A mining research contract report

OCTOBER 1982

BELT CONVEYOR MAINTENANCE AND INSTALLATION PROCEDURES

Contract J0215004

Management Engineers Incorporated

BUREAU OF MINES
UNITED STATES DEPARTMENT OF THE INTERIOR

BELT CONVEYOR MAINTENANCE

AND INSTALLATION PROCEDURES

VOL. I—FINAL REPORT

Contract No. J0215004

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The final report contains a summary of the work performed under this contract. In addition to the report itself, other products were derived from this effort. Several hardware items were prototyped for use with underground belt conveyors, and a manual for installation and maintenance procedures was developed and published under separate cover. Recommendations have been included for implementation of the tools and the manual on an industry-wide basis.

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FOREWORD

This report was prepared by Management Engineers Incorporated (MEI), Reston, Virginia, under USBM Contract number JO215004. It was administered under the technical direction of the Spokane Research Center with Theodore J. Williams acting as Technical Project Officer. David Askin was the Contract Administrator for the Bureau of Mines. This report is a summary of the work recently completed as a part of this contract during the period January 2, 1981 to October 1982. This report was submitted by the author on September 30, 1982.

The final report is only one product resulting from this contract. Other products are an installation and maintenance manual (published under separate cover) and several hardware items prototyped for use with underground belt conveyors.

Daniel Walton was the MEI Project Director, and Svend B. Rondum was the principal investigator and Project Manager for MEI. A heavy amount of attentive and superior editing was provided by Sandra Hoybach, whose valued contribution through professional devotion to excellence is truly appreciated by the author. Other MEI contributors were Peter Kauffman and George Little. Clerical support was cheerfully and competently provided by Pat Arnold, Cathy Mack, and Janine Wright.

Grateful appreciation is extended to the many equipment manufacturers and mining companies that contributed to this report, particularly those mining companies that gave generously of their time for detailed discussions and underground visits.

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ILLUSTRATIONS

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INTRODUCTION

Project Objectives

The underlying objective of this project was improving safety during the installation and operation of belt conveyors in underground coal mines. This was to be accomplished through the development of a comprehensive installation and maintenance manual and through creation of innovative and unique hardware--both of which should measurably reduce conveyor-related accidents.

Scope of Work

The scope of work covered activities in four major areas:

- data collection and analysis
- accident analysis
- hardware development
- preparation of a manual for installation and maintenance procedures

The collection of data from mine companies and manufacturers included on-site visits as well as a mail survey. Analysis activity was directed at developing an understanding of currently used safety practices related to underground coal mine belt conveyors and formulating better safety practices. This activity led to the development of design criteria upon which both the hardware and procedures manual were based. Hardware development consisted of the conceptualization of new and unique solutions to existing problems followed by the successful design, fabrication, and in-mine testing of prototypes. On-site observations and in-depth discussions with all levels of mine personnel together with information from equipment manufacturers helped provide the necessary background for the conceptualization of the procedures manual.

Final Report Structure

The specific purpose of this report is to provide the reader with a clear and concise understanding of the results of the project and the methods used to obtain them. To that end, the report has been structured logically to facilitate rapid comprehension of the project highlights and then to further provide sufficent supportive detail to ensure that the desired levels of confidence have been attained. The report has been organized in four parts. The first section outlines the project's goals; the results are highlighted in the second section. The third section provides recommendations for future action, and the final section presents the derivation of the results.

SUMMARY

Results

The intent of this summary is to provide the reader with a succinct presentation of the cardinal results of this project. These findings, for use in the installation and maintenance of conveyor systems, are outlined below in two major areas: hardware and the manual.

Prototyped Hardware

Four items were prototyped and tested in underground coal mines. All performed successfully according to plan. The items are:

- saucer skid--to be used to assist in transporting conveyor components (see Figure 1)
- armored level--to be factory-mounted on conveyor components to help ensure level installations (see Figure 2)
- controlled load tensioning device (CLTD)--to be used to ensure uniform tension in lashings and supporting wire ropes (see Figure 3)
- turnbuckle tensioning wrench (TTW)--to be used to accurately set the tension in wire ropes and lashings (see Figure 4)

Two of the prototyped items from this project appear to have commercial potential. The TTW has a good possibility of being a viable product for use in the underground coal mining industry. It could also be applicable to other areas where wire rope is used. Management Engineers Incorporated has initiated the manufacture of 20 wrenches for test marketing.

The CLTD appears to have marketable possibilities as a substitute for the ratchet jacks used to lash some tailpiece components. Its economic viability is unclear, and there is some indication that a simplified variation of the prototyped concept might prove to be more saleable.

A power-driving system for setting belt splicing rivets was investigated but not prototyped because the analysis results became a comparison between complex, expensive, and cumbersome hardware and the cost and convenience of a common 2-pound ball peen hammer. A negative response was received from potential users for the following reasons:

- There was no significant savings in time or labor.
- There was only a questionable gain in quality.
- There was no assured improvement in safety.
- There was an increase in inconvenience because it was bulky and it required a portable power source.

