaft sinking, maintenance, inspection or repair work. The laws commonly stipulate that buckets used to hoist men must have specific safety features. If the bucket is attached to the rope by a hook, the hook must be a self-locking type. The bucket must be deep enough to allow men to be transported standing up. Devices also must be used to prevent accidental tipping of self-dumping buckets. The bucket must be guided after shaft depth reaches a prescribed depth. The depth varies from 100 to 300 feet among the states. Generally, coal mining states require guides on shorter shafts than metal-nonmetal producing states. State laws permit the use of rope guides but specify the rope be of a locked coil construction. Along with guides, most states require the use of a crosshead with safety catches once the shaft depth exceeds a specified depth.

Most state regulations require that shaft headgear be of sufficient capacity for the applied load. The regulations do not specify the type of headgear or any direct correlation to hoist or rope strength. Likewise, state regulations specify that ropes used to suspend work decks also be of adequate capacity for the applied load.

Section 4153.12 Construction regulations to be observed in opening mine. Any person, firm, or corporation, beginning the opening of a mine, whether or not such person, firm, or corporation is the owner, lessee, or agent of the property upon which such mine is located, shall notify the chief of the division of mines, and observe the following in the construction of such mine:

(A) If the opening is a slope or vertical shaft, no explosive used therein shall be fired by means of a squib or fuse after the same is extended more than twenty-five feet from the surface, and thereafter and until the slope or shaft reaches the seam and the entry or landing is extended beyond a break-through or other place driven at right angles thereto, no explosive shall be fired except by means of an electric battery operated from the surface after all persons are on the surface.

(B) A substantial structure to sustain sheave wheels or pulleys, ropes, and loads, shall be provided, and if the opening is a shaft, the same shall be placed at a height of not less than twenty-five feet above the tipping place.

(C) A landing platform shall be arranged in such manner that no material can fall into the shaft while the bucket is being emptied, and the shaft shall not be sunk to a depth of more than thirty feet without such structure.

(D) If the bucket used for hoisting material is to land on a truck, the track on which such truck is operated and the platform shall be so constructed that material cannot fall into the shaft.

(E) Rock and coal shall not be hoisted from a shaft or slope except in a bucket or cage attached to a rope by a safety hook, clevis, or other safe attachment, and the bucket or cage securely locked so that same cannot tip or empty while being hoisted.

(F) Such rope shall be fastened to the side of the drum, and not less than three coils of rope shall always remain on the drum.

(G) After the shaft reaches a depth of one hundred feet, the same shall be provided with guides and guide attachments, applied in such a manner as to prevent the bucket from swinging while being lowered or hoisted, and such guides and guide attachments shall be maintained at a distance of not more than seventy-five feet from the bottom of the shaft.

(H) The sides of all shafts shall be properly secured for safety and no loose rock or material shall be allowed to remain on any timber in the shaft after each blast.

(I) All loose timber, tools, and materials shall be kept away from the top of the shaft to reduce the danger of the same falling down the shaft.

(J) Where explosive gas is encountered, the person in charge shall see that the shaft or slope is examined before each shift of men enter to work, and before the men descend after each blast.

(K) The slope, or shaft, shall be properly ventilated so that persons working therein will have the necessary air.

(L) An efficient brake shall be attached to each drum of an engine used in hoisting material and persons, and all machinery, ropes, and chains connected therewith shall be carefully examined once each shift.

(M) Not more than four persons shall be lowered or hoisted in or on a bucket at one time, and no person shall be permitted to ride on a loaded bucket.

(N) The bucket used in lowering or hoisting persons shall be equipped with proper safety devices, so that it cannot become detached from the rope or cable, and cannot tip or turn upside down while being so used.

The chief of the division of mines, and the deputy mine inspector, shall have jurisdiction over such mine when the shaft or slope reaches a depth of twenty-five feet, and such person, firm, or corporation shall comply with any order issued by either or both of them with respect to the safety of persons employed. Other than this section, Chapters 4151., 4153., 4155., 4157., and 4159. of the Revised Code do not apply to the opening of a mine until such opening reaches the seam, and the entry or landing is extended beyond a break-through, or other place driven at right angles thereto.

No owner, lessee, agent, or operator of a mine shall willfully refuse or neglect to comply with this section.

FIGURE 27

OHIO SHAFT AND SLOPE LAWS SECTION 4153.12

Hoisting procedures are specified to a limited extent. Most states require that buckets not be lowered directly to the shaft bottom. Rather, they must be stopped approximately 15 feet above the bottom and held for a signal from the miners on the bottom. Similarly, when hoisted, buckets must be raised approximately 3 feet and stabilized before hoisting to the surface. The regulations commonly add that the muck load be trimmed and the outer surfaces of the bucket brushed clean to prevent excess material from falling back into the shaft. When buckets are to be hoisted, regulations commonly require the bucket be raised slowly to engage the crosshead or to clear work decks before hoisting. When men are being hoisted, the bucket must be raised at a creeping speed with the bell cable constantly attended until the crosshead is engaged. As in federal regulations, men are prohibited from riding loaded buckets or on the rim of any bucket.

Another regulation commonly found in state laws is the requirement for shaft doors at the collar to prevent material from falling into the shaft. Gates are likewise required at the surface and at all landings. Most states also require fixed ladders to be maintained as close to the bottom as practical with chain or rope ladders required from the shaft bottom to the end of the fixed ladder. These requirements are not closely followed, since shaft projects generally do not maintain ladderways. Powered emergency escape systems are used in lieu of ladderways. Such substitution is reasonable since few shafts are completely equipped with sets and compartments during sinking. Furthermore, independent powered escape hoists are more practical for miners to use than to attempt to walk out of a shaft several hundred or more feet deep.

State laws commonly require pre-shift and post-blast inspection by qualified examiners prior to the miners entry. The detail specified for these examinations varies. Most require checks of air quantity and quality, methane content and for the presence of fly rock or unstable wall conditions.

State laws also require that shafts be adequately ventilated. The details of adequate ventilation are usually not specified.

In general, all other appropriate sections of state mining laws are applied to shaft projects. These mining laws closely follow the requirements of federal law. New mines must be reported to the state mine inspector. The level of information varies, with most states requiring some type of plan for the development of the shaft and new mine. These plans are not as detailed as those required under federal law.

Accidents must also be reported to state agencies. The types of accidents requiring reports and the type of investigation required are similar to the federal requirements.

Hoisting requirements of most states are based on and reference ANSI Standard M11.1-1960, The Use of Wire Rope in Mines, as do the federal requirements.

Regulations for blasting equipment and procedures are comparable to federal law.

In certain areas state requirements are more stringent than the federal regulations. State regulations specify that people performing shaft examination be certified. The states are also more specific in establishing requirements for personnel certification. Certificates of a variety of types are issued to mine examiners, various levels of supervisors, and hoist operators. Requirements for certification are established in some detail and examiner boards are used to evaluate candidates and issue certificates of competency. Qualifications generally include training in first aid, air quantity and quality measurement techniques, familiarity with mining law and a set period of experience in a working mine. Requirements for hoist operators may include a certain length of training and experience at hoist operation under the guidance of a qualified hoist operator. Many states also require a physical examination and establish minimum physical standards for hoist operators.

Certification standards vary among the states. Experience and knowledge may not be carefully evaluated before certificates are issued. In addition, experience in a producing coal or metal-nonmetal mine may not be directly applicable to shaft-sinking work. State certification, therefore, may be only partially effective in enforcing shaft safety.

FOREIGN SHAFT-SINKING LAWS

Methods of establishing and enforcing mining laws vary among nations. Some countries such as the Republic of South Africa and the United Kingdom have unified national mining regulations. In other countries such as Canada and Australia, mining laws are primarily enforced at the provincial or state level. Regulations in these countries may vary from province to province. In addition, national philosophies vary. In the United Kingdom, mining regulation and mine ownership are both government activities. In other areas regulatory agencies are designed to be more advisory. They are not part of an adversary system as in the United States.

Mining law, including shaft-sinking regulations, also vary. Most nations surveyed, however, treat shaft-sinking work in much the same way that it is treated by United States state and federal metal-nonmetal mine law. Most nations treat shaft sinking as a specific category of mining operations, and that while all mining laws may apply as appropriate, several sections specify requirements for situations unique to shaft sinking.

As with United States state regulations, foreign mining laws have several common items relative to shaft work. Most nations or provincial laws surveyed require the use of a crosshead to guide the bucket once a certain depth is reached. This depth varies among the mining nations but generally is 100 to 300 feet. Collar doors are required to prevent material from falling into the shaft. The laws specify that the doors be closed except to allow passage of the bucket. Nearly all agencies require positive overhead protection for men working on the bottom when existing shafts are being deepened or when lining, outfitting or other work occurs simultaneously in the shaft.

Pre-shift and post-blast inspections are required in all areas. These inspections must be made by competent, certified persons.

Hoisting operations are closely regulated as in the United States. Hoist operators must be certified, and strict requirements for certification are established. In operation, buckets must not be lowered directly to the shaft bottom. Nearly all laws specified that the bucket be stopped approximately 15 feet, or 5 meters, above the bottom until the bottom crew signals. Likewise, buckets must be lifted from the bottom and steadied before hoisting.

Most nations treat shaft sinking as the exception to usual mining law and permit men to ride buckets during shaft-sinking work. Again, the bucket must be deep enough to allow men to be transported when standing, men must not ride on the rim or with tools or muck, and self-closing hooks are required.

Shaft-sinking operations are commonly subject to the general body of the nation's or province's mining laws. Therefore, examples of appropriate sections of mining laws from various nations and states are included in Appendix C. These laws are included to provide a comparison with United States laws in the areas of hoisting system, blasting, electrical installation and personnel qualifications.

V. ACCIDENT REPORTING PROCEDURES

Current federal and state mining laws require mine operators to report accidents which occur in or about their mines including those at shaft projects under construction by contractors. The reporting requirements are described in detail in Title 30 CFR, Chapter 1, Subchapter N, Section 58 (Metal and Nonmetal Mines) and Subchapter O, Section 80 (Coal Mines). Both regulations are similar in their definition of reportable accidents.

The Metal and Nonmetal Mine Safety Act of 1966 requires that an accident be reported when there has been a fatal or nonfatal injury, exclusive of minor injuries requiring only first aid to any workers. Other accident situations which must be reported whether or not injuries occur include:

- Any outbreak of fire that endangers human life or a fire underground which is not brought under control within 30 minutes;
- Any unplanned ignition of dust or strata gas;
- Any unplanned explosion of dust or gas;
- Any unplanned inundation by water or gas that endangers human life;
- Any unplanned ignition of explosive, including blasting agents;
- Any entrapment that endangers human life;
- Any damage to shafts and ventilation facilities that endangers human life;
- Any damage to hoisting or haulage facilities used for the transportation of men when such damage endangers human life.

The Coal Mine Health and Safety Act of 1969 defines an accident as:

- The death of or any injury to any person (whether or not time is lost);
- A mine explosion, mine ignition, mine fire, or mine inundation;

- An unintentional roof fall (except in abandoned panels or in areas which are inaccessible or unsafe for inspection);

- Any collapse of a highwall in an active working of a surface mine;

- An unintentional or incomplete detonation of explosives, including blasting agents;

- A coal outburst;

- The entrapment of any person;

- Damage to shafts or ventilation facilities or to hoisting or haulage facilities;

- An event at a mine which causes the death of, or bodily injury to, persons other than persons on the mine property;

- Any other event that could have resulted in death or injury had any person been in the immediate area.

Accidents are reported using either the Metal-Nonmetal Injury and Illness Report, Form 6-1555 (Fig. 28), or Coal Accident, Injury, and Illness Report, Form 6-347 (Fig. 29), as appropriate. The forms request specific information concerning the type of accident, equipment involved, nature and extent of injuries and experience of the injured worker.

The laws require reports to be sent to the Mining Enforcement and Safety Administration (MESA) Health and Safety Analysis Center in Denver, Colorado promptly after each accident. These data are used by MESA and the Bureau of Mines in analyses of accidents, calculation of industry accident statistics and the production of periodic and special reports.

The appropriate MESA Subdistrict Manager must be notified immediately using the most rapid means available when serious accidents occur. Among the accidents requiring immediate notice are:

- A fatal injury to a miner or other person on mine property, or an event at the mine which results in the death of a person other than those on mine property;

Form No. 3000-55
(October 1972)

UNITED STATES
DEPARTMENT OF THE INTERIOR
Mining Enforcement and Safety Administration

Form Approved.
O.M.B. No. 42-R1649.

mesa

METAL-NONMETAL MINE INJURY AND ILLNESS REPORT

Do not write above this line.

Date of injury or illness ____ Mo. Day Yr. Time of injury ____ (1) ☐ A.M. (2) ☐ P.M.

Time shift started ____ (1) ☐ A.M. (2) ☐ P.M. (1) ☐ Production (2) ☐ Maintenance (3) ☐ Other, specify ____

MESA ID Number ____ If this report is being submitted by a contractor or lessor check here ☐

Mine Name ____ Company Name ____

Mailing Address ____

A. LOCATION OF ACCIDENT OR ILLNESS

(a) Underground Mine ("x" applicable boxes)

Accident or illness occurred at production point (1) ☐ Yes (2) ☐ No

If "at production point," "x" applicable method. Not "at production point," "x" principal mining method used.
☐ 01 Cut and fill ☐ 02 Shrinkage ☐ 03 Room and Pillar
☐ 04 Open stopes, naturally supported
☐ 05 Open stopes, artificially supported ☐ 06 Block caving
☐ 07 Sub-level caving ☐ 08 Other, specify ____

"x" applicable box indicating where accident or illness occurred.
☐ 09 Shaft or winze ☐ 10 Inclined haulageway
☐ 11 Other haulageway, adit, or drift ☐ 12 Raise ☐ 13 Stope
☐ 14 Other, specify ____

(b) Surface Mine ("x" applicable box)
☐ 01 Open pit or quarry ☐ 02 Dredge
☐ 03 Other, specify ____

(c) Operations, Sub-Unit ("x" applicable box)
☐ 01 Crushing and sizing ☐ 02 Shops and yards
☐ 03 Kiln products: Calcining, sintering
☐ 04 Loading docks ☐ 05 Warehousing
☐ 06 Milling: Grinding and concentrating
☐ 07 Haulage ☐ 08 Sawing and finishing of dimension stone associated with mining operation
☐ 09 Exploration ☐ 00 Office at mine

B. OCCUPATIONAL ILLNESS
("x" applicable box)
☐ 21 Occupational skin diseases
☐ 22 Dust diseases of the lungs
☐ 23 Respiratory diseases (toxic agents)
☐ 24 Poisoning (toxic materials)
☐ 25 Disorders (physical agents)
☐ 26 Disorders (repeated trauma)
☐ 29 All other occupational illness

C. ACCIDENT OCCURRENCE DATA:

THIS BLOCK FOR OFFICIAL USE ONLY

Describe fully the circumstances under which the accident, injury or illness occurred ____

Number of reportable injuries or illnesses resulting from this accident ____
Name equipment, material, or tool involved ____
Model Number ____

COMPLETE DATA BELOW FOR EACH PERSON INJURED OR ILL

D. REGARDING INJURY OR ILLNESS: (1) ☐ Fatal (2) ☐ Nonfatal

What was the agent, object, or tool inflicting injury ____
Type of injury or illness ____ Part of body injured ____
Amputation (1) ☐ Yes (2) ☐ No. If Yes, part of body lost ____

E. REGARDING INJURED OR ILL PERSON:

Full Name of injured or ill person ____
Social Security Number ____ Sex ____ Age ____
Total years of mining experience ____ Total experience in this mine, Yrs. ____ Wks. ____
Regular job title ____ Experience on regular job, Yrs. ____ Wks. ____
What was employee doing when injured ____

Was that activity part of regular job (1) ☐ Yes (2) ☐ No. If no, experience at that activity, Yrs. ____ Wks. ____
Returned to regular job next regular shift (1) ☐ Yes (2) ☐ No. If Yes, at full capacity (1) ☐ Yes (2) ☐ No.
Returned to another job next regular shift (1) ☐ Yes (2) ☐ No.
Was employee transferred to another job or terminated (1) ☐ Yes (2) ☐ No.
If yes (1) ☐ after lost workdays (2) ☐ because of injury or illness, but without lost workdays
Total number of lost workdays ____ Number lost from regular job ____
Date injury or illness reported to operator ____ Mo. Day Yr. Date lost time began ____ Mo. Day Yr.
Date returned to work ____ Mo. Day Yr.

RETAIN THIS ORIGINAL COPY AT THE MINE OR NEAREST MINE OFFICE FOR 3 YEARS

FIGURE 28
METAL AND NONMETAL MINE ACCIDENT REPORT

Form No 3000-1
(October 1974)

UNITED STATES
DEPARTMENT OF THE INTERIOR
MINING ENFORCEMENT & SAFETY ADMIN.

Form Approved
O.M.B No 42-R1640

mesa

COAL ACCIDENT, INJURY AND ILLNESS REPORT

Date of Accident or Illness ______ Time of Accident ______ A.M. [ ] P.M. [ ]

Time shift started ______ A.M. [ ] P.M. [ ] (1) [ ] Production (2) [ ] Maintenance

MESA ID Number ______ Company Name ______

Mine Name ______ Mailing Address ______

(1) (2) (3) (4) (5) (6)
(7) (8) (9) (10) (11) (12) (13)
(14) (15) (16) (17) (18) (19) (20) (21)
(22) (23) (24) (25) (26) (27) (28)
(29) (30) (31) (32) (33)
(34) (35) (36) (37) (38) (39) (40)
(41) (42) (43) (44) (45) (46) (47) (48) (49)
(50) (51) (52) (53)

A. LOCATION OF ACCIDENT OR ILLNESS *(Circle the applicable code)*

(a) Underground Mine

On Section (1) [ ] Section ID Number ______ Operator Section Number ______

Off Section (2) [ ] Operator Location number or name ______

(On Section, circle code for applicable method. Off Section, circle code for principal method used.)

01 Continuous 02 Conventional 03 Hand 04 Long-wall

(Whether on section or off section, circle location codes describing accident)

01 Shaft 02 Slope 03 Drift 04 Entry 05 Room 06 Face Area 07 Intersection

(On section, circle applicable status code. Off section, circle principal status code.)

01 Development 02 Retreat

(b) Surface Mine 03 Strip 04 Auger 05 Culm bank 06 Dredge

(c) Surface Operation 01 Tipple 02 Mechanical Cleaning Plant

03 Preparation-Plant or Breaker 04 Tramline or railroad 05 Central Shops

00 Office at mine 06 Other surface operations: Specify ______

B. TYPE OF ACCIDENT *(Circle the applicable code)*

14 Electricity
13 Explosive & Breaking Agent
12 Explosion of Gas or Dust
03 Fall of Face, Rib, or Side
01 Fall of Roof
08 Handtool
07 Handling material
11 Haulage
20 Ignition of Gas or Dust
04 Inundation
19 Lifting/Pulling
15 Machinery
17 Mine Fire
02 Pressure Bump or Burst
05 Sliding/Falling Material
06 Slip or Fall (Person)
09 Stepping/Kneeling on object
10 Striking or *Bumping*
16 Suffocation
18 Other: Specify ______

C. OCCUPATIONAL ILLNESS *(Circle the applicable code)*

21 Occupational skin diseases
22 Dust diseases of the lungs
23 Respiratory diseases (toxic agents)
24 Poisoning (toxic materials)
25 Disorders (physical agents)
26 Disorders (repeated trauma)
29 All other occupational illness

D. ACCIDENT OCCURRENCE DATA: What brought about the accident or illness reported ______

What was unsafe physical or mechanical condition(s) contributing to accident ______

Name equipment, material, or tool involved ______ Model number ______

Describe any unsafe act(s) contributing to accident ______

Personnel injured (1) [ ] Yes (2) [ ] No Number of persons injured ______

COMPLETE DATA BELOW FOR EACH PERSON INJURED OR ILL

1. REGARDING INJURY OR ILLNESS

What was the agent, object, or tool inflicting injury ______ (1) [ ] Fatal (2) [ ] Nonfatal

Type of injury or illness ______ Part of Body injured ______

Amputation (1) [ ] Yes (2) [ ] No. If yes, part of body lost ______

2. REGARDING INJURED OR ILL PERSON

Full Name of Injured or ill person ______

Social Security Number ______ Sex ______ Age ______ Total years of mining experience ______ Total years experience in this mine ______

Regular job title ______ Years of experience on regular job ______ What was employee doing when injured ______

Was that activity part of regular job (1) [ ] Yes (2) [ ] No. If no, years of experience at that activity ______

Returned to regular job next regular shift (1) [ ] Yes (2) [ ] No. If yes, at full capacity (1) [ ] Yes (2) [ ] No. Returned to another job next regular shift (1) [ ] Yes (2) [ ] No.

Was employee transferred to another job or terminated (1) [ ] Yes (2) [ ] No. If yes (1) [ ] after lost work days (2) [ ] because of injury or illness, but without lost workdays.

Total number of lost work days ______ Number lost from regular job ______ Date returned to work ______

Mail this green copy to the MESA within a period not to exceed 72 hours following occurrence. (To mail remove covering on adhesive,

FIGURE 29
COAL MINE ACCIDENT REPORT

- A serious injury which could result in the death of the injured person;
- A mine fire;
- Mine explosion;
- An ignition of dust, gas, or both;
- Inundation;
- A coal outburst of sufficient intensity to have caused injury had persons been in the immediate area;
- A fall of roof, face or rib of sufficient magnitude to affect ventilation or the passage of men on active working sections and a fall of roof at or above the anchorage zone when roof bolts are used;
- An unintentional or incomplete detonation of explosives including blasting agents;
- The entrapment of any person;
- Damage to shafts and ventilation facilities; and
- Damage to hoisting or haulage facilities used for the transportation of men when such damage interferes with its use for transportation of men.

Following notification of a fatal or serious accident the District or Subdistrict Manager will determine whether or not an investigation is to be conducted by MESA in addition to that conducted by the operator. If it is determined that a federal investigation will be conducted, the operator is notified and advised to take all measures consistent with rescue work to preserve any evidence helpful in determining the cause of the accident. The investigation is conducted by a duly authorized representative of the Secretary of the Interior with assistance from other MESA personnel as required. Information is obtained from an examination of the accident scene, and statements of mine or contractors' officials and workers involved in or witnessing the accident. A report is then prepared which describes in detail the date and time of the accident, the location and description of the accident, and events preceding the occurrence. Conclusions are presented as to the cause of the accident, and recommendations are presented or orders issued to prevent recurrence. Copies of this report are kept in the mine office and the appropriate subdistrict office.

State laws regarding reporting and investigating mine and shaft-sinking accidents generally follow the federal requirements. In those states where a State Plan Agreement is in effect, copies of the federal report are also sent to the appropriate state agency. The State Plan Agreement is a contract between the Secretary of the Interior and the state official responsible for mine safety in one of several states. In these states State Mine Safety laws are equal to or stronger than the federal laws. Under the agreement, the state authorities rather than MESA assume primary responsibility for mine safety. MESA then assumes a more passive monitoring role. State Mine Inspectors in all states may also conduct investigations similar to or in conjunction with the federal investigation.

VI. ANALYSIS OF ACCIDENT DATA

INTRODUCTION

Before improvements can be made in shaft safety, it is necessary to investigate the causes of shaft accidents and to identify and analyze the factors contributing to accidents. In order to accomplish this, records of recent shaft-sinking accidents from both coal and metal-nonmetal shaft projects were obtained and analyzed.

It was intended that, through a review of this data, specific causes of accidents such as equipment failure or improper sinking procedures or other contributing factors such as worker inexperience or lack of training would be identified.

The data used in the analyses conducted for this report were obtained from the Coal Mine and Metal and Nonmetal Accident and Illness Reports filed with MESA by the mine operators. In addition, inspectors' investigation reports of fatal or potentially fatal accidents were obtained from the various MESA Health and Safety District or Subdistrict Managers. A total of 543 reports from coal shaft projects and 386 reports from metal and non-metallic mine shaft accidents were reviewed. The records included accidents that occurred at surface shops and yards of shaft projects as well as those occurring in the shafts themselves. Data from accidents in mills, preparation plants or shafts at producing mines were not included.

Coal Mine Accident Reports covered the period 1972 through 1975. Employment and Production Reports for coal mines were available for 1975. Metal and Nonmetal Mine Accident Reports and Employment and Production Reports were provided to cover the years 1973 through 1975.

The accident reports were obtained from MESA's Health and Safety Analysis Center (HSAC) in Denver. There was some difficulty in collecting complete accident records. The accident reports are often incomplete and fail to identify whether or not the shaft was under construction. In addition, several filing systems are used in the Center. When an accident report is received from an operator it is checked, the data encoded and placed into an automatic data processing system. The original report is then filed in the Center until a sufficient period of record is complete. The forms are then moved to a records holding area for permanent storage. Problems were first encountered in retrieving specific accidents from the data processing system. For this study only accidents occurring during shaft construction were being considered. The HSAC staff was able to provide a list of reports for all accidents which occurred in coal mine shafts from 1972 to 1975. It was impossible, however, to identify which had occurred at shafts under construction as opposed to those in operating shafts.

It was necessary, therefore, to locate the original accident record to identify those for shaft-sinking accidents. A new series of problems then arose. The filing systems at HSAC are constantly being revised and improved. It was necessary to search through both microfilmed records and files to obtain the accident reports. Coal Mine Accident reports for 1972 through 1974 were stored on microfilm in numerical order by individual document number. These were identified using the data list supplied by HSAC. Coal Mine Employment and Production Reports for 1972 through 1974 were also microfilmed and cataloged by document number. Lacking a listing of these document numbers, it was not possible to locate these records. The Coal Mine Accident records and Employment and Production Reports for 1975 are maintained as paper copy in HSAC's files. These records are filed by the Mine Identification Number and were easily located and searched.

Metal and Nonmetal Mine Accident and Employment - Production Reports were not kept by MESA prior to 1973. The records for 1973 through 1975 are kept as paper copy, filed according to Mine Identification Number, in the Center's files. These records were located and searched.

In several cases, however, records of accidents from known shaft-sinking projects could not be located due to a failure to report accidents, improper identification of the mine on the report, or to errors in filing the reports in the Center. In spite of these difficulties, 929 accident reports were obtained, 543 injuries, including 8 fatalities, from coal mine projects, and 386 injuries, including 12 fatalities, from metal and nonmetallic mine projects. The reports included both shaft and slope projects by nearly all major shaft contractors in all major mining regions of the country.

Copies of shaft-sinking accident reports were made from either the microfilm or paper records. In compliance with the Federal Privacy Act the names and Social Security Numbers of the injured miners were obscured from the copies provided for this study.

To complete this analysis it was necessary to compare the safety record of the shaft industry to the overall record of the mining industry. This task required the collection of supporting data such as the number of workers employed, man-hours worked, production rates and the number of recently completed shaft projects.

The following discussion describes the types of data collected, the analyses performed and the results achieved.

DATA TABULATION

A wide variety of data was obtained from published reports, MESA, and individual contractors. All available data on shafts, accidents, and production were collected, sorted into three major groups, and tabulated. A complete description of this collection is presented in the DATA SOURCES section of this report.

The first data group was an inventory of recent shaft projects. This group included the mine identification number, location, mine name, owner, contractor, dimensions, site geology, method of construction, and year completed.

The second data group was a compilation of shaft-sinking production data. Although some of this information was obtained from published sources, the majority was obtained from Monthly or Quarterly Employment and Production Reports provided by MESA's Health and Safety Analysis Center. The data included mine identification number, date of report, number of underground workers, number of man-hours worked underground, number of surface workers, number of man-hours worked at the surface and the number of accidents reported during the record period.

The third data group was comprised of the accident records. The data were obtained from inspectors' reports of fatal or other serious accidents and from accident reports filed with the Health and Safety Analysis Center. Data recorded included mine identification number, document number, accident type, date and time of accident, shift time, victim's age, total mining experience, total experience at mine in which injury occurred, part of body injured, cause, location, equipment, degree of injury and days disabled. The information for coal shaft accidents was supplied as a data printout by the Health and Safety Analysis Center. These data were cross-referenced to the accident report documents to obtain additional details. Information for accidents in metal and nonmetallic mine shafts was obtained directly from the accident reports.

Two of these groups, the Production Data and Accident Records, provided the basis for these analyses. The results of these analyses were compared to previous studies, particularly "Accident Prediction Investigation Study" by

Theodore Barry and Associates (1972); Injury Experience in the Metallic Mineral Industries, MESA (1975); and MESA Safety Reviews for Coal and Metal-Nonmetal Mines. Such studies provide a means of comparing shaft miners and accidents with production miners and mining accidents in the coal and metal-nonmetallic mining industries. The data presented below gives some indication as to the causes of the majority of shaft-sinking accidents.

ACCIDENT FREQUENCY AND SEVERITY

The Employment and Production Reports and Accident Records obtained from MESA's HSAC were used to calculate accident frequency and severity rates for shaft-sinking work. Employment and Production Reports are submitted monthly by coal mine operators and quarterly by metal and nonmetal mine operators. The reports include the number of workers and man-hours worked during the reporting period and the number of reportable accidents that occurred. The frequency and severity rates calculated from these data were compared to published rates for the mining industry in general. Separate rates were calculated for coal and metal-nonmetal mines. The definitions of accident rate, disabling injury-frequency rate, disabling injury-severity rate, and average severity were taken from MESA Informational Report IR 1008, Injury Experience in the Metallic Mineral Industries, 1970-1971 (1975). These definitions are based on United States of America Standards Institute Bulletin 216.1-1967, "Standard Method of Recording and Measuring Work Injury Experiences," and may be applied to work at coal as well as metal and nonmetallic mineral mines.

The accident frequency rate is the number of accidents that occur for each million man-hours worked. The rate may be based on either the number of disabling (work time lost) injuries or the number of all injuries, both disabling and nondisabling.

The disabling injury-frequency rate is the number of disabling work injuries per million man-hours of exposure. It is calculated by multiplying the total number of injuries by one million and dividing the product by the total man-hours of worktime.

The disabling injury-severity rate is the number of days lost or charged from disabling work injuries per million man-hours of exposure. It is calculated by multiplying the total number of days lost or charged by one million and dividing the product by the total man-hours of worktime.

The average severity is the average number of days lost or charged per disabling injury. It is calculated from the total number of days lost or charged divided by the total number of disabling injuries.

The days lost are the number of full calendar days the injured employee was unable to work as the result of a temporary total disability. All fatalities and permanent total disabilities have a standard time-loss charge of 6,000 days. Injuries resulting in permanent partial disability are assigned a time-loss charge depending upon the particular injury as specified by the United States of America Standards Institute Bulletin Z16.1-1967 Table.

Accident Frequency and Severity - Coal Shafts

The calculation to determine the accident frequency rate for coal shafts was based on all injuries indicated on the coal operators' monthly Employment and Production Reports for the period 1972 through 1975. During that period 250 Employment and Production Reports were available for shaft projects. However, only 63 were complete in reporting the number of man-hours worked and the number of reportable accidents. These 63 reports were assumed to be representative for both man-hours worked and number of accidents in the coal shaft industry. In these 63 record months, a total of 638,015 man-hours were worked and 84 accidents were reported. These data indicate a frequency rate of 131.6 accidents per million man-hours worked. For comparison, MESA reported a frequency rate for all coal mine injuries of 66.06 during the 12-month period ending October 1976 (MESA Safety Review, October, 1976). The disability frequency rates for all coal mines for 1972 through 1976 were reported by MESA to be: 46.66 (1972); 40.89 (1973); 29.29 (1974); 30.59 (1975); and 36.41 (1976).

It should be noted that the frequency rate calculated for coal shaft projects was based on a rather limited number of Employment and Production Reports and includes both disabling and nondisabling injuries. The rate, however, was based on data supplied directly to MESA by the operators themselves.

For computations of average severity in coal mine shaft projects, 543 accident reports were located for the period 1972 through 1975. Of these reports 437 recorded a total of 50,771 days lost, including 6 fatal accidents which resulted in the deaths of 8 miners. The average severity was therefore calculated to be 116.2 days lost per accident. Excluding fatalities, the average severity was 6.4 days.

An alternate method for calculating severity is a severity rate. This factor is the number of days lost per million man-hours worked. Attempts were made to calculate a severity rate based on the number of man-hours worked and accidents reported during each of the 63 monthly record periods used to calculate the coal shaft accident frequency rate. The individual accident reports were searched to locate those reported on the Employment and Production Reports for the individual shafts during the record months. This search failed since the number of accident reports available for a given shaft rarely agreed with the reported number of accidents shown on the Production Report. It was therefore determined that any calculation of severity rate based on the available data would be meaningless. An average severity was then calculated based on the total number of accident reports available and the number of days lost or charged per injury.

Accident Frequency and Severity - Metal and Nonmetal Shafts

The accident frequency rate for metal and nonmetal shaft projects was determined in the same manner as that for coal shafts. Operators' Quarterly Employment and Production Reports for the years 1973 through 1975 were used. A total of 95 reports were located, on which were reported a total of 2,459,182 man-hours worked and 386 accidents. These data indicate a frequency rate of 157.8 accidents per million man-hours. During the period of January through September 1975, MESA (Safety Review, Metal and Nonmetal Mine Injuries, Third Quarter 1975) reported an accident rate of 38.6 for all underground metal and nonmetal mines.

As with the coal mine frequency rate, the metal and nonmetal mine rate was based on a sampling of operators' Employment and Production Reports. The rate was calculated using the total number of reported accidents including both disabling and nondisabling injuries. In spite of these limitations, the rates calculated for shaft accidents are the best possible with the data available.

As with coal shafts, attempts were made to determine the severity rate in days lost or charged per million man-hours worked. These attempts failed due to the inconsistencies described above, and an average severity was calculated based on the total number of days lost or charged per accident.

During the period of record, 1973 through 1975, 386 accident reports were located from metal and nonmetal shaft projects. Of these reports, 54 were incomplete. The remaining 332 reports listed a total of 76,938 days lost for an average severity of 231.7 days. This average value includes 10 fatal accidents in which 12 men were killed. Excluding fatalities, the average severity was 14.7 days lost per accident.

In calculating the average severity for metal-nonmetal shafts and coal shaft projects, it must be remembered that these averages were computed based on the number of days reported lost on the accident report form. Some errors may have been included in cases of serious injuries resulting in permanent partial disability. In these cases the extent of disability could not be determined from the reports, and no estimate of days lost could be made. Such missing data would tend to lower the total number of days lost used in computing the average. However, these errors are believed to have been offset by several cases in which an employee received a minor injury and voluntarily never returned to work. These reports indicate a large number of days lost before employment was terminated.

NATURE OF INJURIES

The natures of the injuries resulting from shaft accidents are shown on Tables 1 and 2 for coal and metal-nonmetal projects, respectively. A total of 16 fatal accidents which resulted in 20 deaths occurred during the period 1972 through 1975 for coal shafts and 1973 through 1975 for metal and nonmetal shafts.

As shown on Tables 1 and 2, the leading types of injuries at both types of shaft projects were contusions and bruises. Cuts and sprains were the second and third most common types of injuries.

The majority of injuries appear to be relatively minor. Fractures are the only serious injuries occurring with any frequency, accounting for only 6.8 percent of the coal shaft injuries and 13.0 percent of metal-nonmetal shaft injuries.

Multiple injuries accounted for 4.6 percent of injuries in coal accidents and 3.9 percent of metal-nonmetal shaft accidents. While these types of injuries are relatively uncommon, they are the most severe, commonly resulting in death or permanent disability.

The incidence of chemical burns should be noted. These injuries accounted for only 3.3 percent of the injuries in coal shafts, but in metal-nonmetal shafts, chemical burns, chiefly burns from alkali substances added to concrete, amounted to 9.8 percent of all injuries.

TABLE 1

NATURE OF INJURY
COAL MINE SHAFTS 1972-1975

Description	Number of Accidents	Percent of Injuries
Contusion, crushing, bruise	123	22.6
Sprain, strains	80	14.7
Cut, laceration, puncture	77	14.2
Miscellaneous or unclassified	72	13.2
Fracture	37	6.8
Multiple injuries	25	4.6
Burn (chemical)	18	3.3
Burn or scald	4	0.7
Dermatitis	4	0.7
Hernia, rupture	4	0.7
Amputations or enucleation	2	0.4
Concussion	1	0.2
Dislocation	1	0.2
Scratches, abrasions	1	0.2
Not reported	94	17.3
TOTAL	543	99.8

TABLE 2

NATURE OF INJURY
METAL & NONMETAL MINE SHAFTS 1973-1975

Description	Number of Accidents	Percent of Injuries
Contusion, bruises	84	21.8
Cuts, punctures	59	15.3
Fractures	50	13.0
Sprains	50	13.0
Chemical burns	38	9.8
Miscellaneous	18	4.7
Multiple injuries	15	3.9
Asphyxia, drowning	11	2.8
Scratches, abrasion	10	2.6
Burns	6	1.6
Amputation	4	1.0
Dermatitis	4	1.0
Dislocation	4	1.0
Radiation (flash)	4	1.0
Heat stroke	2	0.5
Hernia	2	0.5
Inflammation of joints	2	0.5
Concussion	1	0.3
Electrical shock	1	0.3
Freezing	1	0.3
Not Reported	20	5.2
TOTAL	386	100.1

CAUSES OF ACCIDENTS

The accident data obtained from MESA's Health and Safety Analysis Center were analyzed to identify the causes and circumstances of each accident. The data were examined and tabulated according to the cause of the accident and the type of accident which resulted. The detailed reports of fatal accidents were studied and compared to all shaft accidents in general. Table 3 summarizes the causes of fatal accidents which occurred in shafts during the period of record.

The results of these analyses provide a general indication as to the causes and circumstances surrounding shaft accidents. Due to the limitations of the basic data described earlier, additional information was needed to substantiate the results of this analysis. Therefore, meetings and site visits were arranged in cooperation with officials of various MESA Health and Safety Districts and Shaft Contractors. The results of these meetings are referred to throughout this report and supplement the results of these analyses.

Tables 4 and 5 show the reported causes of accidents in coal and metal-nonmetal shafts, respectively. The various causes of accidents have been ranked in order of frequency of occurrence, average severity and in number of fatalities resulting. Ranking in order of frequency identifies those causes occurring most commonly regardless of the injuries that result. The average severity ranking identifies the various accident causes that result in the greatest average time lost or charged. From these rankings it can be seen that the most important causes of accidents are haulage, machinery, materials handling, falls of persons, sliding or falling objects, suffocation, and miscellaneous causes including burns and chemical irritations.

The following discussions examine each cause in detail.

Haulage Accidents

Haulage includes all equipment used for transporting men or materials. In shaft and slope work haulage includes hoisting men or materials and placement of buckets on the bottom. As seen from the accident data, haulage was the leading cause of accidents, based on average severity, for both coal and metal-nonmetal shafts. Such accidents were the leading cause of fatalities at metal-nonmetal shafts and the second greatest cause of fatalities at coal

TABLE 3

SUMMARY OF FATAL SHAFT SINKING ACCIDENTS

I COAL - 1972-1975

Date	Description	Number Killed
9/72	In-rush of mud buried loader operator, raise boring project.	1
5/73	Clutch and brakes on mobile crane failed after being soaked by rain. Muck bucket was dropped into shaft crushing victim.	1
12/73	Mucker operator crushed between loaded muck bucket being hoisted and mucker.	1
4/74	Loaded muck bucket was hoisted into the headframe, breaking the rope. Bucket fell into shaft crushing miner.	1
1/74	Ropes on mobile crane and spotting hoist failed dropping work deck.	3
6/75	Wire rope on air winch failed, fell into shaft hitting miner.	1

II METAL - NONMETAL - 1973-1975

Date	Description	Number Killed
12/73	Miner fell from muck bucket being hoisted, bucket tipped when hit broken vent tube.	1
12/73	ST-8 loader ran away in a slope. Operator was thrown clear and killed.	1
4/74	Skip tipped on shaft bottom pinning man between skip and mucker.	2
4/74	Man fell from work deck while installing slick line.	1
9/74	Rope separated from drum on mobile crane, dropping concrete bucket on miner.	1
9/74	Miner tried to free muck jam in raise. Muck broke free dropping man into raise.	1
5/75	Miner put his head outside of skip and was crushed between skip and shaft divider.	1
5/75	Men lowered into gas accumulated in shaft.	2
7/75	Rope on mobile crane broke, dropped sheave block on mechanic (surface shop).	1
12/75	Unknown object fell down shaft, struck miner.	1

TABLE 4

CAUSES OF ACCIDENTS - COAL SHAFTS
1972 - 1975

CAUSE	NUMBER OF ACCIDENTS	NUMBER REPORTING SEVERITY	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	SEVERITY RANK	NUMBER OF FATALITIES	FATALITY RANK	OCCURRENCE RANKING
Haulage	7	7	6,253	893.3	1	1	2	10
Machinery	113	100	42,583	425.8	2	7	1	1
Sliding/Falling Objects	31	31	287	9.3	3	0	0	5
Fall of Person	61	61	540	8.6	4	0	0	3
Miscellaneous	30	30	232	7.8	5	0	0	6
Fall of Face, Rib, or Wall	24	23	179	7.8	5	0	0	8
Fall of Roof or Back	27	27	171	6.3	6	0	0	7
Handling Materials	105	104	443	4.3	7	0	0	2
Explosives	2	2	8	4.0	8	0	0	11
Nonpower Handtools	34	34	73	2.1	9	0	0	4
Stepping/Kneeling on Sharp/Loose Object	11	11	2	0.2	10	0	0	9
Striking/Bumping Object	7	7	0	0.0	11	0	0	10
TOTAL	452	437	50,771	116.2	-	8	-	-
Data Incomplete	91	106						
	543	543						

TABLE 5

CAUSES OF ACCIDENTS - METAL AND NONMETAL SHAFTS
1973 - 1975

CAUSE	NUMBER OF ACCIDENTS	NUMBER REPORTING SEVERITY	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	SEVERITY RANK	NUMBER OF FATALITIES	FATALITY RANK	OCCURRENCE RANKING
Haulage	39	34	31,898	938.2	1	5	1	5
Suffocation & Mine Fires	14	13	12,001	923.2	2	2	2	9
Sliding/Falling Objects	28	28	12,323	440.0	3	2	2	7
Fall of Person	45	43	12,940	300.9	4	2	2	4
Machinery	56	45	6,482	144.0	5	1	3	2
Explosives	1	1	32	32.0	6	0	0	14
Fall of Roof or Back	5	4	56	11.2	7	0	0	12
Handling Materials	46	39	410	10.5	8	0	0	3
Fall of Face, Rib, or Wall	29	26	245	9.4	9	0	0	6
Miscellaneous	62	58	395	6.8	10	0	0	1
Stepping/Kneeling on Sharp/Loose Object	11	11	53	4.8	11	0	0	10
Nonpower Handtools	19	17	66	3.9	12	0	0	8
Striking/Bumping Object	10	9	29	3.2	13	0	0	11
Electricity	3	3	5	1.7	14	0	0	13
TOTAL	368	331	76,935	231.7	-	12	-	-
Details not recorded	18	55						
	386	386						

shafts. Table 6 shows a detailed listing of the various causes of haulage accidents. The greatest number of fatalities resulted from operators being crushed between conveyances or between conveyance and rib while operating. Other serious or fatal accidents resulted from haulage ropes or falling from conveyances, autos or trucks.

Machinery Accidents

Machinery accidents include those resulting from the use of loaders, drills, bolters and all powered tools. Based on average severity, machinery was the second most important cause of coal shaft accidents and the fifth leading cause of metal-nonmetal shaft accidents. A detailed breakdown of the causes of machinery accidents in coal and metal-nonmetal shafts is shown on Table 7. In both cases power drills were the most common causes of machinery accidents.

Drilling accidents commonly resulted from the miners' efforts to control the drill or when changing drill steel. Injuries from broken equipment were less common and usually resulted from broken drill steel. In a few cases air hoses broke, striking the operator or other miner. Other drilling accidents were the result of clothing, hair or hands caught in the drill, foreign objects in eyes, or dropping the drill on hands or feet.

Although power drills caused more injuries, dozers, cranes and front loaders caused more severe injuries and accounted for three fatalities.

Suffocation and Mine Fires

Suffocation and smoke inhalation from mine fires was the second most serious cause of accidents at metal-nonmetal shaft projects. As shown on Table 8, such accidents resulted in 14 injuries including 2 fatalities, both from naturally occurring gases. It should be noted that no suffocation and smoke inhalation accidents were reported at coal shaft projects.

Sliding or Falling Objects

Sliding or falling objects were the third most significant cause of accidents at coal and metal-nonmetal shaft projects. Table 9 details the types of accidents resulting from this cause. In both cases the most severe accidents resulted from falling rock.

TABLE 6

CAUSES OF HAULAGE ACCIDENTS

I. COAL SHAFTS - 1972-1975

CAUSE	NUMBER OF ACCIDENTS	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	NUMBER OF FATALITIES
Struck or squeezed between cars or motors	1	0	0.0	0
Operator squeezed between car and rib	1	6,000	6,000.0	1
Squeezed between car and rib - not machine operator	1	3	3.0	0
Fall from car, scraper, tractor	1	3	3.0	0
Fall while leaving truck or auto	2	243	121.5	0
Miscellaneous haulage	1	4	4.0	0
TOTAL	7	6,253	893.3	1

II. METAL AND NONMETAL SHAFTS - 1973-1975

CAUSE	NUMBER OF ACCIDENTS	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	NUMBER OF FATALITIES
Struck or squeezed between cars - while coupling	2	60	30.0	0
Struck or squeezed between cars - while operating	5	12,251	2,450.2	2
Miscellaneous - struck or squeezed between cars	1	289	289.0	0
Squeezed between car & rib while coupling	1	15	15.0	0
Squeezed between car & rib while operating	5	6,415	1,283.0	1
Miscellaneous - squeezed between car & rib	4	87	21.8	0
Ropes used for haulage	6	6,301	1,050.2	1
Strains from pushing/pulling cars by hand	2	286	134.0	0
Fall from car, scraper, tractor	1	6,000	6,000.0	1
Flying particles from haulage equipment	1	3	3.0	0
Autos, trucks	1	29	29.0	0
Slip or fall leaving auto or truck	2	105	52.5	0
Miscellaneous haulage	3	75	25.0	0
TOTAL	39	31,898	938.2	5
Details not recorded	5			

TABLE 7

CAUSES OF MACHINERY ACCIDENTS

I. COAL SHAFTS - 1972-1975

CAUSE	NUMBER OF ACCIDENTS	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	NUMBER OF FATALITIES
Chain, bucket or nonbelt conveyor	1	0	0.0	0
While moving loader	3	3	1.0	0
Operating loader or mucker	2	0	0.0	0
Power drills - when drilling	40	168	4.2	0
Power drills - when bolting	4	87	21.8	0
Cranes, dozers, front loaders	6	12,059	2,009.8	2
Pumps, compressors - stationary machines	1	0	0.0	0
Flying particles from machines - except bolters	14	5	0.4	0
Flying particles from bolting machines	1	0	0.0	0
All miscellaneous powered machines	28	30,261	1,080.8	5
TOTAL	100	42,583	425.8	7
Details not recorded	13			

II. METAL AND NONMETAL SHAFTS - 1973-1975

CAUSE	NUMBER OF ACCIDENTS	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	NUMBER OF FATALITIES
Belt conveyor	1	74	74.0	0
Chain, bucket or nonbelt conveyor	2	26	13.0	0
Moving mining machine	7	59	8.4	0
Operating loader or mucker	4	73	18.3	0
Power drills - when drilling	13	122	9.4	0
Rock bolting machines	1	0	0.0	0
Cranes, dozers, front loaders	2	6,004	3,002.0	1
Moving any machine except miner or loader	1	3	3.0	0
Flying particles from machines - except bolters	2	18	9.0	0
All miscellaneous machines	12	103	8.6	0
TOTAL	45	6,482	144.0	1
Details not recorded	11			

TABLE 8

CAUSES OF SUFFOCATION, SMOKE INHALATION AND FIRE ACCIDENTS

METAL AND NONMETAL MINE SHAFTS

1973 - 1975

CAUSE	NUMBER OF ACCIDENTS	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	NUMBER OF FATALITIES
Naturally occurring strata gas or oxygen deficiencies	5	12,000	2,400.0	2
Fumes from fires, gasoline engines, etc.	8	1	0.1	0
TOTAL	13	12,001	923.2	2
Data Incomplete	1			

TABLE 9

ACCIDENTS RESULTING FROM SLIDING OR FALLING MATERIALS

I. COAL SHAFTS - 1972-1975

OBJECT	NUMBER OF ACCIDENTS	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	NUMBER OF FATALITIES
Props or timbers	1	0	0.0	0
Object dropped or thrown by co-worker	4	12	3.0	0
Material sliding or falling from car, loaders	4	27	6.8	0
Roll or slide of coal or gob	3	153	51.0	0
All miscellaneous	19	95	5.0	0
TOTAL	31	287	9.3	0

II. METAL AND NONMETAL SHAFTS - 1973-1975

OBJECT	NUMBER OF ACCIDENTS	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	NUMBER OF FATALITIES
Props or timbers	2	10	5.0	0
Object dropped or thrown by co-worker	5	9	1.8	0
Material sliding or falling from car, loader	9	150	16.7	0
Falling equipment under repair	4	23	5.8	0
Roll or slide of ore, waste, or gob	2	6,039	3,019.5	1
Miscellaneous or unknown objects	6	6,092	1,015.3	1
TOTAL	28	12,323	440.0	2

Falls of Persons

Slips and falls were the fourth most serious accidents at both coal and metal-nonmetal shafts. Such accidents are classified as falls on the same level, including slipping on ice or in the shower, or falls from height such as falling from a ladder or scaffold. Tables 10 and 11 show the details of fall-of-person accidents at coal and metal-nonmetal shafts, respectively. Falls at metal-nonmetal shafts resulted in two fatalities.