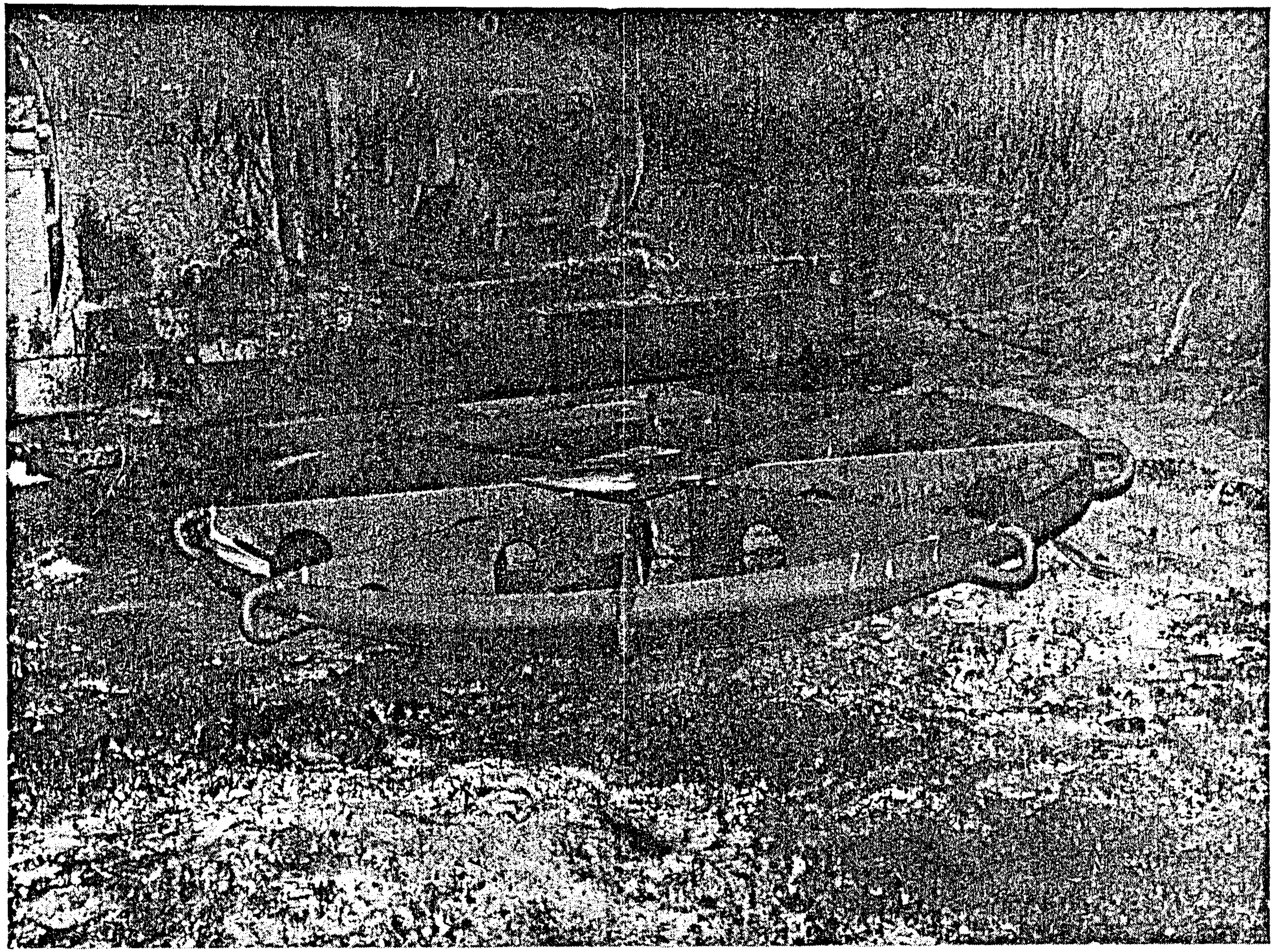


FIGURE 1. - Saucer Skid.

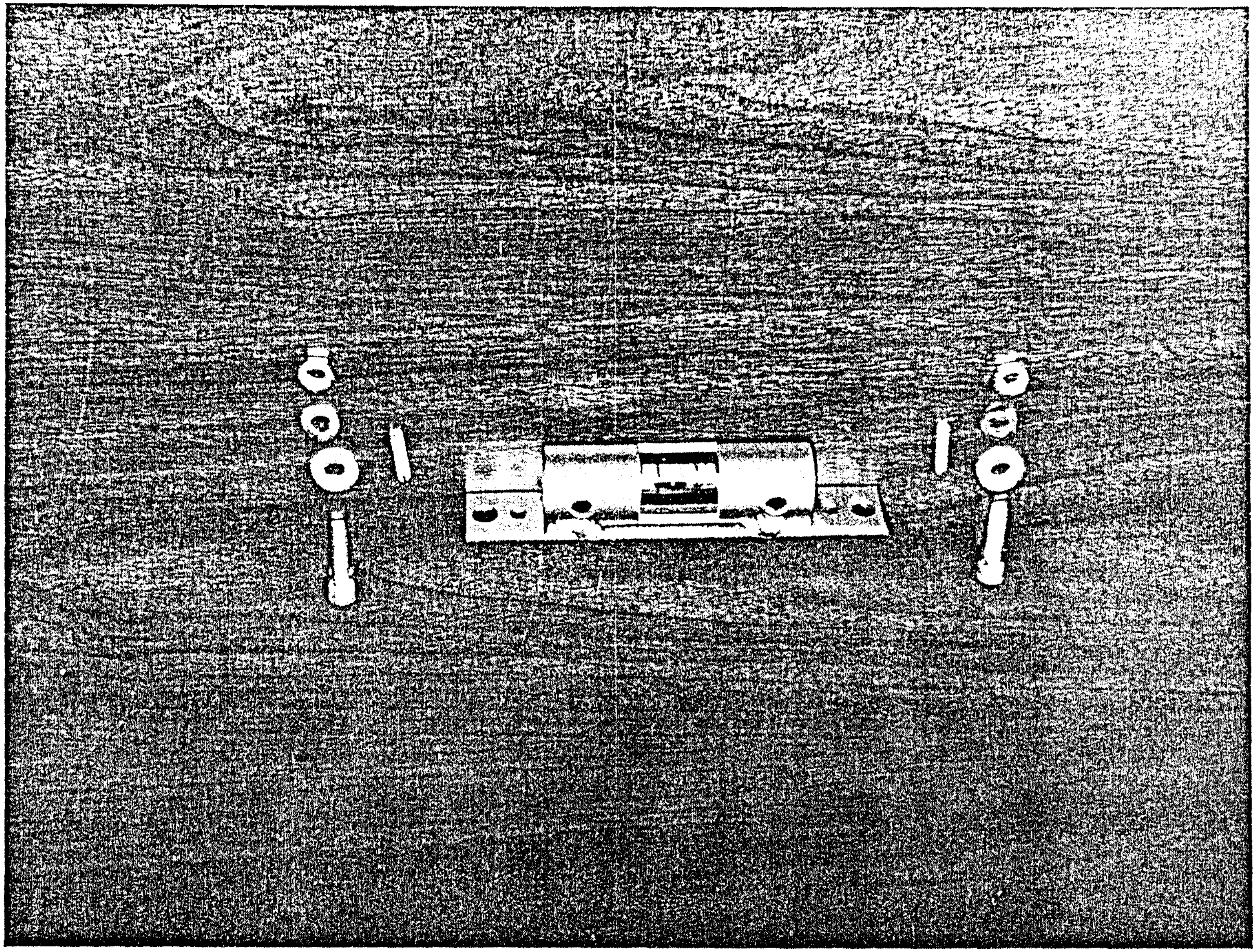


FIGURE 2. – Armored Level.