Other Significant Causes

Accidents resulting from handling materials and miscellaneous causes were significant from a frequency basis. Although common, such accidents were not particularly severe. Materials handling accidents were the second most common type at coal shafts and the third most common type at metal-nonmetal shafts. Table 12 gives details of such accidents. Miscellaneous causes were the most commonly occurring accident at metal-nonmetal shafts and the sixth most common cause of coal shaft accidents. Table 13 details these miscellaneous accidents.

WORKER EXPERIENCE

Many studies (Theodore Barry and Associates, 1971, 1972; Steinkamp, 1975) have indicated that worker experience is a major factor in the cause of accidents. The available accident reports for both coal and metal-nonmetal shaft accidents were studied to determine the experience levels of the injured workers. It was impossible from the available data to normalize the results of these analyses. That is, it was not possible to project the results of the analyses of injured workers to the total population of all shaft miners in the United States. However, discussions with MESA personnel and contractors' representatives substantiated the analyses.

Average Age of Injured Workers

Figures 30 and 31 show the distribution of the ages of workers injured in coal and metal-nonmetal shaft projects. The average age of injured workers in coal shaft projects was approximately 31 years. Over 30 percent of the injured miners were less than 25 years old, with only 17 percent in the 41 to 65 bracket. According to Theodore Barry and

TABLE 10

CAUSES OF FALL-OF-PERSON ACCIDENTS - COAL SHAFTS
1972 - 1975

CAUSE	NUMBER OF ACCIDENTS	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	NUMBER OF FATALITIES
Same level - handling materials	14	59	4.2	0
Same level - nonpowered handtools	4	27	6.8	0
Same level - operating machinery	6	106	17.7	0
Same level - miscellaneous slips and falls	22	134	6.1	0
Subtotal Falls on Same Level	46	326	7.1	0
From height - handling materials	3	58	19.3	0
From height - ladder or scaffold failure	3	2	0.7	0
From height - all miscellaneous	9	154	17.1	0
Subtotal Falls from Height	15	214	14.3	0
TOTAL FALLS	61	540	8.6	0

TABLE 11

CAUSES OF FALL-OF-PERSON ACCIDENTS - METAL AND NONMETAL SHAFTS
1973 - 1975

CAUSE	NUMBER OF ACCIDENTS	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	NUMBER OF FATALITIES
Same level - escaping another hazard	2	1	0.5	0
Same level - handling materials	7	129	18.4	0
Same level - operating machinery	5	38	7.6	0
Same level - miscellaneous slips and falls	14	330	23.6	0
Subtotal Falls on Same Level	28	498	17.8	0
From height - handling materials	3	155	51.7	0
From height - operating machinery	1	0	0.0	0
Fall of person down shaft or slope	5	12,180	2,436.0	2
From height - ladder or scaffold failure	3	98	32.7	0
From height - miscellaneous	3	9	3.0	0
Subtotal Falls from Height	15	12,442	829.5	2
TOTAL FALLS	43	12,940	300.9	2
Details not recorded	2			

TABLE 12

CAUSES OF MATERIAL HANDLING ACCIDENTS

I. COAL SHAFTS - 1972-1975

CAUSE	NUMBER OF ACCIDENTS	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	NUMBER OF FATALITIES
Props, timber, cribbing	5	14	2.8	0
Waste	6	2	0.3	0
Rails, pipe, structural steel	10	88	8.8	0
Wire, wire rope, cables	2	17	8.5	0
Rock bolts	5	3	0.6	0
Flying particles from handling materials	6	8	1.3	0
Miscellaneous supplies	70	311	4.4	0
TOTAL	104	443	4.3	0
Details not recorded	1			

II. METAL AND NONMETAL SHAFTS - 1973-1975

CAUSE	NUMBER OF ACCIDENTS	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	NUMBER OF FATALITIES
Props, timber, cribbing	12	123	10.3	0
Waste	1	0	0.0	0
Rails, pipe, structural steel	9	46	5.1	0
Wire, wire rope, cables	1	1	1.0	0
Flying particles from handling materials	4	48	12.0	0
Miscellaneous supplies	12	192	16.0	0
TOTAL	39	410	10.5	0
Details not recorded	7			

TABLE 13

ACCIDENTS DUE TO MISCELLANEOUS CAUSES

I. COAL SHAFTS - 1972-1975

CAUSE	NUMBER OF ACCIDENTS	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	NUMBER OF FATALITIES
Burns, flash or flying particles from welding or cutting	6	6	1.0	0
Chemical burns	14	121	8.6	0
Burns from controlled fires	2	0	0.0	0
Miscellaneous	8	105	13.1	0
TOTAL	30	232	7.7	0

II. METAL AND NONMETAL SHAFTS - 1973-1975

CAUSE	NUMBER OF ACCIDENTS	TOTAL DAYS LOST OR CHARGED	AVERAGE SEVERITY	NUMBER OF FATALITIES
Wind-blown dirt or debris	2	3	1.5	0
Burns, flash or flying particles from welding or cutting	10	7	0.7	0
Chemical burns	38	295	7.8	0
Miscellaneous	8	60	7.5	0
TOTAL	58	395	6.8	0
Details not recorded	4			

Associates (1972), the average age for injured miners in Pittsburgh Seam mines was 50 years, with the majority of the workers in the 41 to 65 age bracket.

In metal and nonmetal mines, the average age of injured workers was approximately 34 years. Figure 31 shows a more uniform distribution of ages than Figure 30 but is still weighted toward the younger men.

The observation that shaft miners are generally younger than production miners may be explained in two ways. First, these average ages of injured workers may reflect the fact that most shaft miners are younger than production miners. Alternatively, it may indicate that younger miners are more likely to have accidents than older, more experienced workers. Theodore Barry and Associates (1972, p. 111) stated that, nationally, younger miners are more prone to accidents than older men, but in the Pittsburgh Seam mines surveyed, the accident rate for both age groups was nearly equivalent. Research cannot definitely determine which factor applies to shaft workers. It is, however, believed that the shaft construction workers are younger than workers in producing mines.

Total Mine Experience

Tabulations of total underground mine experience reported for each injured miner are shown on Figures 32 and 33 for coal and metal-nonmetal shafts, respectively. Of the 206 coal shaft accident reports which listed total experience, 58.3 percent indicated 2 years experience or less. In their 1972 report (p. 59), Theodore Barry and Associates stated that the average underground miner in the Pittsburgh Seam has 25 years experience in underground mining, and the national average is 16 years.

Injured workers in metal and nonmetal shafts reported somewhat more underground experience. In this case, approximately 25 percent have less than 2 years experience, with the average being approximately 7.3 years.

These observations strongly suggest that one major cause of shaft-sinking accidents is the lack of experience in the work force. This observation was supported by interviews with various MESA inspectors and representatives of contractors and the United Mine Workers of America.

AGE	NUMBER	PERCENT REPORTING AGE
UNDER 20	30	5.9
20 - 24	125	24.7
25 - 29	123	24.3
30 - 34	81	16.0
35 - 39	61	12.0
40 - 44	30	5.9
45 - 49	29	5.7
50 - 54	9	1.8
55 - 59	12	2.4
OVER 59	7	1.4
NOT REPORTING	36	---
TOTAL	543	100

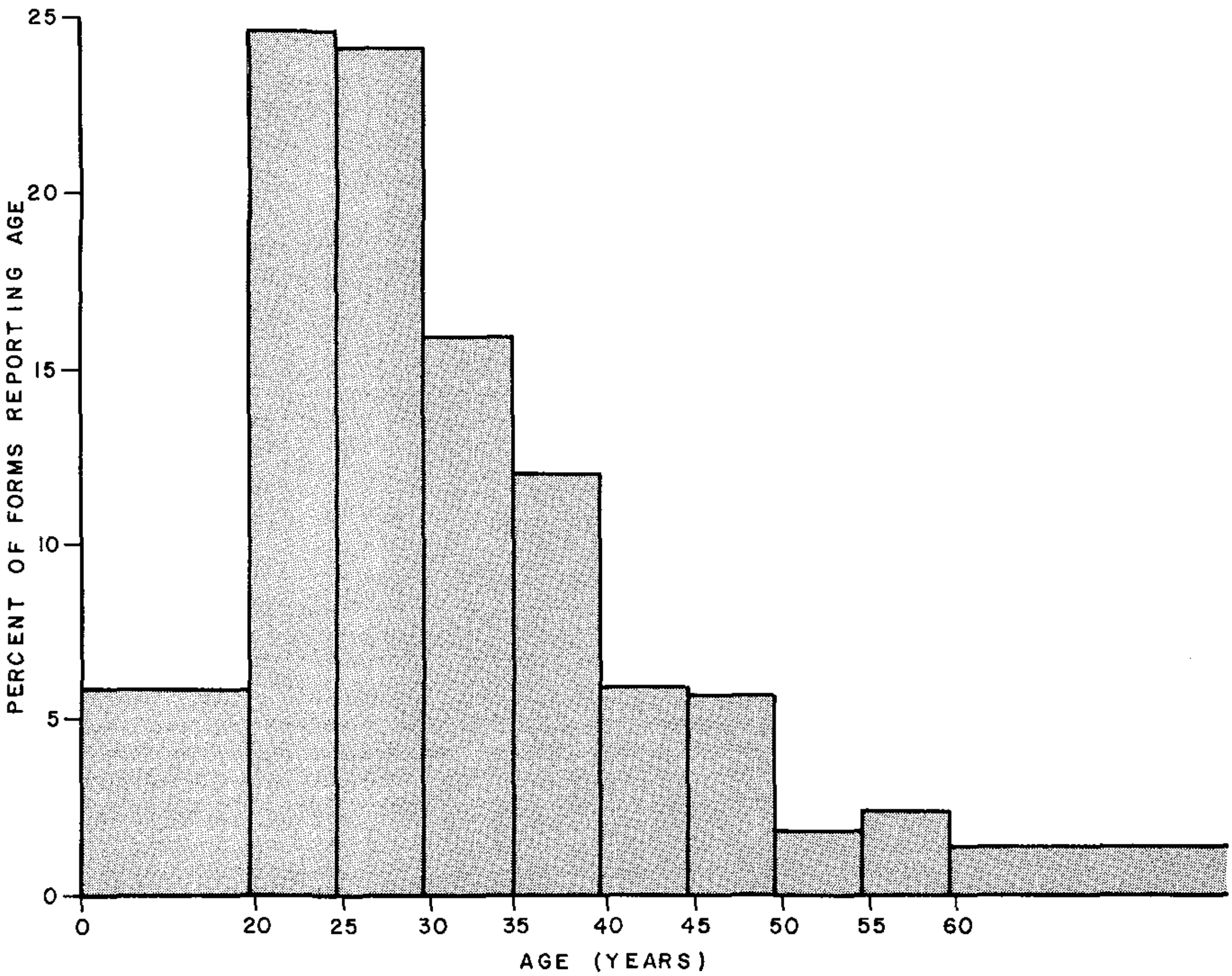


FIGURE 30
AVERAGE AGE INJURED COAL SHAFT MINERS

AGE	NUMBER	PERCENT REPORTING AGE
UNDER 20	10	2.8
20 - 24	56	15.8
25 - 29	60	16.9
30 - 34	86	24.2
35 - 39	40	11.3
40 - 44	53	14.9
45 - 49	23	6.5
50 - 54	20	5.6
55 - 59	4	1.1
OVER 59	3	0.8
NOT REPORTING	31	---
TOTAL	386	99.9

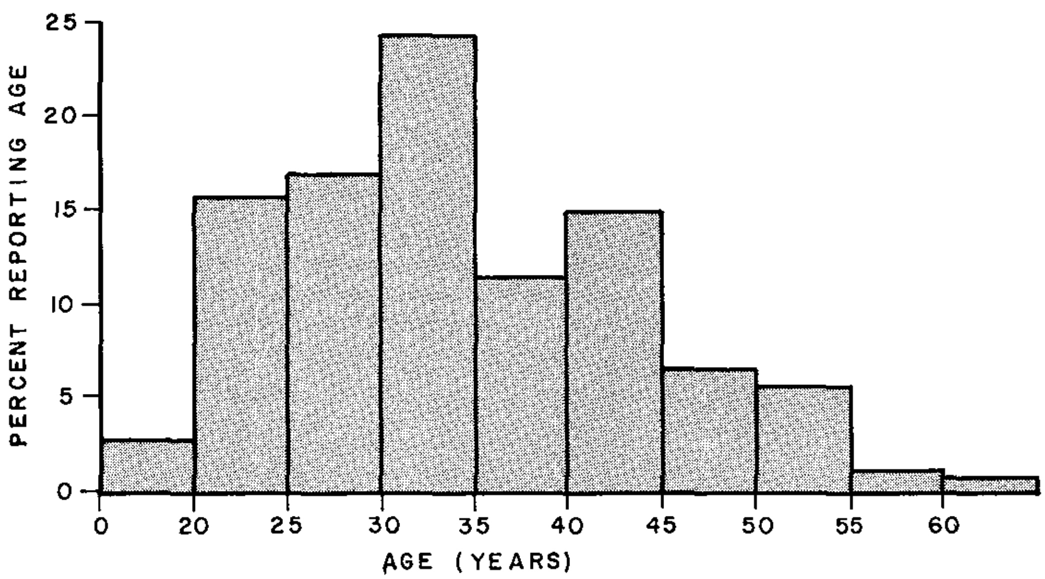


FIGURE 31
AVERAGE AGE INJURED
METAL AND NONMETAL SHAFT MINERS

EXPERIENCE (WEEKS)	NUMBER OF ACCIDENTS	PERCENT OF FORMS REPORTING EXPERIENCE
0 - 13	40	19.4
14 - 27	22	10.7
28 - 40	8	3.9
41 - 52	27	13.1
53 - 79	10	4.9
80 - 104	13	6.3
> 104	86	41.7
NOT REPORTED	337	----
TOTAL	543	100.0

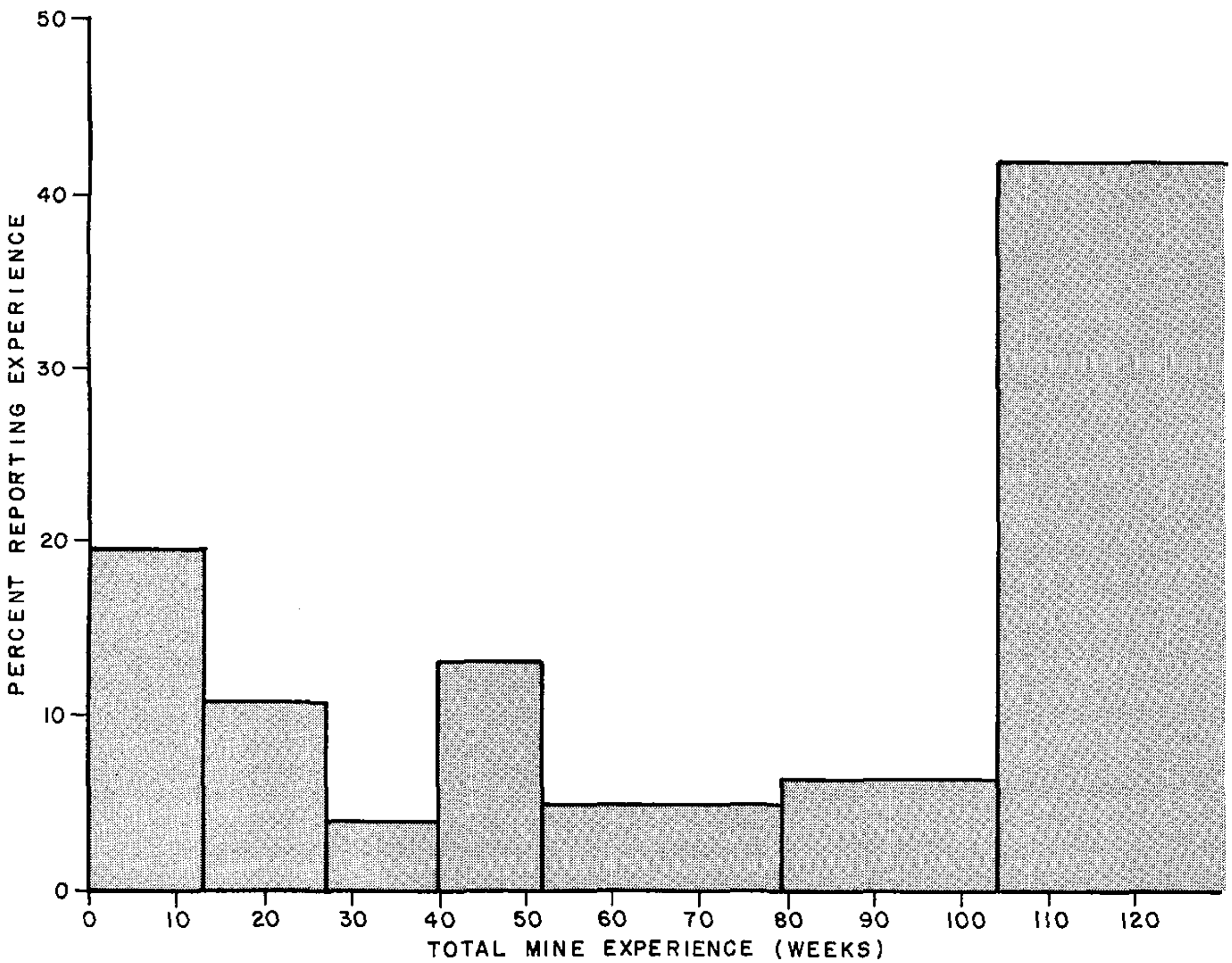


FIGURE 32
TOTAL MINE EXPERIENCE INJURED COAL SHAFT MINERS

EXPERIENCE	NUMBER	PERCENT OF FORMS REPORTING EXPERIENCE
0 - 25 WKS	44	14.9
26 - 51 WKS	10	3.4
1 YR - 1.9 YRS	21	7.1
2.0 - 4.9 YRS	62	21.0
5.0 - 9.9 YRS	72	24.4
10.0 - 14.9 YRS	44	14.9
15.0 - 19.9 YRS	17	5.8
20 + YRS	25	8.5
NOT RECORDED	91	----
TOTAL	386	100.0

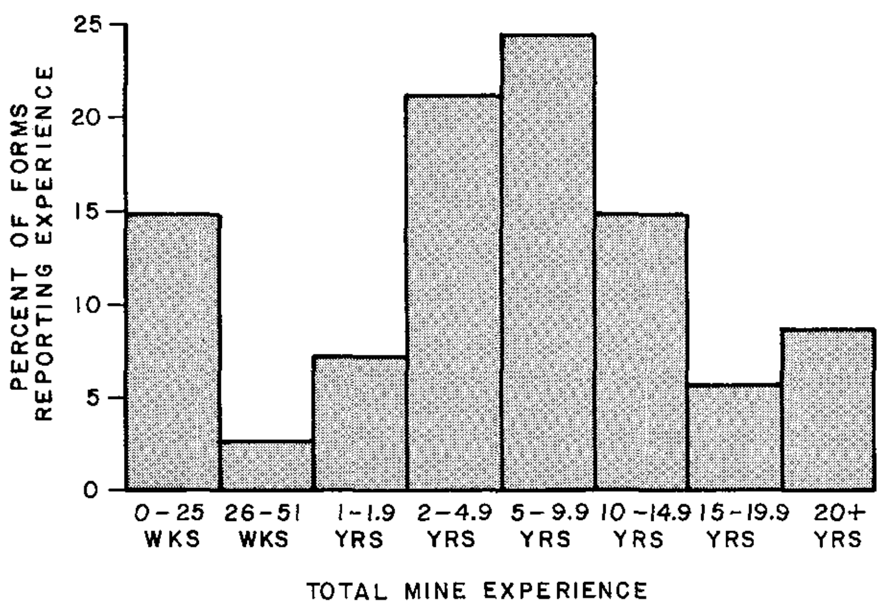


FIGURE 33
TOTAL MINE EXPERIENCE -
INJURED METAL AND NONMETAL SHAFT MINERS

EXPERIENCE (WEEKS)	NUMBER OF ACCIDENTS	PERCENT OF FORMS REPORTING EXPERIENCE
0 - 13	73	26.0
14 - 27	43	15.3
28 - 40	19	6.8
41 - 52	45	16.0
53 - 79	13	4.6
80 - 104	18	6.4
> 104	70	24.9
NOT REPORTED	262	----
TOTAL	543	100.0

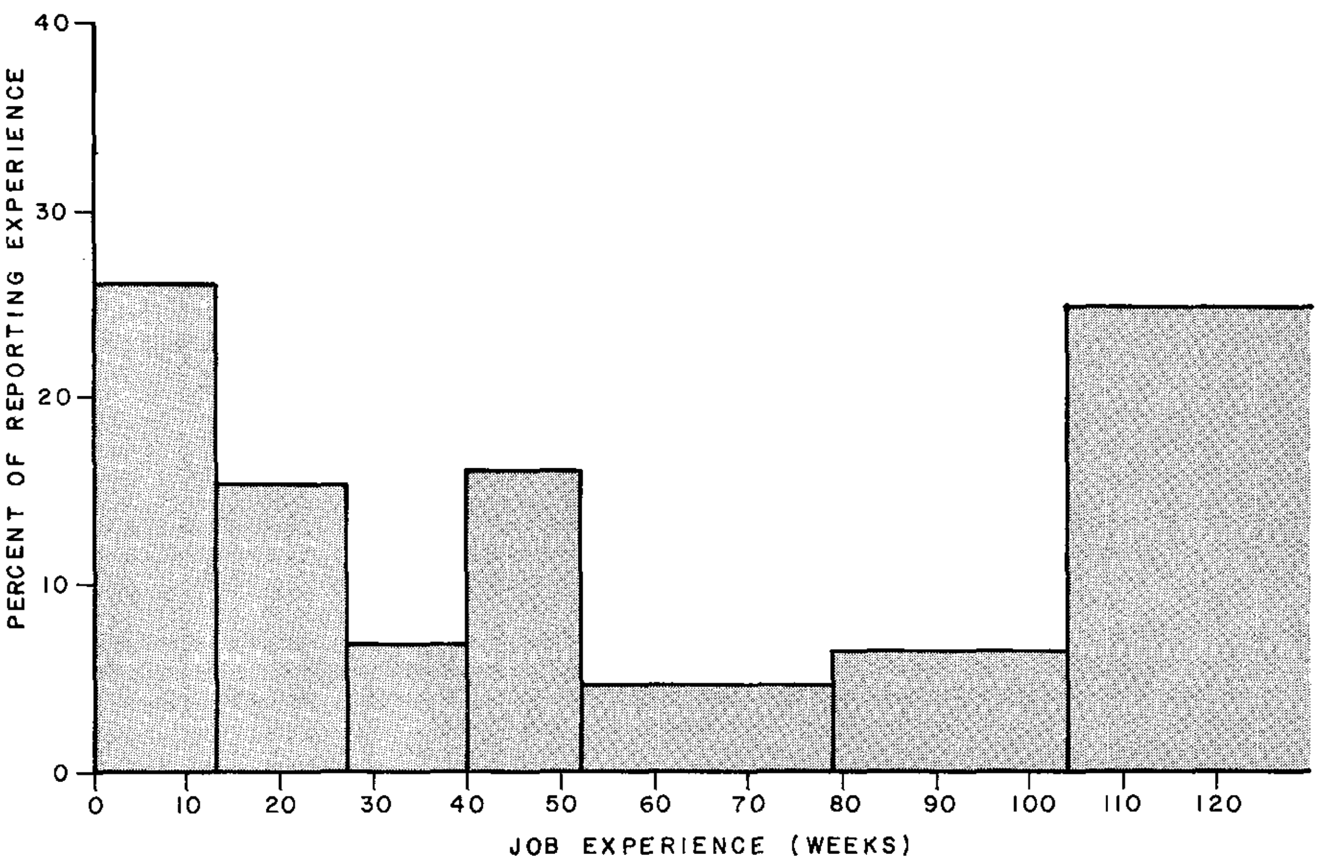


FIGURE 34
JOB EXPERIENCE INJURED COAL SHAFT MINERS

EXPERIENCE	NUMBER	PERCENT OF FORMS REPORTING EXPERIENCE
0 - 25 WKS	108	35.3
26 - 51 WKS	25	8.2
1 YR - 1.9 YRS	34	11.1
2.0 - 4.9 YRS	78	25.5
5.0 - 9.9 YRS	34	11.1
10.0 - 14.9 YRS	12	3.9
15.0 - 19.9 YRS	6	2.0
20 + YRS	9	2.9
NOT RECORDED	80	----
TOTAL	386	100.0

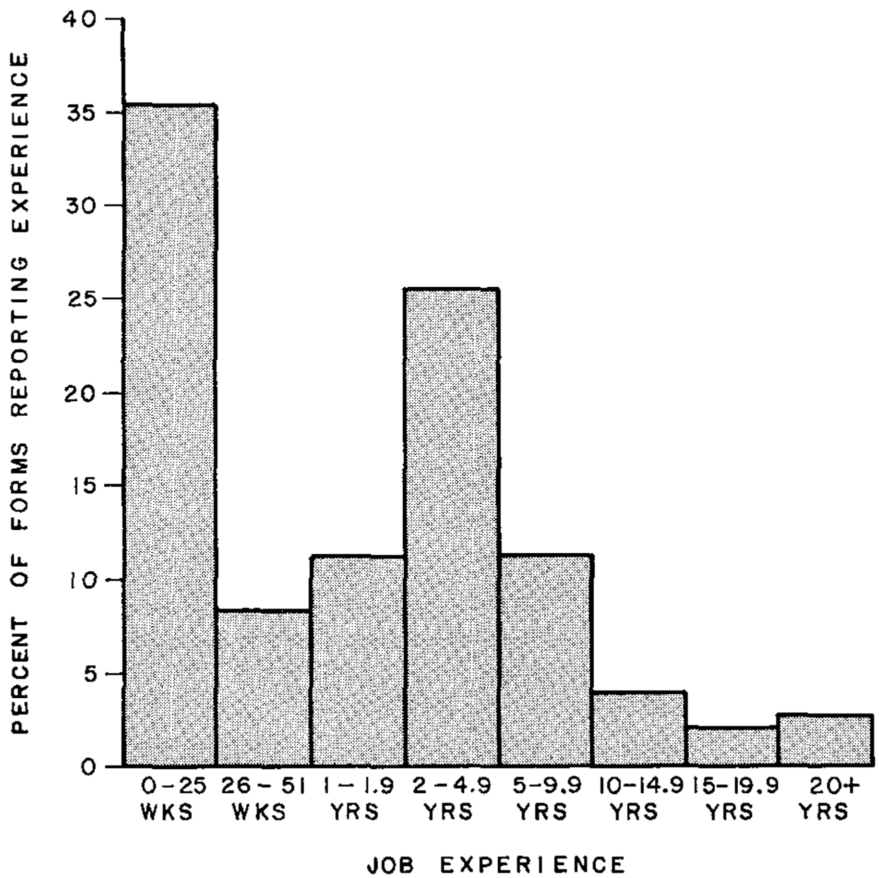


FIGURE 35
JOB EXPERIENCE INJURED
METAL AND NONMETAL SHAFT MINERS

Job Experience

Job experience is that length of time the worker has spent in his current job classification. Figure 34 shows the job experience reported for workers injured in metal-nonmetal shafts. The length of job experience for injured coal shaft workers has been plotted in weeks. According to the reports submitted to MESA, only 25 percent of the injured workers had more than 2 years experience in their job classification. Production miners in the Pittsburgh Seam reportedly average 3 years experience in their classification (Theodore Barry and Associates, 1972).

Figure 35 shows that length of job experience for injured metal-nonmetal shaft miners is somewhat longer than for coal. Although approximately 35 percent reported less than 25 weeks experience, approximately 26 percent reported 2 to 5 years job experience.

VII. CURRENT PRACTICE

INTRODUCTION

To improve shaft safety it is necessary to understand and observe the men and equipment at work in the industry. To this end, sites, officials of key MESA Health and Safety Districts, contractors' representatives, and members of the United Mine Workers of America were visited to get a picture of shaft-sinking practices currently in use. The discussions presented herein are the result of the data analyses and conversations held with the experienced shaft personnel.

THE SHAFT-SINKING INDUSTRY

The mine construction industry, which includes shaft sinking, is a distinct phase of underground mining, and is, in many ways, different from production mining. Shaft sinking is a costly operation requiring a large investment in time, materials, and labor. This expenditure must be committed before mine production can begin and a return realized on the investment. Mining companies and contractors are therefore vitally interested in completing the shaft-sinking in a minimum amount of time. Shaft-sinking contractors are committed to a budget and schedule that requires the work to be completed as efficiently as possible. The mine owners are anxious to have the shaft completed and in service so that mine production may begin or continue. The work is, therefore, relatively temporary, and as a single shaft project does not provide long-term employment, shaft miners are forced to continually travel, seeking work.

In many ways shaft-sinking work is a mixture of mining and heavy construction. Shaft work is done underground and is subject to ground control problems as in mining; ventilation in shafts may be a problem as it is in mines; and a hoisting system is used and is critical to the operation. There are, however, several differences between shaft work and mining. In shaft sinking much work is done from work decks or platforms suspended in the shafts. This is not common in production mining but is more closely related to heavy construction. Other construction tasks are involved: forms are handled and concrete for the shaft lining is placed; and cranes and other temporary lifting devices may be used extensively.

Shaft sinking is a relatively small industry, providing steady employment to a limited number of people. The increased demand for coal and uranium in recent years has increased the need for shafts and the need for skilled workers.

The industry is therefore in a period of growth. New techniques of sinking and drilling are being tested and developed. New regulations are also being proposed and implemented. The situation is one of growth and change.

Site visits conducted during this study focused on actual shaft-sinking practices in use today. Through these visits it was possible to see the effects of regulation, enforcement policies, shaft-sinking methods and equipment. Discussions with contractors and MESA inspectors highlighted safety problems and provided data to supplement the previous data analyses.

REGULATION

Regulation of the shaft-sinking industry is relatively new. The mining industry in the United States was not closely regulated until passage of the Federal Metal and Nonmetallic Mine Safety Act (1966) and Coal Mine Health and Safety Act (1969). These laws greatly increased the inspection responsibilities of the Bureau of Mines, and later, of the Mining Enforcement and Safety Administration. Subsequent federal responsibilities for enforcing health and safety requirements were concentrated on producing mines. The rapid increase in the demand for coal caused an increase in shaft-sinking projects and an increase in shaft accidents. MESA inspectors were generally unfamilar with the detailed procedures of shaft-sinking work. The laws being enforced were designed for producing mines and did not adequately define shaft requirements.

MESA inspectors and their supervisors have had to interpret regulations based on their own training and experience, which has not always been completely applicable to shaft operations. The regulations also contain ambiguities which create confusion among contractors and inspectors.

In most mining nations, shaft sinking is considered mining and is subject to the complete body of mining laws. Special sections are added to exempt shaft sinking from certain provisions or to require additional standards to meet conditions unique to shaft sinking. This method of regulating shaft work is followed by most United States individual state laws and by Section 57 of MESA regulations dealing with metal and nonmetal mines. Federal coal mine laws, however, put shaft sinking in a separate subpart under Section 77, Surface Work of Underground Coal Mines. This section is one of the most detailed sets of shaft-sinking laws in the world. However, individual regulations are ambiguous and the arrangement creates problems in interpretation. Discussions with personnel in the industry indicate a lack of consistent interpretation and enforcement. In several MESA districts, it was found that Section 77, Subpart T - Shaft Sinking is the only regulation that may be applied. Other districts apply all the sections of the Coal Mine Health and Safety Laws to shaft projects.

Part of the controversy results from varying interpretation of the shaft-sinking plan required under Section 77.1900. The plan must be submitted to the appropriate MESA District Manager for approval before actual construction of the shaft may begin.

Some contractors are critical of the interpretation and use of the shaft-sinking plan by various District Managers. The contractors contend that MESA officials often exceed their authority in establishing requirements for approval of the plan beyond the specific requirements of the law. They charge that District Managers refuse to approve plans unless the contractor agrees to unnecessarily stringent types of ground support and ventilation systems. There may be some validity to these charges. In some districts, plans are received, evaluated, and approved with only changes requested to clarify particular points. Other districts will withhold approval of the plans unless the contractor includes such specification as dictated by the District Manager.

The differing interpretations of the use of the shaft plan causes confusion and antagonism between MESA and various contractors. The adversary relationship then tends to hinder cooperation and the achievement of improved safety. At the time of this study there was no formal statement of policy from MESA's administration to guide the District Managers in their interpretation of shaft plan requirements. Lacking such guidance, the District Manager has no choice but to require standards he feels necessary based on his own training and experience and that of his staff. In many cases this leads to unnecessary restrictions, or a lack of sufficient restrictions on shaft-sinking operations.

Several other districts follow a more cooperative approach which includes the use of a checklist of items required in the plan. Using the checklist contractors know what criteria are used to evaluate and approve the plan. MESA personnel also provide technical assistance inspections of shaft equipment prior to the start of sinking operations. These courtesy inspections provide a means of correcting deficiences without the danger of violations and fines.

CONVENTIONAL EXCAVATION

Initial Excavation

Initial excavation practices were observed at several projects and were discussed, for the most part, with local contractors and MESA inspectors. Initial excavation includes the removal of soil and rock to a predetermined depth prior to installation of the shaft collar or sinking headframe. The major safety problems associated with initial excavation are ground control and hoisting. Excavation through soil or unstable overburden is usually done with a backhoe or a crane and clamshell. Men do not work in the excavation when the backhoe or clamshell is in use but may enter the shaft as needed to install shoring. Temporary shoring such as wooden forms or segmented steel liner plates are commonly used until firm rock is encountered. At that point a concrete collar and lining is placed. If bedrock is sufficiently competent and shallow, placement of the concrete lining will be delayed. When bedrock is encountered at a shallow depth, drilling and blasting are necessary. The broken rock may be removed by cranes and clamshells or mucking machines such as the Eimco 630 may be used to load debris into a bucket hoisted by the crane.

During initial excavation men may enter the shaft by fixed ladders or by riding buckets hoisted by the crane. When fixed ladders are used, they must meet required federal and state specifications. Several MESA Health and Safety Districts have policies restricting the use of ladders to shafts less than 40 feet deep. When mobile cranes are used to hoist men, overspeed and overwind devices are required as on fixed hoists.

In at least one MESA district, contractors are prohibited by district policy from permitting men to ride conveyances attached to the main hoist of mobile cranes during initial shaft excavation. In this district, the contractors are encouraged to mount air winches on the boom of the crane for use in man hoisting. In discussion with other authorities, this practice was severely criticized. The critics maintain that the main hoist and rope are stronger and more reliable than the air winches. They also state that proper limit controls such as the Logan Simplex controller can be placed on mobile cranes successfully to make the cranes as effective as a fixed hoist. The critics also argue that placing a winch on the crane boom may be dangerous since the winch places stress on the boom in a location not planned in the machine's design.

The depth to which mobile cranes may be used during initial excavation is another major restriction. Metal and nonmetal shafts may be sunk to 200 feet using cranes for hoists.

Several coal mine districts restrict mobile cranes to shaft depths less than 60 feet. Most MESA coal mine districts limit the use of mobile cranes to shaft depth of 100 feet. At that depth, MESA regulations (Section 77.1908b) requiring conveyance guides are enforced. This practice is reasonable since an adequate depth is required to allow installation of a headframe and work deck and maintain sufficient clearance to prevent blast damage to the equipment. The available data does not indicate that mobile cranes are less safe than fixed hoists and headframes. The cranes must be equipped with proper limit controls, adequately maintained and inspected and operated within rated capacities.

Hoisting Systems

Following the period of initial excavation, the hoist and headgear used to sink the shaft are installed. The installation of this equipment allows the contractor to establish the work cycle to be followed during the remainder of the project. In conventional excavation of shafts, the hoisting system is the key to a safe and efficient project. All access to the shaft is gained with the hoist; men and materials are handled and muck is removed. It has been said that proper installation and maintenance of the hoist system will eliminate nearly all potentially serious safety problems. In addition, a properly designed and maintained hoisting system greatly improves production.

To be truly safe and effective, the hoist system should be carefully designed to insure that the components are compatible and will function together. It is essential that the selection of the hoist, headgear, sheaves, and rope be made carefully. The capacity of the entire system is only as great as its weakest component.

Problems arise when contractors begin shaft projects using any available hoist and sheaves. This equipment may not be compatible with the available rope, or project schedules prohibit waiting for proper equipment to become available. In these cases, some contractors and operators may begin work with improperly matched rope, drum, and/or sheaves. This practice is not only costly, since the rope will wear rapidly and must be replaced, but is also dangerous.

Hoists used on all projects visited during this study were securely mounted on concrete footings and enclosed in temporary shelters to protect them from the weather. All were well maintained and were fitted with automatic controllers.

Winches and Miscellaneous Hoists - In addition to the main hoist, many contractors use a number of small air winches or tuggers to perform a variety of functions. They may be used to handle steel forms for lining the shaft, lower ventilation tubing or concrete mixing devices, or operate shaft cover doors. One operator uses a series of tuggers mounted on the surface to operate a small clamshell mucking machine. Larger electric hoists are used to position the work deck. Since these winches are not usually used to hoist men there is often a tendency to neglect their maintenance. They are often fitted with old, damaged or spliced rope and are not inspected as regularly as the main hoist.

It should be remembered, however, that these hoisting machines are often used to handle equipment over men working in the bottom or on stages. Therefore, the tuggers, air hoses, controls and rope should be carefully inspected and maintained. In cold weather contractors should insure that ice does not collect in controls or otherwise hamper the winches' operation.

Controllers - Nearly all controllers seen during this study were Model D or Simplex devices manufactured by the Logan Activator Company of Chicago. All persons contacted stated that these devices are safe and dependable when properly installed, adjusted, and maintained. Problems with controllers may result from improper installation and maintenance. The operator's manual, provided with the devices, specifies maintenance procedures and recommends that one man be designated to inspect and adjust the controller. It is essential that a trained, qualified person inspect and adjust the controller to insure proper operation.

Current regulations (30 CFR Section 77.1905b) permit the use of a second qualified operator in lieu of automatic controllers. Most persons contacted during this study did not agree that a second operator was a satisfactory substitute for a controller.

Headgear - Several different types of headgear are commonly found on shaft projects. The most common is the steel sinking headframe. The sinking headframe is a temporary structure that may be disassembled and moved to other projects as needed. No accidents were reported to have resulted from headframe failure but several sources noted that these structures should be closely inspected. Since they are moved between jobs, the headframes should be carefully assembled to insure that all necessary structural members are installed and adequately connected. The headframe should have a capacity at least equal to the maximum strength of the hoist and rope and be placed on a foundation adequate for the designed loads.

In addition to the sinking headframe, other types of headgear commonly in use include the stiff leg derrick and tower crane. These devices were criticized by many sources but were defended by those contractors and MESA personnel who had direct experience with them.

The tower crane is a type commonly found on civil construction projects. In shaft sinking, the crane is fitted with controllers for overspeed and overwind protection and a load limit control that applies the brakes and cuts power if the operator attempts to lift a load heavier than a designed amount. Such a limit device controlling the amount of torque applied to the electric hoist motor may also be beneficial on conventional hoists and platform hoists to protect against overstressing the headgear and rope.

The stiff leg derrick is a steel boom supported by a gin pole and guys. The boom swings horizontally and may be raised or lowered. A conventional drum hoist with appropriate controllers is used with the derrick.

If proper limit controls are used, the stiff leg derrick and tower crane appear to be satisfactory types of headgear. As with fixed headframes, they must be properly installed and operated, and have sufficient capacity for the loads to be lifted. The stiff leg derrick and tower crane have the advantage of swinging the load away from the shaft collar. This allows men and supplies to enter or leave the bucket on firm ground and reduces the hazard of dropping materials into the shaft. The ability to swing loads away from the shaft also eliminates the use of a crosshead to stabilize the bucket. Methods other than crossheads may be used to stablize the bucket, but as will be discussed later, they appear less effective.

Rope Strength and Attachments - The rope and attachments are critical factors in hoisting safety. In meeting with various contractors and MESA personnel, it was learned that improper sheave and drum size was the major cause of rope problems. Current MESA regulations for both coal and metal-nonmetal mines cite American National Standards Institute (ANSI) Standard M11.1-1960 as the accepted specification for installation and use of rope. It was stated, however, that the ANSI standard needs revision to include other types of rope construction now being used in mines. In addition, more attention should be given to calculation of factors of safety.

As described earlier in this report, the calculation of the factor of safety is based upon the manufacturer's nominal breaking strength for new rope or upon the results of destructive testing of a sample of used rope. Several rope manufacturers, including the United States Steel Corporation, state in their specifications that the stated strength is based on samples tested with both ends fixed. In use, the strength will be reduced if one end is free to rotate (U.S.S. Tiger Brand Wire Rope Catalog, pg. 20 and 21). This restriction applies to 19 x 7 nonrotating and 8 x 19 spin-resistant ropes, both commonly used in shaft-sinking work. No accurate data were available which specified the amount of strength reduction but several MESA inspectors reported being told the amount could be as much as 35 percent. The strength reduction could be significant since many shaft contractors use hoisting systems that allow buckets to rotate.

The only effective means to prevent bucket rotation is a well designed crosshead. As with other safety devices in shaft sinking, there is controversy as to the value of crossheads. Critics contend that the crossheads present a greater hazard by accidently hanging in the headframe when the bucket is lowered. If the crosshead temporarily hangs up, then falls free, the results are disastrous.

Several contractors prefer not to use work decks in their shafts and therefore have no guide ropes on which to mount the crosshead. Those operators opposing crossheads may use alternatives to stablize the bucket. One alternative method is the use of a weighted line and sling. In this system a single, small-diameter rope is attached to a weight, commonly a concrete-filled, 5-gallon bucket, and lowered by a small winch into the shaft. Men riding the bucket then secure a rope sling around the weighted line and either secure the sling by attaching it to the bucket or holding it by hand. While this system complies with the requirements of the law, it is questionable whether or not it adequately prevents the bucket from rotating or striking the rib. Certainly, a hand-held sling would fail to provide protection during violent or other than routine movement.

Other operators use a non-rotating or spin-resistant rope as a substitute. They argue that the weight of the bucket is sufficient to prevent swinging during hoisting and no other system is required, particularly in the relatively shallow shafts of the eastern coal regions. In view of the rope manufacturers' statements concerning reduced rope strength, the use of free buckets should not be accepted as an alternative method. In addition, it should be noted that besides preventing bucket rotation, a crosshead provides protection against tipping should the bucket strike an obstruction in the shaft.

If crossheads are to be used, they must be attached to a system of shaft guides. In most shaft operations ropes supporting the work deck are used to guide the crosshead. Federal regulation (30 CFR Section 57.19-54) for metal and nonmetal mines requires that ropes used as guides be of locked coil construction. This requirement was not found in coal mine regulations and, in fact, only one coal site visited used locked coil ropes for guides. The regulations similarly do not require the use of safety catches in the crosshead. The safety catches are designed to engage the guides and stop the conveyance in the event of failure of the hoist rope.

In discussion it was questionable whether or not the rope guides would provide a satisfactory surface upon which the catches could operate. Several operators believe that the safety catches would merely stop the crosshead alone and not a loaded bucket. At worst, they might accidentally engage, breaking the stage suspension ropes and causing a major disaster. In visits to shaft sites, only one contractor had safety catches installed. Several expressed the view that specific research should be done to develop a safe, effective safety catch for use on rope guides.

Federal regulations also require a system of bridle chains be used when hoisting men. The bridle chains are secured to the hoist rope at least 3 feet above the bucket connection and are attached to the bucket rim. In discussion with several contractors, questions were raised regarding the actual value of the safety chains. Many contractors and shaft miners object to the use of these chains. The chains prevent tipping of the bucket and therefore must be removed when mucking. The miners object to the extra time needed to attach the chains for man hoisting. They also argue that the chains cause injuries to miners' hands when the men enter or leave the bucket. This arguement is supported by accident records that show many such injuries. There is apparently little firm data available to verify the effectiveness of the chains.

<u>Shaft Covers</u> - Federal regulations require that shafts be guarded to prevent people or materials from accidentally falling into them. Three basic methods of guarding shafts were observed. Several operators placed the shaft collar at ground level. The shaft was then covered with steel plates. Two steel doors provided access into the shaft. The doors were hinged to open upward and were powered by an air over hydraulic system. This system appeared to be extremely safe since the shaft opening was completely covered. Another method consisted of raising the collar about 2 feet above ground level and covering the center third of the shaft opening with a sliding door. The ends of the shaft opening were covered with steel mats. The cover door was moved by two air

winches mounted adjacent to the collar. This system appeared safe and offered the advantage of admitting more light to the shaft. The third method consisted of erecting a fence around the shaft collar. Entrance to the shaft was gained by hoisting with a crane or stiff leg derrick that could swing the load over the fence.

Platforms - Platforms or work decks were observed on several shaft projects. The platforms ranged from single deck scaffolds of wood or steel mats that were jacked against the shaft wall, to large multi-deck galloway stages suspended by ropes from surface-mounted hoists. Among the problems reported with platforms was a lack of good housekeeping.

If the stage is to provide overhead protection to the men on the shaft bottom, care must be taken to insure good housekeeping on the stages. Excess materials, waste concrete and fly rock should not be permitted to accumulate on the deck or on sheaves supporting the suspension ropes. The deck platform should also be fitted with guard rails and toe boards.

Drilling

Drilling on most shaft projects visited was done with hand-held sinker drills although jumbos were common. Those contractors and inspectors contacted in this study had no opinion concerning the safety merits of either method. The accident data analyses, however, indicated that drills were a leading cause of accidents. It would appear that more injuries result from the use of hand-held drills than from jumbos, but no statistical evidence is available for support of this conclusion.

Blasting

In United States coal mines, the law requires the use of permissible explosives unless prior approval is obtained from the MESA Health and Safety District Manager. In metal and nonmetal mines there is no specified requirement for the use of permissible explosives. Permissible explosives are those which are approved by MESA for use in mine atmospheres containing methane or other explosive gases. If an operator desires to use a nonpermissible explosive, he must make a written application to the District Manager explaining the conditions in the shaft which require the use of nonpermissible agent.

The regulations require that all the other work in the shaft be halted when explosives are lowered to the face.

No men other than those actually needed to handle the explosives may be transported in the bucket or cage with the explosives. Charging of the hole must be done only by experienced men. Electric blasting circuits must be separated, preferably on the opposite wall from the power circuits. Blasting switches should be located in a locked box on the surface and unlocked only by authorized persons prior to blasting.

In our discussion with contractors, it was suggested that the primers be prepared on the surface and transported to the bottom. The contractor believed this would substantially reduce the chance of misfires since the primers would be prepared more carefully under better conditions at the surface. This practice would reduce the amount of work on the bottom and the potential damage to the leg wires which leads to misfires. This contractor also advocates the use of plastic containers to hold the powder charge when loading holes. This insures all cartridges are in contact and insures against misfires.

Mucking

The mucking operation is one of the more dangerous tasks in shaft sinking. The work requires at least one man to be on the bottom while muck is being loaded. Men working on the bottom during mucking operations must be alert to machines and buckets moving in restricted areas. The accident data reviewed in this study indicated the significance of mucking accidents but could not identify any particular types of mucking machines as being more dangerous than others. The safety evaluation of each type of machine was based on discussions with people familar with shaft work.

Eimco 630 - The Eimco 630 excavator is the most common type of mucking machine used in the United States. Many persons contacted in this study were critical of the Model 630. They believe the machine is too fast for use in confined shafts. Operating on an uneven muck pile, the operator can easily lose control of the machine. For this reason, several sources suggested restricting use of the machine to shafts at least 20 feet in diameter. Although this restriction may prevent some accidents, the real problem appears to be misuse of the machine. In order for the machine to perform safely, it must be adequately maintained and operated by a trained operator. The machine is available with one of three bucket sizes ranging from 5-1/2 to 9 cubic feet capacity and one of 4 lengths of bucket arms. Naturally, smaller diameter shafts would require a machine assembled with shorter arms and a smaller bucket. Proper maintenance is also essential. Older models of the 630 were equipped with dual tram controls and contained a spring to return the controls to neutral when the operator released pressure on the levers. Operators commonly removed these springs for operating convenience. When this was done the machine would continue to move when the operator released the tram levers. If the operator was thrown from the machine, the mucker would be out of control on the shaft bottom. This dangerous practice is being eliminated after receiving much attention from MESA inspectors resulting in a redesign of the tram controls by Eimco Corporation. The new models of the 630 machine are controlled by a single wobble stick control and appear to be significantly safer than the older models.

Preventive maintenance is also important. At least one contractor has established a practice of cleaning and servicing the mucking machines every time they are removed from the shaft. The operator is responsible for removing debris from the controls, bucket arms, tracks and drive mechanisms. The machines are then inspected and serviced as required. This practice insures that deficiencies are discovered and corrected early. The machines operate more efficiently and safely when properly maintained.

Several persons were critical of some features of the design of the Eimco 630 and suggested changes to improve safety. These people were critical of the machine's method of casting muck backward over the machine. It is believed this method of throwing the muck endangers the operator. It is suggested that guards be installed over the control handles to protect the operator's hands and controls from rocks thrown by the machine. Also recommended was a deadman control or a more easily accessible air cutoff handle on the main air valve.

Safety could also be improved by further training and supervision of operators. Several contractors enforce the policy of always mucking with the operator positioned toward the center of the shaft. In this way, the operator is less likely to be crushed between the machine and shaft wall. All men on the bottom should be instructed to be alert to the position of the machine and buckets at all times. When work stages are used, the mucking machine's hose tender should work from the stage to reduce the number of men on the bottom.

Clamshell - Mucking with clamshell buckets is commonly used during initial excavation and has been adapted by at least one contractor for excavating the entire shaft. This system consists of a small clamshell bucket suspended by rope from two air winches mounted on the surface adjacent to the shaft collar. The clamshell is operated by a miner on the bottom using a button control box. The operator raises and lowers the bucket and opens or closes it to load muck. The clamshell is moved horizontally by two miners using tag lines.

The muck is loaded into buckets by the clamshell and hoisted. This method requires skill and coordination among the miners. The contractor favors this method as fast and economical. The method is criticized by others because:

- the clam support ropes are long and free to swing in the shaft damaging themselves and vent tubing, hoist rope, and other equipment;

- the tugger winches are exposed to weather and have reportedly frozen causing a loss of control;

- if either miner slips or loses control of his tag line the clamshell may swing and strike the men on the bottom; and

- danger exists for broken ropes falling to shaft bottom.

The available accident records did not identify the number of accidents, if any, that resulted from this system. It was reported that the clamshell suspension ropes wear rapidly and must be frequently replaced. Several sources attributed accidents to rope failures but these charges could not be substantiated.

Other Types - Other types of mucking equipment include the Cryderman mucker, LHD tractors, and backhoes. Backhoes have been used in several shafts but no accident data are available for these projects. They appear to have some safety advantage since the operator is located at a control panel hung from the stage or shaft wall. The location provides good visibility and reduces the number of men on the bottom.

The Cryderman mucker is also used but seems to be most commonly found on deep metal and nonmetal shaft projects. Again no details are available for accidents caused by these machines. The only accidents found associated with the Cryderman machine resulted when a rope clip failed when raising the machine. Several MESA officials also commented that the suspension systems used to raise the Cryderman muckers should be carefully designed or controlled by regulations. No details could be obtained defining specific problems or suggested solutions.

Excavation in slopes is commonly done with LHD units. Since these units are controlled by an operator on the machine and do not require the use of tracks or hoists, they present some safety advantage over rail cars. On slopes steeper than approximately 10 degrees, hoists and ropes are used to assist the units in moving up the slope. Accident records indicate one fatality resulted when brakes failed on a Wagner ST-8 loader at a slope project. Several MESA officials have suggested prohibiting the use of this machine in slopes steep enough to require the use of an assist hoist. They believe the unit's brakes are inadequate. The accident records do not indicate whether or not there has been a systematic failure of LHD units in steep slopes. It is possible that the single fatality resulted from failure of an individual unit and not a design failure to be found in an entire line of machines. It was noted, however, that LHD units are subject to severe use on slope projects. Brakes and power train components are taxed when the units must tram up long distances in reverse gear to dump loads, then drive back down the slope to the face. The cycle must be repeated many times in mucking out a round. Inspection and maintenance should be constant and thorough to protect against machine failure. It is questionable whether all contractors maintain the units as required by the demands of slope work.

Lining

Lining is not an essential step in shaft construction but is commonly done and is beneficial to safety during construction and later use. Shafts may be sunk bald or unlined if ground conditions permit. Many contractors prefer this method since speed is increased. This practice is criticized by many authorities, particularly in the eastern United States coal regions. The shale and other sedimentary rocks found in these regions slake easily and decompose after exposure to air, water, and periodic freezing. The rock deterioration may occur rapidly and require frequent inspection and scaling. Several authorities stated they did not believe contractors adequately inspected and scaled the unlined shafts to insure complete removal of weathered rock. Most authorities favored some type of lining.

The most common lining material was concrete. Several safety problems were related to placement of the concrete or handling the forms. Accident reports from metal and nonmetal shaft projects reported a large number of workers receiving alkali burns from accelerators added to the concrete mix. Burns resulted from workers contacting concrete and excess water draining from freshly placed concrete. It would appear, therefore, that the workers are not being informed as to the potential danger involved or are not properly protected with boots or gloves. This problem was found in metal and nonmetal mine projects and not reported from coal projects where the use of accelerators is not as common.

The most common safety problems in shaft lining resulted from handling steel-lining forms. It is common practice to suspend the forms from the work deck. When the forms are to be broken free and lowered into position for the next section of lining, a keyway is removed from the forms. The remainder of the forms are freed by pulling with the platform hoists. This practice places a large load on the hoists and rope. Several authorities contacted stated this was perhaps the largest load placed on the headframe and the most difficult to calculate. It was also stated that, since platforms are not designed to hoist men, they are not considered subject to the specifications for man-hoisting equipment found in Subpart O, 30 CFR. The platform suspension systems are frequently not closely inspected and maintained. In one particularly serious accident, three fatalities were attributed to hoisting failure while repositioning forms.

If lining forms are to be handled by the work deck, it is advisable to withdraw men from the shaft when forms are broken. This is done by at least one contractor. In addition, it is suggested that hoists used to break forms be fitted with controls to limit the amount of torque applied to prevent overstressing the headframes and ropes.

Following placement of concrete, it is particularly important to clean waste concrete and other materials from the work deck. Waste concrete accumulating on the deck creates hazardous footing for men and may jam or damage sheaves and rope resulting in problems during stage movements.

Ventilation

Adequate ventilation is essential for underground work. Continuous circulation of fresh air removes dust, blast fumes and other gases. Federal and state regulations establish minimum standards for air quality and prescribe basic ventilation procedures for producing mines. Application of these requirements to shaft work has created problems. In shaft-sinking work fresh air is conducted to the working face through metal conduits from surface-mounted fans and returns directly up the shaft. Maintenance of the ventilation system is important. Care must be taken to insure that the incoming air can circulate around the platform and reach the working face. The ventilation ducts must be protected against damage during blasting, usually by ending the metal duct a safe distance above the bottom and using fireproof cloth ducts to reach bottom.

Some controversy exists as to which system constitutes adequate ventilation in a shaft. The controversy was found not only between contractors but within MESA itself. The primary disagreements center on the quantity of air required and the distance from the end of the vent tube to the shaft bottom. Several Coal Mine Health and Safety Districts apply coal mine law to shafts and require a volume of 9,000 cubic feet per minute at the tube end no more than 30 feet from the bottom. This value and distance is based on the quantities required at the last open crosscut in the working face of a coal mine. Other districts define adequate ventilation by requiring 9,500 or 10,000 cubic feet per minute. In these districts the vent tubing end may be 50, 60, or 70 feet from the bottom. Other districts do not enforce firm values but require that the air at the shaft bottom be kept clear of dust and methane. The major problem in specifying set volumes and distances is encountered during cold weather. Miners working in water, subjected to a high volume of very cold air, become extremely cold and turn off the ventilation fan for comfort. While this may be more comfortable, it does increase problems from dust and methane. It would seem reasonable to specify that air quality standards be met. The specific arrangement of ventilation system components needed to meet these standards should be left to the operators.

Another real controversy exists over which U.S. Bureau of Mines Permissibility Schedule should apply to use of diesel equipment. Schedule 31 is the more stringent specification and is applied to diesel machines in underground coal mines. Schedule 24 requirements are less stringent and are used in underground metal and nonmetallic mineral mines and tunnel work. In at least one district, contractors are required to use Schedule 31 equipment in driving slopes through rock to reach the coal seam. They contend that Schedule 31 was formulated to prevent ignition of coal dust which is not encountered in the rock excavation. They argue that the Schedule 24 requirements are adequate in that coal dust is not encountered in significant quantities. Schedule 31 specifications require expensive modifications to their equipment, increased maintenance costs and reduce machine efficiency.

Noise

Noise levels in shafts may be extremely high especially during drilling and mucking. No regulations have been formulated or applied to restrict worker exposure to noise during shaft work. The accident records, likewise, did not indicate injuries resulting from prolonged exposure to noise. Several authorities stated that standards should be developed or applied to shaft work.

Lighting

At the present time, the only lighting in shafts is the result of natural light and individual miner's cap lamps. Natural light is restricted to shallow depths and is not available for work at night. Several contractors are reportedly experimenting with portable lights or mounting permissible lights from shuttle cars on work decks. The major problems have been in locating permissible lights that are adaptable to shaft work. Research to develop satisfactory permissible lighting systems is currently being conducted by the Bureau of Mines (Contract Number HO 262042). It has also been reported that promising permissible lights have been developed in the United Kingdom but have not been submitted for permissibility testing in the United States. Many authorities believe that improved lighting in shafts would greatly increase safety.

Maintenance and Inspection

Proper inspection of the shaft before the start-up of a shift, after a blast and periodically during the shift are required by law. Likewise, detailed inspection of all major hoists and hoisting facilities is required. In visiting several shaft projects, it was apparent that well managed projects had definite inspection and maintenance programs beyond the legal minimums. One contractor maintained his hoist inspection records according to the format used in the Province of Ontario. These requirements are more stringent and detailed than those required under United States law. Another contractor required that the mucker operator clean, inspect, and service his machine every time it was brought to the surface. This policy was followed closely and applied to all equipment on the site.

RAISE DRILLING

Raise drilling to develop shafts is rapidly gaining in popularity for several important reasons. Less equipment is required and fewer men are needed to develop the shaft. Work is faster than by conventional methods. The relatively smooth walls and circular cross section are stable and well suited for ventilation shafts. The major safety problems have been in ventilating the shaft during drilling and in protecting the miners removing the cuttings at the shaft bottom.

The accident data surveyed for this study did not indicate a safety problem in shaft ventilation. However, since the raise drilled shaft is connected to an operating mine, it is essential that dust and methane concentrations in the shaft be strictly controlled. Potential problems have been recognized and research is being conducted to develop an acceptable ventilation system.

VIII. CONCLUSIONS

GENERAL

This study into shaft safety has identified some of the problems involved and has led to the development of recommendations to improve safety at shaft-sinking projects. Attempts to identify systematic causes of accidents through analysis of accident records were only partially successful.

Following the review of shaft accident data, it was concluded that data does not exist in sufficient detail to adequately identify specific cases of inherently dangerous equipment or procedures. What was identified are people-related problems, such as mine owners hurrying to develop shafts, contractors working on tight schedules and budgets, and inexperienced and untrained workers performing dangerous work under difficult conditions. The preliminary conclusions reached after reviewing the accident data were tested during site visits and discussions with MESA personnel and shaft contractors. The final conclusions were reached after these meetings and represent the synthesis of shaft accident data and the comments of shaft industry personnel.

ACCIDENT ANALYSIS

As contractors are reluctant to discuss the accident histories of their projects, it was, therefore, necessary to search the accident reports filed with MESA's Health and Safety Analysis Center in Denver to develop the data required for a statistical analysis of shaft safety. The existing requirements for accident reporting do not identify shaft sinking as a separate type of mining activity; therefore, the records are difficult to locate. While a thorough search of the records was made, it is possible that many shaft-sinking accidents were not available for analysis due to the operator's failure to file a report or to inefficiency in the data storage and retrieval system.

The data obtained did indicate that a significant safety problem exists in the shaft industry. Shaft sinking is a dangerous business. During the period of record analyzed in this study, coal shaft projects had an accident frequency rate of 131.6 accidents per million man-hours worked. For comparison, MESA reported a frequency rate of 66.06 for all underground coal mine injuries during the 12-month period ending in October 1976. In metal and nonmetal shaft projects the accident frequency rate was found to be 157.8 accidents per million man-hours worked. This compares with an accident rate of 38.6 for all underground metal and nonmetal mines during the third quarter of 1975.

The severity of accidents at shaft projects was also high. As severity rates based on the number of days lost from injuries per million man-hours worked could not be calculated due to lack of detail in the data, average severity, or the number of days lost per accident, was calculated.

For computations of average severity in coal mine shaft projects, 543 accident reports were located for the period 1972 through 1975. Of these reports, 437 recorded a total of 50,771 days lost, including 6 fatal accidents which resulted in the deaths of 8 miners. The average severity was therefore calculated to be 116.2 days lost per accident. Excluding fatalities, the average severity was 6.4 days.

During the period of record 1973 through 1975, 386 accident reports were located from metal and nonmetal shaft projects. Of these reports, 54 were incomplete. The remaining 322 reports listed a total of 76,935 days lost for an average severity of 232.4 days. This average value includes 10 fatal accidents in which 12 men were killed. Excluding fatalities, the average severity was 14.7 days lost per accident.

The most significant causes of accidents were haulage and machinery. Haulage includes all equipment used for transporting men or materials. In shaft and slope work, haulage includes hoisting men or materials and placement of buckets on the bottom. Haulage was the leading cause of accidents, based on average severity, for both coal and metal-nonmetal shafts. Such accidents were the leading cause of fatalities at metal-nonmetal shafts and the second greatest cause of fatalities at coal shafts. The greatest number of fatalities resulted from operators being crushed between conveyances or between conveyance and rib while operating. Other serious or fatal accidents resulted from errors with haulage ropes or by falling from conveyances.

Machinery accidents include those resulting from the use of loaders, drills, bolters and all powered tools. Based on average severity, machinery was the second most important cause of coal shaft accidents and the fifth leading cause of metal-nonmetal shaft accidents. In both cases power drills were the most common causes of machinery accidents. Drilling accidents commonly occurred during miners' efforts to control the drill or when changing drill steel. Injuries from broken equipment were less common and usually resulted from broken drill steel. In a few cases air hoses broke, striking the operator or other miner. Other drilling accidents were the result of clothing, hair or hands caught in the drill, foreign objects in eyes, or dropping the drill on hands or feet. Although power drills caused more injuries, dozers, cranes and front loaders caused more severe injuries and accounted for three fatalities.

Examination of age and experience data submitted on injured miners suggests several factors possibly contributing to injury-producing accidents. Tabulation of the ages of injured miners indicates shaft miners, particularly those at coal shafts, are substantially younger than production miners. This fact implies a lack of experience, an observation supported by an examination of the injured miners' total mining and job experience. Perhaps this is a reflection of the overall trend in the coal industry in recent times. Previously the United States coal industry was generally depressed and, therefore, was not particularly attractive to younger workers. However, with the increased interest in coal during recent years, a demand for new mines and miners has grown which has not been met by the available work force. Older, more experienced miners are not sacrificing their careers and seniority at established mines to work in relatively short-term shaft-sinking projects. The result is a lack of experienced workers, both as miners and supervisors. The situation in metal and nonmetal mines has not been as dramatic. This portion of the mining industry has been comparatively stable and has provided longer periods of employment. In this area workers have had opportunity to obtain the necessary experience.

In examining the various accident reports it became apparent that nearly all of the incidents could have been prevented by either the victim or a nearby worker applying a little "common sense". Common sense in an undertaking such as shaft sinking, however, is a function of a person's experience and training, which, indicated by the age and experience levels of the injured workers, are lacking in shaft-sinking workers. These observations were verified in several meetings with MESA and contractors' personnel. These meetings also reinforced the belief that the majority of shaft-sinking accidents are relatively minor and would be preventable through improved training. The fatalities, however, appear to be caused by improper equipment procedures or equipment failure, particularly with regard to hoisting equipment. These accidents result from factors beyond the immediate control of the individual miner and must be prevented by proper management and supervision. Management must insure that hoisting systems are properly designed for the job, properly installed, properly maintained and used.

EQUIPMENT

In studying shaft operations it became apparent that the hoisting system is critical to safety and efficiency. To perform safely the hoisting system should be carefully designed, installed and maintained. Many of the hoisting accidents resulted from improper installation or maintenance of hoisting equipment. A review of existing regulations indicates that present standards for hoist installation and use are adequate if applied to shaft operations. Since all hoisting in shafts involves hoisting men or handling materials over men, strict application of man-hoisting standards should apply.

In addition, two other important items were noted. First, Section 77.1905(b) of coal mine regulations permits the use of a second qualified hoist operator in lieu of automatic overspeed, overwind and automatic stop devices. This section should be eliminated since the second operator is less effective than properly installed and adjusted automatic controls.

Second, Section 77.1908(b) requires guides and guide attachments or a no less effective means to prevent bucket swinging when hoisting men from a shaft 100 feet or more deep. At the present time a system comprised of crosshead and guides is the only effective means of stabilizing the bucket. The alternative system of a weighted line and rope sling does not appear to provide equivalent protection although there is no hard data to verify this conclusion.

There is, however, data to indicate that the use of nonrotating or spin resistant rope without guides as used by some contractors is not an effective means of safely stabilizing a bucket. Rope manufacturers state in their catalogs that rope strength is reduced if one end is free to rotate. It is therefore possible that use of an unguided bucket would result in a reduced factor of safety.

Additional research and testing are required to develop alternate means for stabilizing buckets that are no less effective than a crosshead and guides. It is recommended that permission of the appropriate Health and Safety District Manager be required for use of any system other than a crosshead and guide.

Two additional areas of concern, noise and illumination, were noted. Existing regulations governing shaft work do not address these problems. It is believed that safety would be improved by establishing suitable standards for allowable noise levels and illumination in shafts. To implement these standards would require additional research to develop mufflers or other noise suppressants for drills and mucking machines and to develop suitably permissible lighting systems for shafts.

TRAINING

Accident records and comments by experienced personnel indicate a critical shortage of trained shaft miners and supervisors. Many injuries are the direct result of this lack of training and experience. It is firmly believed that improvements in training would provide more immediate and more dramatic improvements in shaft safety than would the development of additional regulations.

Thorough training is essential. No one is allowed to enter a South African shaft project unless he is thoroughly trained or experienced (Swallow, 1960). Methods for training South African miners are detailed (Jamieson and others, 1961) and include practical experience in equipment operation and sinking procedures. The training is conducted in simulated shafts constructed on the surface. While such detailed training may not be economically feasible in the United States, workers should be thoroughly instructed in procedures and safety rules. Men should be instructed in equipment operation of the surface before being permitted to operate machines underground. Supervisors are especially important in insuring safety through enforcement of safety rules and in providing instruction in safe working practices. Certification procedures for shaft supervision should be established and enforced.

REGULATIONS

As stated earlier, the existing regulations are generally adequate to insure safety; however, they should be clarified to remove ambiguities and to clearly indicate their applicability to shaft work. Existing regulations defining safety standards for shaft-sinking tasks should be extracted from all applicable portions of mining laws and compiled into separate subparts which would govern shaft work. In this way shaft sinking would be acknowledged as a special phase of mining as are surface and underground mines. The shaft regulations could be organized in either of two ways. First, a separate subpart could be established under Part 57 of Title 30 CFR to define regulations applicable to sinking shafts in metal and nonmetal mines. This subpart could be patterned after Subpart T of Section 77 which establishes standards for shaft sinking at coal mines. The second method would establish a single section of shaft-sinking regulations patterned after Subpart T to be applied to all shafts, coal and metal-nonmetal. The latter arrangement is preferred since it could be expanded to include all mine construction activities in addition to shaft sinking. A regulation would be needed defining when the project should be considered a mine and therefore subject to underground mining standards. It is suggested that shafts to coal deposits be considered coal mines when the excavation enters the seam to be mined and excavation direction becomes parallel to that seam. Metal and nonmetallic shaft projects could be considered mines when the shaft, including loading pockets and ore passages, reaches its planned depth and development into or towards where the orebody begins.

FUTURE TRENDS

From this study's overall view of the shaft industry it was seen that the increased demand for shafts coupled with increased labor costs and reduced productivity will encourage the development of shaft drilling techniques. These methods appear to offer a significant improvement in safety primarily due to the fact that men do not work in the shaft during sinking. At the present time identified safety problems in raise drill projects include adequate ventilation of the shaft and placement of the collar and lining. In blind drilled projects the major safety problems occur during lining. The solutions to these problems will be found as more drilled shafts are constructed. MESA and industry personnel should critically examine shaft drilling operations to anticipate their potential safety problems. Steps should be taken to rapidly implement additional training for inspectors or develop new regulations as required to meet the safety problems presented by shaft drilling techniques.

IX. RECOMMENDATIONS

The recommendations presented here are based on the results of accident data analyses and interviews with people active in the shaft industry. Four major categories of recommendations are included.

1. Training of shaft miners should be improved and should include training in equipment operation on the surface before beginning work in the shaft. A system of certification for shaft supervisors should also be developed.

2. Several proposed equipment standards are included. Generally, the standards for equipment safety devices currently applied to underground mining machines were found to be adequate. They should, however, be required in shaft work.

3. Recommendations are made suggesting modifications in MESA's policies concerning interpretation of regulation and reporting accidents. The recommendations are designed to clarify regulations and to increase timely return of accident data to aid inspection.

4. There is a need to clarify the regulations governing shaft work. Specific standards are proposed to reduce the ambiguities found in Subpart T of 30 CFR. A similar set of shaft regulations should be established for metal and nonmetallic mineral mines.

TRAINING

It is recommended that MESA act to encourage improvements in training for shaft miners and supervisors. Formal certification should be required for shaft supervisors. The certificates of competancy could be issued by state authority with federal guidance. Certification for shaft supervisors should be separate from surface or underground mining certificates, but could recognize such experience in partial fulfillment of shaft requirements. As a minimum, 4 years experience should be required, of which 2 years could be in underground mining. Candidates should have formal training in first aid, roof and rib control, air quality measurement, principles of hoist system installation and maintenance including the use of mobile cranes and derricks.

or stiff leg derricks that swing the loads away from the collar thereby requiring the rope to be freed from a crosshead. Both methods have merit and should not be prohibited solely because they make crossheads impractical.

When crossheads are used there is no requirement for the use of safety catches to hold the conveyance in the event of a slack rope or rope failure. There is much doubt in the industry whether an existing safety catch would be effective on rope guides as used in shaft work. Research should be considered to evaluate existing safety catches or develop a safety catch for use on shaft projects.

When tower cranes or stiff leg derricks are used in place of fixed headframes indicators should be provided to assist the operator in positioning the conveyance in the center of the shaft. It is important that the operator accurately center the conveyance over the shaft before lowering the load.

Standards are needed defining the requirements for lighting and the permissible noise level in shafts. Most persons contacted in this study stated that improved lighting in shafts would greatly increase safety. The problem, however, is developing a portable, permissible light system suited for use in shafts. Several systems have been developed but have been reported unsatisfactory because they are nonpermissible or require long periods to recharge and provide light for a limited time. Research by the U.S. Bureau of Mines (Information Circular IC8709) indicates that a minimum luminous intensity of 0.06 foot-lamberts is necessary for safe underground mining work and is a practical, attainable standard. Research should be continued to develop a permissible lighting system for use in shafts prior to the establishment of specific lighting requirements.

Standards regulating noise levels in shafts should be implemented. Current standards for employee exposure to noise are contained in 30 CFR Section 57.5-50 for metal and nonmetal mines and Subpart F Section 70.500 through 70.510 for coal mines. These standards restrict worker exposure to noise according to the following table.

Permissible Noise Exposures

Duration per day (hours)	Noise Level (decibels)
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
3/4	107
1/2	110
1/4 or less	115

Noise reduction may require development of modifications to drills, mucking machines or other equipment to reduce noise. Until such modifications are available, suitable ear protection should be required.

MESA POLICY

In addition to the proposed revisions in regulations and training, MESA policies should be established to aid operators in complying with the law and to assist the inspectors. MESA districts should prepare guidelines specifying the criteria to be met in evaluating shaft plans. The criteria should be based on the regulations in Standard 77.1900 and prevailing local conditions. The practice of providing Technical Assistance Inspections should be encouraged particularly prior to activating the sinking hoisting system. The inspection should encourage operators to select and install this vital system properly.

MESA should hire additional experienced shaft personnel as shaft inspectors. Such inspectors could be assigned at district or subdistrict level or be responsible for shaft activities in more than one district as needed. MESA currently has inspectors specializing in electrical systems and surface and underground mining. Shaft sinking and mine construction activities, in general, are sufficiently distinct from mining to warrant specialized inspectors.

Additional training programs should be developed for shaft and slope inspectors. The training could serve to standardize enforcement policies. Shaft contractors could be utilized as advisors in preparing training programs. In line with this recommendation, an inspection guide has been prepared and is included in Appendix A of this report. The guide has been designed to be used by inspectors or other Health and Safety District personnel in reviewing an operator's shaft plan. The guide follows the requirements of Subpart T 30 CFR and may be used as a checklist in training new shaft inspectors or by inspectors in their shaft visits.

MESA's administration should act to revise the system of accident reporting, data processing and feedback to District personnel. As a minimum a system should be established by which the Health and Safety Analysis Center (HSAC) provides weekly or monthly reports to each subdistrict identifying accidents within their area. These reports should describe each accident that occurred listing the mine name, owner or contractor, victim's name and brief description of the accident. The present system of providing statistical summaries fails to provide the inspector with vital background data on the types of accidents occurring in their areas.

The data available in HSAC are extremely valuable if used in a timely manner. The data should be used as an active means of monitoring and improving safety conditions at ongoing shaft projects and not merely as a historical record of past mistakes or tragedies.

PROPOSED REGULATIONS

Current regulations governing shaft sinking for coal or metal and nonmetal mines should be revised and clarified. It is proposed here to include the standards in a new subchapter combining coal and metal-nonmetal shaft-sinking regulations. Recommendations for standards to be included in such a subchapter are presented below. These recommendations are based on the research and discussions included in this study, as well as recent MESA proposed revisions to existing regulations. The proposals are organized following Subpart T, Slope and Shaft Sinking, of 30 CFR revised as of July 1, 1976.

Section 77.1900 - Slopes and shafts; approval of plans

Each operator of a coal, metal or nonmetallic mineral mine shall prepare and submit to the appropriate Health and Safety District Manager a plan providing for the safety of workmen in each slope or shaft to be constructed or deepened. The plan shall be consistent with prudent engineering design and shall be prepared under the supervision of and certified by a registered professional engineer. The methods employed by the operator shall be selected to minimize the hazards to those employed in the initial or subsequent development of any such slope or shaft. The plan shall include but not be limited to:

1. The name and adress of the mine owner;

2. The name, address, Mining Enforcement and Safety Administration Identification Number of the mine, and specific location of the shaft;

3. The name and address of all contractors performing the work;

4. A topographic map at a scale of 1:62,500 or larger showing:

   a. the geographic location of the shaft or slope;

   b. the location of surface drainage and impoundment;

   c. the location and extent of known underground workings, tunnels, oil or gas wells or other facilities within 500 feet of the shaft or within 500 feet of the center line of a slope;

   d. the location of the spoil area.

5. The elevation, depth, and dimensions of the slope or shaft;

6. The general characteristics of the rock and unconsolidated overburden through which the shaft or slope will be developed including:

   a. the elevation of the ground surface at the shaft collar and elevation of the coal seam or mineral deposit;

   b. logs of test borings drilled at the shaft site; for slope projects logs of test borings drilled along the surface projection of the center line of the slope, shall be included.

7. Drawings and specifications for the hoisting facilities including:

   a. the size and capacities of hoists, hoist-drums, ropes, motors, headframes, brakes, and sheaves;

   b. factors of safety for main hoist and platform suspension ropes including the calculations used to compute the factors of safety;

c. methods of rigging including platform rigging;

d. the types of overspeed and overwind devices to be used, a description of the speed and position of the conveyance activating the devices and the position of the nearest rope attachment to the head sheave after overwind devices are activated;

e. emergency hoisting devices.

8. A description of the operational procedures and equipment to be used for conventional excavation:

a. method for initial excavation and shoring of overburden;

b. method for worker access during initial excavation;

c. method for placing shaft collar, depth of shaft when collar is placed, type of shaft cover or collar protection to be used;

d. drilling equipment and procedures;

e. blasting including type and quantity of explosives, pattern, stemming, type of blasting device;

f. methods for inspecting ribs, wall, roof or back, provisions for scaling, and temporary support;

g. loading and removal of broken material including type and capacity of loading machine, number and duties of miners employed at the face during excavation, capacity and number of buckets used to hoist muck, system for handling muck at the surface;

h. method for placing lining, handling forms, placing concrete, shotcrete or gunite, and the use of additives to concrete;

i. installation of service lines or other facilities;

j. ventilation system including: size and capacity of the fan, size, type and location of tubing, schedule for air quality and quantity testing; and

k. establish schedules for inspection and preventive maintenance of hoist, rope, headgear, platforms, drills, excavations and ventilation equipment.

9. For shafts developed by raise boring methods provide:

a. plans and specifications for drilling machine, drill stem, bits and foundation for drill;

b. plans for temporary and permanent support of mine roof in the working area at shaft bottom;

c. ventilation plan to include description of any changes to mine ventilation system during drilling, method for monitoring methane content of air in shaft during drilling;

d. methods for removal of broken material;

e. method for protecting workmen performing maintenance on bit including inspection or change of cutters during drilling;

f. procedures for breaking bit through to the surface including removal of bit from shaft, securing and removal of drilling machine; and

g. method to line the shaft.

10. For blind drilled shafts provide:

a. plans and specifications for drilling machine, drill stem, bits and foundation for the drill, and associated surface facilities;

b. methods for removal of cuttings and disposal of waste on the surface;

c. emergency procedures to protect miners if drilled shaft is to connect with or pass close to existing workings;

d. plans and specifications for man hoisting and ventilation if men are required to enter the shaft during drilling; and

e. method for lining the shaft.

Section 77.1900-1 - Compliance with approved slope and shaft-sinking plans

No work other than surface preparation and grouting shall be permitted prior to approval of the shaft plan by the Health and Safety District Manager. The operator shall be notified in writing of approval or disapproval of the plan. If the District Manager determines that revisions to the plan are required before approval can be granted, the revisions and the reasons for the revisions shall be specified in writing. The operator shall have the opportunity to discuss the plan and any proposed revisions with the District Manager and to present evidence justifying the safety of the proposed methods. Upon approval by the Health and Safety District Manager of a slope or shaft-sinking plan, the operator shall adopt and comply with such plan.

Section 77.1900-2 - Modification of approved slope and shaft-sinking plans

Each operator desiring to modify an approved slope or shaft plan shall, prior to initiating such modification, notify the appropriate Health and Safety District Manager in writing, of the details and reasons for such a modification. The District Manager shall notify the operator in writing of approval or disapproval of the proposed modifications. If the District Manager disapproves the modification or determines that revisions are required prior to granting approval of the modification, he shall specify in writing the reasons for disapproval and the revisions required. The operator shall have the opportunity to discuss the modification and revisions with the District Manager and present evidence justifying the safety of the proposed modification. Upon approval by the Health and Safety District Manager, a proposed modification becomes part of the approved slope or shaft plan.

Section 77.1901 - Preshift and onshift inspections; reports

a) Examinations of slope and shaft areas shall be made by a certified person for hazardous conditions including tests for methane, oxygen deficiency and air quantity:

(1) within 90 minutes before each shift;

(2) at least once each hour on any shift during which men are employed inside any slope or shaft during development;

(3) before and after blasting.

(4) the appropriate Health and Safety District Manager may require additional testing.

(5) the tests shall be made at least 12 inches from the face or walls in the working area of the shaft.

No changes are recommended in subsections "b" through "f".

Section 77.1901-1 - Methane and oxygen deficiency tests; approved devices

No changes are recommended.

Section 77.1902 - Drilling and mucking operations

No changes are recommended.

Section 77.1902-1 - Permissible diesel-powered equipment

No changes are recommended.

Section 77.1903 - Hoists and hoisting; minimum requirements

(a) Hoists used to transport persons or materials in shafts or slopes shall not handle loads greater than the rated capacity of the hoist, rope fastenings, headgear or the static load safety factor of the rope. The rated capacities shall be those stated by the manufacturer or certified by a registered professional engineer.

(b) The static load factor of safety required shall be determined by the following table:

Length of Rope in Shaft (feet)	Minimum Factor of Safety (New Rope)	Minimum Factor of Safety (Retire Rope)
500 or less	8	6.4
501 to 1,000	7	5.8
1,001 to 2,000	6	5.0
2,001 to 3,000	5	4.3
3,001 or more	4	3.6

The factor of safety for new or used rope shall be calculated using ultimate strength values certified by laboratory tests performed by the rope manufacturer or other qualified testing agency.

(c) Hoists used to transport persons or handle platforms shall be equipped with an automatic device designed to cut the power and apply the brakes if the load exceeds the rated capacity of the hoist, rope fastenings, headgear or rope.

(d) Every hoist used to transport persons, materials, or handle platforms shall be equipped with brakes capable of stopping and holding a fully loaded conveyance or platform at any point in the shaft or slope. Loads should not be lowered using the hoist brakes, except in emergencies. All hoists including mobile cranes used to transport persons or materials should raise and lower loads only under power.

(e) Every hoist used to transport persons or materials shall be equipped with overspeed, overwind and automatic stop controls.

(f) Each hoist used to transport persons or materials shall be equipped with an accurate and reliable indicator of the position of the conveyance which shall be installed in clear view of the hoist operator.

(g) The American National Standards Institute "Specifications for the Use of Wire Rope for Mines", M11.1-1960, or the latest revision thereof, shall be used as a guide in the use, selection, installation and maintenance of wire ropes used for hoisting. For ropes not described in this standard, the recommendations of the manufacturer or a registered professional engineer shall be used.

Section 77.1904 - Communications between slope and shaft bottom and hoist operators

Communications between slope and shaft bottoms and hoist operators are adequate as stated. However, communications should also include the shaft collar and work platforms as well as the slope or shaft bottom and hoistman.

Section 77.1905 - Hoist safeguards: general

"Hoist safeguards: general" may be omitted. The requirements for hoist brakes are included in other standards.

Section 77.1906 - Hoists: daily inspection

"Hoists: daily inspection" should be made more specific by detailing the criteria to be used in conducting the daily inspection of the hoist system. Suggested criteria include:

(a) Inspection of the hoist to include proper lubrication and operation of brakes, overspeed, overwind, and automatic stop devices. Hoist drive units shall be protected from the weather, and the mechanism that operates the brakes shall be guarded to prevent material or tools from accidentally fouling or jamming the brake system. The conveyance should be operated through one full cycle to test the proper operation of the overspeed, overwind, and automatic stop devices.

(b) Headgear including the headframe and sheaves should be inspected for damage, missing parts, broken flanges and sheaves, and proper lubrication.

(c) The rope should be inspected for evidence of corrosion, damage, or slippage of fasteners. The rope must be removed from service when any of the following conditions are found:

(1) Six randomly distributed broken wires in one rope lay, or three broken wires in one strand in one rope lay. Snagged, nicked or severely bent wires shall be counted as broken wires;

(2) Abrasion, scrubbing, or peening causing loss of more than 1/3 the original diameter of the outside individual wires;

(3) Evidence of rope deterioration from corrosion;

(4) Kinking, crushing or other damage that results in distortion of the rope structure;

(5) Reduction in nominal rope diameter determined as follows:

i) 1/64 inch for rope diameters up to and including 5/16 inch;

ii) 1/32 inch for rope diameters 3/8 inch to 1/2 inch inclusive;

iii) 3/64 inch for rope diameters 9/16 inch to 3/4 inch inclusive;

iv) 1/16 inch for rope diameters 7/8 inch to 1-1/8 inches inclusive;

v) 3/32 inch for rope diameters 1-1/4 inches to 1-1/2 inches inclusive;

vi) Rope diameters over 1-1/2 inches, as recommended by the wire rope manufacturer.

(d) Wire rope attachments shall be replaced when inspection shows:

(1) Improper installation of attachment;

(2) Cracked, deformed, excessively worn, or loosened attachments;

(3) Wire rope slippage at attachment;

(4) More than one broken wire at the point of attachment of a spelter filled or swaged attachment.

The requirements of Section 77.1906 requiring one complete cycle of hoist operation prior to each working shift and detailed recording of inspection results should be continued.

Section 77.1907 - Hoist construction: general

General hoist construction standards as stated in Section 77.1907 are adequate; no revisions are recommended.

Section 77.1908 - Hoist installation; use

(a) Where men are transported by means of a hoist and the depth of the shaft exceeds 50 feet, the hoist rope shall be suspended from a substantial hoisting installation capable of withstanding a force at least equal to the breaking strength of the rope. The hoist installation should be high enough to provide clearance between the main sheave and the highest rope fastener.

(b) No changes are recommended.

(c) All guides and guide attachments or other no less effective means installed in accordance with Paragraph (b) of this section shall be maintained to a depth of not more than 75 feet from the bottom of the shaft.

Paragraphs (d) through (o) are adequate as published.

Section 77.1908-1 - Hoist operator; qualified hoistman

No changes are recommended.

Section 77.1909 - Explosives and blasting; use of nonpermissible explosives and shot-firing units

(a) Nonpermissible explosives and nonpermissible shot-firing units may be used in shafts and slopes provided that all persons are withdrawn from the shaft or slope to a place of safety on the surface prior to firing the shot and the shot is fired electrically from the surface.

(b) The appropriate Health and Safety District Manager may require the use of permissible explosives and permissible shot-firing units when he determines that the use of nonpermissible explosives or shot-firing units may present a hazard to persons.

Section 77.1910 - Explosives and blasting; general

No revisions are recommended.

Section 77.1911 - Ventilation of slopes and shafts

(a) All slopes and shafts shall be ventilated by mechanical ventilation equipment during development.

The ventilation system shall be capable of producing a volume of 3,000 cubic feet of air per minute at the working face. The air shall contain not less than 19.5 volume per centum of oxygen, not more than 0.5 volume per centum of carbon dioxide and no harmful quantities of other noxious or poisonous gases. Additional ventilation shall be provided when diesel-powered equipment is used underground. The quantity of air required shall be determined by the requirements specified for the type and number of machines in use and shall maintain air quality as specified in this section.

Such ventilation equipment shall be examined before each shift and the quantity of air in the slope or shaft measured by a certified person as specified in Section 77.1901 of this subpart. The results of such examinations shall be recorded in a book approved by the Secretary.

No other revisions are recommended in Section 77.1911 with the exception of Paragraph (b)6ii. This paragraph should state that: Ducts shall extend as close to the bottom as necessary to maintain air quality and quantity as specified in Paragraph (a) of this section.

Requirements of Sections 77.1912, Ladders and stairway; 77.1913, Fire-resistant wood; 77.1914, Electrical equipment; 77.1915, Storage and handling of combustible materials; and 77.1916, Welding, cutting, and soldering: fire protection are adequate and do not require revision.

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APPENDIX A

INSPECTION GUIDE

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INSPECTION GUIDE

INTRODUCTION

This guide was prepared to assist inspectors in their examination of shaft and slope construction projects. It must be emphasized that shaft sinking is a specialized form of mining just as are underground and surface operations. While there are many similarities between shaft work and underground mining, there are also significant differences. Some of the differences create potential hazards not found in production mining while other mining hazards are not present in shaft work. The items included here were found to be significant hazards based on an analysis of accident reports, interviews with MESA inspectors, contractors, and union representatives.

Following the description of critical items is a corresponding outline-checklist which may be used in inspecting shaft and slope projects.

SHAFT PLAN

Coal mine operators are required by 30 CFR, Section 77.1900 to submit a plan to the appropriate Health and Safety District Manager for sinking the proposed shaft. Upon approval, this plan sets the standards to be followed in the shaft-sinking operation. This plan should be reviewed prior to any inspection so that the inspector is familiar with the operator's procedure.

Under present regulations, plans are not required for metal or nonmetal mine shaft projects. However, the inspector should obtain as much information and become as familiar as possible with the project. The following discussion reviews the requirements for coal shafts and may be used either for evaluation of a proposed plan or in preparation for an inspection.

Information Required by Section 77.1900

A. Name, MESA identification number, and address of the mine. If the shaft is to connect with an existing mine, consider the safety problems of that mine. What are the roof, water, or gas problems to be encountered. This is especially important if the shaft is to be raise drilled or when connection is made to the mine.

B. Name and address of the operator and/or contractor performing the work. Consider the operator or contractor actually performing the work as an indication of the overall safety situation. Projects done by operators with their own employees are commonly slower but reportedly safer than those done by contractors who are committed to a schedule. Evaluate the contractor, some are extremely conscientious while others are less so. Has he worked in this district before? What experience has he had sinking shafts? New contractors are entering the industry and may lack vital experience. A meeting with the operator, contractor, the district or subdistrict manager and shaft inspector may be helpful prior to approval of the plan. This is particularly useful with unfamiliar contractors in that all parties become acquainted, the proposed plan is reviewed, and requirements are understood.

C. Under existing regulations, the operator must provide a description of the construction work and methods to be used in the construction of the shaft or slope. Revisions to the existing regulations have been proposed by MESA which require more details in the shaft plan. The following items are not specifically required by existing regulations but should be obtained and reviewed in evaluating a shaft plan.

1. A surface map showing:

   a. Geographic location of the slope or shaft. Examine the shaft area to determine if flooding, snow slides or other factors will endanger the operation. If the shaft is located in a valley or near a stream consider the potential problems from ground water, particularly during initial excavation of the overburden.

   b. Surface drainage and impoundments. Is the shaft collar safe from potential floods? Are there impoundments upstream which might endanger the project? Well engineered reservoirs usually present no problems; however, mine refuse banks, tailings ponds and similar impoundments are usually not engineered and might be potentially hazardous. If such structures are located near the shaft will they be affected by blasting vibrations?

   c. Known underground workings or construction projects within 500 feet. The shaft plan should consider the possibility of gas or water accumulation in old workings near the shaft. How accurately is the location known for such workings? If older surface facilities existed are there buried electrical, gas or other utilities which may be encountered during initial excavation?

d. Spoil areas. Examine the location of the dumping area. Is it near the shaft collar? Will muck removal be done so as not to interfere with other operations? Will muck be handled near the collar where it may fall back into the shaft? If the dump is located away from the collar, will a haul road be maintained? Will the muck pile endanger other facilities or impound surface water?

2. Drawings and specifications of hoisting apparatus showing:

a. Size capacity and safety factor of ropes, drums, headframes, brakes, and sheaves. This data should be reviewed very carefully since the hoisting system is the critical factor in shaft safety. The sheave and drum diameters should be in the proper ratio with the rope diameter and construction. A proper fleet angle should be used. ANSI Standard M11.1-1960 should be used as the guide in establishing the proper installation for the rope. If the rope construction is not listed in that standard, the use should be compatible with the rope manufacturer's recommendation. If the rope has had prior use, insure that it has been properly tested and certified prior to new installation. Although current regulations do not require the submission of calculations to verify safety factors, they should be checked. Rope manufacturers state that their rope strength data were determined by testing samples with both ends fixed and the strength is reduced if one end is free to rotate. Since many contractors use systems which allow the bucket to rotate slightly, the rope strength may be sufficiently reduced to affect the safety factor.

b. Methods of rigging. Rigging of the hoist system is especially important if mobile cranes or stiff leg derricks are used. Rigging schemes should be evaluated to insure that excessive rope wear does not occur. The system must be capable of supporting the planned load.

c. Distance from head sheave to nearest rope attachment after overwind device is activated. Many District Managers currently require 6 feet from the attachment to the head sheave when the conveyance has stopped. This distance should be verified once the system is in operation.

d. Emergency hoisting devices. The emergency escape system should be evaluated to determine its suitability for use under a variety of conditions. Is it available for immediate use? Does it have the capacity to remove the number of men normally employed in a shaft within a reasonable time? Several contractors use the work deck as an emergency escape system. The platform hoists have a maximum speed of approximately 20 feet per minute. This system would require 50 minutes to bring men up from a depth of 1000 feet. The system must be evaluated to determine if this is acceptable. The system must be able to reach the maximum planned depth of the shaft. Provisions must also be included to enable men to reach the work deck from the bottom or to be hoisted directly from the bottom.

3. Operational sequences for initial and subsequent excavation. Many of these activities are routine. Evaluation of their safety problems is best made by watching field operations. Several points must be considered.

   a. Methods for initial excavation and shoring overburden should be considered. Are men required in the shaft? How is access provided? How deep will these methods be used before headframe and other sinking equipment are established?

   b. Blasting procedures should be detailed and comply with applicable regulations governing explosives and blasting found in 30 CFR, Section 57.6 (Metal and Nonmetal Mines) or Subpart N, Section 77.1300 for coal mines. Existing regulations applicable to coal shafts require the use of permissible blasting agents unless a permit is obtained from the District Manager to allow use of nonpermissible explosives. The plan should be closely reviewed to insure a permit is requested if use of nonpermissible blasting agents is planned.

Adequate measures must be taken to protect workers if a nonpermissible blasting device is used. If the operator proposes to use a separate blasting circuit the plan should include provision for its proper installation and use.

c. Loading and transportation of broken rock. The methods and equipment proposed to remove broken material should be closely examined. A variety of mucking machines may be used, and each system has potentially dangerous features which must be considered when inspecting the site. Handling of muck at the surface should be considered. Does the plan provide protection against material accidentally falling back into the shaft?

d. Placement of linings, concrete forms and work platforms. Among the items to be considered are the methods of handling forms. Will the forms be fixed to the platform or suspended by a separate winch system? Is the suspension system adequate for the size and weight of the forms? If the forms are to be freed and transported by the work deck, the platform hoists and ropes must have the capacity to withstand the loads imposed when forms are broken free. Will the system require men to work on the platform while forms are being broken? If so, such hoisting would potentially endanger men and therefore should be subject to the requirements of Subpart O of Section 77 or Section 57.19.

The type of lining should also be reviewed. If a concrete lining is used, will accelerator agents be added to the mix? Such additives are a common source of chemical burns to shaft miners. If other linings are proposed, will they provide adequate protection during the work? Does the plan provide for maintaining the lining sufficiently near the bottom to provide support? Will temporary wall support be required or must the lining be kept closer to the bottom during sinking? If rock bolts are to be used they should be properly installed using a calibrated torque wrench. The plan should include a schedule for periodically testing rock bolts and improving support as needed.

If the contractor proposed to sink the shaft without lining (a bald shaft) consider the rock types present and degree of fracturing. Will the ground conditions permit sinking a bald shaft? Does the operator have a satisfactory method to scale the walls, and periodically examine and rescale them as necessary? If a temporary support system is proposed will it be adequate?

e. The ventilation system should be evaluated. Will the proposed fan and tubing system provide sufficient air to the face? If the tubing is kept close to the bottom how will it be protected from blast damage?

The shaft-sinking plan should be reviewed to verify that the operator is in compliance with the appropriate regulations and is providing for the safety of the workmen. MESA should not be responsible for verification of design or establishment of specific practices unless the operator's proposed methods would present an unusual hazard to the workers. The burden of proving that the proposed methods are safe should rest with the operator. MESA must allow operators to develop more efficient methods provided they are adequately designed and provide worker safety.