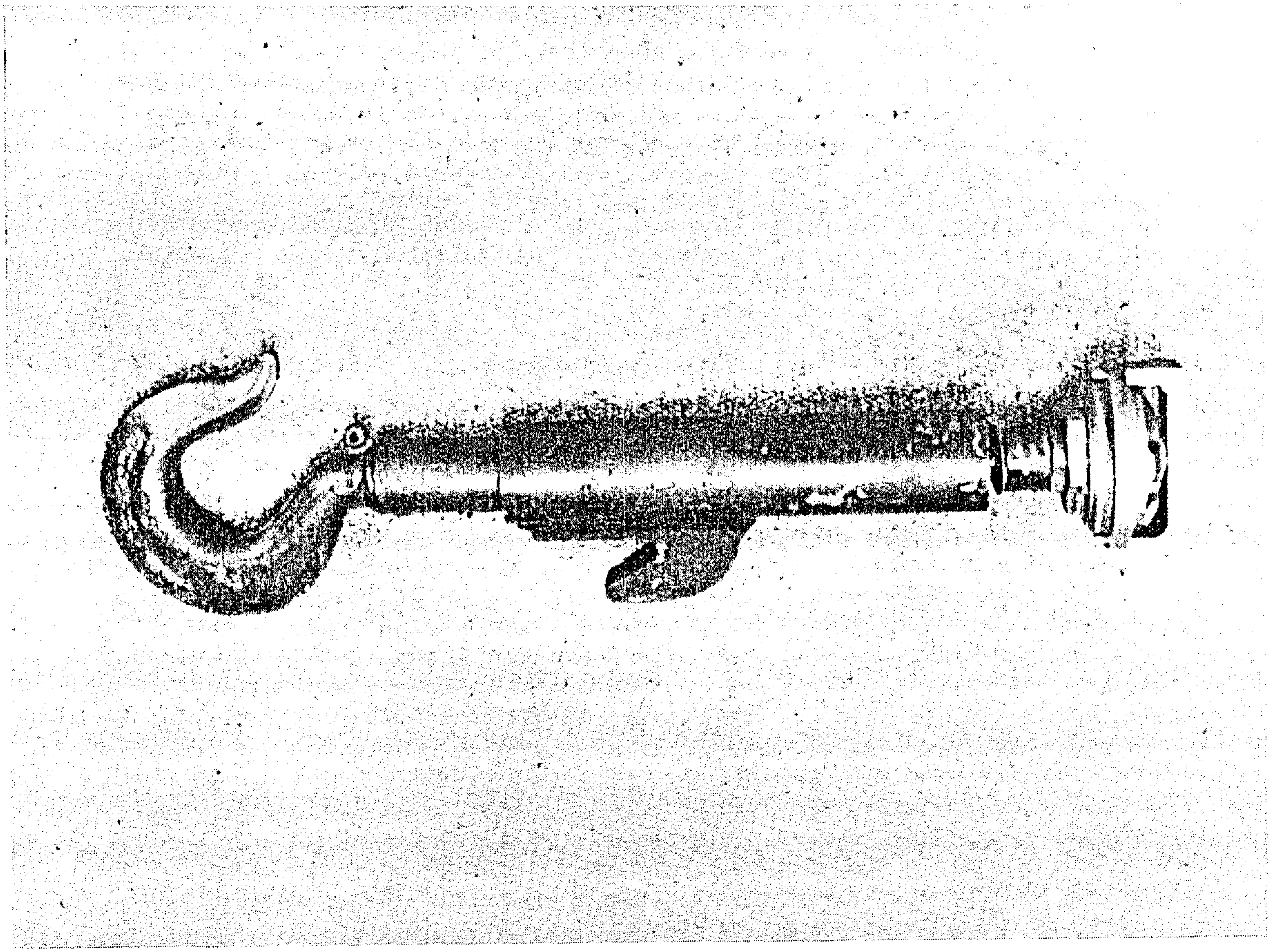


FIGURE 3. – Controlled Load Tensioning Device (CLTD).

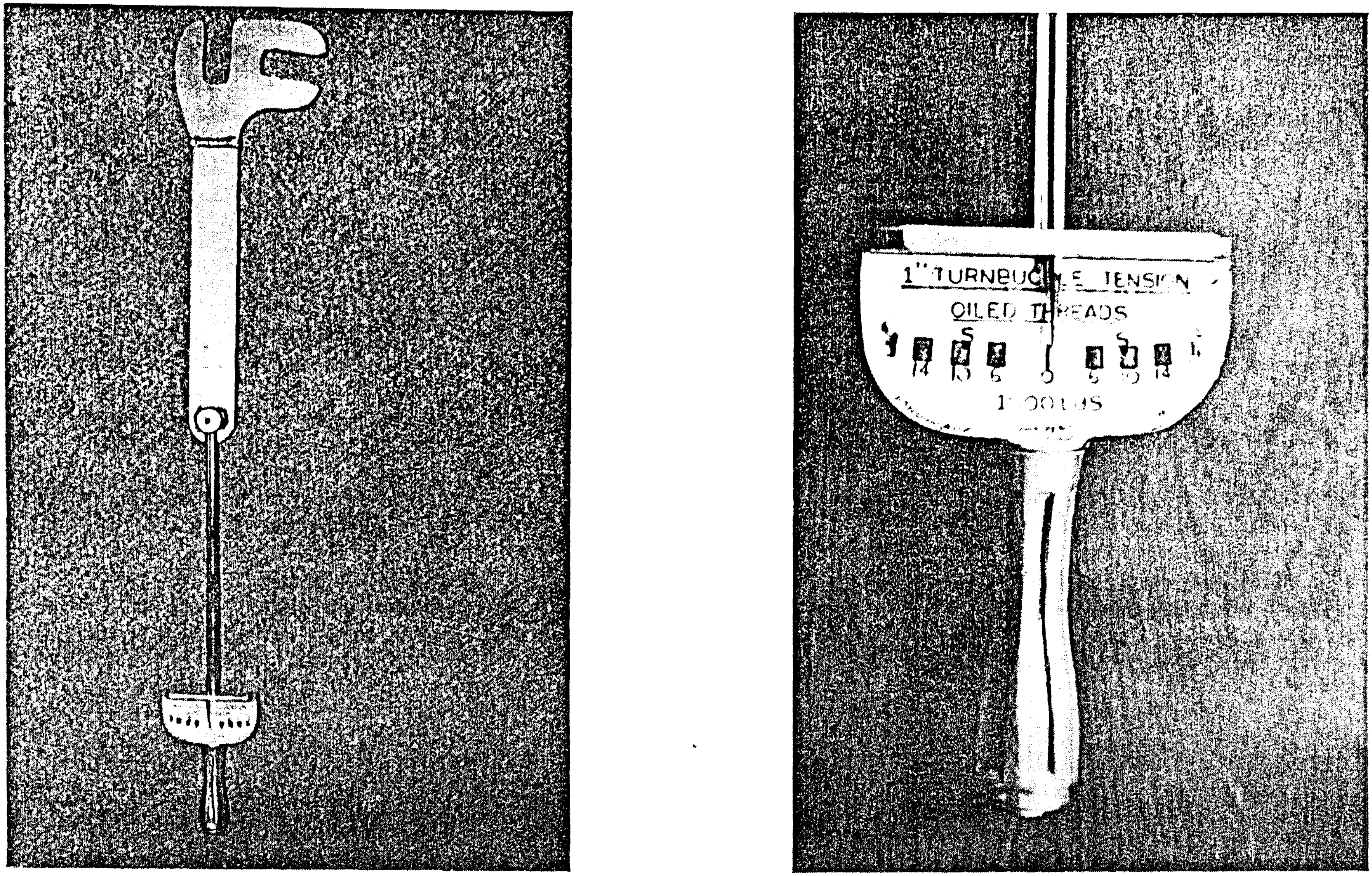


FIGURE 4. - Turnbuckle Tensioning Wrench.

Manual

A pocket-sized manual was produced titled "The Key to Safer Beltways." A copy has been included under separate cover. It is felt that the manual will prove to be very effective because:

- It emphasizes the positive aspects of safe working methods, teaching that quality produces safety.
- It utilizes cartoon characters to promote reader interest; they also can be used as theme principles for a long-term safety campaign.
- It features many illustrations that help reinforce the text.
- It is a handy size and is easy to read.

Substantiation of Results

Field Observations

The conclusions of this project are substantiated by:

- over 20 in-mine personal observations visits
- four visits to equipment makers
- information from numerous equipment suppliers
- numerous consultations with maintenance and engineering personnel

Accident Analysis

A comprehensive analysis of belt conveyor accidents was made utilizing 1978 and 1979 data. The analysis indicated that 54 percent of the conveyor accidents were related directly to installation and maintenance activities; another 15 percent were related to clean-up which is also a maintenance activity. Therefore, it can be stated that approximately 70 percent of conveyor-related accidents are due to installation and maintenance activities. The analysis also closely substantiates the selection of the items that were prototyped under this project in that the saucer skid, controlled load-tensioning device (CLTD), and armored level were ranked first, third, and fourth respectively in a list of 19 recommended ideas for reducing accidents.

As a specific indication of direct accident reduction potential, the following example is offered based on facts obtained during one specific mine visit. During the installation of tailpieces, a miner was struck in the head two different times by the ratchet handle used to operate the ratchet jacks that tighten the lashings. In both instances, the handle springback was partially due to dirt in the ratchet mechanism giving a false sense of security which caused the operator to relax his grip on the handle. The resultant injuries were not severe and only one required an accident report, but MEI feels confident that if one person experienced the handle-striking type of accident more than once, then the same accident may reasonably be expected to happen to others--possibly with different severity. The CLTD now being used on a test basis in this same mine completely eliminates the possibility of this type of accident, since the CLTD uses a ratchet socket wrench to tighten a screw which by its nature has no springback capability.

Sloppy installation and maintenance increase danger due to factors represented by, but not limited to, the following:

- material spillage due to poorly trained and loaded belts
- automatic conveyor startup without prior warning
- improper shoveling techniques
- conventional lashing of tailpieces
- poor housekeeping
- improperly made splices

Therefore, a quality installation that substantially reduces these factors will also substantially improve safety.