INSPECTION DURING INITIAL CONVENTIONAL EXCAVATION

Inspections during the initial stages of excavation are particularly important. During this phase the operator is using temporary hoisting systems and construction methods. The work has not established a routine which will be followed while sinking through rock to the final depth. Careful inspections and a cooperative but firm attitude by the inspector will be beneficial in leading the operator to establish safe work practice for the rest of the project.

Among the items requiring careful attention are:

A. Temporary hoisting systems. Mobile cranes commonly used during initial excavation must be equipped with suitable brakes and limit controls if used to hoist men. If men are not hoisted with the crane, a suitable fixed ladder or other properly equipped hoist should be provided. If a crane and clamshell are used for mucking, men should not be permitted in the shaft while this equipment is being used.

B. The excavation should be properly supported. Soil and unconsolidated overburden require support. In areas where ground water levels are high, extreme care should be taken to insure adequate support of overburden until the collar and lining are placed. Once rock is encountered, the operator should be careful to establish the proper excavation routine to be followed. Close compliance with the shaft plan at this time will establish proper procedures for the job.

C. The surface arrangement should be carefully inspected to establish habits of good housekeeping, and proper equipment maintenance and storage of materials.

HOISTING SYSTEMS

If the hoist system is properly installed and maintained, many serious safety problems are avoided. The inspector should examine the system in the same manner he would that at a producing mine. The hoist should be mounted on a suitable foundation and protected from the weather. The hoist should be fitted with adequate brakes, deadman, and limit controls as required by Subpart O of Section 77 or Section 57.19. The following items should be considered when hoisting systems are being planned and inspected.

A. Hoisthouses should be substantially constructed of fire-resistant materials. They should be capable of withstanding wind and snow loads. The hoisthouse must protect the hoist, ropes, and associated equipment against weather and dust. Maintenance and housekeeping are important. The hoisthouse should not be used as a shop, change room, or storage area.

B. Hoist machinery should be firmly anchored to reinforced foundations capable of withstanding a force at least equal to the capacity of the hoist, rope, and headgear. The machinery should be anchored with bolts of a sufficient size and capacity. The hoist frame should be sound and free from damage.

C. Hoist bearings should be properly aligned and lubricated. Pillow blocks should be firmly anchored. Bearings should be closely inspected for wear, improper alignment, or lack of lubrication.

D. Gears are the only acceptable drive mechanisms for hoist power trains; belts, ropes or chains are unacceptable. Gears should be properly aligned and lubricated. Gear teeth should mesh properly and should show no signs of wear, chipping or missing teeth.

E. Hoist brakes should be capable of stopping and holding a loaded conveyance from full speed at any point in the shaft. Brake blocks should have adequate thickness, uniform contact, be free from oil, and not charred. Brake linings should be inspected. The operating linkage should be inspected for cracked or worn parts.

F. Hoist clutches should be inspected for cracked, worn, or defective parts. All parts should be secured properly. Friction clutches should be inspected for signs of slippage or contamination by grease or other lubricants.

G. The hoist drum should be of a suitable diameter for the size of rope in use. The rope should be securely fastened to the drum by an approved method and there should be at least three full turns of rope on the drum when the conveyance is in the lowest position in the shaft. The drum should be inspected for cracks or other damage to the shell, spokes, or flange. Flanges should be of a proper size for the rope being used. If the drum is grooved, the grooves must match the size of the rope.

H. Hoist controls should be properly installed for easy use and should be easily accessible to the operator. The controls should be inspected for cracked, broken or missing parts or connections. The operator's station should be protected, reasonably comfortable, and free from extraneous materials which may interfere with the operation of the controls. The conveyance position indicator should be accurate and clearly visible to the operator. The code of signals should be clearly posted.

I. Overspeed, overwind, and automatic stop controls should be properly installed, adjusted, and maintained. The devices should be firmly fastened to the hoist in a location that protects them from damage. Trained, experienced mechanics should be assigned to inspect and maintain the devices.

Coal mine regulations specify that men may be hoisted at a maximum speed of 500 feet per minute or 200 feet per minute within 100 feet of any landing. The overspeed control is commonly set to engage if the hoist grid exceeds 575 feet per minute or 115 percent of the maximum man-hoisting speed. The maximum speed limits for man hoisting in metal and nonmetal mines are the same as in coal mines but the regulations are advisory only and may be exceeded at the operator's discretion. In these cases, a maximum speed is selected based on the hoist capacity and shaft conditions and the controller is adjusted accordingly.

The overwind device must be properly adjusted to bring the conveyance to a complete stop with sufficient clearance between the highest rope attachment and the main sheave. In several coal mine Districts, policy states that 6 feet of clearance is required. The conveyance should decelerate smoothly, generally at a rate of less than 6 feet per second.

J. The hoist rope should be carefully inspected for signs of corrosion, excess wear, broken wires, crimping, or flattening. Fasteners should be inspected for proper installation and slippage. ANSI Standard M11.1-1960 should be used as a guide.

K. After inspecting the hoisting system it may be desirable to verify proper adjustment of the brakes and safety devices by testing the equipment in operation. Tests should be conducted after all men have been withdrawn from the shaft. The conveyance should be operated through a complete cycle allowing the overspeed control engage to stop the conveyance. The overwind device should be tested by slowly raising the conveyance into the headframe until the controller engages. The time and distance needed to stop the conveyance should be noted. The clearance between the main sheave and highest rope fastener should be verified when the overwind device has engaged.

L. Regulations require that the operator assign a qualified person to conduct periodic hoist system inspections and to record the results in logs kept for that purpose. Three basic types of records should be kept - a hoistman's log, maintenance log, and a rope log.

The hoistman's log should record the date and shift, results of tests of hoist operation, record incorrect signals, and any unusual hoisting problems and the corrective action taken. The log should also contain special instruction to the hoistmen. The log should be read and signed by each hoistman at the beginning of each shift.

The maintenance log should record the results of all tests and maintenance performed on the entire hoisting system. It should describe problems and the corrective actions applied. The log should contain a detailed description of the hoist specifications including horsepower, drum diameter, drum width, hoist capacity, rope capacity, sheave diameter, depth of shaft and inclination.

The rope log should record the manufacturer's name, rope serial number, date of manufacture, type of construction, diameter, weight per foot, graded steel, type of core, type of lubricant and strength. All logs should be maintained by qualified persons responsible for hoist operation or maintenance and should be countersigned by the superintendent, assistant superintendent, foreman or health and safety supervisor.

HEADFRAME AND COLLAR

The headframes on shaft projects are commonly temporary structures which are transported and used repeatedly on several projects. It is important that they be correctly installed and maintained. The inspection should insure that the foundation is adequate construction and shows no signs of settlement or shifting. The headframe should be securely bolted to the foundation, and assembled as specified in its design drawings. All structural members should be in place and securely fastened. Missing bolts, rivets, stiffeners should be noted and corrected. Ladders and platforms should be adequate and securely fastened. The head sheave should be the proper size for the rope, properly mounted and lubricated. No unnecessary tools or supplies should be stored on or in the headframe.

The shaft collar should be securely guarded to prevent materials or persons from falling into the shaft. The collar should be surrounded with a substantial fence or covered. Shaft doors should operate smoothly and should be constructed to prevent materials or persons from entering the shaft.

CONVEYANCES

The conveyance, attachments, and guides should be inspected. Buckets should be deep enough to allow men to stand with adequate clearance of the attachments or bridle chains, and to prevent men from falling from the bucket. Self-dumping buckets should have positive means of preventing dumping when men are hoisted. Rope attachments should follow approved methods and show no signs of slippage. Bridle chains are required when hoisting men. The chains should attach securely to the bucket and connect to the rope. Guides should be securely fastened and have an adequate capacity. Crossheads or other guides should be properly maintained and lubricated as necessary. They should engage and disengage smoothly as needed.

PLATFORMS AND AUXILIARY HOISTING DEVICES

Conventional shaft-sinking methods commonly utilize a variety of air winches and other small hoists in addition to the main hoist. These hoists are used to support and move the work platform, handle lining forms, lower concrete remix chambers or vent tubing, or to handle a variety of mucking machines. With the exception of platform hoists, these machines are not used to lift men and are therefore not subject to the more stringent man-hoisting requirements. Even so, such equipment must be properly selected, installed, and maintained to perform its function safely.

Platform hoists and rope are commonly used to move steel liner forms and serve as guides for crossheads and conveyances. The hoists should be fitted with suitable brakes. If the sinking procedures require men to be on the platform when it is moved or if it is used for emergency escape, the system should be in compliance with man-hoisting standards. The hoists should have adequate brakes and be fitted with limit controls. The rope should be selected to provide the required factor of safety as specified for man hoisting. Sheave and drum sizes should meet ANSI specifications.

The platform ropes and attachments should be carefully inspected. When a two-part line is employed, the inspection should include an examination of the rope for signs of wear, broken wires, flattening, or corrosion as required. The sheaves on the platform or platform bridle chains should be examined. It has been reported that waste concrete may accumulate on platform sheaves causing rope wear. The attachment of the rope to the headframe should be examined for slippage. Platforms should be substantially constructed. Guard rails are required around the perimeter of each deck and around bucket wells. Housekeeping is especially important. Waste materials and supplies should not be stored on the platforms.

Additional hoists used for handling forms or other materials should also be inspected. The hoist brakes should be capable of stopping and holding the maximum planned load at any point in the shaft. The hoist controls should be protected against weather. The rope and attachments should be of suitable capacity for the planned loads. They should be inspected for excessive wear, corrosion, or broken wires.

LINING AND SUPPORT

The method of lining or other support varies with ground conditions and the ultimate purpose of the shaft. The shaft plan specifies the methods of temporary and permanent support to be used. The inspector should verify that the proposed methods are being followed and are adequate. The exposed rib should be carefully examined by a qualified person and scaled as needed. Reexamination of all exposed ribs should be made according to a definite schedule and scaling performed as needed. Special attention should be given to areas of poor ground including highly fractured, wet and soft, or incompetent strata. If rock bolts are used, they should be properly installed.

The bolts should be applied with the correct amount of torque as specified by the manufacturer and should be rechecked periodically. A calibrated torque wrench should be used for this purpose. The shaft plan should include a schedule for testing and replacing rock bolts as needed. The inspector should verify that such testing is being done.

When gunite or shotcrete linings are to be used, the inspector should insure that the equipment used is properly installed and maintained. Pressure lines should be secured with safety chains. Workers should have available and use respirators and other protective clothing as needed.

Placement of a full concrete lining is perhaps the most common type of ground support used. Installation of the lining includes several operations which are potentially hazardous. Handling the forms entails the greatest potential hazard. The forms may be lowered into position using the work deck or by independent winches. In either case, it is essential that the support hoists and ropes are adequate and well maintained. Breaking the forms free from the previously placed section of lining places a large load on the hoisting system. If men are on the work deck they are exposed to possible injury. If the forms must be pulled free, it is recommended that men be withdrawn to the surface.

Following placement of forms, the concrete must be transported and placed commonly by bucket or slickline. The bucket should close securely to prevent leakage of concrete. Any waste material should be cleaned from the outside of the bucket and dumping chute prior to hoisting.

Slicklines should be securely fastened to the shaft wall or otherwise firmly anchored. All joints should be securely connected to prevent separation during concrete placement.

If the concrete mix includes additives to accelerate setting, workers should be provided with protective clothing and advised of potential hazards. Following concrete placement, the work area should be cleaned to remove waste concrete, especially any accumulation on platform ropes or sheaves.

VENTILATION

The ventilation system for the shaft is outlined in the shaft plan. The inspector should verify that the fan is properly installed and maintained. The vent tubing should be examined and maintained to prevent excessive leakage. Air quality and quantity measurements should be made at the shaft bottom and in other critical areas such as on work decks. A commonly reported problem was insufficient ventilation around work decks; if the ventilation tubing ends above the platform, insure that ventilation is achieved on the bottom.

DRILLING AND MUCKING MACHINES

Nearly all machinery used in shafts is air powered. Although some hydraulic backhoes are used in shafts and rubber-tired diesel tractors are used in slopes, the majority of drills and mucking machines are operated by compressed air. An inspection of a shaft site should include a detailed examination of the compressed air service system including compressor, surge tank and lines. The system should provide air at a sufficient pressure to safely operate the necessary machinery. The surge tank and lines should be sound and capable of operating at the required pressures.

Drilling equipment should be secured to a conveyance when lowered into the shaft. The conveyance may be a shaft drill jumbo or a supply conveyance which contains air distribution lines to individual sinker drills. In either case, the conveyance should be firmly secured to the hoist rope and should not be used to transport men.

Individual drills should be inspected for broken or missing parts, and carefully maintained and lubricated. Particular care should be paid to attachment points of air hoses and drill steel. Connections should be positive and free from broken or chipped surfaces. Safety chains should be used to secure air hoses.

A variety of mucking machines are in use in shaft sinking and each type presents certain safety hazards. The following descriptions outline the critical features of the most common types of mucking machines.

Eimco 630 - Critical safety considerations are maintenance of the tracks, drive mechanisms, and rocker arms and controls. These assemblies should be cleaned and inspected between mucking cycles. Workers should not be permitted to remove the track control centering springs or to wedge the main air supply valve. All linkages should be inspected for worn or broken parts. The operator's platform should be in good repair and firmly fastened to the machine. The 2-inch diameter bull hose should be secured to the machine with a safety chain and should be tended when the machine is in operation. The Eimco 630 may be fitted with a combination of buckets and rocker arms to allow use in shafts as small as 14 feet in diameter. The inspector should verify that the machine is properly assembled for the shaft being sunk. Operating procedures should be observed and hazardous practices prohibited. Among the latter are:

1. operators should not attempt to level the muck pile when the mucker is suspended from the hoist rope;

2. the machine should not be operated with the operator positioned between the mucker and shaft wall or bucket;

3. the bucket should not be used to straighten forms or as an elevated platform;

4. the mucker should not handle excessively large rocks; and

5. the track centering spring should not be removed and the main air valve should not be wedged open.

Cryderman - This machine may be more than 40 feet long and may be suspended vertically in a shaft or in slopes as flat as 20 degrees. The Cryderman requires two suspension systems, one system to raise or lower the machine in the shaft and a second system to provide lateral stability. The inspector should insure that the capacity of the primary suspension system is adequate for the load and vibrations imposed by the machine. If suspended from a surface-mounted hoist, the entire hoist, rope, and headgear system should be carefully inspected. If the machine is suspended from a platform it is vitally important that the platform, hoists and ropes be designed and maintained to withstand the unbalanced load and vibrations. The Cryderman unit itself should be inspected for damage after each blast. All air supply hoses should be fastened with safety chains, all linkages should be inspected for worn, broken or missing parts and lubricated as required. The operator's cabin should be easily accessible and free from damage. When the machine is hoisted in the shaft, the bucket should be locked and safety slings secured.

Operating procedures are extremely important. The Cryderman should be operated only by a trained, experienced related equipment and should span beyond the planned diameter of the shaft. Preparation for drilling should include development in the mine at the bottom of the proposed shaft. Temporary roof support should be added in the shaft area. Adjustments to the mine's ventilation system may be needed and should be checked.

Once the pilot hole has been drilled, the cutter head is assembled and raise boring can begin. Ventilation of the shaft between the bit and the muck pile is particularly important and presents problems. The operator's plan should include a detailed scheme for providing ventilation and periodic monitoring of the methane content in the shaft. The inspector should insure that the operator complies with his plan. Work should be halted if methane content approaches dangerous concentrations and should not be resumed until the ventilation system has cleared the shaft. At the present time several methods are being developed for ventilating shafts and monitoring methane content. Technical support personnel should be consulted to determine the most effective means.

During the boring operation, cuttings fall to the level of the mine and must be removed. It is important that men not be permitted to work below the cutter when mucking. When cutters require replacement or servicing, the head is lowered to the mine level. Temporary overhead protection should be provided for the men working on the equipment.

Extreme care is necessary when the cutter head reaches the surface or other upper level. Men must not approach the bottom of the shaft at this time. Steps should be taken to secure the boring machine and surface facilities to guard against a possible collapse of material into the shaft.

Once the shaft has penetrated the surface, steps should be taken to insure that the new shaft will not adversely affect the mine's ventilation system.

If the shaft is to be lined it will be necessary to place men and equipment in the shaft. The hoist system, platform, lining forms, ventilation and other equipment must conform to all requirements stated earlier. The ribs of the bored shaft are smoother and commonly more stable than those of an excavated shaft but an examination is still necessary and temporary local support may be required.

BLIND DRILLING

Sinking shafts by blind drilling is not as common as raise drilling or conventional methods. As this method is developed further and its use increases, safety problems will be identified. At the present time, safety regulations do not address blind drilling operations. The inspector should consult with MESA technical support personnel for advise when evaluating a shaft plan for a blind drilled project or when inspecting such work. Operators should provide details and specifications of equipment to be used.

Drilling equipment should be secured to substantial foundations. The drilling machine should be inspected for broken or damaged structural members. Since men do not usually enter the shaft, most problems arise from handling materials. Hoisting equipment should be securely mounted and have a capacity sufficient to lift the designed loads. Ropes should be securely fastened to drums and should be inspected for corrosion, broken wires, flattening or other damage. The shaft collar should be adequately guarded to prevent persons from accidentally falling into the shaft. Pumps and drilling fluid circulation lines should be strong enough for the pressures to be used.

If men are required to enter a shaft to construct a lining or to operate a downhole machine, standards for ventilation and man hoisting should be applied as in conventional excavation.

INSPECTION GUIDE - OUTLINE AND CHECKLIST

I. SHAFT PLAN

A. Shaft plan is required for coal mine projects. Similar information is desirable for metal and non-metallic mine projects.

B. Name and location of the mine, and MESA mine identification number.

C. Name and address of operator and/or contractor performing work.

D. Description of methods and equipment to be used.

1. Surface map of shaft area showing:

a. geographic location;

b. surface drainage and impoundments;

c. location of known underground workings or facilities within 500 feet of shaft or slope; and

d. locations of spoil areas and haul roads.

2. Specifications and drawings of hoisting system including:

a. size and capacity of hoist, headframe, and sheaves;

b. type, capacity and safety factor of ropes;

c. method of rigging;

d. type and adjustment of overspeed and overwind devices;

e. clearance between main sheave and highest rope fastener when overwind device stops hoist; and

f. type and capacity of emergency hoisting devices.

3. Operational sequence for initial and subsequent excavation including:

a. methods for initial excavation and support for overburden;

b. equipment for initial access by persons;

c. blasting procedures and agents;

d. types of mucking equipment and handling;

e. placement of lining;

f. use of work decks or platforms; and

g. ventilation system.

II. INSPECTION DURING INITIAL CONVENTIONAL EXCAVATION

A. Check temporary hoisting system including:

1. proper rigging of crane or other device;

2. overspeed and overwind devices if used for man hoisting; and

3. suitability of ladders for personnel access.

B. Excavation method:

1. crane and clamshell - men not in shaft while mucking; and

2. mucking machine and bucket.

C. And, if shoring is required:

1. support for overburden;

2. temporary support for rock; and

3. length of exposed rib prior to placement of lining and collar.

III. HOISTING SYSTEMS

A. Hoisthouse:

1. substantially constructed;

2. fire-resistant materials; and

3. good housekeeping - hoisthouse free of unnessary materials.

B. Hoist securely mounted on substantial foundation.

C. Hoist bearings properly aligned and lubricated.

D. Hoist power train:

1. gears only - no belts, rope, or chains; and

2. gears properly aligned, lubricated, no chipping or missing teeth.

E. Brakes:

1. adequate to stop and hold loaded conveyance;

2. brake blocks with proper thickness and uniform contact;

3. linings free from oil, grease, charring;

4. hydraulic fluid at proper levels; and

5. linkage free from cracks, worn or missing parts.

F. Clutches:

1. all parts securely fastened;

2. linkage free of cracked, worn or missing parts; and

3. friction clutches free from oil or grease - no sign of slippage.

G. Drum:

1. diameter suitable for rope used;

2. rope securely fastened by approved method;

3. at least three full turns on drum at all times;

4. drum free from cracks or damage to shell, spokes, or flanges;

5. flanges proper height for rope used;

6. flanges securely fastened; and

7. drum grooves of proper size for rope.

H. Hoist controls:

1. properly installed and easily accessible;

2. controls and linkage free of broken or missing parts;

3. operator's station free of extraneous materials; and

4. conveyance position indicator clearly visible.

I. Controller:

1. controllers securely mounted in location to protect from damage;

2. overspeed device properly adjusted to maximum permitted man-hoisting speed; and

3. overwind device adjusted to halt conveyance with sufficient clearance between main sheave and highest rope fastener.

J. Rope - inspect for signs of damage, corrosion or wear. Wire rope shall be removed when inspection shows:

1. six randomly distributed broken wires in one rope lay or three broken wires in one strand in one rope lay. Snagged, nicked or severely bent wires shall be counted as broken wires; or

2. abrasion, scrubbing or peening causing loss of more than 1/3 the original diameter of the outside individual wires; or

3. evidence of rope deterioration from corrosion;

4. kinking, crushing, or other damage that results in distortion of the rope structure; or

5. reduction in nominal rope diameter determined as follows:

   a. 1/64 inch for rope diameters up to and including 5/16 inch;

2. ropes securely anchored to headframe or shaft collar on the dead end.

C. Platforms:

1. substantially constructed with guard rails and toe boards;

2. good housekeeping is essential; and

3. sheaves must be proper size for rope used.

VII. SHAFT LINING AND SUPPORT

A. Shaft walls inspected by qualified person and scaled as needed.

B. Rock bolts:

1. expanded shell or resin-grouted type;

2. proper size bearing plate;

3. correct amount of torque as per manufacturer; and

4. calibrated torque wrench used for installation and periodic rechecks.

C. Wire mesh secured firmly against wall to prevent damage.

D. Shotcrete or gunite:

1. shotcrete/gunite machines properly maintained, and safety chains on pressure hoses;

2. shotcrete/gunite applied to full design thickness; and

3. protective clothing for workers.

E. Concrete lining:

1. adequate hoists and ropes for handling forms;

2. concrete bucket well maintained, and dump doors close firmly;

3. slickline securely anchored and assembled;

4. thorough cleanup of waste concrete;

5. workers protected from alkali burns; and

6. workers withdrawn from shaft when breaking forms with platform.

F. Ventilation system:

1. reversible fan offset at least 15 feet from collar;

2. fan and tubing of fireproof construction;

3. tubing securely fastened to wall;

4. metal tubing grounded against static electricity;

5. tubing in good condition, and no leakage; and

6. air quality and quantity meets standards.

VIII. DRILLING AND MUCKING EQUIPMENT

A. Compressed air service system:

1. compressor, surge tank and lines properly installed; and

2. all hoses secured with safety chains.

B. Drills:

1. drills inspected and maintained;

2. operating pressure within limits set by manufacturer;

3. jumbos securely positioned before drilling;

4. men not permitted to ride jumbos; and

5. men instructed in proper use of sinkers, close supervision.

C. Mucking Machines

1. Eimco 630:

a. clean and service tracks, linkage and rocker arms between mucking cycles;

IX. PERSONNEL

A. Certification required or advised for:

1. supervisors;

2. hoist operators; and

3. examiners.

B. Inexperienced miners should receive instruction in procedures and close supervision.

C. Individual safety equipment:

1. hard hat;

2. steel toe safety shoes;

3. self-rescuer;

4. rubber boots, rainsuit as needed;

5. eye protection; and

6. safety belts and lines to prevent falls.

D. Work practices:

1. good housekeeping maintained;

2. explosives and flammable materials stored properly;

3. miners on bottom alert to hazards of moving machines and buckets;

4. miners use individual safety equipment provided; and

5. miners do not ride buckets with tools or materials.

X. RAISE DRILLED SHAFTS

A. Drilling machine firmly mounted.

B. All hydraulic and electrical lines and connections properly maintained.

C. Area at bottom of proposed shaft adequately supported.

D. Ventilation:

1. mine ventilation system adjusted to handle dust from drilling;

2. ventilation into shaft to remove methane and dust; and

3. air quality in shaft monitored for excess methane.

E. Mucking:

1. loader operators work only under supported roof;

2. no one enters area below bit; and

3. positive overhead protection provided if repairs performed on bit.

F. Completion of drilling:

1. drill secured when bit reaches surface;

2. miners not permitted near shaft bottom;

3. shaft collar area guarded; and

4. change in mine's ventilation system is anticipated and controlled.

G. Lining:

1. hoisting system to meet man-hoist requirements if men enter the shaft; and

2. ventilation of shaft required.

XI. BLIND DRILLED SHAFTS

A. Blind drilling is less commonly used than conventional or raise drilled methods and many detailed safety problems have not been identified.

B. Drilling machines should be firmly anchored.

C. Hoisting systems should be adequate for applied loads:

1. power connections should meet applicable electrical codes;

2. hoists securely mounted;

3. system inspected for cracked, broken or missing parts;

4. rope inspected for corrosion, excess wear, and flattening;

5. sheave and drum sizes suitable for rope used; and

6. hydraulic lines and connections inspected for damage.

D. Shaft collar guarded.

E. Personnel:

1. workers have individual protective equipment;

2. supervisors are qualified and closely supervise workers; and

3. workers should be instructed in hazards associated with handling materials.

F. Lining:

1. hoisting system should meet man-hoisting standards if men are required to enter the shaft;

2. ventilation system should be established; and

3. all requirements for lining used in conventional methods should apply if men are required to work in the shaft.

APPENDIX B

SHAFT INVENTORY

APPENDIX B

INVENTORY OF RECENT SHAFT PROJECTS

In an attempt to examine the extent of the shaft-sinking industry, an inventory of shaft-sinking projects completed since 1965 has been compiled. Shafts sunk during this period would reflect the most current state-of-the-art in shaft-sinking technology. The equipment, methods, and accident histories of these projects would provide the most useful base for recommendations to improve safety.

The inventory is subdivided into three major sections, United States coal shafts, United States metal and nonmetallic mine shafts, and foreign shafts.

Every effort was made to obtain accurate, complete information on each shaft; however, it is recognized that certain inconsistencies exist. The data on the shafts were obtained from a variety of sources including mine operators, contractors, federal and state agencies in the United States and other nations, and from published articles in a variety of industry publications. Some information was contradictory or incomplete. It is possible that certain shafts may have been reported by different names in different sources. Some shafts may have been omitted. Details of owners, depth, or cross-sectional dimensions may have been generalized. Attempts were made to identify and correct such discrepancies. It is likely, therefore, that some errors exist. It is hoped these are minor.

TABLE 1

INVENTORY OF RECENT U.S. COAL SHAFTS

STATE	MINE/SHAFT NAME	OWNER	CONTRACTOR	DEPTH	DIMENSION DIAMETER	METHOD	YEAR COMPLETED
Alabama	Oak Grove #2 Intake	United States Steel Corp.	Cowin & Company	1130	20	conv.	1976
Alabama	Oak Grove #3 Intake	United States Steel Corp.	Cowin & Company	1130	20	conv.	1976
Alabama	Oak Grove #2 Fan	United States Steel Corp.	Cowin & Company	1130	20	conv.	1976
Alabama	U.S. Pipe No. 4	U.S. Pipe & Foundry Company	Cowin & Company	NA	NA	conv.	NA
Alabama	Cordova Mine	Alabama By-products Company	NA	NA	NA	NA	NA
Alabama	Mine No. 5 Production	Jim Walters Resources	Underground Development	2075	22	conv.	in progress
Alabama	Mine No. 5 Man/mat'ls	Jim Walters Resources	Underground Development	2200	20	conv.	in progress
Alabama	Mine No. 5 Vent	Jim Walters Resources	Underground Development	2075	20	conv.	in progress
Alabama	Mine No. 3 Vent	Jim Walters Resources	Cowin & Company	1400	20	conv.	in progress
Alabama	Mine No. 3 Intake	Jim Walters Resources	Teton Drillers, Inc.	1500	16	R.D.	in progress
Alabama	Mine No. 3 Exhaust	Jim Walters Resources	Teton Drillers, Inc.	1500	16	R.D.	in progress
Alabama	Oak Grove, Elevator	United States Steel Corp.	Cowin & Company	1130	20	conv.	1974
Alabama	U.S. Pipe No. 3	U.S. Pipe & Foundry Company	Cowin & Company	NA	NA	conv.	1974
Alabama	North River No. 1	Republic Steel Corporation	Cowin & Company	NA	NA	conv.	1974
Alabama	Mary Lee No. 2 (slope)	Alabama By-products Company	Cowin & Company	NA	NA	conv.	1974
Alabama	Nebo Mine	U.S. Pipe & Foundry Company	Cowin & Company	NA	NA	conv.	1975
Illinois	Wabash Vent No. 1	AMAX Coal Company	Frontier-Kemper	806	22	conv.	1976
Illinois	Wabash Vent No. 2	AMAX Coal Company	Frontier-Kemper	806	22	conv.	1976
Illinois	Inland No. 2, Production	Inland Steel Corporation	Zeni-McKinney-Williams	1079	17	conv.	1976
Illinois	Inland No. 2, Materials	Inland Steel Corporation	Zeni-McKinney-Williams	945	20 x 32	conv.	1976
Illinois	Inland No. 2, Man	Inland Steel Corporation	Zeni-McKinney-Williams	942	18	conv.	1976
Illinois	Crown No. 2, shaft	Freeman-United Coal	Zeni-McKinney-Williams	331	20 x 31	conv.	1976
Illinois	Crown No. 2, slope	Freeman-united Coal	Zeni-McKinney-Williams	1517	14 x 15	conv.	1976
Illinois	Monterey No. 2, shaft 1	Monterey Coal Company	Zeni-McKinney-Williams	335	22	conv.	1976
Illinois	Monterey No. 2, shaft 2	Monterey Coal Company	Zeni-McKinney-Williams	335	22	conv.	1976
Illinois	Monterey No. 2, slope	Monterey Coal Company	Zeni-McKinney-Williams	1360	17 x 18	conv.	1976
Illinois	Old Ben 25, Man	Old Ben Coal Company	Zeni-McKinney-Williams	622	20 x 30	conv.	1976
Illinois	Old Ben 25, Production	Old Ben Coal Company	Zeni-McKinney-Williams	697	11 x 20	conv.	1976
Illinois	Old Ben 24	Old Ben Coal Company	Raise Drillers	670	NA	R.D.	1976
Illinois	Orient 3, Vent	Freeman-United Coal	Owner	758	15'3"	R.D.	1972
Illinois	Zeigler No. 5	Zeigler Coal Company	Gunther-Nash Mining Construction	NA	NA	conv.	1972
Illinois	Orient Mine	Freeman Coal Company	Dravo	730	10.5	B.D.	1965
Illinois	West Frankford	Freeman Coal Company	Raise Drillers, Inc.	230	12	R.D.	1972
Illinois	West Frankford	Freeman Coal Company	Raise Drillers, Inc.	780	15'3"	R.D.	1972
Illinois	Baldwin No. 1, Vent	Peabody Coal Company	Raise Drillers, Inc.	125	12	R.D.	1972
Illinois	Baldwin No. 1, Vent	Peabody Coal Company	Raise Drillers, Inc.	132	12	R.D.	1972
Kentucky	Mine No. 1	Leslie Coal Company	Harrison-Western	NA	NA	conv.	1975
Kentucky	Pontiki No. 1	Pontiki Coal Company	Owner	NA	NA	conv.	1975
Kentucky	Scotts Branch Mine	Scotts Branch Coal	Harrison-Western	NA	NA	NA	in progress
Kentucky	Wolf Creek No. 4	Wolf Creek Collieries	NA	NA	NA	R.D.	1976
Kentucky	Pontiki No. 2 Shaft	Pontiki Coal Corporation	Delta Shaft Construction	420	22	conv.	in progress
Kentucky	Pontiki No. 2 Slope	Pontiki Coal Corporation	Delta Shaft Construction	4000@17^{o}	5	R.D.	1976

TABLE 1 (continued)

INVENTORY OF RECENT U.S. COAL SHAFTS

STATE	MINE/SHAFT NAME	OWNER	CONTRACTOR	DEPTH	DIMENSION DIAMETER	METHOD	YEAR COMPLETED
Pennsylvania	Urling No. 3	Rochester & Pittsburgh Coal Co.	Williamson Shaft	210	16 x 36	conv.	in progress
Pennsylvania	Oneida No. 1	Oneida Mining Company	Raise Drillers, Inc.	375	12	R.D.	1972
Pennsylvania	Oneida No. 2	Oneida Mining Company	Raise Drillers, Inc.	375	12	R.D.	1972
Pennsylvania	Oneida No. 3	Oneida Mining Company	Central Cambria Drilling	383	20 x 37	conv.	1975
Pennsylvania	North Portal	Greenwich Collieries Company	Williamson Shaft	435	17 x 30	conv.	1972
Pennsylvania	North Return	Greenwich Collieries Company	R.G. Johnson Company	380	24	conv.	1972
Pennsylvania	South Portal	Greenwich Collieries Company	Williamson Shaft	615	17 x 30	conv.	1972
Pennsylvania	South Return	Greenwich Collieries Company	R.G. Johnson Company	400	18	conv.	1972
Pennsylvania	Cookport Portal	Greenwich Collieries Company	R.G. Johnson Company	615	17 x 30	conv.	1973
Pennsylvania	Gateway Mine, Clayton Shaft Intake	Gateway Coal Company (Joint	R.G. Johnson Company	583	18	conv.	1967
Pennsylvania	Gateway Mine, Clayton Exhaust	Gateway Coal Company	R.G. Johnson Company	584	18	conv.	1967
Pennsylvania	Westland Mine, Lynn Shaft	Pittsburgh Coal Company	Williamson Shaft	214	14 x 32	conv.	1966
Pennsylvania	Florence No. 2 Mine, Shaft No. 1	Florence Mining Company	Williamson Shaft	132	13 x 24	conv.	1970
Pennsylvania	Frye Portal	North American Coal Corporation	R.G. Johnson Company	200	13.5 x 21.5	conv.	1969
Pennsylvania	Mine 33, Howell's	Bethlehem Mines Corporation	NA	451	18'2" x 30'6"	conv.	1969
Pennsylvania	Mine 32, Lehman	Bethlehem Mines Corporation	NA	733	18'2" x 30'6"	conv.	1972
Pennsylvania	Mine 33, Happy Land	Bethlehem Mines Corporation	Central Cambria Drilling	669	18'2" x 30'6"	conv.	in progress
Pennsylvania	Dilworth, Shaft 1	United States Steel Corporation	McGuire Shaft & Tunnel	163	18 x 33	conv.	1974
Pennsylvania	Dilworth, Shaft 2	United States Steel Corporation	R.G. Johnson	337.7	18 x 33	conv.	1973
Pennsylvania	Dilworth, Shaft 3	United States Steel Corporation	R.G. Johnson	521	18 x 33	conv.	1975
Pennsylvania	Laurel Mine	Pittsburgh Coal Company	R.G. Johnson	NA	NA	conv.	1974
Pennsylvania	Cumberland No. 1 Shaft	United States Steel Corporation	R.G. Johnson	NA	NA	conv.	1975
Pennsylvania	Cumberland Mine "C" Shaft	United States Steel Corporation	Zeni-McKinney-Williams	NA	NA	conv.	1976
Utah	Sunnyside Mine	Kaiser Steel Corporation	Owner	1200	7	R.D.	1969
Utah	Sunnyside Mine	Kaiser Steel Corporation	Owner	1200	7	R.D.	1969
Utah	Sunnyside Mine	Kaiser Steel Corporation	Owner	1200	8	R.D.	1970
Virginia	Beatrice "E"	Beatrice Pocahontas Coal Company	Frontier-Kemper	1736	22	conv.	1974
Virginia	Virginia Pocahontas No. 4, A Shaft	Island Creek Coal Company	Centennial Constructors	1325	20	conv.	1971
Virginia	Virginia Pocahontas No. 4, B Shaft	Island Creek Coal Company	Centennial Constructors	1325	24	conv.	1971
Virginia	Virginia Pocahontas No. 4, C Shaft	Island Creek Coal Company	Centennial Constructors	1325	20	conv.	1971
Virginia	Virginia Pocahontas No. 5, A Shaft	Island Creek Coal Company	Centennial Constructors	1565	20	conv.	1976
Virginia	Virginia Pocahontas No. 5, B Shaft	Island Creek Coal Company	Centennial Constructors	1485	22	conv.	1976
Virginia	Virginia Pocahontas No. 5, C Shaft	Island Creek Coal Company	Centennial Constructors	1455	20	conv.	1976
Virginia	Virginia Pocahontas No. 6, A Shaft	Island Creek Coal Company	Centennial Constructors	1500	20	conv.	in progress
Virginia	Virginia Pocahontas No. 6, B Shaft	Island Creek Coal Company	Centennial Constructors	1500	20	conv.	in progress
Virginia	Virginia Pocahontas	Island Creek Coal Company	Centennial Constructors	1500	20	conv.	in progress
Virginia	McClure No. 1, man & materials	Clinchfield Coal Company	Thyssens Mining Constructors	440	22 x 32	conv.	in progress
Virginia	McClure No. 1, vent	Clinchfield Coal Company	Thyssens Mining	440	NA	conv.	in progress
Virginia	McClure No. 1, slope	Clinchfield Coal Company	Thyssens Mining	1600'@16½°	7½ x 24	conv.	in progress
West Virginia	North Branch Shaft	Island Creek Coal Company	Williamson Shaft	NA	NA	conv.	in progress
West Virginia	Robinson Run 95, Jones Run Shaft	Consolidation Coal Company	Williamson Shaft	NA	NA	conv.	in progress
West Virginia	Loveridge/St. Leo	Consolidation Coal Company	Williamson Shaft	NA	NA	conv.	in progress
West Virginia	Arkwright No. 1, wells shaft	Consolidation Coal Company	Central Cambria Drilling	480	15 x 31	conv.	in progress

TABLE 1 (continued)

INVENTORY OF RECENT U.S. COAL SHAFTS

STATE	MINE/SHAFT NAME	OWNER	CONTRACTOR	DEPTH	DIMENSION DIAMETER	METHOD	YEAR COMPLETED
West Virginia	Humphrey 7/Pife	Consolidation Coal Company	Central Cambria Drilling	NA	NA	conv.	in progress
West Virginia	Pursglove 15, Dunkard Beach	Consolidation Coal Company	Williamson Shaft	NA	NA	conv.	in progress
West Virginia	Osage 3/Varner	Consolidation Coal Company	Williamson Shaft	565	15 x 31	conv.	in progress
West Virginia	Federal 2/Shriver	Eastern Associated Coal	Owner	NA	NA	conv.	in progress
West Virginia	Blacksville No. 2, Sanders	Consolidation Coal	Williamson Shaft	NA	NA	conv.	in progress
West Virginia	Blacksville No. 2, Thomas	Consolidation Coal Company	Central Cambria Drilling	NA	NA	conv.	in progress
West Virginia	Keystone No. 4	Eastern Associated Coal	Owner	NA	NA	conv.	1976
West Virginia	Skelton Mine	New River Company	Ohio-Atlas Construction	NA	NA	conv.	in progress
West Virginia	MacAlpin No. 3	Westmoreland Coal Company	Cementation Company of America	NA	NA	conv.	in progress
West Virginia	Lick Run, man shaft	Beckley Basin Company	Ohio-Atlas Construction	860	24	conv.	in progress
West Virginia	Lick Run, vent	Beckley Basin Company	Ohio-Atlas Construction	680	24	conv.	in progress
West Virginia	Lick Run, slope	Beckley Basin Company	Ohio-Atlas Construction	2412@16°	16 x 16	conv.	in progress
West Virginia	Morton Mine (2 shafts)	Carbon Fuel Company	Frontier-Kemper	NA	NA	conv.	in progress
West Virginia	No. 50, Pinnacle Creek	United States Steel Corporation	Cowin & Company	525	20	conv.	in progress
West Virginia	Beckely No. 2, man shaft	Ranger Fuel Corporation	Cowin & Company	340	20 x 30	conv.	1976
West Virginia	Beckley No. 2, vent	Ranger Fuel Corporation	Cowin & Company	400	20	conv.	in progress
West Virginia	Beckley No. 2, slope	Ranger Fuel Corporation	Cowin & Company	1400@16°	12 x 20	conv.	in progress
West Virginia	National Pocahontas	National Mines Corporation	Raise Drillers, Inc.	700	15.3	R.D.	1976
West Virginia	No. 132 Mine, slope	Bethlehem Mines Corporation	Ace Equipment Rentals	NA	NA	NA	1976
West Virginia	Lightfoot No. 1, slope	Eastern Associated Coal	Owner	NA	NA	NA	in progress
West Virginia	Lightfoot No. 2, slope	Eastern Associated Coal	Owner	NA	NA	NA	in progress
West Virginia	Loveridge/Flat Run No. 2	Mountaineer Coal Company	R.G. Johnson	NA	NA	conv.	1975
West Virginia	Beckley No. 1, intake	Range Fuel Company	Cowin & Company	635	20	conv.	1975
West Virginia	Loveridge/Miracle Run	Mountaineer Coal Company	R.G. Johnson	NA	NA	conv.	1972
West Virginia	Mine No. 1	Maple Meadow Mining	Monty Bros. Construction	NA	NA	conv.	1975
West Virginia	Coalwood	Olga Coal Company	Dravo	1000	12	B.D.	1965
West Virginia	Stringtown	Rochester & Pittsburgh Coal	Dravo	482	8	D.H.M.	1965
West Virginia	Morgantown	U.S. Bureau of Mines	Loffland Bros. Drilling	840	6	B.D.	1971
West Virginia	Kermit	IMEC, Inc.	Raise Drillers, Inc.	270	9	R.D.	1971
West Virginia	Kermit	IMEC, Inc.	Raise Drillers, Inc.	288	9	R.D.	1971
West Virginia	Slab Fork	Slab Fork Coal Company	Raise Drillers, Inc.	310	9	R.D.	1972
West Virginia	Slab Fork	Slab Fork Coal Company	Raise Drillers, Inc.	188	9	R.D.	1972
West Virginia	Buchannon	Upshur Coal Company	Raise Drillers, Inc.	130	12	R.D.	1972
Wyoming	No. 1 Slope	Stansbury Coal	Morrison-Knudsen	NA	NA	conv.	1975

TABLE 1 (continued)

INVENTORY OF RECENT U.S. METAL AND NONMETAL MINE SHAFTS

STATE	MINE/SHAFT NAME	OWNER	CONTRACTOR	DEPTH	DIMENSION DIAMETER	METHOD	YEAR COMPLETED
Arizona	Foothills No. 1	Phelps Dodge	NA	1860	20	conv.	1968
Arizona	Foothills No. 1 deepen	Phelps Dodge	Cementation Company of America	275	20	conv.	1975
Arizona	Foothills No. 2	Phelps Dodge	Cementation Company of America	2465	25	conv.	1976
Arizona	San Manuel, 3C	Magma Copper	NA	2859	NA	conv.	1970
Arizona	San Manuel, 3D	Magma Copper	Cementation Company of America	2740	22	conv.	1974
Arizona	San Manuel, 5	Magma Copper	Cementation Company of America	4140	25	conv.	1973
Arizona	Superior No. 9	Magma Copper	NA	4800	22	conv.	1973
Arizona	Miami East No. 11	Cities Service Company	Centennial Development Company	3300	12	conv.	1975
Arizona	Miami East No. 12	Cities Service Company	Centennial Development Company	2900	NA	conv.	1975
Arizona	Miami No. 5	Cities Service Company	Boyles Bros. Drilling	deepened 2350	NA	conv.	1974
Arizona	Casa Grande No. 6 Lakeshore	Hecla Mining Company	Centennial Development Company	NA	NA	conv.	1975
Arizona	Oxide, Lakeshore	Hecla Mining Company	Centennial Development Company	NA	NA	conv.	1975
Arizona	Casa Grande No. 1	ASARCO	M.M. Sundt Construction	NA	NA	conv.	in progress
Arizona	Safford	Phelps Dodge	Teton Exploration	1526	6	R.D.	1972
Arizona	Florence, Service	Continental Oil Company	Teton Exploration Drilling	706	5	B.D.	1974
Arizona	Florence, Production	Continental Oil Company	Teton Exploration Drilling	711	7	B.D.	1974
Arkansas	NA	Reynolds Mining Company	NA	350	5	B.D.	1965
Colorado	Henderson No. 1	AMAX	Boyles Bros. Drilling	2440	23	conv.	1976
Colorado	Henderson No. 2	AMAX	Harrison-Western	3100	30	conv.	1972
Colorado	Henderson No. 3	AMAX	Harrison-Western	2300	23	conv.	1975
Colorado	Henderson West	AMAX	J.S. Redpath Ltd.	1500	11	conv.	1975
Colorado	Schwartzwalden No. 2	Cotter Corporation	Harrison-Western	NA	NA	conv.	NA
Colorado	Schwartzwalden No. 3	Cotter Corporation	Owner	NA	NA	conv.	NA
Colorado	Ajax Shaft	Golden Cycle Gold Corporation	U.S. Energy Corporation	NA	NA	conv.	1975
Colorado	Keystone Mine	U.S. Energy Corporation	NA	NA	NA	conv.	NA
Idaho	Galena Mine	ASARCO	NA	NA	NA	NA	NA
Idaho	Bunker Hill Mine	Bunker Hill Company	NA	NA	NA	NA	NA
Idaho	Cresent Mine	Bunker Hill Company	NA	NA	NA	NA	NA
Idaho	Star Mine	Hecla Mining Company	NA	NA	NA	NA	NA

TABLE 1 (continued)

INVENTORY OF RECENT U.S. METAL AND NONMETAL MINE SHAFTS

STATE	MINE/SHAFT NAME	OWNER	CONTRACTOR	DEPTH	DIMENSION DIAMETER	METHOD	YEAR COMPLETED
Idaho	Lucky Friday Mine	Hecla Mining Company	NA	NA	NA	NA	NA
Idaho	Sunshine Mine	Sunshine Mining Company	NA	NA	NA	NA	NA
Idaho	Clayton Mine	Clayton Silver Mines	NA	NA	NA	NA	NA
Idaho	Atlas Mine	Noranda Exploration	NA	NA	NA	NA	NA
Idaho	Tamarack Mine	Day Mines, Inc.	NA	NA	NA	NA	NA
Idaho	Pope-Shenon Mine	Grandview Metals	NA	NA	NA	NA	NA
Idaho	Horsehoe Mine	Myko, Inc.	NA	NA	NA	NA	NA
Idaho	Salmon Canyon Mine	Salmon Canyon Copper Company	NA	NA	NA	NA	NA
Idaho	Delamar Mine	Earth Resources, Inc.	NA	NA	NA	NA	NA
Idaho	Democrat Mine	Mr. Sandy Sims	NA	NA	NA	NA	NA
Idaho	Coeur Project	ASARCO	NA	NA	NA	NA	NA
Idaho	Interstate Mine	Day Mines, Inc.	NA	NA	NA	NA	NA
Idaho	Rex Mill Mine	Mr. Herb Zanetti	NA	NA	NA	NA	NA
Idaho	Hoodoo Mine	Hoodoo Mining Company	NA	NA	NA	NA	NA
Idaho	Morning Mine	ASARCO	NA	NA	NA	NA	NA
Idaho	Blackbird Mine	Idaho Mining Company	NA	NA	NA	NA	NA
Idaho	Hercules Mine	Day Mines, Inc.	NA	NA	NA	NA	NA
Idaho	Morning Star	Welker Mining & Development Co.	NA	NA	NA	NA	NA
Idaho	Silver Moon Mine	Universal Exploration Company	NA	NA	NA	NA	NA
Illinois	Spivey Mine	Minerva Oil Company	Roy Pennell	NA	NA	NA	NA
Illinois	Knight Shaft	Ozark Mahoning	Owner	850	6 x 7	conv.	1975
Illinois	Deardorf/North Victory	Minerva Oil Company	NA	NA	NA	NA	NA
Kentucky	Lafayette Mine	Minerva Oil Company	NA	NA	NA	NA	NA
Kentucky	Maysville Mine	Dravo Lime Company	Dravo	960	14	conv.	1975
Kentucky	Babb Barnes	Cerro Sparr	Centennial Development Company	800	8 x 17	conv.	1973
Kentucky	Babb Barnes	Cerro Sparr	Raise Drillers. Inc.	700	6	R.D.	1974
Kentucky	Corntown	Marble Cliffs Quarries	Dravo	636	6	B.D.	1966
Michigan	Centennial No. 6	Homestake Copper	Owner	NA	NA	NA	NA
Michigan	White Pine	White Pine Copper	Dravo	1591	12	D.H.M.	1969
Michigan	Kentwood Mine	Georgia Pacific Corporation	Bechtel Corporation	300	16	conv.	1971
Michigan	White Pine No. 3	White Pine Copper	Boyles Bros. Drilling	1660	24	conv.	1966
Michigan	White Pine	White Pine Copper	Teton Exploration Drilling	1758	7	R.D.	1970
Minnesota	Maturi Shaft	International Nickel	Cementation Company of America	900	10 x 16	conv.	1968
Minnesota	Babbitt	AMAX	NA	1712	NA	NA	NA

TABLE 1 (continued)

INVENTORY OF RECENT U.S. METAL AND NONMETAL MINE SHAFTS

STATE	MINE/SHAFT NAME	OWNER	CONTRACTOR	DEPTH	DIMENSION DIAMETER	METHOD	YEAR COMPLETED
Missouri	Brushy Creek Mine	St. Joe Minerals	Owner	NA	NA	conv.	1973
Missouri	Ellington	Ozark Lead	Kuhen & Rhodes	1250	7	B.D.	1965
Missouri	Frederickstown	Bunker Hill Company	Camay Drilling	116	8	B.D.	1966
Missouri	Frederickstown	Bunker Hill Company	Camay Drilling	1500	5	B.D.	1966
Missouri	Bixby	Comince American	Loftland Bros.	125	7.5	B.D.	1966
Missouri	Frederickstown	Bunker Hill Company	Camay Drilling	1450	9	B.D.	1967
Missouri	Sweetwater	Ozark Lead Company	Loftland Bros.	150	7.5	B.D.	1970
Montana	Brooklyn Mine	Black & White Mining Company	NA	NA	NA	NA	NA
Montana	Black Pine	Inspiration Consolidation *Copper Corporation*	NA	NA	NA	NA	NA
Nevada	Gooseberry Mine	Apco Oil Corporation	NA	NA	NA	NA	NA
Nevada	Tungsten Group	Tungsten Properties Ltd.	NA	NA	NA	NA	NA
Nevada	Marmac Mines	U.S. Platinum Catalyst	NA	NA	NA	NA	NA
New Mexico	Church Rock	United Nuclear	Owner	1800	14	conv.	NA
New Mexico	Johnny M, Product	Ranchers Exploration and Development	Harrison-Western	1350	14	conv.	1974
New Mexico	Johnny M, Vent	Ranchers Exploration and Development	Teton Exploration Drilling	1300	5	R.D.	1974
New Mexico	Johnny M, Vent	Ranchers Exploration and Development	Teton Exploration Drilling	1300	5	R.D.	1975
New Mexico	P-10 Decline	Anaconda	Kop. Ran Development	200@12½°	11 x 19	conv.	1975
New Mexico	Jay Joy No. 1	Sohio Petroleum	Kop. Ran Development	670	14	conv.	1975
New Mexico	Ambrosia Lake	United Nuclear	Teton Exploration Drilling	900	7	B.D.	1966
New Mexico	Ambrosia Lake	Homestake-Sapin	Teton Exploration Drilling	NA	7	R.D.	1967
New Mexico	Ambrosia Lake	United Nuclear	Teton Exploration Drilling	1425	6	B.D.	1967
New Mexico	Ambrosia Lake	United Nuclear	Teton Exploration Drilling	800	7	R.D.	1968
New Mexico	Ambrosia Lake	Homestake-Sapin	Teton Exploration Drilling	614	7	R.D.	1968
New Mexico	Ambrosia Lake	United Nuclear	Teton Exploration Drilling	NA	NA	R.D.	1969
New Mexico	Gallup	United Nuclear	Teton Exploration Drilling	1750	7	R.D.	1969
New Mexico	Ambrosia Lake	Kermac Nuclear	Kerr-McGee	784	16.5	B.D.	1970
New Mexico	Ambrosia Lake	Kermac Nuclear	Kerr-McGee	1325	6	B.D.	1970
New Mexico	Ambrosia Lake	Kermac Nuclear	Teton Exploration Drilling	677	5	R.D.	1971

TABLE 1 (continued)

INVENTORY OF RECENT U.S. METAL AND NONMETAL MINE SHAFTS

STATE	MINE/SHAFT NAME	OWNER	CONTRACTOR	DEPTH	DIMENSION DIAMETER	METHOD	YEAR COMPLETED
New Mexico	Ambrosia Lake	Kermac Nuclear	Teton Exploration Drilling	1325	6	B.D.	1970
New Mexico	Ambrosia Lake	United Nuclear	Teton Exploration Drilling	677	5	R.D.	1971
New Mexico	Ambrosia Lake	Kermac Nuclear	Teton Exploration Drilling	677	5	R.D.	1971
New Mexico	Ambrosia Lake	Kermac Nuclear	Kerr-McGee	1300	6	B.D.	1971
New Mexico	Ambrosia Lake	Kermac Nuclear	Kerr-McGee	1402	6	B.D.	1971
New Mexico	Ambrosia Lake	Kermac Nuclear	Kerr-McGee	1459	6	B.D.	1971
New Mexico	Ambrosia Lake	Kermac Nuclear	Kerr-McGee	1285	6	B.D.	1971
New Mexico	Ambrosia Lake	Kermac Nuclear	Teton Exploration Drilling	268	6	R.D.	1971
New Mexico	Ambrosia Lake	Kermac Nuclear	Teton Exploration Drilling	268	6	R.D.	1971
New Mexico	Church Rock	Kermac Nuclear	Kerr-McGee	1770	6	B.D.	1972
New Mexico	Mt. Taylor	Gulf Energy & Minerals	Harrison-Western	NA	NA	conv.	1975
North Carolina	Jancy Jordan No. 5	Hitchcock Corporation	Cowin & Company	686	12	conv.	1970
New York	Gouverneur	St. Joe Minerals	Raise Drillers, Inc.	1700	6	R.D.	1972
Tennessee	Tennessee Shaft	Cities Service Corporation	Boyles Bros.	2860	20	conv.	1972
Tennessee	Boyd B	Cities Service Corporation	Shaft Drillers, Inc.	800	8	B.D.	1973
Tennessee	Immel, Products	ASARCO	Cementation Company of America	1859	24	conv.	1966
Tennessee	Immel, Vent	ASARCO	Cowin & Company	1060	14	conv.	1967
Tennessee	Young, Air No. 2	ASARCO	Cowin & Company	1200	14	conv.	1968
Tennessee	Young, Air 14-48	ARARCO	Cowin & Company	784	14	conv.	1975
Tennessee	New Market, Air No. 2	ASARCO	Raise Drillers, Inc.	1200	5	R.D.	1968
Tennessee	New Market, Air No. 4	ASARCO	Raise Drillers, Inc.	805	4	R.D.	1975
Tennessee	New Market, Air No. 5	ASARCO	Cowin & Company	NA	NA	conv.	in progress
Tennessee	Coy, Air	ASARCO	Raise Drillers, Inc.	750	5	R.D.	1968
Tennessee	Elmwood Mine	New Jersey Zinc Company	Cowin & Company	NA	NA	conv.	1974
Tennessee	New Market	New Market Zinc	Camay Drilling Company	1400	6	B.D.	1965
Tennessee	New Market	New Market Zinc	Raise Drillers, Inc.	1083	5	R.D.	1967
Tennessee	Jefferson City	American Zinc	Raise Drillers, Inc.	680	6	R.D.	1969
Tennessee	Jefferson City	American Zinc	Raise Drillers, Inc.	145	9	R.D.	1969
Tennessee	Jefferson City	United States Steel Corporation	Raise Drillers, Inc.	325	6	R.D.	1969
Tennessee	Jefferson City	United States Steel Corporation	Raise Drillers, Inc.	242	6	R.D.	1969
Utah	Carr Fork No. 1	Anaconda	Owner	3782	19	conv.	in progress
Utah	Carr Fork No. 2	Anaconda	Peter Kiewit	3845	19	conv.	in progress
Utah	Carr Fork No. 3	Anaconda	Owner	3510	18	conv.	in progress

TABLE 1 (continued)

INVENTORY OF RECENT U.S. METAL AND NONMETAL MINE SHAFTS

STATE	MINE/SHAFT NAME	OWNER	CONTRACTOR	DEPTH	DIMENSION DIAMETER	METHOD	YEAR COMPLETED
Utah	Carr Fork No. 4	Anaconda	Thyssen Mining	3250	22	conv.	in progress
Utah	Bonanza	American Gilsonite	Teton Exploration Drilling	1400	5	B.D.	1965 - 17 shafts
Utah	Bonanza	American Gilsonite	Teton Exploration Drilling	450	11	B.D.	1965
Utah	Bonanza	American Gilsonite	Teton Exploration Drilling	1100	5	B.D.	1968 - 9 shafts
Utah	Moab	Texas Gulf Sulfur	Camay Drilling	2710	6	B.D.	1968
Utah	Far West Incline	Atlas Minerals Corporation	Owner	NA	NA	conv.	NA
Wyoming	Black Fork No. 2	Texasgulf, Inc.	Cementation Company of America	NA	NA	conv.	in progress
Wyoming	Alchem No. 1	Allied Chemical Corporation	Weyher Construction	NA	NA	NA	NA
Wyoming	FMC No. 7	FMC Corporation	Dravo	1500	22	conv.	1975
Wyoming	Alchem No. 3	Allied Chemical Corporation	Centennial Development Company	NA	NA	conv.	1974
Wyoming	Bill Smith Shaft	Kerr-McGee Corporation	Mine Contractor	1100	14	conv.	1975
Wyoming	Sheep Mountain No. 1	Western Nuclear	Owner	NA	NA	NA	in progress
Wyoming	Sheep Mountain No. 2	Western Nuclear	Owner	1400	14	NA	in progress
Wyoming	Buffalo Shaft	Exxon Corporation	Harrison-Western	670	14	NA	1975

TABLE II. FOREIGN PROJECTS

COUNTRY	STATE	OWNER	MINE	CONTRACTOR	DEPTH	DIA.	DIM. L	DIM. W	METHOD	TECH.	YR. COMP.
SOUTH AFRICA	TRANSVAAL	JOHANNBURG CON INVST	ELSBURG SUBVERT	SHAFT SINKERS	3201	25			CONV		71
SOUTH AFRICA	TRANSVAAL	JOHANNBURG CON INVST	ELSBURG MAIN	SHAFT SINKERS	4733	33			CONV		69
SOUTH AFRICA	TRANSVAAL	JOHANNBURG CON INVST	COOKE 1 MAIN	SHAFT SINKERS	3070	18			CONV		73
SOUTH AFRICA	TRANSVAAL	JOHANNBURG CON INVST	PAALDERKRAAL	SHAFT SINKERS	2575	26			CONV		73
SOUTH AFRICA	TRANSVAAL	RAND MINES LTD	DURBAN DEEP	SHAFT SINKERS	2060	17			CONV		68
SOUTH AFRICA	ORANGE FREE STATE	RAND MINES LTD	HARMONY GOLD MINE	SHAFT SINKERS	722	22			CONV		67
SOUTH AFRICA	ORANGE FREE STATE	RAND MINES LTD	MERRIESPRUIT NO 1	RVC MINING CONT	5307	24			CONV		68
SOUTH AFRICA	ORANGE FREE STATE	RAND MINES LTD	MERRIESPRUIT 2 SUBV	SHAFT SINKERS T	708	20			CONV		67
SOUTH AFRICA	ORANGE FREE STATE	RAND MINES LTD	MERRIESPRUIT NO 3	CEMENTATION	3624	24			CONV		IP
SOUTH AFRICA	ORANGE FREE STATE	RAND MINES LTD	MERRIESPRUIT 3A SUB	NA	584	16			CONV		70
SOUTH AFRICA	ORANGE FREE STATE	SOUTH AFRICA COAL	SIGMA INCLINE	SHAFT SINKERS	1450	-1			CONV		65
SOUTH AFRICA	ORANGE FREE STATE	SOUTH AFRICA COAL	SIGMA 7	SHAFT SINKERS	820	22			CONV		71
SOUTH AFRICA	ORANGE FREE STATE	SOUTH AFRICA COAL	SIGMA 8	SHAFT SINKERS	820	26			CONV		71
SOUTH AFRICA	ORANGE FREE STATE	SOUTH AFRICA COAL	SIGMA	SHAFT SINKERS	541	24			CONV		65
SOUTH AFRICA	ORANGE FREE STATE	SOUTH AFRICA COAL	SIGMA 6	SHAFT SINKERS	574	16			CONV		65
SOUTH AFRICA	EAST TRANSVAAL	CAPE ASBESTOS	PENGE MINE	SHAFT SINKERS	741	15			CONV		66
SOUTH AFRICA	CAPE PROVINCE	DEBEERS CONSOL MINE	BULTFONTEIN	SHAFT SINKERS	466		30	9	CONV		67
SOUTH AFRICA	NA	DEPT WATER AFFAIRS	ORANGE FISH TUNNEL 3	SHAFT SINKERS	1256	16			CONV		73
SOUTH AFRICA	NA	DEPT WATER AFFAIRS	ORANGE FISH TUNNEL 4	SHAFT SINKERS	1151	16			CONV		73
SOUTH AFRICA	NA	DEPT WATER AFFAIRS	ORANGE FISH TUNNEL 5	SHAFT SINKERS	1250	16			CONV		73
SOUTH AFRICA	NA	ISCOR	HOORNBOSCH	SHAFT SINKERS	872	16			CONV		70
SOUTH AFRICA	TRANSVAAL	ISCOR	THABAZIMBI MOSTERT	SHAFT SINKERS	541		34	27	CONV		64
SOUTH AFRICA	TRANSVAAL	SOUTH WITBANK COAL	SOUTH WITBANK NO 3	SHAFT SINKERS	300	-1			CONV		71
SOUTH AFRICA	SOUTH WEST AFRICA	TSUMEB CORP	MATCHLESS PHASE 1	SHAFT SINKERS	446	-1			CONV		68
SOUTH AFRICA	SOUTH WEST AFRICA	TSUMEB CORP	MATCHLESS PHASE 2	SHAFT SINKERS	1132	-1			CONV		69
EIRE	COUNTY MEATH	TARA EXPLOR AND DEV	TARA MINE	CANADIAN MINE	1120		21	7	CONV		74
ENGLAND	CORNWALL	WHEAL JANE LTD	WHEAL JANE MINE	THYSSENS G B	1200	14			CONV	GROUT	69
ENGLAND	CHESHIRE	IMPERIAL CHEMICAL	WINSFORD ROCK SALT	CEMENTATION MIN	600	16			CONV	GROUT	74
ENGLAND	CORNWALL	CORNWALL TIN MINING	MT WELLINGTON MINE	THYSSENS G B	954	15			CONV		75
ENGLAND	NORTH WARWICKSHIR	NATIONAL COAL BOARD	DAW MILL COLLIERY	CEMENTATION MIN	1800	18			CONV		70
ENGLAND	LANCASHIRE	NATIONAL COAL BOARD	PARKSIDE COLLIERY	KINNEAS MOODIE	2670	18			CONV	GROUT	60
ENGLAND	CORNWALL	SOUTH CROFTY LTD	PENDARVES MINE	THYSSENS G B	850		16	8	CONV		68
ENGLAND	CLEVELAND	CLEVELAND POTASH	BOULBY MINE NO 1	THYSSENS G B	3772	18			CONV	FREEZE	69
ENGLAND	CLEVELAND	CLEVELAND POTASH	BOULBY MINE NO 2	THYSSENS G B	3772	18			CONV	GROUT	69
ENGLAND	NORTHUMBERLAND	NATIONAL COAL BOARD	LYNEMOUTH COLLIERY	CEMENTATION MIN	700	18			CONV	GROUT	68
EIRE	COUNTY TIPPERARY	MOSUL OF IRELAND LTD	SILVERMINES	NA	930		18	14	CONV		65
ENGLAND	MANCHESTER	MANCHESTER WATER BD	MANCHESTER SHIP CANL	THYSSENS G B	98	16			CONV		68
ENGLAND	MANCHESTER	MANCHESTER WATER BD	MANCHESTER SHIP CANL	THYSSENS G B	88	10			CONV		68
ENGLAND	CORNWALL	CAMBORNE TIN	PENDARVES NO 1	THYSSENS G B	850	-1			CONV		69
ENGLAND	PEMBROKE	C E G B	PEMBROKE OUTFALL 2	THYSSENS G B	66	13			CONV		68
ENGLAND	PEMBROKE	C E G B	PEMBROKE OUTFALL 1	THYSSENS G B	66	13			CONV		68
ENGLAND	SCOTLAND	N SCOTLAND HYD ELECT	CRUACHAN EAST	THYSSENS G B	1233	22			CONV		65
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	LADY WINDSOR NO 2	THYSSENS G B	2122	17			CONV		59
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	BRYNLLIW NO 2	THYSSENS G B	1138	13			CONV		58
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	BRYNLLIW NO 1	THYSSENS G B	1096	13			CONV		58
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	CYNHEIDRE NO 3	THYSSENS G B	2280	18			CONV		58
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	CYNHEIDRE NO 2	THYSSENS G B	2500	20			CONV		56
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	CYNHEIDRE NO 1	THYSSENS G B	2500	24			CONV		56
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	CWNGWRACH VENT	THYSSENS G B	600	15			CONV		61
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	LADY WINDSOR NO 1	THYSSENS G B	2060	19			CONV		61
ENGLAND	YORKSHIRE	NATIONAL COAL BOARD	KELLINGLEY NO 2	THYSSENS G B	2519	24			CONV	FREEZE	62
ENGLAND	YORKSHIRE	NATIONAL COAL BOARD	KELLINGLEY NO 1	THYSSENS G B	2594	24			CONV	FREEZE	62
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	FERNHILL NO 5	THYSSENS G B	1296	20			CONV		62
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	MORLAIS VENT	THYSSENS G B	69	12			CONV		60

TABLE II. FOREIGN PROJECTS

COUNTRY	STATE	OWNER	MINE	CONTRACTOR	DEPTH	DIA.	DIM. L	DIM. W	METHOD	TECH.	YR. COMP.
SOUTH AFRICA	TRANSVAAL	ANGLO AMERICAN CORP	ARNOTT COLLIERY VERT	SHAFT SINKERS	1446	18			CONV		69
SOUTH AFRICA	TRANSVAAL	ANGLO AMERICAN CORP	ARNOTT COLLIERY INCL	SHAFT SINKERS	2588		21	10	CONV		69
SOUTH AFRICA	TRANSVAAL	ANGLO AMERICAN CORP	CORNELIA	SHAFT SINKERS	321	-1			CONV		66
SOUTH AFRICA	NA	DEBEERS CONSOL MINE	KOFFIEFONTEIN MAIN	SHAFT SINKERS	2296	25			CONV		75
SOUTH AFRICA	WEST RAND	ANGLO AMERICAN CORP	ELANDSRAND NO 1	SHAFT SINKERS	7052	27			CONV		IP
SOUTH AFRICA	WEST RAND	ANGLO AMERICAN CORP	ELANDSRAND NO 2	SHAFT SINKERS	7052	30			CONV		IP
SOUTH AFRICA	ORANGE FREE STATE	ANGLO AMERICAN CORP	FREDDIES NO 3	SHAFT SINKERS	6199	22			CONV		66
SOUTH AFRICA	NATAL	ANGLO AMERICAN CORP	IDUMENI	SHAFT SINKERS	676	10			CONV		69
SOUTH AFRICA	NA	ANGLO AMERICAN CORP	INAIMENI	SHAFT SINKERS	676	10			CONV		67
SOUTH AFRICA	TRANSVAAL	ANGLO AMERICAN CORP	NEW CORONATION	SHAFT SINKERS	180	16			CONV		65
SOUTH AFRICA	ORANGE FREE STATE	ANGLO AMERICAN CORP	PRES STEYN NO 4	SHAFT SINKERS	7961	36			CONV		71
SOUTH AFRICA	ORANGE FREE STATE	ANGLO AMERICAN CORP	PRES STEYN 1A VENT	SHAFT SINKERS	5399	22			CONV		64
SOUTH AFRICA	ORANGE FREE STATE	ANGLO AMERICAN CORP	PRES STEYN 2A VENT	SHAFT SINKERS	3201	22			CONV		64
SOUTH AFRICA	TRANSVAAL	ANGLO AMERICAN CORP	SOUTH VAAL MAIN	SHAFT SINKERS	8016	28			CONV		71
SOUTH AFRICA	TRANSVAAL	ANGLO AMERICAN CORP	SOUTH VAAL VENT	SHAFT SINKERS	8016	28			CONV		71
SOUTH AFRICA	TRANSVAAL	ANGLO AMERICAN CORP	VAAL REEFS NO 2 SUB	SHAFT SINKERS	1860	26			CONV		70
SOUTH AFRICA	TRANSVAAL	ANGLO AMERICAN CORP	WEST DEEP LEVEL NO3	SHAFT SINKERS	2706	26			CONV		IP
SOUTH AFRICA	ORANGE FREE STATE	ANGLO AMERICAN CORP	WEST HOLDINGS 2A VEN	SHAFT SINKERS	4297	22			CONV		65
SOUTH AFRICA	ORANGE FREE STATE	ANGLO AMERICAN CORP	WEST HOLDINGS NO 4	SHAFT SINKERS	5573	22			CONV		68
SOUTH AFRICA	ORANGE FREE STATE	ANGLO AMERICAN CORP	WEST REEFS NO 4	SHAFT SINKERS	6481	22			CONV		67
SOUTH AFRICA	TRANSVAAL	ANGLO AMERICAN CORP	SCHOONGEZIGHT	SHAFT SINKERS	216	16			CONV		65
SOUTH AFRICA	NA	ANGLO AMERICAN CORP	S WITBANK CLYDESDALE	SHAFT SINKERS	771	20			CONV		66
SOUTH AFRICA	TRANSVAAL	ANGLO AMERICAN CORP	WELKOM GOLD MINE	SHAFT SINKERS	4484	-1			CONV		69
SOUTH AFRICA	TRANSVAAL	ANGLO TRANSVAAL	ATHENS	SHAFT SINKERS	2926	19			CONV		75
SOUTH AFRICA	ORANGE FREE STATE	ANGLO TRANSVAAL	LORAINE NO 4 VENT	SHAFT SINKERS	5117	21			CONV		IP
SOUTH AFRICA	TRANSVAAL	GENERAL MINING CORP	BUFFELSFONTEIN PR UP	SHAFT SINKERS	5300	28			CONV		68
SOUTH AFRICA	TRANSVAAL	GENERAL MINING CORP	BUFFELSFONTEIN PR DN	SHAFT SINKERS	4999	28			CONV		68
SOUTH AFRICA	TRANSVAAL	GENERAL MINING CORP	BUFFELSFONTEIN SC DN	SHAFT SINKERS	4300	28			CONV		70
SOUTH AFRICA	TRANSVAAL	GENERAL MINING CORP	BUFFELSFONTEIN SO DN	SHAFT SINKERS	5248	28			CONV		71
SOUTH AFRICA	NATAL	GENERAL MINING CORP	NORTHFIELD	SHAFT SINKERS	551	17			CONV		67
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	DOORNFONTEIN NO 1 AX	GOLDFIELDS	2224	13			BORED		67
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	DOORNFONTEIN 2 SUB	GOLDFIELDS	3077	22			CONV	FREEZE	69
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	E DRIEFONTEIN 1 SUB	GOLDFIELDS	-1	24			CONV		IP
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	E DRIEFONTEIN NO 1	GOLDFIELDS	5028	24			CONV	FREEZE	70
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	E DRIEFONTEIN NO 2	GOLDFIELDS	6596	24			CONV	FREEZE	73
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	E DRIEFONTEIN NO 3	GOLDFIELDS	-1	28			CONV	FREEZE	IP
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	E DRIEFONTEIN NORTH	GOLDFIELDS	3270	19			CONV	FREEZE	69
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	E DRIEFONTEIN AX SUB	GOLDFIELDS	1033	13			CONV		IP
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	KLOOF NO 1	GOLDFIELDS	6698	31			CONV	FREEZE	68
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	KLOOF NO 1 SUBVERT	GOLDFIELDS	2194	24			CONV		72
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	KLOOF NO 1 VENT	GOLDFIELDS	5943	24			CONV	FREEZE	67
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	KLOOF NO 2 SUBVERT	GOLDFIELDS	-1	24			CONV		IP
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	KLOOF NO 3	GOLDFIELDS	-1	25			CONV	FREEZE	IP
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	KLOOF VENT	GOLDFIELDS	2106	13			CONV		IP
SOUTH AFRICA	TRANSVAAL	GOLDFIELDS S A LTD	W DREIFONTEIN 3 SUB	GOLDFIELDS	3765	22			CONV	FREEZE	65
SOUTH AFRICA	TRANSVAAL	JOHANNBURG CON INVST	RANDFONTEIN EST 1 MN	SHAFT SINKERS	3070	-1			CONV		NA
SOUTH AFRICA	TRANSVAAL	JOHANNBURG CON INVST	RANDFONTEIN EST 1 VT	SHAFT SINKERS	2528	-1			CONV		73
SOUTH AFRICA	TRANSVAAL	JOHANNBURG CON INVST	RICHARD	SHAFT SINKERS	2601	33			CONV		69
SOUTH AFRICA	TRANSVAAL	JOHANNBURG CON INVST	NEW MONARCH	SHAFT SINKERS	492	-1			CONV		71
SOUTH AFRICA	TRANSVAAL	JOHANNBURG CON INVST	MONARCH EAST	SHAFT SINKERS	6321	-1			CONV		71
SOUTH AFRICA	TRANSVAAL	JOHANNBURG CON INVST	COOKE 1 VENT	SHAFT SINKERS	2529	13			CONV		73
SOUTH AFRICA	TRANSVAAL	JOHANNBURG CON INVST	COOKE 2 MAIN	SHAFT SINKERS	3705	20			CONV		IP
SOUTH AFRICA	TRANSVAAL	JOHANNBURG CON INVST	COOKE 2 VENT	SHAFT SINKERS	2940	18			CONV		75
SOUTH AFRICA	TRANSVAAL	JOHANNBURG CON INVST	RUSTENBERG SPUD	SHAFT SINKERS	3759	26			CONV		IP

TABLE II. FOREIGN PROJECTS

COUNTRY	STATE	OWNER	MINE	CONTRACTOR	DEPTH	DIA.	DIM. L	DIM. W	METHOD	TECH.	YR. COMP.
AUSTRALIA	NEW SOUTH WALES	CLUTHA DEVELOPEMNT	TAHMOOR MINE	R G CRAM SONS	1300	16			CONV		IP
AUSTRALIA	NEW SOUTH WALES	BELLAMBI COAL CO LTD	SOUTH BULLI VENT	R G CRAM SONS	1500	17			CONV		IP
AUSTRALIA	NEW SOUTH WALES	BROKEN HILL PTY LTD	MACQUARIE COLLIERY 1	DRAVO	1000	23			CONV		IP
AUSTRALIA	NEW SOUTH WALES	BROKEN HILL PTY LTD	MACQUARIE COLLIERY 2	DRAVO	1000	17			CONV		IP
AUSTRALIA	NEW SOUTH WALES	AUSTRALIAN IRON LTD	TOWER MINE UPCAST	AUST IRON LTD	1500	20			CONV		IP
AUSTRALIA	NEW SOUTH WALES	AUSTRALIAN IRON LTD	TOWER MINE DOWNCAST	AUST IRON LTD	1500	25			CONV		IP
AUSTRALIA	NEW SOUTH WALES	AUSTRALIAN IRON LTD	CORDEAUX UPCAST	AUST IRON LTD	1500	20			CONV		IP
AUSTRALIA	NEW SOUTH WALES	AUSTRALIAN IRON LTD	CORDEAUX DOWNCAST	AUST IRON LTD	1500	25			CONV		IP
AUSTRALIA	NEW SOUTH WALES	COALCLIFF COLLIERIES	WESTCLIFF PRODUCTION	NA	-1	-1			CONV		NA
AUSTRALIA	NEW SOUTH WALES	COALCLIFF COLLIERIES	WESTCLIFF VENT UPCST	NA	-1	-1			CONV		IP
AUSTRALIA	NEW SOUTH WALES	COALCLIFF COLLIERIES	DRAKES FOREST DNCST	NA	-1	-1			CONV		NA
AUSTRALIA	NEW SOUTH WALES	COALCLIFF COLLIERIES	COALCLIFF UPCAST	NA	-1	-1			CONV		NA
AUSTRALIA	NEW SOUTH WALES	COALCLIFF COLLIERIES	COALCLIFF DOWNCAST	NA	-1	-1			CONV		NA
CANADA	NEWFOUNDLAND	ALCAN LTD	NEWFOUNDLAND FLUORSP	J S REDPATH LTD	1520	15			CONV		IP
CANADA	ONTARIO	AGNICO EAGLE MINES	TROUT LAKE NO 3	ROSS FINLAY MIN	1058		8	14	CONV		72
CANADA	ONTARIO	ALGOMA STEEL CORP	MCLEOD MINE SERVICE	ALGOMA STEEL	3000		11	15	CONV		IP
CANADA	ONTARIO	ALGOMA STEEL CORP	MCLEOD MINE CONVEYOR	ALGOMA STEEL	3000		9	13	CONV		IP
CANADA	ONTARIO	CAMPBELL RED LAKE	BALMERTON	R LUNDSTROM	4317		21	7	CONV		73
CANADA	ONTARIO	FALCONBRIDGE NICKEL	FECUNIS NORTH	MACISAAC MINING	4375		8	13	CONV		70
CANADA	ONTARIO	FALCONBRIDGE NICKEL	EAST NO 2 MINE	MACISAAC MINING	2420		15	15	CONV		72
CANADA	ONTARIO	FALCONBRIDGE NICKEL	CREAN HILL MAIN	MACISAAC MINING	4165	19			CONV		74
CANADA	ONTARIO	FALCONBRIDGE NICKEL	CREAN HILL VENT	P HARRISON CO	3618	12			CONV		72
CANADA	ONTARIO	FALCONBRIDGE NICKEL	CREAN HILL EXPLORAT	MACISAAC MINING	4422		15	15	CONV		71
CANADA	ONTARIO	FALCONBRIDGE NICKEL	NA	J S REDPATH LTD	311		15	15	CONV	GROVT	71
CANADA	ONTARIO	FALCONBRIDGE NICKEL	LEVACK EXPLORATION	MACISAAC MINING	5353		15	15	CONV		IP
CANADA	ONTARIO	FALCONBRIDGE NICKEL	LEVACK EXPLORATION	MACISAAC MINING	5700	15			CONV		IP
CANADA	ONTARIO	FALCONBRIDGE NICKEL	ONEX SHAFT	MACISAAC MINING	46		15	15	CONV		70
CANADA	ONTARIO	HOLLINGER MINES LTD	HOLTYRE NO 1	ROSS FINLAY LTD	450		12	20	CONV		70
CANADA	ONTARIO	INTERNATIONAL NICKEL	COPPER CLIFF SOUTH	MACISAAC MINING	885		14	17	CONV		70
CANADA	ONTARIO	INTERNATIONAL NICKEL	VICTORIA NO 2	MACISAAC MINING	3102		6	12	CONV		70
CANADA	ONTARIO	INTERNATIONAL NICKEL	FROOD RAMP	DRAVO	619		14	17	CONV		73
CANADA	ONTARIO	INTERNATIONAL NICKEL	LITTLE STOBIE RAMP	INT NICKEL	800		14	17	CONV		74
CANADA	ONTARIO	INTERNATIONAL NICKEL	STOBIE NO 7	MACISAAC MINING	4150		15	24	CONV		IP
CANADA	ONTARIO	INTERNATIONAL NICKEL	COPPER CLIFF NORTH	DRAVO	452		14	17	CONV		70
CANADA	ONTARIO	INTERNATIONAL NICKEL	COPPER CLIFF SOUTH 1	DRAVO	4245		20	13	CONV		72
CANADA	ONTARIO	INTERNATIONAL NICKEL	CREAN HILL PRODUCT	MACISAAC MINING	4250		15	18	CONV		71
CANADA	ONTARIO	INTERNATIONAL NICKEL	COPPER CLIFF	MACISAAC MINING	4134		8	12	CONV		71
CANADA	ONTARIO	INTERNATIONAL NICKEL	LEVACK MINE	MACISAAC MINING	1550		17	14	CONV		74
CANADA	ONTARIO	METTABI MINES LTD	IGNACE RAMP	CANADIAN MINE	3000		9	13	CONV		IP
CANADA	ONTARIO	METTAGAMI LAKE MINES	LYON LAKE PROJECT	P HARRISON CO	300		21	8	CONV		IP
CANADA	ONTARIO	METTAGAMI LAKE MINES	LYON LAKE PROJECT	P HARRISON CO	1555		23	9	CONV		IP
CANADA	ONTARIO	NORANDA MINES LANGMU	SOUTH PORCUPINE MAIN	MASSE GAUTHIER	1462		23	9	CONV		72
CANADA	ONTARIO	SELCO MINING CORP	EAR FALLS NO 6	MASSE GAUTHIER	1800		9	24	CONV		75
CANADA	ONTARIO	SELCO MINING CORP	EAR FALLS	MASSE GAUTHIER	1760		7	23	CONV		IP
CANADA	MANITOBA	SHERRITT GORDON MINE	FOX MINE	MASSE GAUTHIER	2343		18	14	CONV		68
CANADA	ONTARIO	TEXASGULF CANADA	KIDD CREEK MINE NO 1	CEMENTATION	3050	24			CONV		72
CANADA	ONTARIO	TEXASGULF CANADA	KIDD CREEK MINE NO 2	MACISAAC MINING	5300	25			CONV	PREBOR	IP
CANADA	ONTARIO	TEXASGULF CANADA	KIDD CREEK RAMP	TEXASGULF	1600		10	17	CONV		74
CANADA	ONTARIO	UNION MINIERE MINING	THIERRY NO 1	MACISAAC MINING	1780		20	8	CONV		73
CANADA	ONTARIO	UNION MINIERE MINING	CENTRAL PATRICIA RMP	MACISAAC MINING	300		15	12	CONV		IP
JAPAN	NIGATA PREFECT	TOHO ZINC CO LTD	HUIKA MACHI	HOKUSHIN CONST	656		9	9	BORED	ALIMAK	69
JAPAN	FUKUOKA PREFECT	MITSUI MINING CO LTD	OMUTA CITY	NA	1748	20			CONV		72
JAPAN	AKITA PREFECT	NIPPON MINING CO LTD	ODATE CITY	NA	1246	13			CONV		67
JAPAN	AKITA PREFECT	DOWA MINING CO LTD	ODATE CITY	NA	1305	18			CONV		66

TABLE 11. FOREIGN PROJECTS

COUNTRY	STATE	OWNER	MINE	CONTRACTOR	DEPTH	DIA.	DIM. L W	METHOD	TECH.	YR. COMP.
JAPAN	OKAYAMA PREFECT	DOWA MINING GO LTD	KUME GUN	NA	1663		13 12	CONV		69
JAPAN	AKITA PREFECT	DOWA MINING CO LTD	KAZUNO GUN	HOKUSHIN CONST	531	15		CONV		75
JAPAN	AKITA PREFECT	DOWA MINING CO LTD	KAZUNO GUN	HOKUSHIN CONST	1122	15		CONV		69
JAPAN	AKITA PREFECT	MITSUBISHI METAL CO	ODATO CITY	NA	853	13		CONV		72
JAPAN	HOKKAIDO	HOKKAIDO COLLIERY CO	MIKASA CITY	HOKUSHIN CONST	3424	21		CONV		74
JAPAN	HOKKAIDO PREFECT	MITSUBISHI METAL CO	SHIMOKAWA MACHI	KOKEN BORING CO	984	4		BORED	RAISED	74
JAPAN	AKITA PREFECT	MITSUBISHI METAL CO	ODATE CITY	NA	853	13		CONV		71
JAPAN	AKITA PREFECT	DOWA MINING CO LTD	KOSAKA MACHI	HOKUSHIN CONST	531	13		CONV		75
JAPAN	HOKKAIDO	HOKKAIDO COLLIERY CO	YUBARI CITY	MITSUI CONST CO	3116	23		CONV		73
JAPAN	HOKKAIDO	SUMITOMO COAL MINING	AKAHIRO CITY	SUMITOMO CONST	2624	21		CONV		70
JAPAN	GIFU PREFECT	JAPAN HIGHWAY PUBLIC	ENASAN TUNNEL VENT	HAZAMA GUMI LTD	2034	20		CONV		73
CANADA	BRITISH COLUMBIA	ANACONDA CANADA	BRITTANIA BEACH 10	BOLAND	2500		8 10	CONV		69
CANADA	SASKATCHEWAN	CAMINCO LTD	VANSCOY NO 1	CEMENTATION	3754	19		CONV	FREEZE	68
CANADA	SASKATCHEWAN	CAMINCO LTD	VANSCOY NO 2	CEMENTATION	3556	16		CONV	FREEZE	68
CANADA	BRITISH COLUMBIA	CRAIGMONT MINES LTD	MERRITT	R F FRY ASSOC	630		12 7	BORED	RAISED	63
CANADA	MANITOBA	FALCONBRIDGE NICKEL	MANIBRIDGE MINE	P HARRISON CO	1423		23 9	CONV		70
CANADA	MANITOBA	HUDSON BAY MINING	FLIN FLAN AREA	NA	1600		15 15	BORED		IP
CANADA	SASKATCHEWAN	POTASH CO AMERICA	PATIENCE LAKE NO 1	CEMENTATION	3300	16		BORED	FREEZE	NA
CANADA	SASKATCHEWAN	POTASH CO AMERICA	PATIENCE LAKE NO 2	CEMENTATION	3300	18		BORED	FREEZE	70
CANADA	SASKATCHEWAN	SYLVITE OF CANADA	ROCANVILLE SERVICE	THYSSENS	3200	16		CONV	FREEZE	70
CANADA	SASKATCHEWAN	SYLVITE OF CANADA	ROCANVILLE PRODUCT	THYSSENS	3350	16		CONV	FREEZE	70
CANADA	MANITOBA	TANTALUM MINING CORP	BENIC LAKE	NA	530		15 15	BORED		67
CANADA	YUKON TERRITORY	WHITEHORSE COPPER	WHITEHORSE	THYSSENS	1200	14		NA		72
CANADA	QUEBEC	NIOBEC	ST HONORE	HASSE GAUTHIER	940		8 17	CONV		75
CANADA	MANITOBA	INTERNATIONAL NICKEL	THOMPSON MINE T2	P HARRISON CO	1057		7 18	CONV		58
CANADA	MANITOBA	INTERNATIONAL NICKEL	THOMPSON MINE T1	P HARRISON CO	4427		15 24	CONV		69
CANADA	MANITOBA	INTERNATIONAL NICKEL	THOMPSON MINE T3	P HARRISON CO	2607		15 16	CONV		65
CANADA	MANITOBA	INTERNATIONAL NICKEL	THOMPSON MINE T4	P HARRISON CO	744		7 16	CONV		63
CANADA	MANITOBA	INTERNATIONAL NICKEL	BIRCHTREE MINE B2	P HARRISON CO	1374		7 18	CONV		65
CANADA	MANITOBA	INTERNATIONAL NICKEL	BIRCHTREE MINE B1	P HARRISON CO	2820		15 20	CONV		67
CANADA	MANITOBA	INTERNATIONAL NICKEL	SOAB MINE NORTH	R F FRY ASSOC	1652		7 18	CONV		67
CANADA	MANITOBA	INTERNATIONAL NICKEL	SOAB MINE SOUTH	R F FRY ASSOC	2037		10 20	CONV		68
CANADA	MANITOBA	INTERNATIONAL NICKEL	PIPE MINE EXPLOR	P HARRISON CO	1587		9 15	CONV		61
CANADA	MANITOBA	INTERNATIONAL NICKEL	PIPE MINE NO 1	R F FRY ASSOC	1785		10 18	CONV		69
CANADA	MANITOBA	INTERNATIONAL NICKEL	PIPE MINE NO 2	P HARRISON CO	3061	22		CONV		73
CANADA	MANITOBA	INTERNATIONAL NICKEL	MOAK MINE EXPLOR	P HARRISON CO	1325		8 17	CONV		55

TABLE II. FOREIGN PROJECTS

COUNTRY	STATE	OWNER	MINE	CONTRACTOR	DEPTH	DIA.	DIM. L W	METHOD	TECH.	YR. COMP.
ENGLAND	NORTH WALES	C E G B	DINORWIC VENT	THYSSENS G B	-1	-1		NA		1P
ENGLAND	WALES	G P O	CABLE TUNNEL SHAFT 3	THYSSENS G B	66	10		CONV		73
ENGLAND	CORNWALL	CORNWALL TIN MINING	WELLINGTON	THYSSENS G B	725	15		CONV		71
ENGLAND	CORNWALL	CONSOL GOLDFIELDS	WHEAL JANE NO 2	THYSSENS G B	1204	14		CONV		71
ENGLAND	SOUTH WALES	W GLAMORGAN WATER BD	LLYNBRIANNE SURGE	THYSSENS G B	200	14		CONV		72
ENGLAND	SCOTLAND	N SCOTLAND HYD ELECT	FOYERS EXPLORATION	THYSSENS G B	161	12		CONV		68
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	TAFF MERTHYR	THYSSENS G B	-1	-1		NA		NA
ENGLAND	YORKSHIRE	NATIONAL COAL BOARD	ACKTON HALL SILKSTON	THYSSENS G B	1765	18		CONV		66
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	CYNHEIDRE NO 4	THYSSENS G B	2102	18		CONV		65
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	FERNHILL NO 4	THYSSENS G B	112	20		CONV		61
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	PENALLTA NO 1	THYSSENS G B	2447	21		CONV		61
ENGLAND	SOUTH WALES	NATIONAL COAL BOARD	CROSS HANDS VENT	THYSSENS G B	298	10		CONV		61
SWEDEN	NA	BOLIDEN	AITIK	CRYDERMAN	476	15		CONV		71
SWEDEN	NA	BOLIDEN	STEKEN JOKK	BURMAC	177	15		CONV		75
SWEDEN	NA	BOLIDEN	KIMHEDEN	BURMAC	315	15		CONV		71
SWEDEN	NA	BOLIDEN	RAVLIDEN	BURMAC	804	19		CONV		71
SWEDEN	NA	BOLIDEN	LAANGSELE	CRYDERMAN	863	19		CONV		71
SWEDEN	NA	GRANGES	ZINKGRUVAN	SCHEIOT	492	12		CONV		75
SWEDEN	DANNEMORA	AB DANNEMORA GRUVOR	DANNENEMORA GRUVOR	DANNENMORA GRUV	2034		33 10	BORED		68
AUSTRALIA	TASMANIA	ELECTROLYTIC ZINC	ROSEBERRY NO 2 MAIN	SHAFT SINKER	1758	22		CONV		71
AUSTRALIA	NEW SOUTH WALES	COBAR MINES PTY LTD	CHESNEY MINE NO 3	CEMENTATION	2724	20		CONV		75
AUSTRALIA	WESTERN AUSTRALIA	METAL EXPLORATION	MT KEITH	JOINT VENTURE	505		10 8	CONV		72
AUSTRALIA	WESTERN AUSTRALIA	METAL EXPLORATION	NEPEAN	CEMENTATION	961		13 5	CONV		IP
AUSTRALIA	NEW SOUTH WALES	COBAR MINES PTY LTD	CSA NO 1	COBAR MINES LTD	3356	14		CONV		74
AUSTRALIA	WESTERN AUSTRALIA	INTERNATIONAL NICKEL	MT EDWARDS 26 NORTH	DRAVO	926		18 9	CONV		70
AUSTRALIA	WESTERN AUSTRALIA	ANACONDA AUSTRALIA	REDROSS	ANACONDA AUSTRA	840		20 8	CONV		73
AUSTRALIA	WESTERN AUSTRALIA	ANACONDA AUSTRALIA	WANNAWAY	ANACONDA AUSTRA	450		20 8	CONV		73
AUSTRALIA	WESTERN AUSTRALIA	GREAT BOULDER MINES	SCOTIA MITCHELL	GREAT BOULDER	1077	-1		CONV		72
AUSTRALIA	WESTERN AUSTRALIA	GREAT BOULDER MINES	CARR BOYD	GREAT BOULDER	691	-1		CONV		72
AUSTRALIA	WESTERN AUSTRALIA	SELCAST EXPLORATION	SPARGOVILLE	SELCAST EXPLOR	1274		18 18	CONV		72
AUSTRALIA	WESTERN AUSTRALIA	AUSTRAL ANGLO AMER	NEW BLUE SPEC	AUST ANGLO AMER	515		16 8	CONV		71
AUSTRALIA	WESTERN AUSTRALIA	AUSTRAL ANGLO AMER	DECLINE	AUST ANGLO AMER	635		7 8	CONV		IP
AUSTRALIA	WESTERN AUSTRALIA	WESTERN MINING CORP	DURKIN	WESTERN MINING	1014	14		CONV		67
AUSTRALIA	WESTERN AUSTRALIA	WESTERN MINING CORP	SILVER LAKE	WESTERN MINING	1525		21 6	CONV		66
AUSTRALIA	WESTERN AUSTRALIA	WESTERN MINING CORP	JAN	WESTERN MINING	784		21 12	CONV		73
AUSTRALIA	WESTERN AUSTRALIA	WESTERN MINING CORP	LONG SHAFT	WESTERN MINING	-1	-1		NA		IP
AUSTRALIA	WESTERN AUSTRALIA	WESTERN MINING CORP	MCMAHON	WESTERN MINING	6101		16 18	BORED		66
AUSTRALIA	WESTERN AUSTRALIA	WESTERN MINING CORP	FISHER	WESTERN MINING	6068		16 18	BORED		68
AUSTRALIA	WESTERN AUSTRALIA	WESTERN MINING CORP	HUNT	WESTERN MINING	4002		16 18	BORED		73
AUSTRALIA	WESTERN AUSTRALIA	WESTERN MINING CORP	OTTER	WESTERN MINING	2788		16 18	BORED		75
AUSTRALIA	TASMANIA	MT LYELL MINING CO	PRINCE LYELL	ROBERTS HOLLAND	1350	30		CONV		75
AUSTRALIA	QUEENSLAND	MOUNT ISA MINES LTD	NA	MOUNT ISA MINES	3000	26		CONV		NA
AUSTRALIA	NEW SOUTH WALES	METRO WATER SEWER BD	MEPEAN	METRO WATER BD	93	27		CONV		71
AUSTRALIA	NEW SOUTH WALES	METRO WATER SEWER BD	AVON	METRO WATER BD	93	27		CONV		71
AUSTRALIA	NEW SOUTH WALES	METRO WATER SEWER BD	PIPEHEAD POTTSHILL 4	JOHN HOLLAND	110	33		CONV		73
AUSTRALIA	NEW SOUTH WALES	COAL ALLIED INDUSTRY	WALLARAH VENT	NA	-1	16		CONV		71
AUSTRALIA	NEW SOUTH WALES	BROKEN HILL PTY LTD	NORTHERN COLLIERY 1	DRAVO	1000	20		CONV		IP
AUSTRALIA	NEW SOUTH WALES	BROKEN HILL PTY LTD	NORTHERN COLLIERY 2	DRAVO	1000	20		CONV		IP
AUSTRALIA	NEW SOUTH WALES	AUSTRALIAN ANTIMONY	DORRIGO	PEARSON BRIDGE	500	12		CONV		71
AUSTRALIA	NEW SOUTH WALES	COBAR MINES LTD	COBAR NO 1	COBAR MINES LTD	3300	12		CONV		75
AUSTRALIA	NEW SOUTH WALES	ELCOM COLLIERIES	LIDDELL STATE MINE	ALLIED CONSTRUC	300	18		CONV		72
AUSTRALIA	NEW SOUTH WALES	NEW BROKEN HILL CON	NO 3 SOUTH AIRWAY	NEW BROKEN HILL	3300	24		CONV		70
AUSTRALIA	NEW SOUTH WALES	NORTH BROKEN HILL LT	NO 4	NORTH BROKN HIL	1000	16		CONV		70
AUSTRALIA	NEW SOUTH WALES	NORTH BROKEN HILL LT	NO 3	NORTH BROKN HIL	2000		32 16	CONV		71

APPENDIX C

EXAMPLES OF

FOREIGN SHAFT-SINKING LAWS

NEW SOUTH WALES

Coal Mines Regulation Act of 1912

Certified June 4, 1971

MISCELLANEOUS.