Hardware Testimonials

There has been positive testimonial support for the project hardware from the following sources:

- letters from mine operators
  --Safety Inspector, Brushy Creek Mine
  --Mining Engineer, Inland Steel Coal Mine #2

- verbal reports
  --various personnel from above mines
  --equipment manufacturing engineers

Manual Feedback

The manual has received positive preliminary reviews on the format, content, and reader interest from the following sources:

- management of Brushy Creek Mine
- mining engineers at Inland Steel Coal Mine #2
- mining engineering department at NERCO
- numerous other mining personnel

RECOMMENDATIONS

Management Engineers Incorporated respectfully makes the following recommendations to the U.S. Bureau of Mines with regard to the hardware, the manual, and other considerations.

Hardware Distribution

The underground coal mining industry should be informed of the advantages and benefits of using the items developed under this project--i.e., the saucer skid, controlled load tensioning device (CLTD), armored level, and the turnbuckle tensioning wrench (TTW).

Manual Media Campaign

Regarding the manual, we urge that the following steps be taken:

- Expeditiously publish the manual.
- Introduce the manual to selected mines for formalized training evaluation.
- Introduce the manual informally to another group of mines.
- Initiate a long-range safety campaign using the cartoon characters as theme principles generic to the underground coal mining industry.
- Following an introduction of the characters to the industry, produce and distribute posters of the manual cartoons that carry a stand-alone message. Examples of this type of cartoon are shown in Figures 5-11.
- Follow the posters mentioned above with posters using the rest of the cartoons from the manual.

Other Considerations

- Make a prompt and forceful effort to make it mandatory that an automatic pre-start warning system be installed on <u>all</u> belt conveyors, regardless of their location.
- Push hard to effect a fundamental policy change that will reflect recognition of real-world conditions so that situations actually experienced by mine personnel can be made safer. The following scenario is offered as the best means for explaining what is intended by the foregoing statement.

SCENE: The scene is a conveyor crossing located about midpoint from either end of a 2000-ft long conveyor. The crossing is an overhead one with only enough clearance for a person to crawl on hands and knees when traversing the horizontal portion of the crossing.

ACTION: Miner "Lumpy" approaches the crossing. He furtively glances around and seeing no one, he proceeds to grasp an idler support chain with his right hand and steps onto the supporting wire rope with his right foot. As he launches himself in an attempt to jump across the conveyor, his right foot slips and he falls onto the moving conveyor. He scrambles to grab a passing support chain and succeeds in jumping off the conveyor. In the process, he strikes his left knee against a sharp stone, severely cutting his knee as well as brusing it.

RESULT: He dutifully reports to the infirmary. When interviewed, he blandly explains that he was looking at the conveyor because something caught his eye that didn't look right, and he stumbled against a projecting stone.

GOB LICE PRODUCE LOUSY WORK. THEY ALSO CAUSE THE SHORTCUT ITCH CAUSING CARELESS FEVER WHICH TENDS TO CAUSE ACCIDENTS.

FIGURE 5. - "An Eager-Stage Gob Louse."

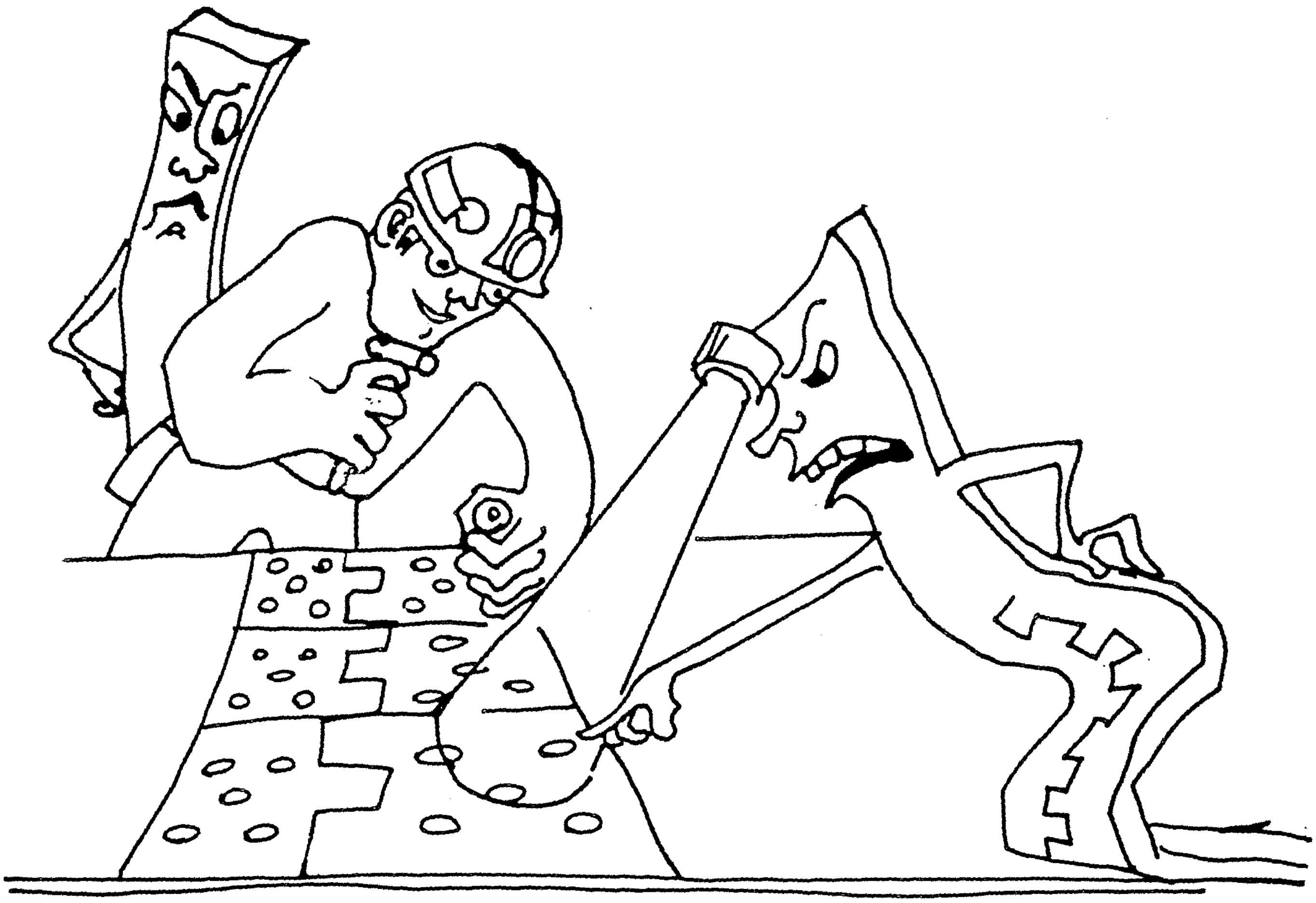
FASTER THAN A LOUSE

TOUGHER THAN A WORM

SUPER BILLY LEADS TO SAFETY

AT EVERY TURN

FIGURE 6. - "Super Billy."



GRIPE, GRIPE, GRIPE FROM THE WORM
WHEN THE RIVETS ARE TIGHT AND FIRM.

FIGURE 7. - "Griping Splice Worms."