207. Where by the regulations any duty is imposed upon, or authority is given to, any official of the mine, that duty may be observed or fulfilled or that authority exercised by and at the discretion of any official who is his superior at the mine.

No person acting in a place of trust shall depute anyone else to do his work without the sanction of his superior official.

208. No *person shall interfere with the function of the manager,* under-manager or other official in the operation of any department of the mine.

209. Every person shall in all matters relating to the management and working of the mine or to safety obey strictly the orders of the *manager, under-manager or other official or person placed in authority.*

New regulation added, Gazette No. 7 of 19th January, 1968, p. 137.

209A. (1) The manager, under-manager or other official or person placed in authority shall not issue to any person an order, compliance with which would result in a contravention of the Act or the Rules or Regulations made thereunder.

(2) Notwithstanding any other provision of these Regulations no person shall be required to comply with such an order as is referred to in subsection (1) of this Regulation.

210. Any person in or about the mine, whether workman or otherwise, is subject to the regulations, except as otherwise provided in this Act.

Short heading amended, Gazette No. 122 of 30th October, 1964, p. 3406.

ADDITIONAL REGULATIONS FOR SINKING AND RISING SHAFTS.

Amended, Ibid.

211. For the purpose of Regulations 211 to 230 both inclusive "bucket" includes kibble, hoppit, skip, barrel or cage.

212. In addition to the daily examination required by General Rule 5, the master sinker, or when there is no master sinker the competent person appointed for the purpose by the manager shall once at least in every twenty-four hours examine thoroughly the state of the shaft and the state of all gear by which cradles, platforms, or pumps are slung in the shaft or by which persons or materials are raised or lowered.

213. The manager shall specify, by a notice which shall be kept posted at the top of the shaft in a prominent position, the number of persons who may ride in the bucket at one time and the banksman or chargeman, as the case may be, shall not allow any number of persons in excess of that number to ride in the bucket.

214. No person shall ride on a full bucket or on the edge of a bucket except with the permission of the manager.

215.

215. No engine worked by mechanical power other than a fixed engine shall be used for lowering and raising persons and material in the shaft. Amended, Gazette No. 122 of 30th October, 1964, p. 3406.

This Regulation shall not apply to the raising or lowering of material for the first sixty feet in any sinking shaft provided that a safe ladderway is provided and maintained from the bottom of the shaft to the surface.

216. Every cradle or platform used in the shaft shall be constructed with a grid or other suitable contrivance, when necessary to secure the efficient ventilation of the whole of the shaft.

217. * * * * * Repealed, Ibid.

218. While men are at work on any cradle or platform in the shaft the following precautions shall be strictly observed:—

(a) The cradle or platform shall be so secured as to prevent it swinging unduly.

(b) The flap over the bucket hole shall be securely fastened.

(c) If the cradle or platform is constructed of two or more pieces hinged the pieces shall be securely bolted to the hinge or hinges.

(d) The cradle or platform shall not be moved except by the express direction of the manager, under-manager, master-sinker or chargeman.

219. If shaft sinking work is carried on during the night the surface at the shaft top shall be efficiently lighted. Amended, Ibid.

220. The competent person appointed under General Rule 4 shall during his shift have entire charge of the operations in the shaft subject, however, to the directions of the master sinker or of the manager or under-manager of the mine, and is in these Regulations referred to as the chargeman. Amended, Ibid.

221. The examination required to be made by the chargeman before the commencement of work shall be made immediately before the entry of workmen in a shift. Amended, Ibid.

222. The chargeman shall as part of his examination before the commencement of work, or if work is carried on without any interval *by a succession of shifts, then as part of his examinations during his* shift, examine carefully the sides of the shaft, take off any loose stones, and otherwise satisfy himself that the shaft is in a safe condition for men to work. When men are engaged in walling or tubbing the shaft a similar examination shall be made by a competent person appointed by the manager. Amended, Ibid.

223. The chargeman shall be the last man to leave the shaft at the end of the shift, and if his shift is succeeded immediately by another shift, he shall not leave the shaft until after the entry of the chargeman of the next shift. Amended, Ibid.

224.

C-3

224. The chargeman shall in all cases be present at the firing of shots, and shall not allow anyone to fire shots excepting under his supervision. He shall see that all shot-firing regulations contained in the Fifth Schedule to this Act which are applicable are carried out.

225. When coal, stone, debris, or gear, tools, or materials are being sent to the surface the chargeman shall see—

(a) that the bucket is properly loaded;

(b) that no stones, coal, or debris are packed above the level of the top of the bucket;

(c) that gear, tools, or materials are put into an empty bucket and if they project above the level of the top of the bucket are securely fastened to the bow or chains of the bucket before the bucket is sent away; and

(d) that the bucket, before being sent away from the bottom, is put into line with the pulley and carefully steadied, and that the bottom and sides are free from adhering stones and dirt.

Amended. Gazette No. 122 of 30th October, 1964, pp. 3406, 3407.

226. No person shall enter the shaft after any cessation of work in the shaft caused by the withdrawal of the workmen for shot-firing or other purposes until the chargeman, accompanied if necessary by not more than two other persons, has entered and examined the shaft and found it to be safe in all respects. The examination shall be made with a locked oil flame safety-lamp or with a device approved by the chief inspector of a type which will indicate the presence of gas.

227. The winding engineman shall not work the winding engine when men are in the shaft except in pursuance of a signal received from the banksman or chargeman.

Amended. Ibid. p. 3407.

228. When lowering the bucket in a sinking shaft the winding engineman shall stop it when it has reached a point approximately 18 feet above the bottom of the shaft or above any cradle or platform upon which the bucket is to alight, and shall await the signal from the chargeman to let it down. When raising the bucket he shall stop the engine as soon as the bucket has been raised approximately 4 feet from the bottom in order that the chargeman may see that the rope is steadied, and shall not again move his engine until he has received the signal from the banksman or chargeman.

Amended. Ibid.

229. When gear, tools, or materials are being lowered in a sinking shaft the banksman shall see—

(a) that the bucket is properly loaded;

(b) that no loose material is packed above the level of the top of the bucket;

(c) that gear or tools are put into an empty bucket and if they project above the level of the top are securely fastened to the bow or chains of the bucket, and

(d) that timber and other bulky articles are safely slung.

Amended. Gazette No. 122 of 30th October, 1964, p. 3407.

230. At a sinking shaft the banksman shall not leave the pit top while men are in the shaft unless the opening over the shaft mouth is protected and he is within hearing of the signals nor shall he allow any person to remain about the pit top, or to approach the mouth of the shaft, without the authority of the manager. He shall see that the pit top doors, or trolly, are properly shut down or placed over the shaft before the bucket or any material is landed. He shall see that the bucket is lifted clear of the doors or trolly and properly steadied before he opens the doors or removes the trolly and on no occasion shall he allow anything to be put into the bucket while it is hanging over the open shaft. He shall at all times keep the shaft top and landing edge free from loose metal.

231. The following signals shall be used:—

To raise up	1
To lower down	2
To stop when in motion	1
When men are to ride, a preliminary signal of	3
To raise slowly	4
To lower slowly	5

The manager shall fix other signals as required.

232. No person other than the banksman or chargeman, or other authorised person, shall give any signals.

New regulation added, Ibid.

232A. Where notice is required to be given in pursuance of section thirty-seven of this Act in respect of working commenced for the purpose of opening a new shaft for or a seam of any mine, such notice shall clearly indicate—

(a) the method to be used in driving the shaft;

(b) the means of ventilation to be employed;

(c) steps to be taken to support the walls of the shaft;

(d) the method to be adopted to protect workmen from falling material; and

(e) the means to be employed in disposing of material won from the shaft.

WEST AUSTRALIA

Government Gazette

April 1, 1976

PART 16.—SHAFT SINKING.

16.1. Regulation 16.1 to regulation 16.18, inclusive, apply to all shaft sinking operations. **Application.**

16.2. The provisions contained in this Part of these regulations apply to shaft sinking operations in addition to, and not in substitution for, the provisions of Part 15, but where there is any inconsistency in the requirements of those provisions the regulations contained in this Part shall prevail. **Part 15 provisions, inconsistency.**

16.3. For the purposes of this Part, "factor of safety" used in relation to any rope or attachment means the ratio of the breaking force or strength of that rope or attachment to the maximum total static force on it including the component of its own weight. **Interpretation.**

16.4. (1) Prior to sinking any new shaft or extending any existing shaft, the owner, agent or Manager shall notify the Senior Inspector in writing of his intention so to do and shall submit plans and specifications showing— **New shaft sinking operations.**

(a) the location of the shaft;

(b) the general layout of the sinking project;

(c) details of the sinking and hoisting equipment and the conveyances, rope type and size and attachments to be used; and

(d) the ventilation arrangements.

(2) The Senior Inspector may request further details relevant to the proposed operation and any such further information shall be forwarded by the owner, agent or Manager within one month of that request.

Approval prior to commencement.

16.5. The owner, agent or Manager shall not cause or permit any shaft sinking operation to be commenced unless the Senior Inspector has given his approval in writing.

Use of crane.

16.6. (1) Subject to subregulation (3) and to the written approval of the Senior Inspector a crane may be used to hoist the broken rock from the initial surface excavation and from the shaft, to a maximum depth of 50 metres.

(2) The Senior Inspector may impose conditions under which a crane may be operated, and may at any time withdraw his approval if in his opinion the use of a crane could create a danger.

(3) A crane shall not be used when the shaft perimeter has been traversed by dividers or any other structure which could be an obstruction to the free passage of the shaft conveyance.

(4) The load lifted by a crane in shaft sinking operations shall not exceed 50% of the normal safe working load as provided in Australian Standard CB2, Crane and Hoist Code.

(5) The crane shall be of a slewing type and shall be located in a fixed position during the hoisting and dumping operations.

(6) The crane driver and the crane are each required to be certificated under and are subject to the requirements of the Inspection of Machinery Act, 1921, or an Act repealing or replacing that Act.

(7) Where a crane is used, an effective method of signalling approved by the Inspector shall be installed to communicate with the driver.

(8) A person may not be raised or lowered from a shaft excavation by means of a crane unless—

(a) he travels in a kibble or similar conveyance;

(b) he wears a safety belt attached to the rope or conveyance if more than one-third of his body is outside the conveyance; and

(c) he is within sight of a person stationed in a place to communicate with the crane driver.

(9) A person shall not remain in the shaft excavation while the crane is used to hoist broken rock by means of a grab.

Alternative means of travel.

16.7. (1) During shaft sinking operations, unless there is an alternative winding plant available for the raising or lowering of men in an emergency in the event of power failure or winding plant failure, a substantial ladderway securely supported at intervals of not more than 5 metres shall be installed from the surface to the bottom of the shaft but the lower end of that ladderway may be constituted by a chain ladder.

(2) Where a sinking stage is used provision shall be made by means of a chain ladder or otherwise to permit travel from the shaft bottom to that stage.

Factors of safety.

16.8. The minimum factors of safety to be used in shaft sinking operations shall be—

(a) for ropes hoisting men and materials or rock 7.5—O.001L where L equals the depth of wind in metres;

(b) for ropes raising and lowering a sinking stage—6;

(c) for chains used for the suspension of a kibble, a combined factor of 20;

(d) for all components of attachments—10.

16.9. The provisions of Part 15 relating to the history, inspection, maintenance and discarding of winding ropes and attachments shall apply to winding ropes used in shaft sinking operations, but for the winding ropes used to support a shaft sinking stage the following inspection and maintenance procedures shall apply— **Ropes, inspection and maintenance.**

(a) at least monthly the structure of every rope shall be examined for—

(i) the incidence of broken wires;
(ii) any obvious increase in the lay length;
(iii) any obvious corrosion; and
(iv) any other unsafe condition,

(b) at least monthly each rope shall be lubricated with a suitable lubricating compound;

(c) when a physical inspection of the rope shows that it appears to be unsafe for the use to which it is subjected it shall be discarded; and

(d) the period of service of any such rope shall not exceed two years.

16.10. When the depth of a shaft exceeds 50 metres— **Monkeys, crossheads and other conveyances.**

(a) a kibble and monkey or crosshead arrangement; or

(b) some other conveyance,

each of a design approved by the Senior Inspector and provided with an overhead cover for the protection of men when travelling, shall be used for haulage purposes in the shaft.

16.11. (1) A kibble used in shaft sinking operations shall be of robust construction and of a shape which will prevent it from catching on any obstruction during its travel in the shaft. **Kibbles and attachments.**

(2) The kibble may be suspended by a bridle, or by means of at least three chains equally spaced around the perimeter of the kibble top.

(3) Chains used for the suspension of the kibble shall be of identical dimensions and strength and shall be of sufficient length to ensure that the included angle at the apex of the suspension of any two chains is not greater than 60 degrees.

16.12. A kibble or skip used in shaft sinking shall not be over filled with loose rock above its brim. **Overfilling of kibbles or skips.**

16.13. Unless otherwise authorised in writing by the Senior Inspector, firing in shaft sinking operations shall be by means of electricity initiated from the surface or some other safe location. **Firing.**

16.14. (1) When a shaft is to be sunk below any level which is being worked it shall be protected below that level by a securely constructed pentice to the satisfaction of the Inspector. **Pentices.**

(2) The plans of any proposed pentice shall be submitted for approval to the Senior Inspector who shall arrange for it to be inspected during its construction.

16.15. Where timber is used to line a shaft, bearer sets or other means of support shall be provided between working levels or at distances of not more than 60 metres apart. **Timber, bearer sets.**

16.16. (1) During shaft sinking operations adequate provision shall be made and maintained to prevent spillage from falling down the shaft during dumping operations. **Protection.**

(2) A door or doors for covering the sinking compartment shall be provided and maintained at the collar of every shaft while sinking operations are in progress

(3) Unless suitable alternative protection is provided to prevent spillage from falling down the shaft, the doors shall be kept closed at all times when men, tools or material are being loaded into or unloaded from the kibble or skip at the collar of the shaft, or when the kibble or skip is being dumped.

Warning of obstruction. 16.17. Any doors or other shaft protective devices which, when moved into the haulage way or travel area of a shaft, would interfere with the free passage of the conveyance shall be so equipped that their position is positively indicated to the winder driver.

Signals. 16.18. With the approval in writing of the Senior Inspector, signals in addition to those specified in Part 15 may be used in a shaft sinking operation.

Lowering men after blast.

9.32 During sinking operations in any shaft, the bucket or skip used for returning men to the working place, following any blasting operation, shall

(a) not be lowered on the initial trip beyond the point where, owing to the blast, it may be unsafe to go without a careful examination, and that point shall not be less than fifty feet above the blasting set or bulkhead;

(b) be lowered on signal from the men accompanying it, and at such speed as to be fully under control, by signal, of those men;

(c) carry only sufficient men on such trip as are required to conduct a careful examination of the shaft or winze.

Use of bucket or skip.

9.33 During shaft sinking operations, the bucket or skip

(a) shall not be allowed to leave the top or bottom of a shaft unless the workman in charge thereof has steadied it or caused it to be steadied;

(b) shall not be lowered directly to the bottom but
  (i) shall be held at least fifteen feet above the bottom, and
  (ii) shall remain there until a separate signal to lower it has been given by an authorized person;

(c) shall be stopped by the hoistman, when being raised from the bottom, when the crosshead has been reached; and

(d) shall not be hoisted farther until the bucket or skip conveyance has been brought to rest and a distinct pause made.

Level of load in sinking bucket.

9.34 (1) In a shaft in the course of sinking, the bucket or skip shall be filled only in such a manner that no piece of loose rock projects above the brim.

Protection from dumping.

9.34 (2) Subject to section 9.03, during any shaft sinking operation, provision shall be made and maintained to assure the impossibility of the bucket or skip being dumped while the dumping doors are open, or other approved means shall be applied to prevent spillage falling into the shaft.

Safety doors at collar.

9.35 While sinking is in progress, an adequate door, or set of doors, to close the opening of the shaft completely shall be

(a) installed and maintained at the collar or other point of service of each shaft while sinking is in progress;

(b) kept closed at all times that tools are, or material is, being loaded into, or unloaded from, the bucket or skip, except when the bucket or skip is unloaded by dumping, when arrangements required under subsection (2) of section 9.34 shall be used.

Note: *See section 10.62 re. Safety Devices on Shaft Obstructions.*

Precaution with shaft mucking machine.

9.36 When any person is on or below a shaft mucking machine in a shaft, the machine shall be secured in an approved manner.

Shaft timbering and lining during sinking.

9.37 During shaft sinking, the timbering, lining or casing shall be maintained within a safe distance of the shaft bottom and the safe distance shall not exceed

(a) fifty feet for timbered shafts;

(b) an approved distance for shafts lined with concrete or other lining or casing.

Protection of men in sinking operations.

9.38 *During shaft sinking operations, no work shall be done in any place* in the shaft while men are working in another part of the shaft, or below such a place, unless the men working in the lower position are protected from the danger of falling objects by an approved, securely constructed covering, extending over a portion of the shaft sufficient to afford complete protection.

Auxiliary ladder in shaft sinking.

9.39 During sinking operations, if the ladder is not maintained to the bottom of the shaft, an auxiliary ladder, which will reach from the permanent ladders to the bottom, shall be provided in such a convenient position that it may be lowered promptly to any point at which men are working.

ONTARIO

Handbook of Requirements Governing

the Operation of Mines

Parts IX Sections 621, 624, 625 and

Part 626 Part XI of the Mining Act of Ontario

1971

(*f*) All head, tail, drive and tension pulleys shall be guarded at the pinch points and the length of such guards shall be extended to at least three feet from the pinch point.

PROTECTION IN WORKING PLACES OF MINES

Overhead operations

251. No person shall work in a location in a mine where another person is working overhead unless such measures for protection are taken as the nature of the work requires.

Fencing of shafts and other openings

252. The top of every working shaft in a mine shall be securely fenced or protected by a gate or guard-rail, and every pit or opening in a mine dangerous by reason of its depth shall be securely fenced or otherwise protected.

Gate at shaft entrances

253.—(1) At all shaft and winze openings on the surface and on every level in a mine, unless securely closed off, the hoisting compartments shall be protected by a substantial gate, which shall be kept closed except when the hoisting conveyance is being loaded or unloaded at such level.

Idem

(2) The clearance beneath any such gate shall be kept to a minimum.

Hoisting compartment gates

(3) Where haulage tracks lead up to a hoisting compartment on surface or underground, the gate on such compartment shall be reinforced in such a manner that it is sufficiently strong to withstand any impact imparted thereto by collision therewith of any locomotive, train or car operated on such tracks.

Idem

(4) Hoisting compartment gates shall be sufficiently reinforced where there is a hazard of impact due to the approach of a motor vehicle.

Shaft and winze timbering

254.—(1) Every shaft and winze in a mine shall be securely cased, lined or timbered, and during sinking operations the casing, lining or timbering shall be maintained within a safe distance of the bottom.

Idem

(2) In no instance shall such distance exceed fifty feet.

Strength of guides, etc.

(3) The guides, guide attachments and shaft casing, *lining or timbering shall be of sufficient strength and* shall be suitably designed, installed and maintained so that the safety catches referred to in section 324 may grip the guides properly at any point in the *shaft.*

Protection at shaft stations

255. There shall be provided a safe passageway and standing room for a person outside the shaft at all workings opening into a shaft of a mine, and the manway shall in all cases be directly connected with such openings.

Lining compartments at levels

256.—(1) Except during sinking operations, if material *is handled in a shaft or winze compartment of a mine,* there shall be maintained around that compartment, except on the side on which material is to be loaded or unloaded, a substantial partition at the collar and at all levels.

Idem

(2) Such partition shall extend above the collar and all levels a distance not less than the height of the hoisting conveyance plus six feet and it shall extend below the collar and all levels at least six feet and it shall conform to the size of the conveyance allowing for necessary clearances.

Partition between manway and hoisting compartments

257. The *footway or ladderway in a shaft or winze of a* mine shall be separated from the compartment or division of the shaft or winze in which material, conveyance or counterweight is hoisted by a suitable and tightly-closed partition in the location required by section 256, and similarly in the remaining shaft sections, or by metal of suitable weight and mesh.

*Counter*weight compartment

258. Wherever a counterweight is used in a shaft or winze of a mine, it shall be safely enclosed, unless it travels on guides.

Protection in sinking operations

259. *During shaft-sinking operations in a mine, no work* shall be done in any place in a shaft or winze while persons are working in another part of the shaft or winze below such place, unless the persons working in the lower position are protected from the danger of falling material by a securely-constructed covering extending over a sufficient portion of the shaft to afford complete protection.

Open hooks not to be used

260.—(1) Open hooks shall not be used in conjunction with the suspension of any shaft staging of a mine.

Idem (4) The short-circuit shall be replaced immediately after the cables have been disconnected from the blasting machine or the circuit from the blasting switch has been opened.

Idem (5) The firing cables or wires used for firing charges at one working place shall not be used for firing charges in another working place until all proper precautions have been taken to ensure that such firing cables or wires have no connection with the leads from the first working place.

Idem (6) When firing cables or wires are used in the vicinity of power and lighting cables, the blaster shall take proper precautions to prevent the firing cables or wires from coming in contact with the lighting or power cables.

Where electricity from supply line used (7) Where electricity, other than from a portable, hand-operated device, is used for firing charges, a fixed device of a design certified by the district electrical-mechanical engineer as meeting the requirements of section 515 shall be used.

Idem (8) One such device shall be maintained for each individual working place in which firing is done by means of electricity using circuits complying with the requirements of section 517.

EXAMINATION OF MINE WORKINGS AND SHAFT INSPECTION

Examination of mine workings 311.—(1) The manager of a mine or some authorized person or persons shall examine on each working shift all parts where drilling and blasting are being carried on, shall examine at least once a week the other parts in which operations are being carried on, such as shafts, winzes, levels, stopes, drifts, cross-cuts and raises, in order to ascertain that they are in a safe condition.

Idem, scaling (2) The manager of a mine or some authorized person or persons shall inspect and scale or cause to be inspected and scaled by a qualified person the roofs, walls and faces of all stopes or other working places as often as the nature of the ground and of the work performed necessitates.

Shaft inspection 312.—(1) The manager of a mine where a hoist is in use shall depute some competent person or persons whose duty it is to make an inspection of the shaft at least

once each week, and in addition a thorough examination shall be made at least once each month of the guides, timber, walls and hoisting compartments generally of the shaft, and a record of such inspection and examination shall be made in the Shaft Inspection Record Book by the person making the examination.

(2) Every such manager shall keep or cause to be kept at the mine a book for each shaft termed the Shaft Inspection Record Book in which shall be recorded a report of every such examination, as is referred to in this section, signed by the persons making the examination. Shaft Inspection Record Book

(3) Such entries of examinations shall be read and initialled every week by the person in charge of the maintenance of the shaft. Entries to be initialled

(4) A notation shall be made of any dangerous condition reported and the action taken regarding it over the signature of the person in charge of the maintenance of the shaft. Dangerous conditions noted

(5) The Shaft Inspection Record Book shall be made available to an engineer at all times. Available to engineer

LADDERWAYS AND LADDERS

313.—(1) A suitable footway or ladderway shall be provided in every shaft and winze. Ladderways in shafts and winzes

(2) In shafts and winzes, no ladder, except an auxiliary ladder used in sinking operations, shall be installed in a vertical position. Not in vertical position

(3) During sinking operations, if a ladder is not maintained to the bottom, an auxiliary ladder that will reach from the permanent ladders to the bottom shall be provided in such convenient position that it may be promptly lowered to any point at which a person is working. Sinking operations

(4) Wherever, about shafts and winzes and headframes used in conjunction therewith, it is necessary for persons to examine or inspect appliances installed therein, suitable ladderways or stairways and platforms shall be maintained to permit such work to be carried out in a safe manner. Headframes

Partition between manway and hoisting compartments

314. The footway or ladderway in a shaft or winze shall be separated *from the compartment or division of* the shaft or winze in which material, conveyance or counterweight is hoisted by a suitable and tightly-closed partition in the location required by section 256, and similarly in the remaining shaft sections, or by metal of suitable weight and mesh.

Ladderway in shaft, over 70 degrees

315.—(1) In a shaft or winze inclined at over 70 degrees from the horizontal or in a headframe used in conjunction with the shaft or winze, substantial platforms shall be built at intervals not exceeding twenty-one feet in the ladderway and shall be covered, except for an opening large enough to permit the passage of a person's body, and the ladders shall be so placed as to cover this opening in the platform.

Idem, under 70 degrees

(2) In a shaft or winze inclined at less than 70 degrees from the horizontal or in a headframe used in conjunction with the shaft or winze, the ladders may be continuous, but substantial platforms shall be built at intervals not exceeding twenty-one feet in the ladderway and shall be covered, except for an opening large enough to permit the passage of a person's body.

When stairway permissible

316.—(1) Stairways may be used in a shaft or winze inclined at less than 50 degrees from the horizontal.

Hand-rail

(2) All stairways in shafts and winzes shall be equipped with a suitably placed hand-rail.

Ladderways, other mine workings

317.—(1) All ladderways in raises, stopes and other manways shall be installed and maintained in a safe condition to reduce to a minimum the hazard of a person falling therefrom.

Landing platforms

(2) In manways inclined at 70 degrees or more, landing platforms shall be installed at intervals not exceeding *twenty-one feet in the ladderway and the ladders* shall be off-set at the platforms.

Idem

(3) In manways inclined at less than 70 degrees and more than 50 degrees, landing platforms shall be installed at intervals not exceeding twenty-one feet in the ladderway and the ladders may be continuous.

Idem

(4) In manways inclined at 50 degrees or less, the ladders may be continuous and no platforms are required except at points of off-set.

Wire rope ladders

318. Wire rope or strands of wire rope shall not be used *or be allowed* to be used for climbing purposes if they are frayed or have projecting broken wires.

Hand-rails for ladders

319.—(1) Every ladder shall project at least three feet above its platform, except where strong hand-rails are provided.

Ladders

(2) Every ladder shall be of strong construction, shall be securely placed and shall be maintained in a safe condition.

Distance between rungs

(3) The distance between the centres of rungs of ladders *shall be not more than twelve inches and not* less than ten inches, and the spacing of rungs shall not vary more than one-half inch in any ladderway.

Distance from wall

(4) In order to give a proper foothold, the rungs of ladders shall in no case be closer than four inches from the wall of a shaft, winze or raise or any timber underneath the ladder.

Material handling in ladderways

320. No person shall be or be permitted to be in a ladderway while,

(*a*) a bucket is being loaded or unloaded at the top; or

(*b*) a bucket or material is being hoisted or lowered.

SINKING EQUIPMENT

When crosshead required

321.—(1) After a depth of 300 feet below the sheave has been attained in the sinking of a vertical shaft or winze at a mine, a suitable bucket and crosshead, as referred to in subsection 2 and in section 322, shall be used.

Suspension barrel-shaped bucket

(2) When a closed type of crosshead is not used, the bucket shall be barrel-shaped and shall be suspended *by the upper rim.*

Safety appliance on crosshead

322.—(1) All sinking crossheads at a mine shall be provided with a safety appliance of a design approved by the district electrical-mechanical engineer for attaching the bucket to the crosshead, so constructed that the crosshead cannot stick in the hoisting compartment without also stopping the bucket.

Approval

(2) *All crossheads shall be of a design approved by the* district electrical-mechanical engineer.

SHAFT CONVEYANCES, CONSTRUCTION AND OPERATION

Protection of men in shaft conveyances

323. No cage or skip shall be used in a mine for the raising or lowering of persons unless it is constructed so as to prevent any part of the body of a person riding in it from accidentally coming into contact with the timbering or sides of the shaft or winze.

Construction of cages and skips, etc.

324. All cages and skips used for lowering or raising persons in a mine shall comply with the following:

1. The hood shall be made of steel plate not less than three-sixteenths of an inch in thickness or of a material of equivalent strength.
2. The cage shall be provided with sheet-iron or steel side-casing not less than one-eighth of an inch in thickness or of a material of equivalent strength, and the casing shall extend to a height not less than five feet above the floor of the cage.
3. The cage shall be equipped with doors made of suitable material that extend to a height not less than five feet above the floor.
4. The doors shall be so arranged that it is impossible for the doors to open outward from the cage.
5. Doors shall be fitted with a suitable latch and shall have a minimum clearance at the bottom.
6. i. The safety catches and mechanism shall be of sufficient strength to hold the shaft conveyance with its maximum load at any point in the shaft and shall be of a type the design of which has been approved by the chief engineer.
   ii. Such safety catches and mechanism shall not be used until approved by the district electrical-mechanical engineer and such approval shall be based upon test performance.
   iii. Such approval shall not be considered until the safety catches and mechanism are found to function satisfactorily under load conditions during such number of tests as are required by the chief engineer, each test to consist of suddenly releasing the shaft conveyance

in a suitable manner under maximum loading conditions for persons so that the safety catches will have the opportunity to grip the guides when the conveyance is descending at maximum rated speed.
   iv. A report of such tests shall be submitted to the chief engineer.
7. Before a shaft conveyance equipped with an approved type of safety catches and mechanism is first used for the purpose of lowering and raising persons, the safety catches and mechanism shall be found to function efficiently according to the requirements of the district electrical-mechanical engineer during a test under the same conditions as set out in paragraph 6, and a permit for the use of the conveyance for lowering and raising men shall be obtained from the district mining engineer.
8. A notation of such test shall be entered in the Hoisting Machinery Record Book and two copies of the report shall be sent to the district electrical-mechanical engineer.
9. A shaft conveyance previously permitted for use by the district mining engineer for the purpose of lowering or hoisting persons on which alterations or repairs to the safety catch mechanism necessary to rectify any distortion of the mechanism from its proven satisfactory position are made shall not be put to such use until the safety catch and mechanism have been found to function efficiently according to the requirements of the district electrical-mechanical engineer during a test made under the same conditions as set out in paragraph 6, and the district mining engineer has again issued permission for the use of the conveyance for such purpose.
10. A notation of such test shall be entered in the Hoisting Machinery Record Book and two copies of the report shall be sent to the district electrical-mechanical engineer.
11. A certificate of load capacity of the conveyance and attachments, which shall include the weight of the tail rope, if any, or other suspended load, shall be obtained from the manufacturer and made available to the district electrical-mechanical engineer.

12. Devices for attaching the conveyance to the rope shall have a factor of safety of not less than 10.

13. — (*a*) When newly installed, each device for attaching the rope or ropes to the conveyance shall have a factor of safety of not less than 10.

(*b*) When newly installed, or rebuilt, all bails, frame members and other parts affecting the safe operation of the conveyance shall have a factor of safety of not less than 10.

14. The bails and suspension gear of all shaft conveyances shall be cleaned and thoroughly inspected at least once in every twelve months and a record of such inspection shall be made in the Hoisting Machinery Record Book.

Hoisting without safety catches

325. The chief engineer may give permission in writing for hoisting men without safety catches if he is satisfied that the equipment and conditions are such that maximum safety is provided.

Operating chairs by lever

326. The cage shall not have chairs attached to it that are operated by a lever or a chain through or from the floor of the cage.

Automatic operation of chairs

327. When chairs are used for the purpose of landing a shaft conveyance at any point in a shaft or winze, other than at the lowest point of travel for a skip, they shall be so arranged that they automatically fall clear and remain clear of the hoisting compartment when the cage or other conveyance is lifted off.

Bails, safety latches, etc.

328. The bucket and any device such as the bail, safety latch or other attachment to the bucket shall be of a design approved by the district electrical-mechanical engineer.

HOIST BRAKES

Brakes required

329.—(1) Every device used for lowering into or hoisting from mine workings shall be equipped with a brake or brakes that may be applied directly to each drum so as to safely stop and hold the drum when carrying its maximum load.

Arranged to test separately

(2) The brakes shall be so arranged that they can be tested separately and, whether the hoist is at work or at rest, can be easily and safely manipulated by the hoistman when at the levers controlling the hoist.

Not operated by foot

(3) No hoist used for lowering or raising persons or for shaft sinking shall be equipped with a brake or brakes operated by means of the hoistman's foot, unless such brake is an auxiliary electrical device.

Adjustments to be maintained

(4) The adjustments of the brake or brakes and brake mechanism shall be maintained in such condition that the brake lever or any other part of the brake mechanism will not come to the limit of travel before the normal power of the brake or brakes is applied.

Loss of brake pressure

(5) All brake engines shall be so equipped that, in the event of inadvertent or accidental loss of pressure in the brake system, the brakes can be applied.

Brake for friction hoists

(6) The brakes for a friction hoist shall be designed, adjusted and maintained to safely stop and hold the conveyance under all conditions of loading, direction of travel and speed.

Brakes

(7) At all times that persons are in or on a shaft conveyance, the hoist shall be equipped with more than one brake, each capable of safely stopping and holding the drum or drums in use.

Clutched-in drum

(8) In shaft inspection, maintenance or sinking operations, persons may be in or on a shaft conveyance attached to the fixed or clutched-in drum when changing balance.

Automatic operation

(9) At least one of the brakes required shall be arranged for automatic application upon operation of any of the safety devices for brake application.

Freedom of falling weights

(10) In a brake system where weights are used to furnish auxiliary pressure on loss of air, the weights shall be tested at least once every twenty-four hours to ensure their freedom of movement.

Single drum air or steam

(11) In the case of single drum air or steam driven hoists, automatic valves to control engine compression, arranged for operation by the safety devices, may serve as a brake.

Idem

(12) The arrangements mentioned in subsection 11 are subject to the approval of the district electrical-mechanical engineer.

HOIST CLUTCHES

Clutch-locking arrangement

330. The device for operating the clutch of the drum shall be provided with adequate means to prevent the inadvertent withdrawal or insertion of the clutch.

Interlocking brake and clutch

331. The brake and clutch operating gear shall be so installed that it will not be possible to unclutch a drum unless the brake or brakes on the drum are applied, nor shall it be possible to release the brake or brakes until the clutch of the drum is engaged.

HOIST DRUMS

Securing of drum parts

332. Such bolts and other fittings of the drums, brakes and clutches as might be a danger in the event of their becoming loosened shall be rendered secure by means of suitable locking devices other than spring lockwashers.

Slipping of rope on drum

333. On the drum of every hoist used for lowering or raising persons, there shall be flanges and also, if the drum is conical, such other appliances as are sufficient to prevent the rope or cable from slipping off.

Suitability of hoist drum for rope

334.—(1) In all hoist installations, the dimensions of the drum or drums shall be suitable for the kind, diameter and length of the rope in service.

Bending stresses in rope

(2) The diameters of the hoist drums shall be large enough to prevent the occurrence of unduly large bending stresses in the rope.

Rope risers

(3) Where multiple-layer winding is used, proper arrangements shall be made and maintained to permit the rope to rise evenly from one layer to another and to wind properly without cutting down through any lower layer.

Drum hoist installations

335.—(1) On and after the 15th day of June, 1948, in all installations of newly-acquired drum hoists and modifications of existing hoists designed to increase the load ratings of the hoist,

(*a*) all hoist drums over sixty inches in diameter shall have grooving properly machined to fit the rope used, except that, in the case of shaft sinking, preliminary development operations and operations of a temporary nature, hoists with plain drums may be used;

(*b*) the drums shall have sufficient rope-carrying capacity to permit hoisting from the lowest regular hoisting point to the highest point of travel in the shaft without the necessity of winding more than three layers of rope on the drum;

(*c*) the diameter of a hoist drum shall be not less than 80 times the diameter of the hoisting rope in use when the diameter of the rope is greater than one inch and shall be not less than 60 times the diameter of the rope in use when the diameter of the rope is not greater than one inch, except that, in the case of shaft-sinking and preliminary development operations,

(i) a hoist may be used having a drum whose diameter is not less than 60 times the diameter of the hoisting rope in use when the diameter of the rope is greater than one inch, and

(ii) a hoist may be used having a drum whose diameter is not less than 48 times the diameter of the hoisting rope in use when the diameter of the rope is not greater than one inch; and

(*d*) the hoist and the head sheaves shall be so located in relation to one another as to permit the proper winding of the rope on the hoist drum.

Change of location

(2) In any change of location of a hoist installed prior to the coming into force of this section, the requirements of clause *b* of subsection 1 apply.

Friction hoist installations

(3) In fricton hoist installations,

(*a*) the drum diameter of every friction hoist installed on or after the day on which this Part comes into force shall be not less than 100 times the diameter of the rope in use;

(*b*) the hoist drive, control and brakes shall be so designed and maintained that slippage of the rope on the drum will not occur under normal operating conditions; and

(*c*) the rope treads shall be inspected regularly and maintained in good condition;

Tapered guides

(*d*) in a friction hoist installation, tapered guides or other approved devices shall be installed above and below the limits of regular travel of the conveyance and arranged so as to brake and stop an overwound or underwound conveyance in the event of failure of other devices.

SHEAVES

Head and deflection sheaves

336—(1) Head and deflection sheaves shall be machined and maintained to fit the rope properly.

Diameter of head sheaves

(2) The diameter of a head sheave shall be determined by clause *c* of subsection 1 of section 335 as required for a hoist drum.

Diameter of deflection sheaves

(3) The diameter of a deflection sheave shall be determined by,

(*a*) in the case of a drum hoist system, clause *c* of subsection 1 of section 335; and

(*b*) in the case of a friction hoist system, clause *a* of subsection 3 of section 335.

UTILITY HOISTS

Care of utility hoists

337. Utility hoists, including tugger hoists, ropes and other equipment used in connection with the installation, shall be maintained in a safe working condition.

INDICATORS

Indicator required

338.—(1) Every hoist shall, in addition to any marks on the rope or drum, be provided with a reliable depth indicator that will clearly and accurately show to the operator,

(*a*) the position of the bucket, cage or skip;

(*b*) at what position in the shaft a change of gradient necessitates a reduction in speed;

(*c*) the overwind or underwind position of the shaft conveyance or counter-balance; and

(*d*) the position above or below the limits as in clause *c* beyond which the conveyance is not to move.

Operation of indicator

(2) Hoist depth indicators shall be driven by a reliable means.

Means to adjust indicator on friction hoist

(3) Means shall be provided on a friction hoist to adjust the depth indicators and protective devices on the hoist to the position of the conveyance in the shaft.

OVERWINDING, ETC. — AIR HOISTS AND STEAM HOISTS

Overwind and underwind protection

339. Air hoists and steam hoists shall be provided with suitable overwind, underwind and emergency protection for the hoisting conveyance, except that, in shaft-sinking, the underwind protection is not required.

Gauge required

340. At all air hoists and steam hoists, there shall be installed within plain view of the operator a gauge to indicate the air or steam pressure, as the case may be.

SPECIFICATIONS AND SPECIAL TESTING

Specifications required

341.—(1) The specifications of hoists and equipment and the general arrangement of the headframe in new installations and in shaft deepening projects shall be approved by the chief engineer.

Commissioning tests

(2) Before a new hoisting installation is put in service, tests shall be conducted to prove its compliance with this Act.

Record kept available

(3) A record of such tests and the results obtained shall be kept on file and made available to the district electrical-mechanical engineer.

Special testing by the district electrical-mechanical engineer

(4) If the district electrical-mechanical engineer deems it necessary, he may, after consultation with the manager, conduct or require to be conducted specific tests of the efficiency of all brakes, clutches, overwind devices or other hoist controls.

New equipment

342.—(1) All shafts, drums, mechanical linkage for controls, brake rods and other vital parts of a mine hoist which could affect the safety of the equipment shall be non-destructively tested before the hoist is placed in service.

Equipment in service

(2) Hoist and sheave wheel shafting, hoist brake and mechanical linkage for controls, conveyance drawbars, pins and structural members and other hoisting equipment affecting the safety of the installation shall be non-destructively tested at regular intervals or as required by the district electrical-mechanical engineer.

Reports of tests

(3) Dates of the non-destructive testing shall be recorded in the Machinery Record Book and the results shall be reported to the district electrical-mechanical engineer.

Approved methods

(4) The non-destructive testing shall be carried out by methods acceptable to the chief engineer.

EXAMINATION

Examination of hoisting equipment

343. The manager of a mine where a hoist is in use shall depute some competent person or persons whose duty it is to examine at least once in each week,

(a) deflection, head and idler sheave wheels;

(b) attachments of the hoisting ropes to the drums and to the counterweights, buckets, cages or skips;

(c) brakes;

(d) interlocks;

(e) depth indicators;

(f) buckets;

(g) counterweights;

(h) cages;

(i) skips;

(j) external parts of the hoist;

(k) mechanical hoisting signalling equipment, if any;

(l) shaft dumping and loading arrangements;

(m) sinking doors and blasting sets, and any attachments thereto;

(n) attachments to any cage, skip or bucket for any underslung regularly-used equipment; and

(o) guide or rubbing rope tensioning devices and attachments,

and to record the report of such examination in a book called the Hoisting Machinery Record Book.

HOISTING MACHINERY RECORD BOOK

344.—(1) The manager shall keep or cause to be kept at the mine the Hoisting Machinery Record Book referred to in section 343, in which shall be entered a report of every examination or report referred to in sections 324 and 343, subsection 2 of section 355, subsection 3 of section 359 and sections 360 and 361, and a notation of any failure of, accident to, correction or repairs to the hoist, the ropes, the shaft conveyance or any other part of the hoisting, dumping or loading equipment, signed by the person making the examination or report. Entering of reports

(2) Such entries shall be read and signed each day, week or month, as required by this Act, by the person in charge of such equipment or accessories thereto. Entries to be signed

(3) A notation shall be made in the Hoisting Machinery Book of the action taken regarding the report of any failure of, accident to, corrections or repairs to the hoist, the ropes, the shaft conveyance or any other part of the hoisting, dumping or loading equipment, over the signature of the person in charge of such equipment or accessories thereto. What to be entered

(4) The Hoisting Machinery Record Book shall be made available to the engineer at all times. Books to be available

HOISTING ROPES

345.—(1) The connecting device between the hoisting rope and the bucket, cage, skip, counterweight or other device shall be of such nature that the risk of accidental disconnection is reduced to a minimum. Rope connection

(2) Such connecting device shall be of a design approved by the chief engineer. To be approved

Safety factor of drum hoist ropes

(3) Every hoisting rope, when newly installed on a drum hoist, shall have a factor of safety of not less than 8.5 at the end of the rope where it is attached to the conveyance and where the total weight consists of the combined weight of the conveyance and the maximum load to be carried.

Idem

(4) In addition, the hoisting rope, when newly installed, shall have a factor of safety of not less than 5 at the *point where the rope leaves the head sheave and,* the rope being fully let out, the total weight consists of the combined weight of the conveyance plus the maximum load to be carried plus the weight of that part of the rope that extends from the head sheave to the conveyance.

Safety factor for friction hoist ropes

(5) The factor of safety of the hoisting ropes for a given friction hoist installation is the lowest actual breaking strength, as determined by the Ontario Government Cable Testing Laboratory, for the ropes, times the number of ropes, divided by the sum weight of the conveyance and attachments, the maximum conveyance *load carried and the maximum weight* of rope suspended in one compartment of the shaft.

Idem

(6) When the hoisting rope is installed on a friction hoist, the factor of safety shall be not less than that determined from the following formula: F. of S.= 8.0 - .0005 d, where d is the maximum length of rope suspended below the head sheave in feet.

Idem

(7) For friction hoists, the factor of safety of the hoisting ropes shall be not less than 5.5 for any depth of shaft when the ropes are installed.

Safety factor of tail ropes

(8) *The factor of safety of tail ropes shall be not less than* 7 when installed.

Safety factor of guide and rubbing ropes

(9) The factor of safety of guide and rubbing ropes shall be not less than 5 when installed.

Rope discard criteria

354.—(1) No hoisting rope shall be used in a shaft or winze of a mine where in any part of the rope,

(*a*) the existing strength has decreased to less than 90 per cent of the original strength of the rope;

(*b*) *the extension of a test piece has decreased* to less than 60 per cent of its original extension when tested to destruction;

(*c*) the number of broken wires in any section of the rope equalling the length of one lay of the rope exceeds six;

(*d*) marked corrosion occurs;

(*e*) the rate of stretch in a friction hoisting rope begins to show a rapid increase over the normal stretch noted during its service.

Idem

(2) No tail rope, guide or rubbing rope shall be used in a shaft where in any part of the rope,

(*a*) the existing strength has decreased to less than 75 per cent of the original strength of the rope;

(*b*) the extension of a test piece has decreased to less than 60 per cent of its original extension when tested to destruction;

(*c*) the number of broken wires in any section of the rope equalling the length of one lay of the rope exceeds six;

(*d*) marked corrosion occurs.

Rope dressing

355.—(1) The rope dressing used on a drum hoisting rope shall be suited to the operating conditions of the rope, and the dressing shall be applied at least once in every month and as often as is necessary to maintain the coating on the rope in good condition.

Idem

(2) Every time the rope is dressed, a report of the treatment shall be recorded in the Hoisting Machinery Record Book and signed by the person who performed the work.

Testing of hoisting ropes

356.—(1) After 18 months of service, and thereafter at intervals of six months, the hoisting rope of a drum hoist shall have a portion not less than 8 feet in length cut *off the lower end from a position above the* clamps or other attachment.

Idem

(2) The portion of rope so cut shall have the ends adequately fastened with binding wire before the cut is made to prevent the disturbance of the strands and it shall be sent to the Ontario Government Cable Testing Laboratory for a breaking test.

Recording of test

(3) The certificate of the test shall be kept on file and a summary thereof recorded in the Rope Record Book.

Electro-magnetic testing

(4) All hoisting ropes on drum hoists and friction hoists shall be tested throughout their working length by an electro-magnetic testing device within the first six months of service, and thereafter at intervals of four months, or as required by the chief engineer.

Idem

(5) All tail ropes, guide and rubbing ropes shall be electro-magnetically tested at the end of twelve months service, and thereafter at such intervals as is necessary to ensure that the rope is in safe condition.

Idem

(6) The electro-magnetic testing service and the agency or company supplying such service shall be approved by the chief engineer.

Tests to be recorded

(7) The dates and results of the electro-magnetic tests shall be entered in the Rope Record Book.

Submission of results

(8) Records of each electro-magnetic test, including graphs and interpretations, over the signature of the person making the interpretation, shall be sent to the chief engineer and to the district electrical-mechanical engineer within fourteen days after the test is made.

Special testing of used hoisting ropes

357.—(1) The chief engineer may require that test specimens be cut from any rope discarded for use in mine hoisting at points specified by him and sent to the Ontario Government Cable Testing Laboratory for special testing and investigation if he is of the opinion that such testing and investigation are in the interests of better mine hoisting practice.

No charge for testing

(2) No charge shall be made for such special testing and investigation, but the mine is responsible for the cost of cutting, preparation and shipment of the test specimens.

CLEARANCE FOR TAIL ROPES

Tail ropes to be clear

358. Water and spillage in a shaft sump in a mine shall be kept at such a level at all times that,

(a) tail ropes have clear passage; and

(b) guide and rubbing rope connections and tension devices are clear.

ROPE ATTACHMENTS

Examination of attachments

359.—(1) Any rope in hoisting service when newly put on, and after any subsequent loosening of the connecting attachments between the rope and the bucket, cage, skip or counterweight and the connection between the rope and the hoist drum, shall have the attachments carefully examined by a qualified person or persons authorized by the manager and shall not be used for ordinary transport in a shaft or winze until two complete trips up and down the working parts of the shaft or winze have been made with the bucket, cage, skip or counterweight bearing its authorized load, and the connecting attachments have been re-examined.

Record to be kept

(2) The hoistman shall make a record of such two complete trips in the Hoistman's Log Book.

Results to be recorded

(3) The results of the examination of the connecting attachments between the bucket, cage, skip or counterweight and hoist drum and the rope shall be recorded in the Hoisting Machinery Record Book and signed by the person making the examination.

Cleaning and examination of rope connections

360.—(1) In drum hoist installations, after every six months of service, that portion of the rope at the conveyance end within the clamps shall be cut off and discarded.

Idem

(2) At such time, the connection between the rope and the drum shall be thoroughly cleaned and examined.

Idem

(3) In friction hoist installations, after every six months of service, the position of the hoisting rope within the clamps shall be changed, if practicable, or that portion of the rope within the clamps shall be thoroughly cleaned and examined.

Idem

(4) Every six months, the tail rope, guide and rubbing rope attachments and tensioning devices shall be thoroughly cleaned and examined.

EXAMINATION OF ROPES AND SAFETY APPLIANCES

Examination of ropes and safety appliances

361.—(1) The manager shall depute a competent person or persons who shall examine, (*a*) at least once in each day, the exterior of the hoisting rope and tail rope to detect the presence of kinks or other visible damage and to note the appearance of the rope dressing;

(*b*) at least once in each month, the structure of that portion of the hoisting rope that is not on the hoist drum when the conveyance is at its lowest stopping point, and the tail, guide and rubbing ropes, with a view to ascertaining *the deterioration thereof, and for the purpose* of this examination the rope shall be cleaned at points selected by such person or persons, who shall note any reduction in the diameter or circumference of and the proportion of wear in the rope, and the starting point of the examination shall be changed slightly from month to month in order to obtain more complete information, but any portion showing appreciable reduction in diameter or circumference or appreciable wear shall be checked when the rope is again examined;

(*c*) at least once in each month, the portion of the rope that normally remains on the drum of a drum hoist when the conveyance is at its lowest stopping point, and shall lubricate such portion, and, if, during the examination of the rope, significant deterioration is found in the portion on the drum or at the cross-over points, the rope shall be shortened sufficiently to eliminate any crushed portion or to change the position of the cross-over points if either or both are necessary;

(*d*) at least once in each day, the safety catches, if any, of the conveyance, to be sure they are clean, sharp and in proper adjustment and working condition;

(*e*) at least once in every three months, the safety catches of the cage or other shaft conveyance so equipped by testing the same, such test to consist of releasing the empty conveyance suddenly in some suitable manner from rest so that the safety catches have the opportunity to grip the guides, and, in case the safety catches do not act satisfactorily, the cage or other shaft conveyance shall not be used further for lowering or raising men until the

safety catches have been repaired and have been proved to act satisfactorily, as referred to in paragraph 9 of section 324.

(2) In friction hoist installations, the stretch of the hoisting rope or ropes shall be measured and recorded in the Friction Hoist Machinery Record Book. Stretch to be recorded

(3) In friction hoist installations, measurement of rope diameters and the location and number of broken *wires shall be recorded monthly in the Friction Hoist* Machinery Record Book. Rope diameters and broken wires to be recorded

(4) If the district electrical-mechanical engineer deems it necessary, he may, after consultation with the manager, conduct or cause to be conducted specific tests of the safety catches with which a conveyance is equipped. Engineer may conduct tests

(5) If on examination there is discovered any weakness or defect whereby the safety of persons may be endangered, the weakness or defect shall be immediately reported to the manager or person in charge and, until the weakness or defect is remedied, the hoisting plant shall not be used. Defects to be remedied at once

(6) It is the duty of the person referred to in subsection 1 to record the reports of all examinations therein referred to and also to record all reports referred to in subsection 5 in a book called the Hoisting Machinery Record Book or the Friction Hoist Machinery Record Book, whichever is applicable. Recording of examination and reports

HOIST LOADING

362.—(1) In this section, Interpretation

(*a*) "authorized maximum load of persons" means the total weight of persons permitted by the district mining engineer to be carried at any time in the shaft conveyance;

(*b*) "maximum allowable weight" means the maximum weight permitted by this Part to be attached to the rope in service or the maximum weight attached to the rope that the hoist is capable of handling or the maximum weight of material that the conveyance is capable of handling whichever is the least.

Rated loading, drum hoists

(2) Every drum hoist shall be accompanied by a certificate from the manufacturer, or an independent person approved by the chief engineer, giving the maximum permissible rope pull for each drum and the maximum permissible suspended load of the hoist, and the hoist shall not be loaded beyond the maximum loads so specified.

Rated loading, friction hoists

(3) Every friction hoist shall be accompanied by a certificate from the manufacturer, or an independent person approved by the chief engineer, giving the maximum rated unbalanced load and the maximum rated suspended load of the hoist, and the hoist shall not be loaded beyond the maximum loads so specified.

Approval for increased capacity

(4) No alterations designed to increase the hoisting capacity shall be made to a hoist unless approval is given by its manufacturer or an independent person approved by the chief engineer.

Determination of maximum load on conveyance, drum hoists

(5) Except as provided in clause *b* of subsection 1, the maximum allowable load to be lowered or raised on the shaft conveyance of a drum hoist means the maximum allowable weight at the end of the rope less the weight of the conveyance.

Idem, friction hoists

(6) The maximum material-load allowed on the conveyance of a friction hoist shall be determined from the lesser of the following calculations:

1. Maximum allowable suspended load on the hoist, less the weight of the hoisting ropes, less the weight of tail ropes, less the weight of the conveyances and the attachments.

2. The breaking strength of the rope, divided by the required factor of safety, minus the maximum weight of rope suspended in one compartment, minus the weight of the conveyance and attachments in that compartment; and, where multiple ropes are used, the lowest breaking strength of any rope shall be used for all ropes in load calculations.

3. The unbalanced load on the hoist as rated by the manufacturer, which shall not be exceeded.

4. The maximum allowable load on any conveyance, which shall not be greater than that for which the conveyance was rated by the manufacturer.

Maximum persons load when conveyance also used for materials

(7) Where a shaft conveyance is used for the lowering or raising of both persons and materials, the weight on the conveyance when handling its authorized maximum load of persons, shall not exceed 85 percent of the maximum allowable weight permitted for materials.

Certificate respecting maximum loads

(8) The manager shall obtain from the district mining engineer resident in the district a certificate in writing setting out the maximum loads of persons or materials that may be carried in the shaft conveyance before persons are so carried.

When certificate issued

(9) The district mining engineer may issue the certificate referred to in subsection 8 if he is satisfied that the hoisting installation and signalling equipment meet the requirements of this Act.

SHAFT HOISTING PRACTICE

Hoisting by automatic control

363.—(1) The hoisting of persons or materials in a mine shaft by automatic control is subject to the approval of the chief engineer.

Idem

(2) Where a hoist in a mine is being operated by automatic control and no other means of hoisting persons is provided, there shall be available a person qualified to operate the hoist manually when persons are underground.

Lowering and raising material

364.—(1) Where steel, timber or other material is being lowered or raised in a shaft conveyance in a mine, it shall be loaded in such a manner as to prevent it from shifting its position, and, if necessary, it shall be secured to the conveyance.

Long material properly secured

(2) When such material projects above the sides of the conveyance, it shall be securely fastened to the conveyance or lashed to the hoisting rope in such a manner as not to damage the rope.

Compartment to be lined where crosshead not used

365. Where a crosshead is not used in a vertical shaft or winze in a mine, the compartment in which the bucket works shall be closely lined with sized lumber.

Level of load in bucket or skip

366. In the course of sinking a shaft or winze in a mine, the bucket or skip shall be filled only in such a manner *that no piece of loose rock projects above the level* of the brim.

Hoisting men in buckets

367. In shaft-sinking operations in a mine, where the hoisting speed exceeds 1,000 feet per minute, persons shall ride in the bucket above the bottom crosshead stop.

Lowering men after blast

368.—(1) During sinking operations in a shaft or winze *in a mine, the bucket or skip used for returning* persons to the working place following a blasting operation shall not be lowered on the initial trip beyond the point where, owing to the blast, it may be unsafe to go without a careful examination, and in no case shall the point be less than fifty feet above the blasting set or bulkhead.

Idem

(2) The bucket or skip shall be lowered from such point only on signal from the persons accompanying it and at such speed as to be fully under control, by signal, of such persons.

Idem

(3) Only sufficient persons shall be carried on such a trip as are required to properly conduct a careful examination of the shaft or winze.

Bucket or skip not to be lowered directly to face

369. *In the course of sinking a shaft* or winze in a mine, the bucket or skip shall not be lowered directly to the bottom but shall be held at least fifteen feet above the bottom and shall remain there until a separate signal to lower it has been given by an authorized person.

Bucket to be steadied

370. No bucket shall be allowed to leave the top or bottom of a shaft or winze in a mine until the person in charge of it has steaded it or caused it to be steadied.

371.—(1) In the course of sinking a shaft or winze in a mine, adequate provision shall be made and maintained to ensure the impossibility of the bucket or skip being dumped while the dumping doors are open and means *shall be applied* to prevent spillage from falling into the shaft or winze. Protection from dumping

(2) A door or doors to cover the sinking compartments shall be provided and maintained at the collar or other point of service of every shaft or winze in a mine while sinking is in progress. Door to cover sinking compartment

(3) The design of the things required under subsections *1 and 2 shall be submitted for the approval of the* district electrical-mechanical engineer before such things are installed. Design to be approved

(4) The door or doors referred to in subsection 2 that are at the point of loading shall be kept closed when tools or material are being loaded into or unloaded from the bucket or skip, except when the bucket or skip is unloaded by dumping arrangements as provided for in subsection 1. Doors to be closed

(5) The door or doors referred to in subsection 2 shall be closed when persons are loaded or unloaded, except where a safety crosshead fills the compartment at the collar or other point of service. Idem

(6) Any doors or other shaft fixture which when moved into the travel area of a shaft compartment would interfere with free passage of the conveyance shall be so equipped that their position is indicated to the hoistmen by signal lights. Warning of obstruction

372. Except during sinking operations, whenever a mine shaft or winze exceeds 300 feet in vertical depth, a suitable cage or skip constructed as required by sections 323 and 324 shall be provided for lowering or raising men in the shaft or winze. Cage for handling men

373.—(1) No person shall travel or be permitted to travel in a cage at any time, except during shaft inspection, unless the doors of the cage are securely closed. Cage doors to be closed

(2) The doors of a cage shall not be opened until a full stop has been made at the point or station signalled except, Idem

(*a*) during trips of inspection; and

(*b*) as permitted by subsection 3.

Idem

(3) In the case of an inadvertent stop at a point in the shaft or winze other than a station, the cage doors may be opened and then persons may leave the cage only on the instructions of an authorized person outside the cage.
amended.

Operation of chairs

374.—(1) Where chairs are used for the purpose of landing a shaft conveyance at a point in a shaft or winze, except when hoisting in balance from that point, the chairs shall not be put into operation unless the proper chairing signal has been given to the hoistman.

Idem

(2) Chairs shall not be used when persons are in or on a shaft conveyance.

Hoisting persons and material simultaneously

375.—(1) Except as provided for in clause *c* of section 376, no person shall travel or be permitted to travel in a bucket, cage or skip operated by a hoist that is being simultaneously used for the hoisting of mineral or material.

Persons only in approved conveyances

(2) No person shall be lowered or raised or permit himself to be lowered or raised in a shaft or other underground opening except in an approved raise climber, or a scaling platform, or in an approved hoisting conveyance as provided for in section 376, but this prohibition does not apply where persons are lowered or raised by hand or by means approved by the district electrical-mechanical engineer for use in construction, maintenance or repair work.

When persons not to be hoisted

376. No person shall be lowered or raised or allow himself to be lowered or raised in a shaft, winze, or other underground opening of a mine,

(*a*) in a bucket or skip, except that persons employed in shaft sinking may ascend and descend to and from the sinking deck or other place of safety and the persons employed in shaft inspection and maintenance may be lowered or raised in the shaft by means of such conveyance;

(*b*) in a cage or skip that does not meet the requirements of sections 324 and 326, except as provided for in clause *a* of this section or section 325;

(*c*) in a cage, skip or bucket that is loaded with explosives or blasting agents, steel, timber or other material or equipment, except where such person is authorized to handle such material in a cage, skip or bucket and the materials are adequately secured as required by section 364, but nothing in this clause prohibits persons from carrying personal hand tools or equipment approved by the district mining engineer in a shaft conveyance if such tools or equipment are properly protected with guards and the conveyance is not overcrowded;

(*d*) in any shaft conveyance, except during shaft sinking operations or shaft inspection and maintenance operations, except where a person authorized to give signals is in charge of the shaft conveyance.

Use of conveyance if drum unclutched

377. Except in the course of sinking a shaft in a mine, no person shall enter or be allowed to enter a shaft conveyance or work upon or under a shaft conveyance when the corresponding drum of the hoist is unclutched, unless the conveyance is first secured in position by chairing or blocking.

Permission necessary to handle men in skip or bucket

378. Permission shall be obtained from the chief engineer before a skip or bucket is used for lowering or raising persons in a shaft or winze of a mine, except during sinking, inspection or maintenance operations.

Use of shaft buckets

379. Where a bucket is used in a shaft or winze in a mine for other than sinking purposes,

(*a*) a set of doors as required by subsection 2 of section 371 shall be installed at the collar and every point of service of the shaft or winze;

(*b*) a suitable landing device shall be used at every working level when the bucket is being loaded or unloaded at that level; and

Signal required

392.—(1) Except as provided in subsection 2, the hoistman *shall not move the hoisting conveyance* until he has received a proper signal.

Exception

(2) In the event of an inadvertent *stop* at some *point in* the shaft or winze other than at a station from which a signal may be given, the hoistman may move the conveyance when he has assured himself that the hoist controls are in proper working order and, when lowering or raising persons he has received instructions from an authorized person.

Only authorized persons to give signal

393.—(1) No person, unless he is authorized so to do, shall give any signal for moving or stopping a bucket, cage or skip in a mine.

Idem

(2) No unauthorized person shall give any signal or in any way interfere with the hoist signalling arrangements.

Voice communication

394.—(1) A system shall be installed in any active shaft or winze to provide voice communication *between the* collar and regular landing places.

Idem

(2) Such installations shall be provided at suitable intervals.

***Position of* conveyance**

395. No signal *shall be given unless the bucket, cage or* skip is at the level from which the signal is to be given.

Hoistman to remain at controls

396.—(1) Except when the hoist is operating under automatic control, the hoistman shall remain at the hoist controls at all times the hoist is in motion.

Idem

(2) Before a hoistman leaves the hoist controls, he shall ensure that the brakes are fully set and that there *will be no inadvertent motion of the hoist drums.*

Only authorized persons may operate hoist

(3) No person, unless he is authorized so to do, shall operate any equipment for controlling the movement of the hoist or interfere with the equipment.

HOISTING PROCEDURE

Hoisting *after* stoppages

397.—(1) *If at the commencement* of a shift there has been a stoppage of hoisting in a shaft for a period exceeding two hours duration, no regular hoisting shall be done until the shaft conveyance has made one complete *trip through the working part of the* shaft or, where shaft repairs have been made, a return trip of the shaft conveyance has been made through and below the affected part of the shaft.

Record of stoppages

(2) The hoistman shall record all such stoppages and trips in the Hoistman's Log Book.

Man safety device

398. Where a hoist is equipped with an auxiliary overwind device for preventing persons from being hoisted to the dumping position in skips or in skips of skip-cage assemblies as required in section 533, the hoistman shall place the device in operation or assure himself that it is in operation at all times that persons are in or on the conveyance.

Obstructions

399. Where obstructions such as those referred to in *section 527 may* exist, the hoistman shall not lower or raise the shaft conveyance without proper authority.

Testing overwind devices

400. *All overwind and underwind devices shall be tested* at least once during every twenty-four hours of operation and a record of the test shall be posted immediately in the Hoistman's Log Book.

Brakes to be tested

401.—(1) The operator of a hoist shall, after going on shift and before a shaft conveyance is lowered or raised, assure himself that the brake or brakes are in proper condition to hold the loads suspended on the corresponding drum or drums by testing the brakes of the drums against the normal starting power of the engine or, in the case of an electric hoist, against the normal starting current.

Drum not to be unclutched

(2) The operator of a hoist shall not unclutch a drum of the hoist until the test mentioned in subsection 1 has been made.

Friction *clutches*

402.—(1) Where a hoist is fitted with a friction clutch, the operator shall, after going on shift and before a conveyance is lowered or raised, test the holding power of the clutch, the brake of the corresponding drum being kept on and the brake of the other drum being kept off.

Idem

(2) In the case of a steam or air hoist, the test mentioned in subsection 1 shall be made against the normal starting power of the engine and, in the case of an electric hoist, against the normal starting current.

Use of brake when drum unclutched

403.—(1) When the drum of a hoist is unclutched, the brake of the drum shall be used only for the purpose of maintaining the drum in a stationary position, and no lowering shall be done from an unclutched drum.

Unclutching procedure

(2) Before commencing unclutching operations, the hoistman shall ensure that the brakes have been applied on both hoist drums.

When clutch to be kept in

(3) When persons are in or on a shaft conveyance, the corresponding drum of the hoist shall be kept clutched in.

HOISTMAN'S LOG BOOK

Hoistman's Log Book

404.—(1) At every shaft or winze hoist, there shall be kept a Hoistman's Log Book in which the following shall be recorded:

1. A report of the working condition of the hoist, including the brakes, clutches, interlocking devices between the brake and clutch, depth indicators and all other devices and fittings pertaining to the safe operation of the hoist.

2. A report of the working condition of the signalling apparatus and a notation of any signals received by the hoistman, the accuracy of which he has questioned.

3. Any special instructions received involving the safety of persons, such entry to be signed by the hoistman and by the person issuing the instructions.

4. A report of the tests of the overwind and underwind devices.

5. Where the required tests of the overwind and underwind devices are conducted by a hoistman operating on another shift, the hoistman assuming duty shall note over his signature that he has examined the entry in the log book of the hoistman who performed the tests.

6. A report of all abnormal circumstances in connection with the operation of the hoist or attachments thereto and such abnormal conditions as have come to the hoistman's knowledge in connection with the hoisting operations in the shaft or winze.

7. A report of all trial trips referred to in sections 359 and 397.

(2) A notification to the hoistman on a succeeding period of duty of any special circumstances or matter affecting the continued operation of the hoist or the safety of persons in the shaft or winze shall be made in the Hoistman's Log Book. Idem

(3) All such entries shall be read and countersigned by the hoistman assuming duty for the succeeding period. Idem

(4) Such entries as are required by this section shall be made and signed by every hoistman for his period of duty on a shaft or winze hoist and the time and duration of his period of duty shall also be noted, and such entries as have been made during the preceding twenty-four hours shall be read and countersigned each day by the master mechanic or other authorized person. Idem

(5) The log book shall be available to the district engineer at all times.

RAISE CLIMBERS

405.—(1) Raise climbers shall be fitted with more than one means of braking, each capable of stopping the climber and holding it in place. Brakes

(2) The operator of a raise climber shall ensure at the beginning of his shift that the brakes are in safe working condition. Testing of brakes

(3) Raise climbers shall be maintained in safe operating condition. Maintenance

(4) The rated load capacity of a raise climber as certified by the manufacturer shall not be exceeded. Load capacity

Type of lighting fixtures required

509. Lighting fixtures shall be of an approved dust-tight type.

Overcurrent protection for lighting circuits

510. Lighting circuits shall be protected by fuses or manual reset overcurrent devices rated at not more than 10 amperes.

Lightning protection

511. Circuits supplying power to explosives or blasting agents storages shall be protected against lightning surges.

Type of heating required

512. Heating systems for explosives or blasting agent storages or cap and fuse houses shall be of a type acceptable to the district electrical-mechanical engineer.

Radiators to be grounded

513. Where a liquid is the medium used for distribution of heat for an explosive or blasting agent storage or a cap and fuse house the radiators shall be grounded.

Fusing of heater circuits

514. Heater circuits shall be fused at not more than 125 per cent of normal current.

ELECTRIC BLASTING DEVICES

Construction

515. The firing device used for firing charges with electricity in accordance with subsection 7 of section 310 shall be so arranged that,

(*a*) the switch mechanism will automatically return by gravity to the open position;

(*b*) the live side of such device is installed in a fixed locked box and shall be accessible only to the authorized blaster;

(*c*) provision is made that the leads to the face are short-circuited when the contacts of the electric blasting device are in the open position;

(*d*) the box in which the electric blasting device and the short-circuiting device are mounted is provided with a lock and the door is so arranged that it cannot be closed or locked unless the contacts of the electric blasting device are open and the short-circuiting device is in place;

(*e*) where electricity from 550-volt circuits is used for blasting, the device shall be electromagnetically operated, except as provided in subsection 7 of section 310.

Precautions re installation of blasting cables

516. When blasting cables or wires are installed in the vicinity of power or lighting cables, proper precautions shall be taken to prevent the blasting cables or wires coming in contact with the lighting or power cables.

Isolated, ungrounded power source

517. Circuits used for blasting from any source other than hand-held portable blasting devices shall be from an isolated, ungrounded power source and shall be used for blasting only.

ELECTRIC HOISTS

General

518. Sections 519 to 544 apply to all electric hoists regardless of the method of operation.

Braking

519.—(1) For each electric hoist, protective devices shall be provided, which, in conjunction with the mechanical braking system, shall be capable of bringing a conveyance or counterbalance safely to rest under all conditions of authorized loading, direction of travel and speed without assistance from the drive.

Idem

(2) Where supplementary electrical braking is employed, at least the same degree of safety shall be supplied.

Safety requirement

520. Except where otherwise specified, current-carrying parts of any safety device shall be so designed, installed and maintained that the failure of any such part will initiate emergency braking action to bring the hoist safely to rest.

Track limits required for overwind protection

521. Devices shall be installed in each hoisting compartment that, in the event of an overwound conveyance or counterbalance, shall be operated directly by the conveyance or counterbalance to initiate an emergency stop and bring the conveyance or counterbalance to rest safely before it or its rope attachments reach any obstruction to its free passage.

Underwind protection required

522. Devices shall be installed for each hoisting compartment that, in the event of an underwound conveyance or counterbalance, shall initiate an emergency stop and bring the conveyance or counterbalance to rest safely before it or its rope attachments reach any obstruction to its free passage, except that, in the case of shaft sinking the protection for an underwound conveyance or counterbalance may be dispensed with.

Overwind and underwind requirements for high-speed hoists

523. Devices, driven from the operating drum or drums, shall be installed, where the hoist operates at a rope speed of 750 feet per minute or greater, that, in the event of an overwound or underwound conveyance or counterbalance, will initiate an emergency stop and bring the conveyance or counterbalance to rest safely before it or its rope attachments meet any obstruction to its free passage, except that, in the case of shaft sinking the protection for an underwound conveyance or counterbalance may be dispensed with.

Overspeed

524. Each electric hoist shall have installed a device that will initiate an emergency stop and bring the conveyance or counterbalance to rest safely should the rope speed exceed the authorized maximum by a predetermined amount.

Enforced slowdown

525. Devices, driven from the operating drum or drums, shall be installed where the hoist operates at a rope speed of 750 feet per minute or greater, that will enforce any necessary reduction in speed as the conveyance approaches the end of travel.

Adjustment of protective devices

526. No person shall alter the adjustment of any protective device without proper authority.

Intermediate obstructions

527.—(1) Where ore or waste dumps, loading boxes or spill-doors are installed in a shaft or winze at points other than the upper and lower limits of normal travel of a conveyance and where any part of such dump box or door interferes with the free passage of a conveyance, there shall be installed,

(*a*) travel-limiting devices;

(*b*) travel-limiting devices as required to section 523, where applicable;

(*c*) enforced slow-down devices as required by section 525, where applicable; and

(*d*) positive locking devices for maintaining such obstructions out of the operating position in the shaft or winze.

Idem

(2) The manager, or his agent, of a mine employing such an intermediate obstruction shall provide a procedure to be followed to ensure the safe operation of the installation.

Idem

(3) Before such an installation is made, plans and procedure shall be submitted to the chief engineer for approval.

Protection required for hoist electrical system

528. Emergency braking action shall be initiated to bring a conveyance or counterbalance to rest safely before it or its rope attachments reach any obstruction to its free passage in the event of,

(*a*) the failure of the power supply to the hoist electric system;

(*b*) an overload on the hoist-drive motors of a magnitude and duration exceeding what would be considered an operating overload; or

(*c*) a short-circuit on the hoist electric system.

Backout

529.—(1) Every electric hoist shall have installed a device to enable a conveyance or counterbalance to be removed from an overwound or underwound position.

Idem

(2) Every such device shall be manually operable only.

Backout switch, motor torque-brake interlock

(3) Every such device shall be so designed and installed that the brake or brakes holding a conveyance or counterbalance, when in an overwound or underwound position, cannot be released until sufficient drive motor torque has been developed to ensure movement of the conveyance or counterbalance in the correct direction only.

Emergency switch

530. A manually-operable switch shall be installed for each electric hoist within reach of the manual controls that will, when operated, initiate emergency braking action to bring the conveyance or counterbalance safely to rest.

Underwind by-pass switch

531. An underwind by-pass switch may be installed, where necessary, that will allow the conveyance to be lowered through the underwind position if it is held in the closed position by the hoistman and will return automatically to the open position when not so held.

Load meter required

532. Each electric hoist shall have installed, within plain view of the manual controls, a meter that will indicate, at all times, the hoist motor load.

Man-safety requirements

533.—(1) Where men are transported in skips or the skips of skip-cage assemblies, there shall be installed a device that will prevent the conveyance, carrying the men, from entering the dumping position.

Idem

(2) Except in shaft sinking, such device shall be so installed that, when it is put into operation, a distinctive signal will be given, automatically, to men about to enter the conveyance.

Idem

(3) Such device is not required on electric hoists where men are hoisted for shaft inspection or maintenance operations only.

Idem

(4) Such device shall be put into operation, either manually or automatically, when men are transported.

Idem

(5) In those cases where the device is automatically put into operation by the hoistman's return of the 3-bell *signal, the circuit shall be so arranged* that the failure of the relay coils will not render the device inoperative.

Approach warning signal

534. Each electric hoist shall have installed a device whereby the hoistman is warned, audibly, that a conveyance or counterbalance is about to enter the region where a reduction in speed is necessary for safe manual braking.

Automatic hoists

535. Sections 536 to 544 apply to all electric hoists that may be operated automatically.

Selection of manual or automatic control

536.—(1) Every electric hoist shall have installed, only *in the same location as the manual controls, a device* for the change-over from manual to automatic control.

Idem

(2) Such device shall be operated by authorized personnel only.

Level or cage control

537. Where an electric hoist is designed to be operated from control stations on the levels or from a control station on the conveyance, any device used to effect the change-over of control shall be operable only at the level at which a conveyance is stopped.

Operation of level-installed controls

538.—(1) Devices installed on the levels for the purpose of selecting the conveyance's destination and for initiating hoist motion shall be operable only when the conveyance is stopped at that level, except where the installation has been approved for call operation.

Idem

(2) There shall be a minimum delay of five seconds between the operation of the level control device used to initiate hoist motion and the actual motion when men are being handled.

Idem

(3) The level control device used to initiate hoist motion shall be so located that it may be operated by someone in the conveyance stopped at that level.

Idem

(4) Devices installed on the levels for the purpose of initiating hoist motion shall, except for jogging, be operable only when the shaft gate at the level at which the conveyance is stopped is in the closed position.

Operation of cage-installed control

539.—(1) Devices installed in a conveyance for the purpose of controlling hoist motion shall, except for jogging, be operable only when the cage door is in the closed position.

Idem

(2) Where devices are installed in a conveyance for the purpose of controlling hoist motion, one of the devices shall be capable of initiating emergency braking action to bring the conveyance safely to rest.

Friction hoists

540. Sections 541 to 544 apply to all electric friction hoists.

Jammed conveyance device

541. Each electric friction hoist shall have installed a device that will initiate emergency braking action to bring the drum to rest in the event of the occurrence of slip between the hoisting rope or ropes and the hoist drum, such as might occur with a conveyance or counterbalance jammed in the shaft or caught at the end of travel.

Synchronizing device

542. Where creep or slip may alter the effective position of safety devices, a means of synchronizing the safety devices with the position of the conveyance in the shaft shall be provided.

Special testing

543. If the district electrical-mechanical engineer deems it necessary, he may, after consultation with the manager, conduct or require to be conducted specific

tests of the efficiency of all electric overwind and underwind devices, signalling and warning devices and hoisting controls and equipment.

Electrical Hoisting Equipment Record Book

544.—(1) The manager of a mine where an electric hoist is in use shall depute some competent person or persons whose duty it is to examine at least once in each week the hoist motor and control apparatus, electric safety devices and hoisting signalling equipment.

Idem

(2) The report of such examination shall be recorded as provided in subsection 3.

Idem

(3) The manager shall keep or cause to be kept at the mine for each hoist a book called the Electric Hoisting Equipment Record Book in which shall be recorded a report of every such examination and a notation of any failure or accident to such equipment and the action taken regarding it, signed by the person making the examination.

Idem

(4) Such entries of the weekly examination shall be read and signed every week by the person in charge of such equipment or accessories thereto.

Idem

(5) A notation of the action taken regarding the report of any failure or accident to any part of the electrical equipment used in connection with the hoist or the signalling equipment shall be made over the signature of the person in charge of such equipment or accessories thereto.

Idem

(6) The Electrical Hoisting Equipment Record Book shall be made available to the district electrical-mechanical engineer at all times.

UNDERGROUND ELECTRICAL INSTALLATIONS

General

545. The provisions of this Part that apply to surface electrical installations apply equally to underground electrical installations, except sections 546 to 563, which apply only to underground electrical installations.

Control of underground feeders

546.—(1) Where electrical energy is taken underground, provision shall be made so that the current may be cut off on the surface.

Idem

(2) The control device shall be accessible to authorized persons only.

Wiring methods

547.—(1) Conductors for all circuits not over 150 volts to ground shall either be installed in standard conduits, armoured or have non-flammable jackets and be adequately supported.

Idem

(2) All fixed conductors transmitting power underground at over 150 volts to ground shall be installed in standard conduits or armoured, shall be adequately supported, and any outer jacketing shall be of a non-flammable type.

Idem

(3) Open-type wiring shall not be used except in cases of emergency.

Cable test required

548. All new cables purchased for the transmission of power underground at a potential in excess of 750 volts shall be accompanied by the manufacturer's certified report of insulation tests, a copy of which shall be filed with the chief engineer.

Cable rating

549.—(1) All cables transmitting power underground at a potential exceeding 750 volts shall have a voltage rating of 50 per cent higher than the normal operating voltage.

Idem

(2) Cable of standard rating for the normal operating voltage may be used where the cable is supplied through a circuit-breaker from a circuit where the neutral point is grounded in such a manner as to,

(a) limit ground fault current; and

(b) limit the possible rise of ground fault potential on any connected equipment to a maximum of 100 volts,

and where ground fault protection is provided.

Bonding requirements

550. The armouring or casings of all cables shall be bonded together so as to be electrically continuous and shall be connected at some point or points to a satisfactory ground on surface.

REPUBLIC OF SOUTH AFRICA

Mines and Works Act and Regulations

Act 27 of 1956 as Amended

15.10.3 every such workshop shall be under the charge of a competent scheduled person who shall be appointed in writing by the manager and who shall have successfully completed a course on gases and gas-testing similar to that provided in regulation 28.40.7.3;

15.10.4 the person appointed to be in charge shall ensure that—
(*a*) the workshop is kept clean at all times, and
(*b*) any equipment to be welded, flame-cut or flame-heated is properly cleaned and free from oil;

15.10.5 if for any reason the person appointed to be in charge is required to leave the workshop, he shall first satisfy himself that all gas or electrical welding, cutting, grinding, vulcanising, soldering or similar equipment is rendered inoperative and is securely locked in a box or compartment of robust construction in the workshop and of which he has the key;

15.10.6 in each such workshop an effective alarm system shall be installed and maintained in working order to give an alarm in the workshop whenever the main fan, which serves the workings in which the workshop is situate, ceases to operate. When such alarm is received the use of all equipment for the purposes contemplated in terms of regulation 15.10.1 shall cease forthwith;

15.10.7 each electric power-feed circuit into any such workshop shall be controlled by a circuit breaker situated not more than 100 *metres* outbye of the workshop in an intake airway and every such circuit breaker shall incorporate effective "no-volt", "overload" and "earth leakage" trips;

15.10.8 a hose of sufficient length to reach from an adequate water supply to all points in the workshop shall be kept connected and ready for immediate use;

15.10.9 for the intentional creation of an arc or spark for the lighting of welding or cutting torches in a workshop approved of in terms of regulation 15.10.1, only lighters of the friction type may be taken into the workings for use in the workshop. Each such lighter shall bear a distinctive mark or number and shall be issued under signature of the manager to the competent scheduled person referred to in regulation 15.10.3. Such lighters shall not be taken to or from the workshop except personally by such competent scheduled person.

Right of search.

15.11 At every fiery mine—

15.11.1 the manager shall appoint a banksman or some other person or persons to be present at each entrance to the workings of the mine at all times and such banksman or other person or persons shall ask every person about to enter the workings of the mine whether he is in possession of any of the articles prohibited in terms of regulation 15.8.5, 15.9.1 or 15.10.1, and the banksman or other person or persons so appointed shall have the right to search any person about to enter the workings of the mine for such articles: Provided that a non-scheduled person shall not have the right to search a scheduled person. Any person, when asked or searched in terms of this regulation, shall immediately produce and hand over any of the prohibited articles which may be in his possession;

15.11.2 a mine overseer or an official of equal or higher rank shall have the right to search any person in the workings of the mine for articles prohibited in terms of regulation 15.8.5, 15.9.1 or 15.10.1 if he suspects that such person has any such articles in his possession, and no person shall hinder or obstruct such mine overseer or other official in his search for such articles.

CHAPTER 16.

WINDING.

THE CONVEYANCE OF PERSONS IN SHAFTS AND WINZES.

No conveyance of persons without permission.

16.1 No person shall ride or cause or permit any other person to ride in a conveyance operated by a winding engine except in terms of permission granted under regulation 16.2 or as is provided for in regulation 16.94.

Winding plant to have permit.

16.2.1 Except as provided for in regulation 16.94, the manager of a mine or works shall not use a winding plant nor permit a winding plant to be used unless he is in possesion of a permit issued by the Inspector of Machinery.

Application for use.

16.2.2 Every application for the use of a winding plant shall be made to the Inspector of Mines on the form obtainable from him.

Inspector to issue permit

16.2.3 The Inspector of Machinery may grant a permit to use such winding plant, subject to conditions as he may specify.

Test by inspector.

16.2.4 The Inspector of Machinery shall not issue a permit to use a winding plant until he has satisfied himself by actual test, to the extent practicable, that the requirements of regulations 16.5 to 16.15 inclusive, regulations 16.25 to 16.40 inclusive and regulations 16.57 to 16.61 inclusive, as far as they are applicable, are complied with.

Where permit to be kept.

16.2.5 The permit shall be kept at the mine office and a legible copy thereof shall be displayed in a suitable glazed frame in the engine room.

Cancellation of permit.

16.2.6 The Inspector of Machinery may amend, suspend or cancel the permit if such action is deemed necessary by him.

Periodic tests.

16.3 The Inspector of Machinery may carry out specific or periodic tests or inspections of any winding plant.

DESIGN OF WINDING ENGINE.

Mass *of person.*

16.4 In calculating the *total mass* of persons for the purpose of regulation 16.6 and regulations 16.30 to 16.40 inclusive, 70 *kilograms* shall be allowed for each person.

16.5 The winding engine shall be such that—

Starting and stopping.

16.5.1 when running at various speeds with light or heavy loads it can be readily slowed and stopped and after being stopped it can be restarted immediately in either direction, and

Lifting power of engine.

16.5.2 it can lift from the bottom to the top of the shaft or winze the maximum unbalanced load on one drum. This provision shall not apply where other means exist enabling persons employed below to reach the top of the shaft or winze.

Brakes and holding power.

16.6.1 Each winding drum or winding sheave shall be provided with an adequate brake or brakes which shall be kept in proper working order.

16.6.2 For drum type of winding engines where the rope is securely attached to the winding drum the brake or brakes, without the assistance of any counterbalancing effect of any load supported by the other drum, shall be capable of holding without slipping a load on the rope at the drum equivalent to the *combined mass* of—

(*a*) the conveyance and its attachments,

(*b*) the maximum permitted *mass* of mineral, or double the maximum permitted *mass* of persons, or the maximum permitted *mass* of material together with double the maximum permitted *mass* of persons when both material and persons are conveyed simultaneously, whichever is the greatest, and

(*c*) the *mass* of rope between the sheave and the conveyance, when the conveyance is at a point in the shaft which produces the maximum static torque on the brakes.

[1]16.6.3 *For a friction drive or sheave type winding engine where the rope or ropes are not securely attached to the winding drum or winding sheave, the brake or brakes shall be capable of holding without slipping the maximum static out-of-balance load which occurs when one of the conveyances, or where a counterpoise is used the conveyance—*

(*a*) *is loaded with the permitted mass of mineral; or*

(*b*) *is loaded with double the permitted number of persons; or*

(*c*) *is loaded with double the permitted mass of material together with double the mass of the permitted number of persons when both material and persons are conveyed simultaneously; or*

(*d*) *is removed from its bridle.*

Flanges or horns.

16.6.4 Every winding drum shall have flanges or horns, and if conical or spiral, such other appliances to prevent the rope from slipping off or coiling unevenly.

Minimum turns of rope on drum.

16.6.5 Except for friction drive or sheave type of winding engines, there shall not be less than 3 turns of rope upon the drum when the cage, skip or other means of conveyance is at the lowest point in the shaft or winze from which hoisting is effected and the end of the rope where applicable shall be fastened securely round the arm or the shaft of the drum.

Slip where friction drive.

16.6.6 For friction drive or sheave type of winding engines where no part of the rope is securely attached to the winding drum or sheave, there shall be no dangerous slipping of the rope on such drum or sheave under any possible working conditions.

Operating levers.

16.6.7 Every winding drum at the driver's right hand side shall have overlay rope; where only one drum is used it shall have overlay rope.

16.6.8 The reversing lever of every steam or air operated winding engine and the control lever of every electrically operated winding engine shall follow the overlay rope in the direction of movement.

16.6.9 Where a hand-operated brake lever is provided on any winding engine it shall be pulled towards the driver to apply the brakes.

16.6.10 The relief and throttle valve levers of every steam or air operated winding engine shall be in a central position.

Locking devices.

16.6.11 The operating mechanism of the clutch of every winding drum shall be provided with a locking arrangement which shall be used to prevent inadvertent withdrawal of the clutch. If the clutch is not clearly visible from the driver's operating position, means shall be provided to indicate to the driver at all times the extent to which the clutch is engaged or disengaged.

16.6.12 It shall be impossible to unclutch any winding drum unless the brake or brakes of such drum are fully applied and it shall be impossible to release the brake or brakes of such drum until the clutch is fully engaged and securely locked.

16.6.13 All bolts and other fittings of winding drums, brakes and clutches shall be rendered secure by means of suitable locking devices.

Depth indicator.

16.7 In addition to any marks on the rope, every winding engine shall be provided with reliable depth indicators conveniently situated, which will at all times show clearly and accurately to the winding engine driver at his operating position the position of the cage, skip or other means of conveyance and where a reduction in winding speed is necessary. The pointer of the dial indicator on the driver's right hand side shall move in a clockwise direction when lowering, and the pointer of a post and spiral indicator shall move up or down as the conveyance moves up or down. On every winding engine where the rope is driven by friction, every single-drum winding engine and every winding engine having 2 drums permanently fixed on one shaft, only one indicator need to be provided.

Warning device.

16.8 Where the length of wind below the uppermost landing place for persons exceeds 100 *metres*, adequate provision shall be made whereby the winding-engine driver is warned of the arrival of the ascending cage, skip or other means of conveyance at a point in the shaft, the distance of which from the uppermost landing place for persons is not less than the equivalent of 3 revolutions of the drum or sheave of the winding engine.

1. Substituted by G.N. No. R. 2101 dd. 15.11.1974.

Overwinding prevention device.

16.9 Every winding engine shall be fitted with at least one effective automatic overwinding prevention device.

Speed indicator and tachograph.

16.10 Any winding engine with a permitted speed of over *five metres per second* shall be fitted with a speed indicator and a tachograph, which shall be used and maintained in efficient working order. The speed indicator shall be so situated that the winding speed can be easily read at all times by the winding-engine driver from his operating position.

CONSTRUCTION OF WINDING PLANT CONVEYANCES.

Cages.

16.11 Every cage used for the regular conveyance of persons shall be of substantial construction and shall be provided with a proper roof or cover and doors. The cage shall be enclosed in such a manner as to prevent any portion of the body of any person therein from accidentally coming into contact with the timbering or other equipment in the shaft or winze or the sides of the shaft or winze. The doors shall be securely attached to the cage and so arranged that they cannot be opened outwards or accidentally. Provision shall be made for adequate ventilation through the cage.

Other conveyances.

16.12 Every skip or kibble, used for the regular conveyance of persons in a vertical or steeply inclined shaft or winze shall be provided with a substantial roof or cover that will safeguard the occupants.

Roof or cover.

16.13 Every conveyance used for examining, repairing or doing other work in a vertical or steeply inclined shaft or winze shall be provided with a substantial roof or cover and shall be sufficiently enclosed to protect any person from accidentally falling out.

Examination platform.

16.14 Where the roof or cover of a cage or skip is used as a platform for persons engaged in examining, repairing or doing other work in a vertical or steeply inclined shaft or winze, the persons so engaged shall be protected by a hood or cover immediately above them. Such hood or cover shall be removed as soon as this work is completed.

Trailers.

16.15 No trailer or trolley shall be attached to a conveyance operated by a winding engine in a shaft or winze where persons are regularly conveyed unless permission in writing has been obtained from the Inspector of Machinery who may impose conditions for its use.

CONNECTION TO WINDING PLANT CONVEYANCES.

Adequate strength.

16.16 No rope, bar, link, chain or other connection shall be used for winding purposes unless it is of good quality and manufacture, free from any patent defect and of adequate calculated strength.

Accidental disconnection.

16.17 The connection between—

(*a*) any winding rope and the cage, skip, bucket, kibble, other means of conveyance or *counterpoise*,

(*b*) any balance rope or tail rope and the conveyance or *counterpoise*, and

(*c*) any connecting rope and the conveyance and any trolley, trailer or other attached conveyance,

shall be such that no accidental disconnection can take place.

Annealing.

16.18 At intervals of not more than 6 months the connections between—

(*a*) any winding rope and the conveyance or *counterpoise*,

(*b*) the conveyance and any trolley, trailer or other attached conveyance, and

(*c*) any balance rope or tail rope and the conveyance or *counterpoise*,

shall be annealed or given other proper heat treatment or shall be discarded and replaced. With connections of a class of steel approved by the Government Mining Engineer, the interval for heat treatment may be extended with the written permission of the Government Mining Engineer.

Record of heat treatment.

16.19 A proper record shall be kept of the heat treatment and working life of the connections referred to in regulation 16.18 and a person appointed in terms of regulation 2.13.1, 2.13.2 or 2.13.3 shall add to the record his report on the method and procedure followed in such treatment and his comments on the results. All such connections and their component parts shall be marked clearly for the purpose of identification.

WINDING ROPES.

Suitability.

16.20 In any shaft, winze or vertical or inclined plane the winding rope shall be made of steel wire, and the gauge of the wires used in the construction of the rope shall be suited to the diameter of the sheaves and drums fitted.

Spliced rope.

16.21 A spliced winding rope shall not be used without the written permission of the Government Mining Engineer.

Defective rope.

16.22 A winding rope shall not be used if a weak or defective portion has been cut from it and the ends spliced.

Use of old rope.

16.23 A winding rope which has previously been in use in any place beyond the control of the manager shall not be put on anew except with the written permission of the Government Mining Engineer.

Spare rope.

16.24 At least one spare winding rope suitable for each winding plant in use shall be kept in reserve on the mine, and shall be at all times ready for use, unless the Inspector of Mines has granted written exemption from the requirements of this ergulation.

Test of new rope.

16.25 A new winding rope, balance rope, tail rope or guide rope shall not be used unless the manager is in possession of a certificate showing the *breaking force* as obtained by actual test.

Test of old rope.

16.26 A winding rope, balance rope, tail rope or guide rope which has previously been in use shall not be put on anew unless the *breaking force* of a specimen cut off from the end of the rope has been obtained by actual test at a testing station approved of by the Government Mining Engineer.

Examination of attachments and test run.

16.27 A winding rope, balance rope, tail rope or guide rope newly put on, whether new or previously used, and the attachments connecting any such rope to any conveyance or [1]*balance-piece* or *counterpoise* shall be examined carefully by a competent person appointed for the purpose by the manager and shall not be used in connection with the raising or lowering of persons until the conveyance loaded with the *maximum permitted mass* has been run 2 complete test trips down and up between the highest and lowest stopping places ordinarily in use. The result of this examination and test shall be recorded immediately in the Rope Record Book provided in terms of regulation 16.79. The record shall be signed by the person who conducted the examination and test.

1. Substituted by G.N. No. R. 2102 dd. 15.11.1974.

Particulars of rope to inspector.

16.28 When a new winding rope, balance rope or tail rope to be used in connection with the raising or lowering of persons is put on, the particulars specified in paragraphs (*a*) and (*b*) of regulation 16.79.2 shall be forwarded in duplicate to the Inspector of Mines.

16.29 When a winding rope, balance rope or tail rope which has previously been in use and which is to be used in connection with the raising or lowering of persons is put on anew, the particulars specified in paragraphs (*a*), (*b*) and (*c*) of regulation 16.79.2 shall be forwarded in duplicate to the Inspector of Mines.

Definitions.

16.30.1 *For the purpose of regulations* 16.31 *to* 16.40 *inclusive—*

"*effective combined weight*" *shall mean the static weight resulting from the mass of any load where winding is conducted in a vertical plane and it shall be* 1,05 *times the incline component of this static weight where winding is conducted in an inclined plane;*

"*attachments*" *shall include everything suspended from or attached to the conveyance other than the winding rope and shall include any balance rope or tail rope;*

"*lenghth of winding rope*" *shall mean the lenghth between the sheave or drum in the headgear and the lowest working point of the conveyance;*

"*balance rope or tail rope*" *shall include all balance ropes or tail ropes.*

16.30.2 *In determining, in accordance with the provisions of regulations* 16.31 *to* 16.40 *inclusive, the minimum allowable breaking force of any rope used in connection with winding, the weight in newtons of any mass carried by the rope shall be obtained by multiplying this mass in kilograms by a factor of* 9,8.

Ratio of man load to mineral load.

16.31 The total *mass* attached to the winding rope when persons or material are conveyed shall not exceed nine-tenths of the *mass* attached to the winding rope when mineral is conveyed.

Multiple ropes.

16.32 Where a conveyance is suspended by 2 or more winding ropes, the ropes shall be of approximately equal size and strength. Adequate arrangements shall be made to equalize the tension in the ropes and, in calculating the *breaking force* of the ropes, each rope shall be assumed to carry an equal share of the load.

Factors of safety, winding ropes.

16.33 A winding rope, balance rope or tail rope shall not be used if the *breaking force* at any point in the rope is less than nine-tenths of the initial *breaking force*.

16.34 Where the winding system is such that it allows of the periodic testing of the winding rope or ropes as required by regulation 16.41 and a balance rope or tail rope is not used, a winding rope shall not be used for the raising or lowering of persons or material if the *breaking force* at any point in the rope is less than whichever is the greatest of—

16.34.1 10 times the effective combined weight of the conveyance and its attachments and the maximum permitted number of persons or load of material, or

16.34.2 9 times the effective combined weight of the conveyance and its attachments and the maximum permitted load of mineral, or

16.34.3 5 times the effective combined weight of the length of winding rope, the conveyance and its attachments and the maximum permitted number of persons or load of material, or

16.34.4 4,5 times the effective combined weight of the length of winding rope, the conveyance and its attachments and the maximum permitted load of mineral.

16.35 Where the winding system is such that it does not allow of the periodic testing of the winding rope or ropes as required by regulation 16.41 and a balance rope or tail rope is used, a winding rope shall not be used for the raising or lowering of persons or material if the *breaking force* at any point in the rope is less than whichever is the greater of—

16.35.1 9 times the effective combined weight of the length of winding rope, the conveyance and its attachments, the maximum permitted number of persons or load of material, and *one-half that* of any tail carriage and sheave, but this factor may be reduced by 0,001 5 *for every metre* of the length of the winding rope, provided that the factor shall not be less than—

(*a*) 7,5 where the conveyance is suspended by a single winding rope,

(*b*) 6,875 where the conveyance is suspended by 2 or 3 winding ropes,

(*c*) 6,25 where the conveyance is suspended by 4 or more winding ropes, or

16.35.2 8,1 times the effective combined weight of the length of winding rope, the conveyance and its attachments, the maximum permitted load of mineral, and *one half that* of any tail carriage and sheave, but this factor may be reduced by 0,001 35 *for every metre* of the length of rope provided that the factor shall not be less than—

(*a*) 6,75 where the conveyance is suspended by a single winding rope,

(*d*) 6,19 where the conveyance is suspended by 2 or 3 winding ropes,

(*c*) 5,62 where the conveyance is suspended by 4 or more winding ropes.