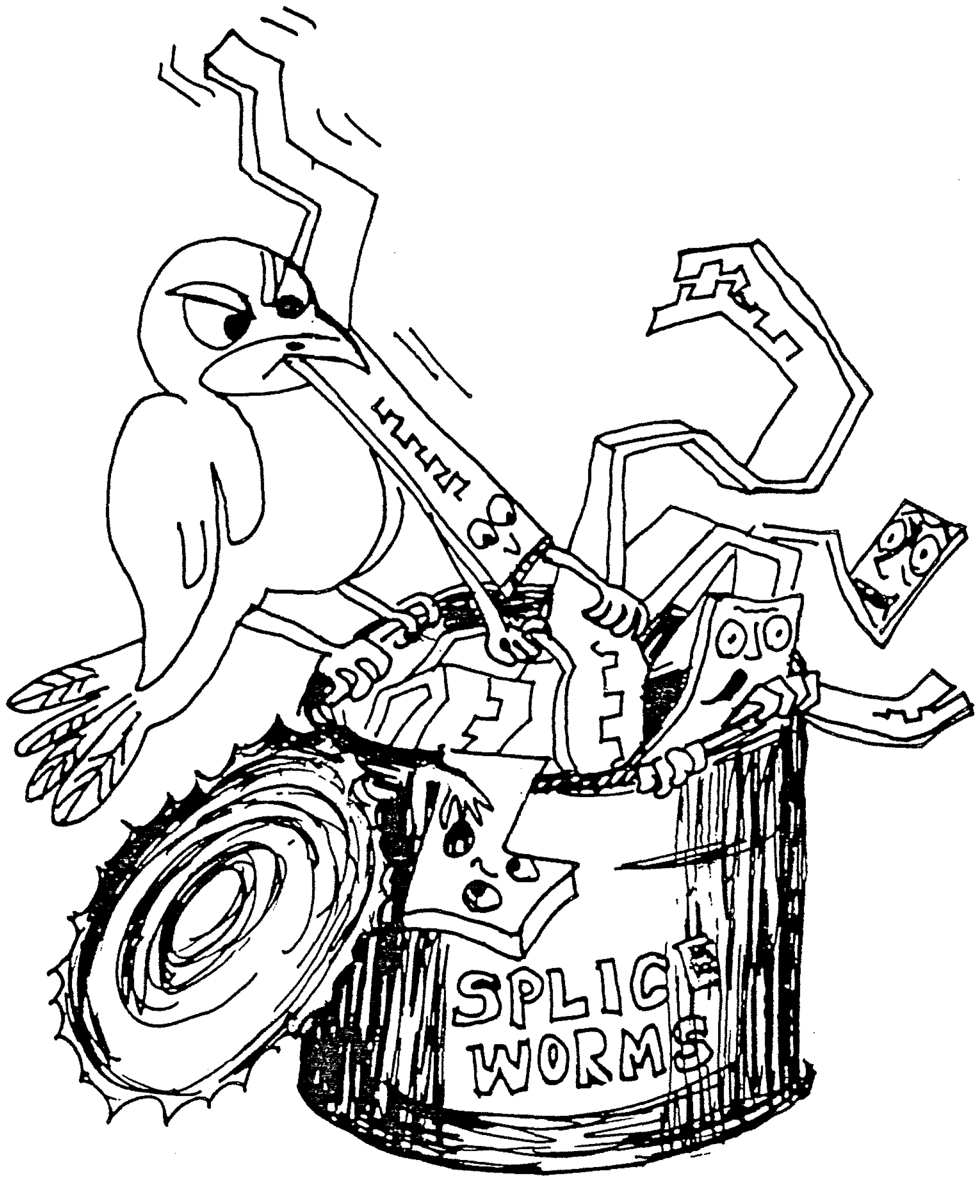
FIGURE 8. - "Proper Feedback Will Make It Take the Bath--Not You."

MAINTAIN BELT SAFETY!

CLEAN HOUSE. . . CAN THAT LOUSE.

FIGURE 9. - Example of Safety Message Cartoon

FIGURE 10. - "For Safety's Sake."



WHEN IT COMES TO MAINTENANCE,

BE AN EARLY BIRD

BUT TAKE IT ONE STEP AT A TIME!

FIGURE 11. - "Early Bird Gets the Splice Worm."

OBSERVATION: No person will report an accident to himself or a friendly co-worker that would indicate that he was in the wrong. That's a basic fact of human nature. Further, Miner "Lumpy" is not the only one who violates that particular rule at that particular crossing. This is evidenced by the lack of footprints leading to and from the stiles. Also, there are many footprints some leaving deep impressions on either side of the conveyor in close proximity to the "safe" crossing. The deep impressions are obviously due to heavy landing by a jumping person.

LESSON: The person was injured while performing an unsafe act because the means to perform the required function had been made so inconvenient that he would not use it.

SOLUTION: It is obvious that to improve safety at this type of crossing, a means for traversing the conveyor should be provided that is convenient enough that it will be used. Such a solution is illustrated in Figure 12. The stirrups provide sure footing and the handgrips give balance and support. Also, such devices would always be located on the downstream side of any low overhead obstructions.

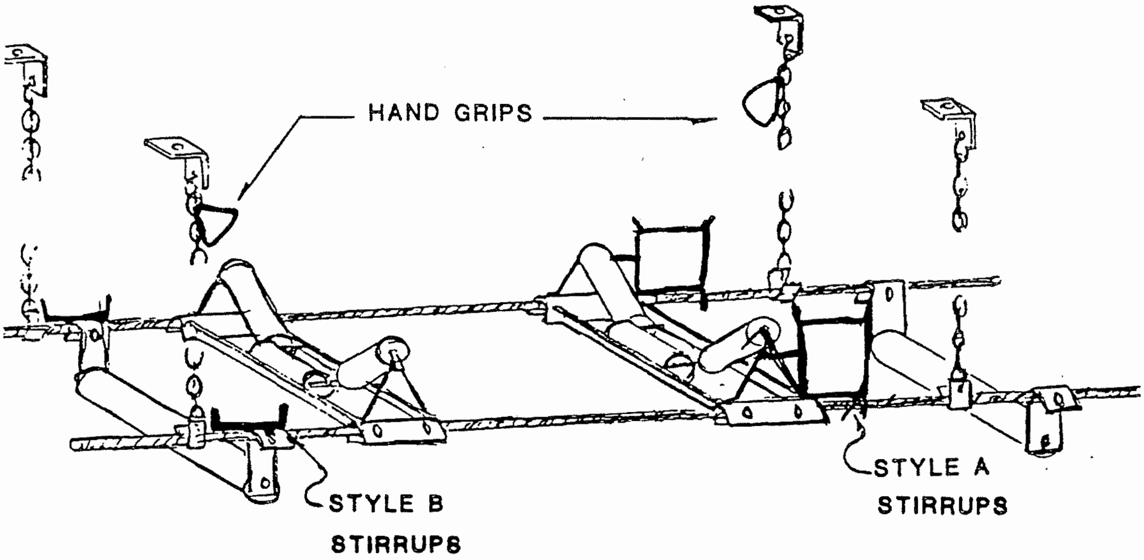
DISCUSSION: Perhaps the only way this situation can be improved is to provide the traditional, "safe" crossing in addition to the alternative solution suggested above. Liability laws being what they are, it would be unreasonable to expect that one would not provide "safe" crossing. However, with real-world conditions being what they are, one should be truly cognizant of the above-described situation and take appropriate action that will actually help reduce accidents and not tend to cause them. When the condition of underground coal mining is studied with the real-world theme in mine, many such cases can be found. Every effort should be made to recognize them and remedial solutions that are willingly accepted should be implemented.

- Make a concerted effort to sell the idea and develop a mine-friendly shovel (Figure 13) which is basically a standard long-handled, square-pointed shovel that has been redesigned to reduce back strain and to prevent the user from being pulled into machinery. This may be accomplished by the following modifications:

  - The angle of the handle with respect to the blade has been altered and a back spill barrier has been added to the blade. This permits shoveling from a standing position.