16.36 Where the winding system is such that it allows of the periodic testing of the winding rope or ropes as required by regulation 16.41 and a balance rope or tail rope is used, a winding rope shall not be used for the raising or lowering of persons or material if the *breaking force* at any point in the rope is less than whichever is the greater of—

16.36.1 8,1 times the effective combined weight of the length of winding rope, the conveyance and its attachments, the maximum *permitted number of persons* or load of material, and *one-half that* of any tail carriage and sheave, but this factor may be reduced by 0,001 35 *for every metre* of the length of winding rope provided that the factor shall not be less than—

(*a*) 6,25 where the conveyance is suspended by a single winding rope,

(*b*) 5,94 where the conveyance is suspended by 2 or 3 winding ropes,

(*c*) 5,62 where the conveyance is suspended by 4 or more winding ropes, or

16.36.2 7,29 times the effective combined weight of the length of winding rope, the conveyance and its attachments, the maximum permitted load of mineral and *one-half that* of any tail carriage and sheave, but this factor may be reduced by 0,001 2 *for every metre* of the length of winding rope provided that the factor shall not be less than—

(*a*) 5,62 where the conveyance is suspended by a single winding rope,

(*b*) 5,34 where the conveyance is suspended by 2 or 3 winding ropes,

(*c*) 5,06 where the conveyance is suspended by 4 or more winding ropes.

16.37 Where the winding system is such that it allows of the periodic testing of the winding ropes as required by regulation 16.41 and a balance rope or tail rope is not used and each conveyance is suspended by 2 or more winding ropes in conjunction with a rope-tension compensator, the winding ropes shall not be used for the raising or lowering of persons or material if the *breaking force* at any point in any of the ropes is less than that specified in regulations 16.34.1, 16.34.2 and 16.34.3 or less than 0,95 times that specified in regulation 16.34.4, whichever is the greatest.

16.38 Where a winding plant which is not used for the raising or lowering of persons or material operates in a shaft or winze where persons are regularly conveyed, no winding rope shall be used on such winding plant if the *breaking force* at any point in the rope is less than the minimum permitted for a similar winding system in terms of regulations 16.33 to 16.37 inclusive.

Factor of safety, balance rope.

16.39 A balance rope or tail rope shall not be used in a shaft or winze where persons are regularly conveyed if the *breaking force* at any point in such rope is less than 6 times the effective combined weight of the balance rope or tail rope and *one half that* of any tail carriage and sheave.

Factor of safety, guide rope.

16.40 A guide rope shall not be used in a shaft or winze where persons are regularly conveyed if the *breaking force* at any point in such rope is less than 6 times the effective combined weight of the rope and its tensioning weight. This provision shall not apply to any guide rope which is also used as a winding rope to raise or lower a stage, in which case the *breaking force* at any point in the rope shall not be less than 5 times the *effective combined weight* of the length of winding rope, and its *share of the combined weight* of the stage and attachments, the maximum permitted number of persons and the load of material.

Cutting, recapping and testing.

16.41.1 Unless the winding system is such that it does not allow of the shortening of the winding rope, a portion of the winding rope shall be cut from the end attached to the conveyance, the [1]*balance-piece* or the *counterpoise*, as the case may be, at intervals not exceeding 6 months and the rope shall be recapped. The length of the portion so cut off shall be at least 3,7 *metres* or such shorter length as the Government Mining Engineer may permit in writing.

1. Substituted by G.N. No. R. 2102 dd. 15.11.1974.

16.41.2 From the portion of the rope cut off in terms of regulation 16.41.1, a specimen shall be sent without delay for test to a testing station, approved of by the Government Mining Engineer, where its actual *breaking force* and general condition shall be determined. The test shall be at the expense of the owner. The testing station shall send the manager a certificate showing the results of such test and shall send a copy of the certificate to the Government Mining Engineer. If the specimen of the rope received at the testing station is in a condition not admitting of a satisfactory test, a fresh specimen shall be sent by the manager.

WINDING PLANT SIGNALLING ARRANGEMENTS.

16.42 Unless exempted in writing by the Inspector of Mines—

System where persons are conveyed.

16.42.1 every shaft in which winding is carried on, other than a shaft in the course of being sunk, shall be provided with some efficient signalling arrangement in respect of each winding plant for interchanging distinct and definite signals between—

(*a*) the winding-engine driver and the bank, and

(*b*) the winding-engine driver and every established point below the bank from which winding is carried on.

Where persons are regularly conveyed in such shaft and the signalling arrangements are operated by electricity, the provisions of regulation 16.43 shall be complied with;

System for shaft examination.

16.42.2 every shaft where persons travel on or in the conveyance while carrying out any examination, repair or other work shall be provided with some efficient means, approved by the Inspector of Machinery, whereby persons doing such examination or work can signal effectively from any depth in the shaft to the winding-engine driver;

System at inclined sinking shafts.

16.42.3 every inclined shaft in the course of being sunk shall be provided with some efficient signalling arrangement in respect of each winding plant for interchanging distinct and definite signals between—

(*a*) the winding-engine driver and the bank, and

(*b*) the winding-engine driver and every established intermediate landing station below the bank, and

(*c*) the winding-engine driver and a point not more than 40 *metres* from the bottom of the shaft. When this point is more than 15 *metres* from the bottom of the shaft, some efficient signalling arrangements shall also be provided and used for signalling from the bottom of the shaft to this point; and

System at vertical sinking shafts.

16.42.4 every vertical shaft in the course of being sunk shall be provided with 2 separate means for each winding plant whereby persons employed in the sinking process can signal effectively from the bottom of the shaft and from any depth in the shaft to the winding-engine driver and there shall also be provided in respect of each winding plant an efficient signalling arrangement for interchanging distinct and definite signals between the winding-engine driver and the bank and between the winding-engine driver and every established intermediate landing station below the bank.

Electric signalling systems.

16.43 At every shaft and winze, other than a shaft or winze in the course of being sunk, where persons are regularly conveyed and where the signalling arrangements are operated by electricity, the following provisions, except as is provided for in regulation 16.44, shall be observed in respect of each winding plant used for the raising or lowering of persons:—

16.43.1 There shall be provided and maintained in good working order 2 separate, independent, and efficient signalling arrangements, hereinafter referred to as the locked-bell system and the call-bell system, which shall be used for transmitting signals.

Locked-bell system.

16.43.2 The locked-bell system shall be for the interchange of signals between—

(*a*) the winding-engine driver and the bank, and

(*b*) the winding-engine driver and every established point below the bank from which winding is normally carried on, but it shall not enable the banksman to signal on this system to anyone but the winding-engine driver.

16.43.3 The system shall be arranged so that the winding engine-driver can easily distinguish between signals received from the bank and signals received from below the bank.

Locking of signal mechanism.

16.43.4 The sytem shall further be arranged and maintained so as to prevent as far as possible signals being given by unauthorised persons. The signal operating mechanism at the bank and at all points below the bank shall be securely enclosed in a metal casing of substantial construction and shall be kept locked when not in actual use. The key shall be removable and when not required shall be removed and retained by the banksman, onsetter or other authorised person: Provided that other locking arrangements may be used if approved by the Inspector of Machinery.

Bell-brake interlocking device.

16.43.5 There shall be in use a device which automatically prevents the conveyance or conveyances being raised or lowered after the winding-engine driver has given a signal on the circuit of the locked-bell system provided for interchanging signals with the bank or on the circuit of the locked-bell system provided for interchanging signals with the established points below the bank from which winding is normally carried on, until he has received a signal on each of the circuits on which he gave a signal.

Call-bell system.

16.43.6 The call-bell system shall enable signals to be transmitted—

(*a*) to the winding-engine driver from the bank, and

(*b*) to the winding-engine driver from every established point below the bank from which winding is normally carried on,

and shall also enable signals to be interchanged between the bank and every established point below the bank from which winding is normally carried on, but it shall not enable the winding-engine driver to transmit signals on this system.

Accessibility of call-bell.

16.43.7 The signal operating mechanism of the call-bell system shall be accessible to any person to transmit the signals "10 followed by station signal" and "one long ring" referred to in regulation 16.45, but it shall not be used for any other purpose: Provided that the banksman or onsetter or any person duly authorised by the manager may use the system to indicate the station at which the conveyance is required and subject to the approval of the Inspector of Machinery to transmit special signals.

Tone of bells.

16.43.8 The tone of the bells of the call-bell system shall be such as to be easily distinguishable from that of the bells of the locked-bell system.

Telephone in place of call-bell.

16.43.9 In a shaft or winze where efficient telephonic intercommunication is provided between the bank and every established landing station for persons below the bank, it shall be necessary to provide only one call-bell system in respect of all the winding plants serving such shaft or winze.

Other systems—approval.

16.44 Signalling arrangements other than those required by regulation 16.43 may be used with the written approval of the Government Mining Engineer.

Code of signals.

16.45 The following code of signals shall be used and strictly observed where a winding plant is operated at a shaft or winze where persons are regularly allowed to ride:

Knocks or rings—

1	Raise when engine at rest.
1	Stop when engine in motion.
2	Lower.
3	Persons about to travel.
3	In reply: persons may continue to travel or may enter the cage or other conveyance for the purpose of travelling.
3	From engine-driver when cage or other conveyance containing persons is brought to rest at a station: Persons may leave the cage or other conveyance.
[1]2 *pause* 2	*To driver (Clear signal): driver may move at his discretion.*
2 pause 2 pause 2	From driver: persons must leave the conveyance.
2 pause 2 pause 2	In reply: no persons in the conveyance.
2 pause 2 pause 2 pause 2	Cancel or repeat signal.
3 pause 3 pause 3	*Person giving signal about to travel.*
3 pause 3 pause 3	In reply: acknowledgement by driver that person signalling is about to travel.
4 pause 1	Raise slowly.
4 pause 2	Lower slowly.
4 pause 4	To driver: Mark signal.
4 pause 4	In reply: acknowledgement by driver of "mark" signal.
4 pause 4 pause 4	To driver: clutching signal.
4 pause 4 pause 4	In reply: clutching operations completed.
5 pause 5	To driver: explosives about to be placed in the conveyance.
5 pause 5	*In reply: Explosives may be placed in the conveyance.*
5 pause 5	From driver when conveyance containing explosives is brought to rest at a station: explosives may be removed from the conveyance.
5 pause 5 pause 5	To driver: no explosives in the conveyance.
5 pause 5 pause 5	In reply: acknowledgement by driver that there are no explosives in the conveyance.
6 pause 6	To driver: winding compartments served by engine locked.
6 pause 6	In reply: acknowledgement by driver of "compartments locked" signal.
6 pause 6 followed by station signal	To driver: winding compartments served by engine locked below station designated.
pause 6 followed by station signal	In reply: acknowledgement by driver of "compartments locked below station designated" signal.
6 pause 6 pause 6	To driver: compartments served by engine re-opened.
6 pause 6 pause 6	In reply: acknowledgement by driver of "compartments served by engine re-opened" signal.
6 pause 6 pause 6 pause 6	To driver: shaft examination and repairs about to take place.
6 pause 6 pause 6 pause 6	*In reply: acknowledgement by driver "shaft examination and repairs" signal.*
7	To driver: persons about to have access to the conveyance for a purpose other than travelling or the loading or unloading of mineral in trucks or of material.

1. English version corrected by G.N. No. R. 2103 dd. 15.11.1974.

7	In reply: person may have access to conveyance for a purpose other than travelling or the loading or unloading of mineral in trucks or of material.
7 pause 7	To driver: conveyance is clear of all persons who have had access to it for a purpose other than travelling or the loading or unloading of mineral in trucks or of material.
7 pause 7	In reply: acknowledgement by driver of "persons clear" signal.
15	Electrician testing bells.
15	In reply: acknowledgement of "bell testing" signal.
15 pause 2 pause 2	Electrician has completed test.
10 followed by station signal	Accident to person: station where conveyance is required.
1 long ring	Accident to shaft: winding operations to be suspended immediately in all compartments of the shaft.

In any purely mechanical signalling system "continued ringing" shall replace "one long ring" for the "accident to shaft" signal.
When raising or lowering mineral in trucks or material:

Knocks or rings—

8	To driver: raising or lowering of mineral in trucks or of material about to commence.
8	In reply: acknowledgement by driver that raising or lowering of mineral in trucks or of material is about to commence.
1	From driver: persons may have access to conveyance for the purpose of loading or unloading mineral in trucks or material.
8 pause 8	To driver: raising or lowering of mineral in trucks or of material completed.
8 pause 8	In reply: acknowledgement by driver that raising or lowering of mineral in trucks or of material is completed.

Special signals.

16.46 In addition to the foregoing signals, special signals may be used provided they have been approved in writing by the Inspector of Machinery.

Offence.

16.47 Any person acting in conflict with the code of signals referred to in regulation 16.45 or of any of the special signals used on a mine shall be guilty of an offence.

Access to conveyance.

16.48 No person shall enter or have access to or be permitted to enter or have access to a cage or other conveyance for any purpose whatsoever or shall continue to travel in a cage or other conveyance or shall leave or be permitted to leave a cage or other conveyance unless and until the appropriate signals required in terms of regulation 16.45 have been exchanged, or, if a signal cannot be given on the bell system, some other appropriate and distinct signal has been received from the winding-engine driver.

Code to be posted up.

16.49.1 The code of signals referred to in regulation 16.45 or an abridged form thereof approved by the Government Mining Engineer, as well as the special signals that may be in use on a mine, shall be displayed suitably in the form of distinctly legible notices in letters and figures not less than *ten millimetres* in height. The decision whether such notices are suitably displayed and distinctly legible shall rest with the Inspector of Machinery. Such notices shall be posted up in the winding-engine room, at the bank and at all shaft or winze stations for the time being in use.

16.49.2 Where only some of the signals in the aforementioned code are used it shall be necessary to display only that portion of the code which is used.

REQUIREMENTS IN SHAFTS AND WINZES.

Guides in vertical shafts.

16.50 Every vertical shaft and every vertical winze exceeding 30 *metres* in depth and used for winding purposes shall be provided with guides for skips, cages or other conveyances unless exempted in writing by the Inspector of Machinery.

Provision for crossing shaft.

16.51 At any place in a shaft where it is necessary for workmen to pass from one side to the other, provision shall be made for them to do so without entering or crossing a compartment in which winding is taking place; such passage shall be securely fenced off from moving parts of machinery and from any conveyance.

Entering winding compartments.

16.52 No person shall enter or cross a compartment of a shaft or of a headgear in which winding is taking place, except for the purpose of entering, leaving or having access to a cage, skip or other conveyance or for the purpose of conducting an examination, effecting repairs or doing other necessary work in such compartment.

Winding during repairs.

16.53 No winding operations shall be carried on in a shaft or a headgear while persons are engaged in effecting repairs, conducting an examination or doing other work in such shaft or headgear, except—

16.53.1 where such winding operations are necessary for the purpose of effecting the repairs, conducting the examination or doing the other work, or

16.53.2 where the persons engaged in effecting the repairs, conducting the examination or doing the other work are adequately protected from the conveyances and other winding equipment used in such winding operations as well as from falling stones and falling material.

Repairs in shaft.

16.54 No person shall effect repairs, conduct an examination or do other work in a shaft or a headgear while winding operations are being carried on in such shaft or headgear, except—

16.54.1 where such person is adequately protected from the conveyances and from other winding equipment as well as from falling stones and falling material; or

16.54.2 where the winding operations are necessary for such person to effect the repairs, conduct the examination or to do the other work.

Driver to be specially warned.

16.55 The person in immediate charge of any repairs or examination in a winding compartment of a shaft or a headgear or in immediate charge of any work in connection with maintenance or installation of equipment in a winding compartment of a shaft or a headgear shall warn the driver of the winding engine operating the conveyance in such compartment that such repairs, examination or work are about to be undertaken and where practicable shall enter forthwith, in the presence of the driver on duty at the time, such warning in the driver's logbook provided in terms of regulation 16.81. Such entry shall be countersigned by the driver and by any driver relieving him. Where it is not practicable for the person in charge of such repairs, examination or work to enter such warning, the entry shall be made by the driver on duty. Except where the provisions of regulations 16.53.2 and 16.54.1 are complied with, the driver of every other winding engine operating conveyances in the shaft or headgear shall be warned in a similar manner. The entry shall be cancelled by the person in immediate charge of such repairs, examination or work on completion thereof.

16.56 For the purpose of regulations 16.53, 16.54 and 16.55 work in a shaft shall not include work at the bottom of a shaft in the course of being sunk.

Spring keps or jack catches.

16.57 Where winding is carried on in a shaft there shall be fitted above the bank spring keps or jack catches or some other effective contrivance to support any conveyance detached from the winding rope as a result of an overwind.

Detaching hooks.

16.58 For a winding system in a vertical shaft where the end of the winding rope is fastened to the drum of the winding engine, there shall be fitted detaching hooks to detach from the winding rope any conveyance overwound in the headgear and to support it. Such detaching hooks shall be additional to the devices required in terms of regulation 16.57: Provided that the Inspector of Machinery may grant exemption from the requirement of fitting detaching hooks in the case of a winding system in a vertical shaft in the course of being sunk.

Retarding device.

16.59 For a winding system in a vertical shaft where the winding rope is not fastened to the drum or sheave of the winding engine—

16.59.1 the over-run space in the headgear above the highest established stopping place shall be provided with rigid guides or other appliances arranged so that an overwound conveyance is retarded to minimise the risk of the conveyance coming into contact with the rope sheave or the buffer stops in the headgear, and

16.59.2 the over-run space at the bottom of the shaft below the lowest established stopping place shall be provided with rigid guides or other appliances arranged so that an overwound conveyance is retarded and arrested before it can come into contact with any fixed obstacle.

Over-run clearance.

16.60 The headgear shall be carried sufficiently high to allow a clearance of at least 7,5 *metres* in which the conveyance can travel above or beyond the highest landing place for persons before it comes into contact with any fixed obstacle excluding any retarding appliance provided in terms of regulation 16.59.

16.61 The shaft shall be carried sufficiently deep to allow an over-run space of at least 7,5 *metres* in which the conveyance can travel below or beyond the lowest landing place for persons before it comes into contact with any fixed obstacle excluding any retarding appliance provided in terms of regulation 16.59: Provided that such over-run space need not be provided in a shaft in the course of being sunk or in a shaft not exceeding 300 *metres* in depth or length below the bank where the winding system does not include the use of a balance rope or tail rope.

LOADING OF WINDING PLANT CONVEYANCES.

Simultaneous winding of men and mineral.

16.62 No person shall travel in a conveyance operated by a winding engine if such conveyance is loaded or partially loaded with mineral, and no person shall travel in a conveyance operated by a winding engine that is being used simultaneously for the winding of mineral: Provided that, if authorised by the manager or mine overseer, persons engaged in sinking operations in a vertical shaft or winze may descend such shaft or winze in a conveyance operated by a winding engine that is being used simultaneously for the raising of mineral.

Travelling with material.

16.63 Except as is provided for in regulation 16.65, no person shall travel in a conveyance, operated by a winding engine, with material except detonators, safety fuse, igniter cord, lighting torches or articles which are unlikely to endanger persons travelling and for which permission has been granted by the manager or mine overseer, and no person shall travel in a conveyance operated by a winding engine that is being used simultaneously for the winding of such material.

List of permitted material.

16.64 The manager shall cause a list to be kept at the shaft or winze of all articles regularly conveyed in such shaft or winze for which permission has been granted in terms of regulation 16.63 and he shall ensure that every banksman, onsetter and other person authorised to give signals for the raising and lowering of persons are made aware of the articles included in the list. A copy of the list shall be accessible to all persons concerned.

Persons authorised to travel with material.

16.65 The manager or the mine overseer may authorise the following persons to travel in a shaft or winze with material prohibited in terms of regulation 16.63 if such travelling is necessary for the efficient carrying out of their duties:—

16.65.1 Onsetters and their gangs;

16.65.2 Persons required to distribute explosives;

16.65.3 Persons engaged in sinking operations or in conducting an examination, effecting repairs or doing other work in the shaft or winze;

16.65.4 Persons required to ensure the safe passage through the shaft or winze of material which cannot be conveyed inside a conveyance.

Loading of explosives.

16.66 No person shall place explosives in or remove them from a conveyance operated by a winding engine except under the immediate supervision of the banksman or onsetter or a responsible scheduled person authorised thereto by the manager or mine overseer.

Riding outside conveyance.

16.67 No person shall ride in any shaft or winze on the roof, top, side, bow, rim, bridle or frame of or in any position outside a conveyance operated by a winding engine, except that persons engaged in examining or repairing the shaft or winze or doing other work in the shaft or winze may ride on the roof of such conveyance or on a special platform if authorised to do so by the manager or mine overseer and if riding on the roof of such conveyance or on the special platform is necessary for the efficient carrying out of such examination, repairs or other work.

No travelling in attached conveyance.

16.68 Persons shall not be regularly raised or lowered in a conveyance attached to the normal conveyance.

Conveyance to be steadied.

16.69 No bucket or other means of conveyance that can sway shall be allowed to leave the top or bottom of the shaft or winze unless the workman in charge thereof has steadied it or caused it to be steadied.

Overfilling of conveyance.

16.70 No bucket or other means of conveyance shall be filled with loose rock or ground above the level of the brim.

Fastening projecting material.

16.71 When tools, timber or other material, which project above the top of the cage, skip, bucket, kibble or other means of conveyance, are raised or lowered in a shaft or winze, the projecting portion or portions shall be fastened securely to the winding rope or to the bow of the conveyance.

TRIAL RUN OF WINDING PLANT.

16.72 When winding in any compartment or compartments of a shaft, winze or headgear has been stopped for repairs or blasting operations or when it has been stopped for any other purpose for a period exceeding one hour in duration or when a conveyance has been changed, the winding engine serving such compartment or compartments shall not be used for the raising or lowering of persons until the cage, skip or other means of conveyance has been run at least one complete trip up and down such compartment or compartments: Provided that this regulation shall not apply to the use of the winding engine for the raising or lowering of persons conducting an examination or effecting repairs; and provided further that where such stoppage is confined to a portion of any compartment or compartments, the requirements of this regulation shall apply only to such portion.

EXAMINATION OF WINDING PLANT AND SHAFT.

Appointment of persons to examine shafts.

16.73 The manager or subordinate manager appointed in terms of regulation 2.6.1 shall appoint in writing some competent scheduled person or persons whose duty it shall be to examine carefully at least once in each week the guides or rails and the winding compartments generally, including the doors, gates or barriers and ancillary equipment at stations, landing platforms and loading boxes.

Appointment of persons to examine winding equipment.

16.74 The person appointed in terms of regulation 2.13.1, 2.13.2 or 2.13.3 shall appoint in writing some competent scheduled person or persons whose duty it shall be to examine carefully—

16.74.1 at least once in each day the winding ropes, the balance ropes or tail ropes, the connection of the winding ropes to the drums, the connections referred to in regulation 16.18, the conveyances and the main members by which they are suspended and any safety catches attached thereto, the pulley wheels and sheaves, the brakes, the depth indicators, the safety devices and all external parts of the winding equipment upon the proper working of which the safety of persons depends: Provided that these examinations will not be necessary on any day mentioned in section 9(1) of the Act, if the winding plant makes less than 50 trips during any such day, and

16.74.2 at least once in each week the signalling arrangements and safety devices used in connection therewith.

Examination by engineer of winding equipment and ropes.

16.75 A person appointed in terms of regulation 2.13.1, 2.13.2 or 2.13.3 shall examine carefully—

16.75.1 at least once in each week the overwinding prevention devices and the external parts of the winding engine;

16.75.2 at least once in each year the winding engine as to the condition of the internal mechanical parts and, as far as reasonably practicable, the internal electrical parts;

16.75.3 at least once in each calendar month at intervals not exceeding 45 days the structure of the winding rope and the balance rope or tail rope, with a view to ascertaining the amount of deterioration thereof. For the purpose of this examination the rope shall be cleaned at places selected by the person making the examination who shall note any reduction in the circumference of the rope, any variation in the length of lay of the rope, the superficial concondition of the wires as to wear, corrosion, fractures and brittleness, and all other data necessary for ascertaining the amount, extent, and distribution of the deterioration of rope. If the examination discloses features such as undue or rapid wear or fractures of the wires, which, although not constituting sufficient reason for condemming the rope, call for more than usual attention, the examination required under this paragraph shall be made more frequently;

16.75.4 at least once in each calendar month at intervals not exceeding 45 days the connections between the winding rope and the drum and the connections referred to in regulation 16.18; and

16.75.5 after every accident or occurence referred to in regulation 25.6(*a*) and before winding operations are resumed, all portions of the winding equipment affected by such accident or occurence on which the safety of persons depends.

16.76 In the case of connections referred to in regulation 16.18 being of a class of steel approved by the Government Mining Engineer, such connections and their component parts shall be dismantled, cleaned and then examined by the person appointed in terms of regulation 2.13.1, 2.13.2 or 2.13.3 at intervals not exceeding 12 months.

Duty when defect discovered.

16.77 If on any examination required in terms of regulations 16.73, 16.74, 16.75 and 16.76 there is discovered any weakness or defect which may endanger the safety of persons, and such weakness or defect cannot be remedied immediately, the person making the discovery shall report such weakness or defect to the manager without delay. Until such weakness or defect is remedied the winding plant shall not be used except in so far as may be necessary to remedy such weakness or defect.

WINDING PLANT RECORD AND LOG BOOKS.

Machinery record book.

16.78 The manager shall provide for each winding plant a book to be termed the Machinery Record Book in which shall be entered—

16.78.1 the name of each person appointed under regulation 16.74 to perform the duties called for in the said regulation together with the particulars of the duties of each such person; and

16.78.2 a true report of every *examination referred to in regulations 16.74, 16.75* and *16.76.* These reports shall be recorded and signed without delay by the person making such examination. The reports made by the persons appointed in terms of regulation 16.74 shall be scrutinised and *countersigned by the person appointed in terms of regulation* 2.13.1, 2.13.2 or 2.13.3 at least once in each week.

Rope record book.

16.79 The manager shall provide a book to be termed the Rope Record Book in which shall be entered—

16.79.1 the name of each person appointed under regulation 16.27;

16.79.2 the following particulars for each winding rope, balance rope or tail rope used on each winding plant:—

(*a*) Name of manufacturer.
Date of manufacture.
Coil number.
Length in metres.
Mass per metre in kilograms.
Diameter in millimetres, or
Width and thickness in millimetres.

Construction of rope—
type and length of lay;
number of strands;
class of heart;
type of lubricant.

Construction of strands—
number of wires;
diameter of wires *in millimetres;*
class of core;
class of steel in wires;
tensile strength of steel *in megapascals.*
Breaking force in kilonewtons.

Rope test certificate number and place of test;

(*b*) Whether used for winding or balance purposes.
Name and type of shaft.
Name of compartment.
Winding plant certificate number.
Date put on;

(*c*) Dates of recapping, shortening or turning end for end.
Dates of testing and the *breaking force* obtained at each test.
Date taken off.
Dates of annealing or renewing connections; and

16.79.3 a true report of every test or examination referred to in regulation 16.27. These reports shall be recorded and signed without delay by the person making such test or examination.

Shaft log book.

16.80 The manager shall provide for each shaft or winze where persons are regularly conveyed a book to be termed the Shaft Log Book in which shall be entered—

16.80.1 the name of each person appointed under regulation 16.73 to perform the duties mentioned therein together with the particulars of the duties of each such person;

16.80.2 a true report of every examination referred to in regulation 16.73. This report shall be recorded and signed without delay by the person making such examination and the reports shall be scrutinised and countersigned by the manager or mine overseer and by the person appointed in terms of regulation 2.13.1, 2.13.2 or 2.13.3 at least once each week.

Driver's log book.

16.81 The manager shall provide for each winding engine a book to be termed the Driver's Log Book which shall be kept in the winding-engine room and in which shall be recorded in duplicate—

16.81.1 a true report of the condition of the winding engine, including the brakes, clutches, reversing gear, depth indicators and all other fittings. Such report shall be made and signed by the winding-engine driver for each period of charge, the time and duration of which shall be recorded;

16.81.2 a true report of the condition of the signalling arrangements together with a record of any signals received by the winding-engine driver which he has questioned. Such report shall be made and signed by the winding-engine driver for each period of charge;

16.81.3 any special instructions involving the safety of persons given to the winding-engine driver and the time such instructions were given. Such entry shall be signed by the person giving the instruction and shall be countersigned by the winding-engine driver; and

16.81.4 any warning given in terms of regulation 16.55 and the time such warning was given.

16.82 The entries in the Drivers' Log Book shall be scrutinised and countersigned daily by the persons appointed to carry out the duties specified in regulation 16.74. The duplicate shall be scrutinised and countersigned within 24 hours by the person appointed in terms of regulation 2.13.1, 2.13.2 or 2.13.3, and shall be retained by him for at least 30 days.

WINDING-ENGINE DRIVERS.

Winding-engine driver to have certificate.

16.83 No person shall drive or be permitted to drive any winding engine for which a permit has been granted in terms of regulation 16.2, or any other winding engine while it is being used for the conveyance of persons, unless he is the holder of a winding-engine driver's certificate, issued in terms of these regulations, provided that a learner winding-engine driver may drive a winding engine for which a permit has been granted in terms of regulation 16.2 under the immediate supervision of a certificated winding-engine driver while persons are not being conveyed.

Record of certificate to be kept.

16.84 Upon engaging a winding-engine driver, who is required in terms of regulation 16.83 to be the holder of a certificate, the manager shall record or cause to be recorded the number and type of such certificate.

Driver not to be distracted.

16.85 No person shall speak to or in any way distract the attention of the person operating a winding engine while it is in motion, except a person in authority, and then only in cases of necessity or emergency.

16.86 The driver of a winding engine—

When driver may start engine.

16.86.1 shall not start his engine before he has received a distinct and proper signal to do so, unless he has been instructed to do so by the manager, the mine overseer or the person appointed in terms of regulation 2.13.1, 2.13.2 or 2.13.3, or unless he has received the "clear signal" 2 pause 2, or unless he has sole control of the cage, skip or other means of conveyance;

Action on signal.

16.86.2 shall not act on any signal if he has been unable to do so within one minute after receiving it, but shall await a fresh signal: Provided that for the "clear signal" 2 pause 2, he may move his engine at his discretion at any time during his shift, but if a period of more than 5 minutes has elapsed since receiving such clear signal he shall move away the conveyance slowly;

Control of speed.

16.86.3 shall not run such engine at a greater speed than that fixed by the Inspector of Machinery;

Avoidance of shocks.

16.86.4 shall, except in the case of emergency, avoid shocks in starting, in running and in stopping the said engine;

Prevention of overwinds.

16.86.5 shall apply correctly every device and means at his disposal to prevent the conveyance over-running—

(*a*) the signalled destination, or

(*b*) when the destination is not signalled, the highest or lowest landing place when persons are being conveyed and the highest or lowest established stopping place when persons are not being conveyed,

to an extent which may endanger the safety of persons or may cause damage to the winding equipment;

Moving in wrong direction.

16.86.6 shall apply correctly every device and means at his disposal to prevent the conveyance moving in a direction opposite to that signalled;

Pause before starting.

16.86.7 shall not start his engine until the expiry of at least 10 seconds after receiving a signal to raise or lower persons: Provided that this requirement shall not apply when blasting is about to take place in a shaft or winze in the course of being sunk;

Response to call-bell signal.

16.86.8 shall not act in response to any signal on the call-bell system other than the one long ring referred to in regulation 16.45;

Unclutching of drum.

16.86.9 shall not unclutch a drum of his engine until he has assured himself immediately beforehand by testing the brake of the drum against sufficient power of the engine that the brake is in proper condition to hold the load suspended from the said drum;

Lowering on unclutched drum prohibited.

16.86.10 shall when a drum of his engine is unclutched, use the brake only for the purpose of maintaining such drum stationary. Lowering from an unclutched drum shall not be permitted;

Testing of friction clutch.

16.86.11 shall when such engine is fitted with a friction clutch, test the holding power of the clutch after engaging the clutch and before releasing the brake of the corresponding drum. For a steam engine or an air engine the test shall be made against the full power of the engine, and for an electric engine against the normal starting current, while the brake of the other drum is kept off;

When clutching prohibited.

16.86.12 shall not perform clutching operations while persons are in either of the conveyances operated by his engine;

[1]**16.86.13** *shall not, unless he intends operating the winding engine on single drum during shaft examination, shaft repairs or shaft sinking operations, give the signal that clutching operations are completed until he has engaged the clutch and has securely locked it and where applicable has carried out the test prescribed in regulation* 16.86.11; *and*

Duration of shift.

16.86.14 shall not work nor shall be caused or permitted to work a longer shift on the winding engine than 10 hours, except where permission has been obtained from the Inspector of Machinery and under such conditions as he may direct.

BANKSMEN AND ONSETTERS.

Interference with signalling arrangement.

16.87 No unauthorised person shall give any signal other than an accident signal, or shall in any manner whatsoever interfere with the signalling arrangements provided for winding operations.

1. Substituted by G.N. No. R. 2101 dd. 15.11.1974.

Appointment of onsetter.

16.88 No person shall be permitted to carry out the duties of a banksman or onsetter unless he is the holder of an onsetter's certificate issued in accordance with these regulations. Every appointment of a banksman or onsetter shall be made in writing by the manager.

Who may give signals.

16.89.1 No person, other than the banksman or onsetter on duty, shall give or shall be caused or permitted to give any signals for the raising or lowering of persons provided that—

(*a*) when the banksman or onsetter is not available, a responsible scheduled person to whom the manager has given written permission to do so may give signals for the conveyance of himself and of any person travelling with him,

(*b*) the ganger or miner in charge at the bottom of a shaft or winze in the course of being sunk or a person acting under his immediate supervision may give a signal to raise persons, and

(*c*) any person duly authorised in writing by the manager or mine overseer may give signals for the conveyance of persons between the main mineral loading station at the bottom of a vertical or inclined shaft and the lowest landing station for persons.

The Inspector of Mines shall be furnished on demand with a list of the persons to whom permission has been granted in terms of paragraph (*a*) above and may order its revision.

16.89.2 No person other than the banksman or onsetter on duty shall give any signal for the raising or lowering of material or mineral unless duly authorised by the manager or mine overseer. Where the winding plant is also used for the conveyance of persons, such authorisation shall be in writing.

Onsetter to have knowledge of shaft operations.

16.90 No person shall be appointed as a banksman or onsetter, nor shall any person be authorised to give signals, unless such person has sufficient knowledge of the shaft operations and of the signals to be given in connection with such operations.

Special duties of onsetters.

16.91 The banksman, onsetter or other person authorised to give signals for winding operations—

16.91.1 shall not, after the winding-engine driver has signalled that persons may enter the conveyance for the purpose of travelling or that persons in the conveyance may continue to travel, give any signal on the signalling arrangements for that winding compartment until all persons are properly placed in the conveyance and the doors or gates of the conveyance and the gates or barriers at the bank, station or landing platform are properly shut: Provided that when the banksman, onsetter or other person authorised to give signals intends to travel, such doors, gates or barriers as will prevent his entrance to the conveyance may be left open until he has given the signal to raise or lower and has entered the conveyance;

16.91.2 shall not, when the conveyance containing persons is brought to rest in the proper position at the bank, station or landing platform and the winding-engine driver has signalled that persons may leave the conveyance, give any signal on the signalling arrangements for that winding compartment until all persons who are to leave the conveyance are out and clear of it.

The provisions of regulations 16.91.1 and 16.91.2 shall not be taken to prohibit the giving of the "accident to shaft" signal;

16.91.3 shall ensure that the roof, cover or hood, required to be provided in terms of regulations 16.11 to 16.14 inclusive, is properly in position before persons are raised or lowered in or on such conveyance;

16.91.4 shall take all reasonable measures to prevent persons from having unauthorised access to the conveyance and to the winding compartments;

16.91.5 shall not allow any person to travel in a conveyance operated by a winding engine if such conveyance contains mineral and, except as is provided for in regulation 16.62, shall not allow any person to travel in a conveyance operated by a winding engine that is being used simultaneously for the winding of mineral;

16.91.6 shall not, except as is provided for in regulations 16.63 and 16.65, allow any person to travel in a conveyance operated by a winding engine that is being used simultaneously for the winding of material;

16.91.7 shall not, except as provided for in regulation 16.67, allow any person to ride on the roof, top, side, bow, rim, bridle or frame of or in any position outside a conveyance operated by a winding engine;

16.91.8 shall acquaint himself with the maximum number of persons authorised by the Inspector of Machinery to travel at any one time in the cage and on each deck of the cage, or in the skip or other means of conveyance and shall not allow such maximum to be exceeded;

16.91.9 shall not allow any unauthorised person to give signals on the signalling arrangements used in connection with winding operations;

16.91.10 shall not give the "clear signal" 2 pause 2 or any signal to raise or lower the conveyance unless all persons at the bank, station, landing platform, loading box or other place where he is in charge, are in a position in which they will not be endangered by the movement of such conveyance or any other conveyance operated by the same winding engine;

16.91.11 shall not give a signal to clutch unless all persons are out of and clear of the conveyance or conveyances operated by the winding engine;

16.91.12 shall not cause or permit any person to enter or have access to the conveyance or conveyances until he has received a signal from the winding-engine driver that clutching operations are completed; and

16.91.13 shall take all reasonable measures to safeguard against accident all persons at the place where he is in charge, whether such persons are under his direct supervision or not.

NOTICES REQUIRED AT WINDING PLANTS.

16.92 Where a winding plant is used the following shall be kept posted up:—

16.92.1 At each winding engine—

(*a*) a copy of the permit issued in terms of regulation 16.2; and

(*b*) the code of signals and any special signals.

16.92.2 At each bank, station or landing platform—

(*a*) a notice showing clearly the maximum number of persons permitted to ride in each conveyance, or a notice prohibiting the conveyance of persons where the Inspector of Machinery has not granted permission for the conveyance of persons; and

(*b*) the code of signals and any special signals.

REQUIREMENTS AT SHAFTS BEING SUNK.

16.93 In addition to the provisions of the foregoing regulations, the following provisions shall apply to any winding plant used at any shaft in the course of being sunk:—

Speed through stage.

16.93.1 The winding-engine driver shall control the speed of the winding engine in such manner as to ensure that when any bucket or other means of conveyance is approaching or passing through the stage, or the covering provided in accordance with the requirements of regulation 16.93.4, it does so slowly and safely and that the crosshead is picked up or released, as the case may be, without shock.

Stopping above shaft bottom.

16.93.2 The bucket or other means of conveyance shall not be lowered directly to the bottom of the shaft if men are there present but shall be stopped by the winding-engine driver at least *five metres* above the bottom and shall not be lowered further until the signal has been given by one of the sinkers thereat.

Guides in vertical shafts.

16.93.3 In a vertical shaft where sets are used to support the guides, guides for conveyances shall extend down to the lowest set which shall not be more than 15 *metres* from the bottom and when winding is being done to the bottom the crosshead shall travel to the lowest set but one. In a vertical shaft where the guides are not supported by sets, the guides for conveyances shall extend down to 30 *metres* or less from the bottom, and when winding is being done to the bottom the crosshead shall travel to as near the end of the guides as is practicable.

Protective cover.

16.93.4 No person shall work or be caused or permitted to work at the bottom of the shaft unless protected by an adequate covering extending over the whole area of such shaft, sufficient space only being left therein for the passage of any bucket, skip or other means of conveyance. In a vertical shaft such covering shall be situated not more than 25 *metres* from the bottom. In an inclined shaft such covering shall be situated not more than 30 *metres* from the bottom.

Access to conveyance.

16.93.5 No person shall enter the conveyance at the bottom of the shaft until such conveyance has been raised and lowered or until some other distinct signal has been received from the winding-engine driver.

Signal when blasting.

16.93.6 The person in charge of blasting operations shall notify the winding-engine driver by a special signal, namely 5 knocks or rings, when blasting is about to take place, and, except in the case of firing by electricity, the driver shall reply by raising and lowering the conveyance *approximately two metres.*

SMALL WINDING PLANTS.

Permit not required.

16.94 The permit mentioned in regulation 16.2 shall not be required for a winding plant that is driven by an engine or motor developing not more than 100 *kilowatt*, provided that such winding plant—

[1]**16.94.1** *is not used for the raising or lowering of persons other than persons engaged in repairing or examining a shaft or winze; and*

16.94.2 does not operate in any portion of a shaft or winze in any manner likely to interfere with the conveyance or conveyances operated in that shaft or winze served by a winding plant for which permission in terms of regulation 16.2 has been granted.

Regulations not applicable.

16.95 The winding plant referred to in regulation 16.94 shall not be subject to the provisions of regulations 16.5.1, 16.5.2, 16.7, 16.9 to 16.15 inclusive, 16.18, 16.19, 16.24 to 16.29 inclusive, 16.41.1, 16.41.2, 16.49.1, 16.58 to 16.61 inclusive, 16.74, 16.75 and 16.81: Provided that the manager or subordinate manager appointed in terms of regulation 2.6.1 shall appoint in writing some competent scheduled person or persons to carry out the duties and examinations prescribed in regulation 16.74 and provided further that the person appointed in terms of regulation 2.13.1, 2.13.2 or 2.13.3 shall appoint in writing some competent scheduled person or persons whose duty it shall be to examine carefully at least once in each week the items specified in regulation 16.74.1. Notwithstanding the provisions or regulations 16.78 and 16.79, a Small Hoist Record Book or card index system may be provided in place of the Machinery Record Book.

Competency of driver.

16.96 The person appointed in terms of regulation 2.13.1, 2.13.2 or 2.13.3 shall satisfy himself that any person required to drive a winding engine referred to in regulation 16.94 is competent to do so.

Prospecting shafts, scrapers and lifting machines.

16.97 The provisions of regulations 16.2 and 16.3 shall not apply to any prospecting shaft or winze where the length of wind does not exceed 30 *metres* and where winding is done by manual or animal power or to any hoist or winch used for the scraper cleaning of broken ground or to any lifting machine or lifting tackle.

LIFTING MACHINE AND LIFTING TACKLE.

Use of lifting machines.

16.98 No lifting machine or lifting tackle shall be used unless—

16.98.1 it is of good construction, sound material, adequate strength and free from any patent defect;

16.98.2 it is so used that the safety of persons is not endangered;

1. Substituted by G.N. No. R. 2101 dd. 15.11.1974.

16.98.3 it is provided, where practicable, with a brake or other device which automatically prevents the inadvertent downward movement of the load when the raising effort is removed;

16.98.4 it is provided, where practicable, with a limiting device which will cut off automatically the power when the load reaches its highest safe working position; and

16.98.5 the maximum load it is designed to carry with safety is marked conspicuously and clearly on it; when the load varies with the conditions of use such as the varying angle of the jib, a table showing the maximum load for every variable condition shall be posted up in a conspicuous place easily visible to the operator: Provided that, with jib cranes, tower cranes and the like the Inspector of Machinery may require the installation and use of either visual or auditory safe-load indicators or both.

Factors of safety.

16.99 Any rope or chain forming part of a lifting machine shall have a factor of safety of at least 10 for fibre ropes and at least 6 for steel wire ropes and for chains, calculated on its static load. When the load is shared equally by 2 or more ropes or chains the factor of safety may be calculated on the sum of their breaking loads.

Suitability of rope.

16.100 A steel wire rope shall not be used on any lifting machine unless the diameter and construction of such rope are suited to the diameter of drum, pulley or sheave on which it is used.

Crank-handle.

16.101 Every windless, crab or winch operated by hand shall be fitted with a proper crank-handle for applying power. Where persons are being raised or lowered 2 such crank-handles shall be provided and at least one person shall manipulate each handle.

Hooks.

16.102 Every hook used for the lifting of loads shall be designed and proportioned, or shall be provided with a device, so that no accidental disconnection of the load can take place.

Attachment of load.

16.103 No person shall attach and no person shall cause or permit the attachment of any sling or any rope or chain to any load, lifting machine or lifting tackle unless—

16.103.1 it is so attached that no accidental disconnection can take place; and

16.103.2 the stability of the load and of the lifting machine during lifting or transportation is ensured and maintained.

Raising of persons prohibited.

16.104 No person shall be raised, lowered or transported by any lifting machine unless written permission has been obtained from the Inspector of Machinery and then only subject to such conditions as he may impose.

CHAPTER 17.

ELEVATORS.

Permission to use an elevator.

17.1.1 No elevator shall be used unless a permit for its use has been issued by the Inspector of Machinery.

17.1.2 The Inspector of Machinery shall not issue a permit to use an elevator until he has satisfied himself by actual inspection and test, to the extent practicable, that the requirements of the regulations as far as they are applicable are complied with.

UNITED KINGDOM

The Law Relating to Safety and Health in Mines and Quarries

Part 2

be the duty of the manager of every mine consisting of or comprising a shaft or staple-pit in the course of being sunk to ensure that a scheme for the systematic examination of plant at that mine made in pursuance of the said regulation seven provides for the thorough examination* at intervals not exceeding twenty-four hours of all gear by which any cradle, platform or other thing is suspended in that shaft or staple-pit.

(2) Where walling or tubbing is being carried out in a shaft or staple-pit in the course of being sunk, the manager shall make and ensure the efficient carrying out of arrangements to secure that it is thoroughly examined by a competent person appointed by him immediately before or during each shift in which work is carried out thereon, whether in the course of an inspection required by regulations or otherwise.

72. (1) Any place where a person could fall off any cradle or platform on which he works in a shaft or staple-pit in the course of being sunk shall be protected by fencing or otherwise to prevent him doing so.

(2) While any person is at work on any such cradle or platform it shall be secured to the side of the shaft or staple-pit to prevent it swinging and shall not be moved except upon the direction of the deputy for that shift or an official of the mine superior to the deputy.

(3) While any person is at work on any such cradle or platform which is constructed of two or more parts hinged together, those parts shall be securely bolted together.

73. At any shaft or staple-pit in the course of being sunk it shall be the duty of the banksman to ensure that the top of the shaft or staple-pit and any landing thereat is kept free of mineral or any other thing which might fall into that shaft or staple-pit and cause injury.

74. No engine which is not fixed shall be used for raising or lowering any person or thing in a shaft or staple-pit in the course of being sunk.

75. (1) In a shaft or staple-pit in the course of being sunk the provisions of regulations thirty-two to thirty-nine of these regulations shall not apply in relation to the determination or transmission of signals, but the following signals and no other shall be used for the purposes specified in relation thereto, that is to say—

to raise up	1
to lower down	2
to stop when in motion	1
when men are to be raised or lowered the person transmitting the signal shall transmit a preliminary signal of ..	3.

(2) In relation to any shaft or staple-pit in the course of being sunk the manager may determine a signal to be transmitted to give any indication (other than one for which a signal is specified in this regulation) and no person shall transmit any signal which is not so specified or determined.

*No. 14 of the Mechanics and Electricians Regulations 1965, requires reports to be made on these examinations. The appropriate form is M. & Q. Form No. 282.

(3) No person other than the banksman, an official of the mine or a person authorised in writing by the manager to transmit such signals shall transmit any signal in any shaft or staple-pit in the course of being sunk.

76. (1) When anything is to be raised or lowered in any kibble through any shaft or staple-pit in the course of being sunk, it shall be the duty of the deputy for that shift or the banksman or other person authorised to transmit signals in relation thereto, as the case may be, to ensure that it is properly loaded and in particular that—

(*a*) no mineral* projects above the rim;

(*b*) tools, equipment or other materials for use or used in the mine are not loaded together with mineral;

(*c*) when things which project above the rim are carried, they are securely fastened to the bow or chains supporting the kibble;

(*d*) nothing capable of causing injury is adhering to the outside of the kibble;

(*e*) when the kibble is being raised, it is in line with the pulleys and carefully steadied.

(2) When anything is to be lowered otherwise than in a kibble through a shaft or staple-pit in the course of being sunk, it shall be the duty of the banksman or other person authorised to transmit signals in relation thereto to ensure that it is safely slung.

77. No person shall ride on the edge of a kibble when being raised or lowered thereby.

78. The person operating any winding apparatus at a shaft or staple-pit in the course of being sunk—

(*a*) when lowering the kibble, shall stop it eighteen feet above the point to which it is being lowered and shall not lower it further until he has received another signal to lower down;

(*b*) when raising the kibble, shall stop it four feet above the point from which it is being raised and shall not raise it further until he has received another signal to raise up.

79. If a shaft or staple-pit is being sunk through any rock or stratum containing or likely to contain water (whether dispersed or in natural cavities) there shall be provided and maintained as a means of escape from the bottom of the shaft or staple-pit to the surface or to some other place of safety, in any case in which more than ten persons are employed below ground at any one time, at least four ladders and, in any other case, at least two ladders.

PART XIII

Miscellaneous provisions

Provision of means of telephonic communication

80. (1) Where in any mine vehicles can be moved by means of rope haulage apparatus or locomotives from a point at or near an entrance to a shaft or

*As defined in Section 182 (1) of the 1954 Act.