  - A "D" handle grip has been added to the top end of the handle.

  - A breakaway joint has been included in the handle to permit separation when the shovel is placed in a predetermined excessive



BELT CONVEYOR MAINTENANCE AND INSTALLATION PROCEDURES

Crossing Stirrups/Hand Grips

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FIGURE 12. - Crossing Stirrups/Hand Grips.

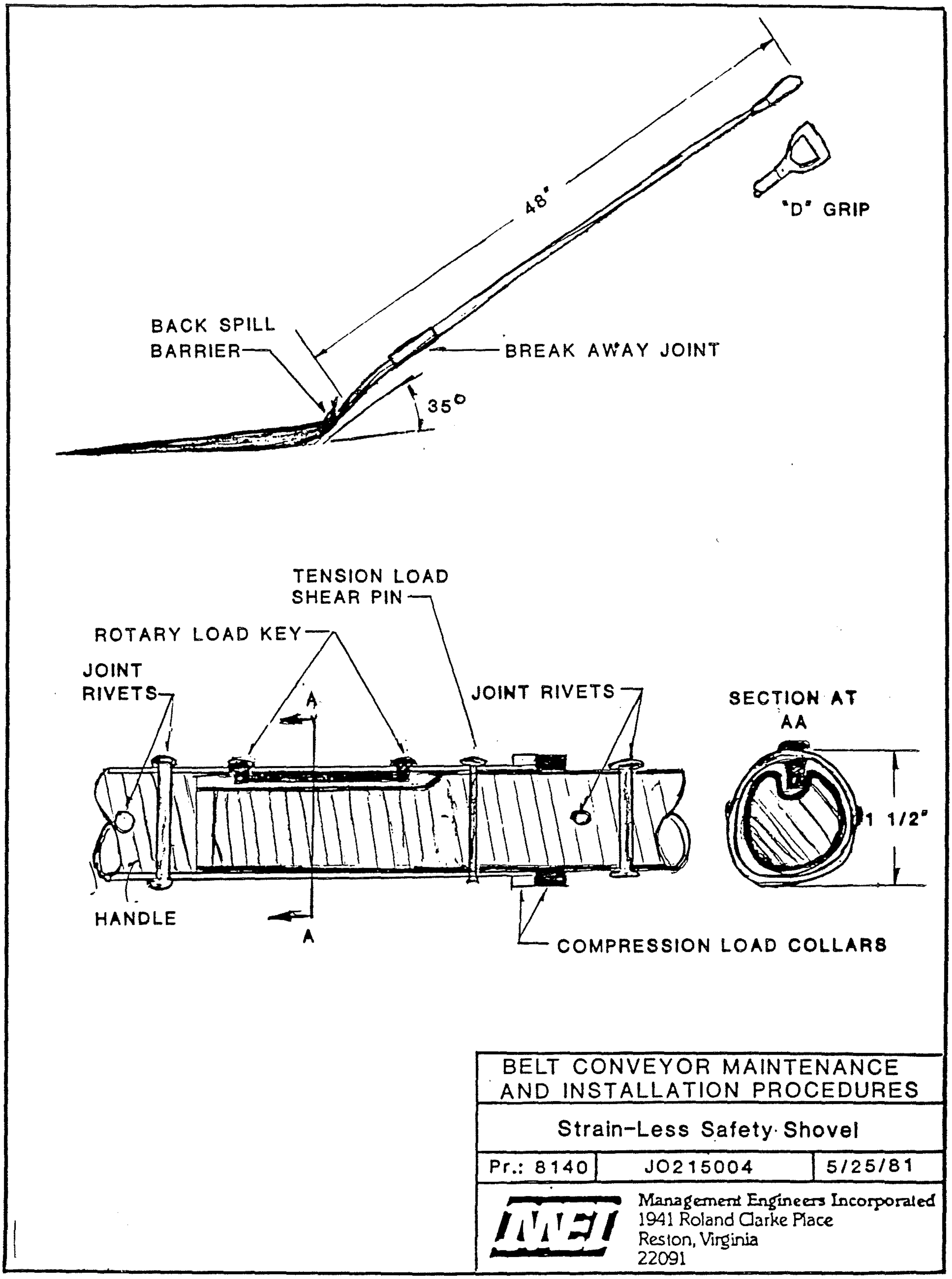


FIGURE 13. - Strain-Less Safety Shovel.

tension stress mode. This essentially is a modified standard coal shovel that will permit its user to efficiently shovel coal with little or no back bending. It also will prevent the user from being pulled into machinery by having the handle separate when the blade is captured in a pulling action piece of equipment.

- It is strongly recommended that protective clothing as described below and shown in Figures 14 and 15 be introduced attractively to the industry.

  - Safety Garment. This garment contains armored elbows, knees, and crotch and retention controlled sleeve and pants cuffs. The armor is light, flexible, shock absorbent, and puncture resistant. It is made of felt-like padding and woven nylon or kevlar mesh. Cuff control may be attained by one of several means including, but not limited to, knit wear, in-situ elastic banding, velcro, or buttons.

  - "Complete" Miner's Boot. The ultimate mining boot, in addition to steel toes and metatarsal protection, would have slip-resistant soles and heels and maximum ankle support regardless of the material from which it is made. It is anticipated that the soles would be of high friction material and properly cleated for maximum gripping and self cleaning. The built-in ankle support would be modeled after the principles used in the construction of hiking and rock climbing boots, all of which snugly encapsulate the ankle and shin bone.

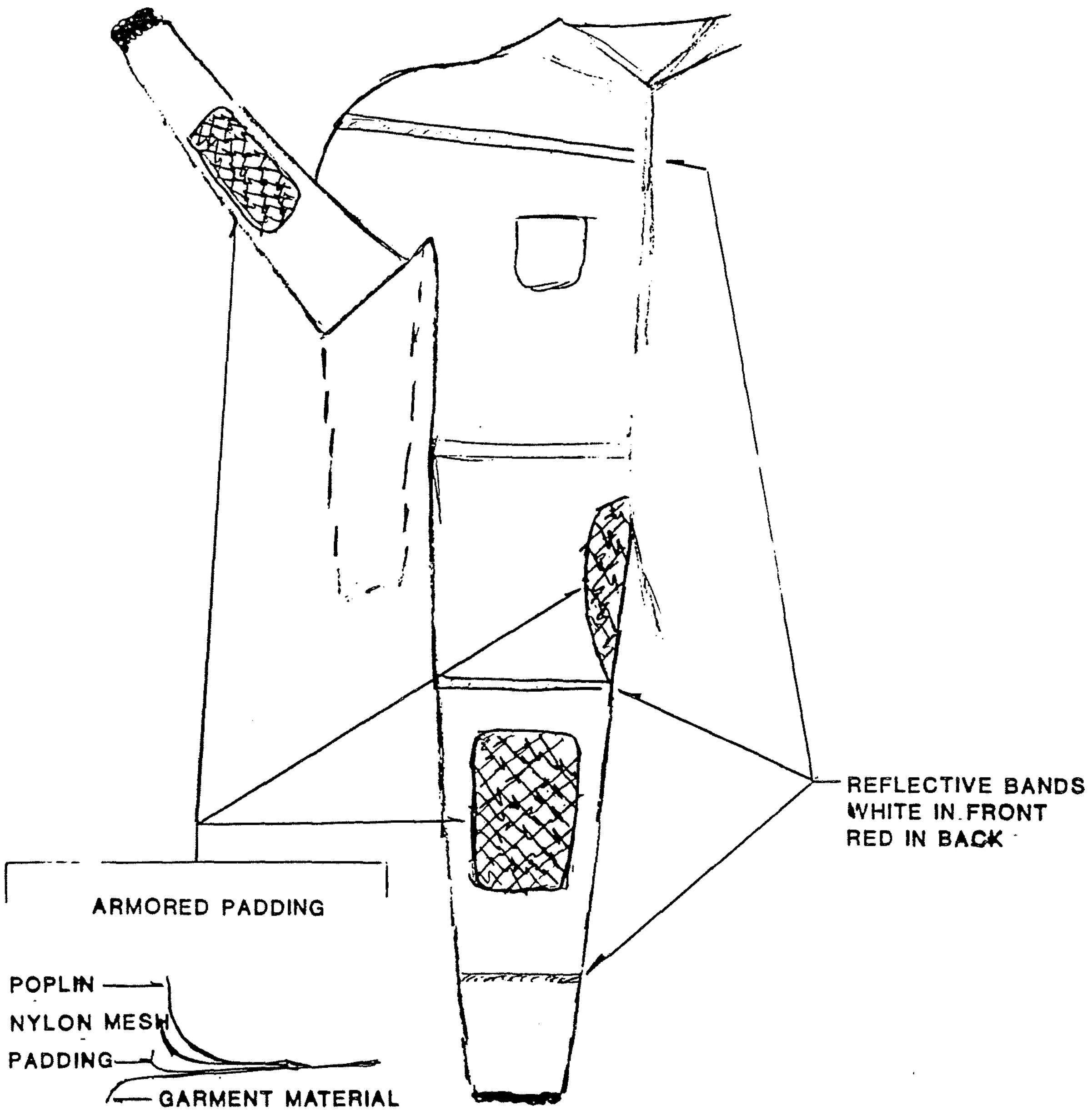
  - Exoskeleton Hard Boot. Another concept envisions an exoskeleton hard boot that will provide the necessary protection when worn over another nonsafety work shoe. These may or may not be molded plastic, formed stamped steel, or a combination of both materials.

CONDUCT OF THE STUDY

Project Organization

A project plan was developed and subsequently approved that delineated the methodology to be followed for the successful pursuit of the previously stated objectives. The plan basically divided the work into two major divisions with a total of 17 tasks. Very little modification was made to the plan during the project. One item that changed was the inclusion, as a subtask, of an in-depth accident analysis. Another inclusion, as a no-cost modification, was the investigation of power driving Flexco rivets. Two no-cost time extensions were requested and approved, extending the original 15-month contract to 18 months. These requests resulted from in-mine testing factors beyond the direct control of Management Engineers Incorporated.

The program plan was formulated with the final report in mind so that the plan's structure could easily be followed for the creation of an information base. To that end, this report merely summarizes work that is more fully detailed in appendices. These appendices are included as an integral part of the report for convenient reader reference.



BELT CONVEYOR MAINTENANCE AND INSTALLATION PROCEDURES

Protective Clothing, Garment

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FIGURE 14. - Protective Clothing, Garment.

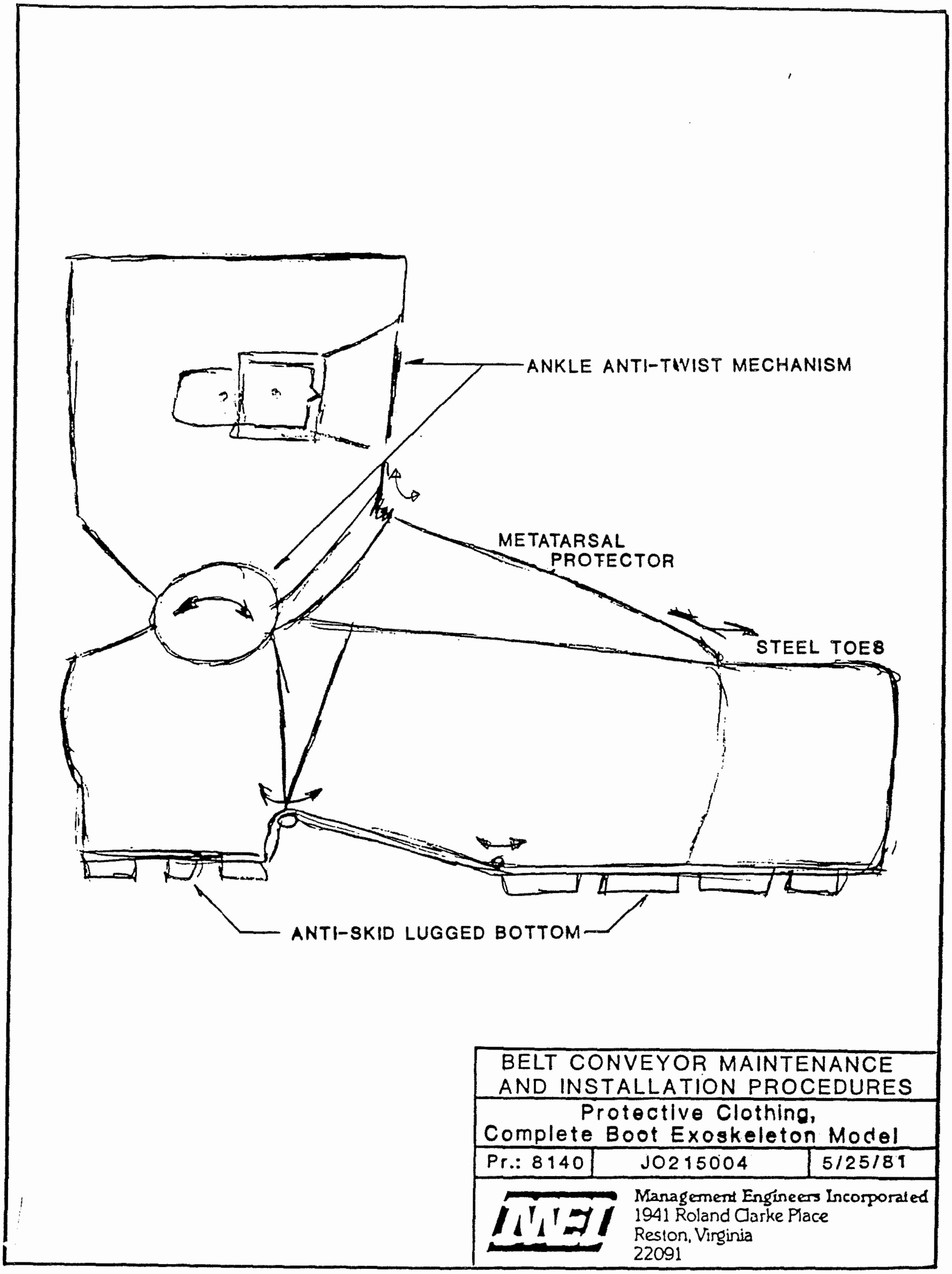


FIGURE 15. - Protective Clothing, Complete Boot, Exoskeleton Model.

Data Collection

Mine Visits

Early in the project, approximately 15 mines were contacted for the purpose of arranging visits for gathering firsthand information about conveyor activities. From this group, eight mines were selected. Mine selection criteria were size, location, type of haulage, type of operation, and cooperativeness. A list of the mines visited for this project is shown in Table 1.

TABLE 1.--Mines Visited

Mine Name	Company Name	Location	Initial Visit
Vesta #5	Jones & Laughlin Steel Corp.	California, PA	01/14/81
Blue Creek #5	Jim Walter Resources, Inc.	Brookwood, AL	02/10/81
Blue Creek #4	Jim Walter Resources, Inc.	Brookwood, AL	02/12/81
Wabash	AMAX Coal Company	Keensburg, IL	03/17/81
Brushy Creek*	Kenellis Energies	Harco, IL	03/17/81
Orient #3	Freeman United Coal Co.	Midvale, UT	03/19/81
(being planned)	Coastal States Energy Co.	Midvale, UT	04/07/81
Sunnyside #1	Kaiser Steel Company	Sunnyside, UT	04/08/81
No. 2*	Inland Steel	McLeansboro, IL	12/08/81

*Sites used for in-mine testing of project hardware.

A comprehensive checklist, shown in Figure 16, was used as a guide for gathering data pertinent to the project. Individual field trip reports and documentation were prepared at the conclusion of each trip. A small tape recorder was carried to record conversations, thus permitting the project observer to pay close heed to interviewees and the demonstrated activity or actions. Also, where more than one person was part of the investigative team, specific observational and recording assignments were given so that little or nothing escaped attention.

The wealth of knowledge gained through these visits played a key part in determining the basic philosophy of the manual and for conceptualizing the hardware to be recommended for implementation for the purposes of improving safety. Coastal States Energy Company in Midvale, Utah was visited to discuss the planning functions for a new mine and to get exposure to the conveyor engineering and operational considerations given prior to actual implementation. Of the seven other mines visited, all used track haulage for supplies with the exception of Brushy Creek which used rubber-tired service only. Even in supply track mines, a commonality exists with Brushy Creek mine in that movement from the end of the track to the ultimate end use position for conveyor components was traversed over the bare mine floor. This provided a uniformity in the problem of how to final position the equipment without undue physical strain by the persons involved. This evidence, indicating that almost all mines had a common problem, subsequently led to the conceptualization and prototyping of the saucer skid as a partial solution.

MINE VISIT DATA GATHERING CHECKLIST

1.0 IDENTIFICATION — 8140.11

Company Name ________ Date ________

Address ________ By ________

Mine Name and Location ________

Type ________

Contact Name/Title ________

Address ________

Phone (____) ________

2.0 CONVEYOR SYSTEM

Item	Type					Remarks
	Panel	Main Haul	Slope	Other	Mfg.	
2.1 Installation						
2.1.1 Initial						
2.1.2 Teardown						
2.1.3 Move						
2.2 Maintenance						
2.1.1 Routine						
• Lube						
• Other						
2.2.2 Preventive						
• Planned						
• Unplanned						

7.0 Downtime:

7.1 Average ________

7.2 Condition, System/Components ________

____

8.0 Transfers

8.1 Quantity ________

8.2 Performance ________

9.0 Mine Environment

9.1 Entry Size(s) ________

9.2 Clearance(s) Typ. ________

9.3 Temperature(s) Max ________ °F Min ________ °F

10.0 Ratio Feeders

10.1 Method(s) ________

10.2 Type(s) ________

11.0 Low Seam Constraints

11.1 Installation ________

11.2 Inspection/Maintenance ________

12.0 Procedures/Schedules

12.1 Installation ________

12.2 Maintenance ________

12.3 Training (skills) ________

13.0 Safety Features

13.1 Fire (Warning/Quench) ________

2.3 Emergency ________

2.4 Belt Alignment ________

2.5 Grade of belt entry ________

3.0 Conveyor Specifications

3.1 Belt

W ______ L ______ SPEED ______ LOAD CAP. ______

3.2 Trough Idler

Angle ______ Spacing ______ Type ______

3.3 Drive

Type ______ Power Reqmt ______

3.4 Takeup

Type(s) ________

3.5 Cleaner/Scraper

Type(s) ________

3.6 Supports

Type(s) ______ Spacing(s) ______

4.0 System General Arrangements: (dwg/sk includes)

Drive(s) ____ Tailpiece(s) ____ Takeup(s) ____ Idlers ____

Frame Style(s) ____ Belting ____ Feeder(s) ____ Loading point(s) ____

5.0 Surge Bins, in-line:

____

6.0 Skirting, method(s)/type(s):

____

13.2 Guards ________

13.3 Overload ________

13.4 Claxon/Beacon ________

13.5 Other ________

14.0 Hazardous Conditions (conditions meeting FMSA; noncompliance)

____

____

____

____

15.0 Mine Peculiar Item (nongeneric)

____

____

16.0 Accident Data Related to Conveyor Activity

16.1 Fatalities ________

____

16.2 Lost Time Accidents ________

____

____

16.3 Other Accidents ________

____

____

FIGURE 16. - Mine Visit Data Gathering Checklist.

Equipment Information

Approximately 25 suppliers of conveyor systems and components were contacted requesting catalog literature, installation and maintenance manuals, and other miscellaneous information that might benefit the project. The larger, total system manufacturers readily responded and offered complete cooperation. Two companies offered their facilities for visitation to review their operations and discuss the project further. These companies were the Jeffrey Manufacturing Division of Dresser Industries, Inc. in Belleville, South Carolina and the Continental Conveyor Company in Winfield, Alabama. It was interesting to note that each used a different method for manufacturing idler rollers. Jeffrey personnel proved to be especially cooperative and indicated that they would be willing to participate later in the project if conditions warranted. This subsequently proved to be the case when Jeffrey mounted armored levels on Inland Steel's tailpiece and head boom.

Accident Information

Information regarding accidents related specifically to underground belt conveyor activities and operations was requested from each mine visited. Some responded by making such data immediately available, others provided the information at a later date, and some politely refused. In one instance, a project team member was invited to personally use the files and gather the pertinent data from the original accident reports. The basic handwritten accident report was the source document sought for the most comprehensive information about accidents. In lieu of that, an attempt was made to obtain a narrative description of the accident in addition to the vital statistics.

A second source of information was the USBM, Denver, Colorado which provided, through the Mine Safety & Health Administration (MSHA), a copy of the narrative description of belt-related accidents for the years 1978 and 1979. The Bureau also loaned MEI a computer tape with the accident data for 1980. However, MEI was unable to process it through its computer system, so the tape was returned to the Bureau. A comprehensive analysis was made and an interim report was prepared.

Hardware Activity

In preparation for the June 1, 1981 oral briefing, 51 raw ideas were reviewed and analyzed from which a candidate list of 17 ideas was recommended for further study. For various reasons, only three were approved for prototyping. These were the saucer skid, the controlled load tensioning device, and the armored level. Details of their conceptualization and fabrication are given in the material that follows.

Hardware Development

Saucer Skid

The conceptual genesis of the saucer skid started with the observation of heavy conveyor components (heads, tails, drives) being moved across bare mine floors where final positioning is done by brute force and muscle power assisted by the use of jacks, come-a-longs, block-and-tackle, and sometimes a tow vehicle. Since final positioning requires omni-directional movement, it becomes obvious that the runner-nosed characteristics of the base structures of the components are of assistance. However, when the unit motion is in any direction other than that which is exactly parallel to the long axis of the runner-like base members, a bulldozing or scraping action occurs. Depending upon a myriad of conditions, this action can vary from slightly favorable to extremely difficult to the point of damaging the equipment, road surface, and overstressing bodies and muscles. Several thoughts were investigated to overcome this problem by making the base structure easy to slide in all directions; two ideas were followed up by design concepts.

One concept required welding angled plates to the base beams producing a runner-like nosing on the sides of the beams. The second was the use of pipe or tubing for the base members, but a cost and structural analysis proved this to be less than desirable even though it solved the problem. The concept of a saucer skid evolved whose fully radiused saucer bottom would offer the least resistance when carrying a load. However, when used singly, it would not be as stable as a flat-bottomed skid nor would it have as low a profile. The original concept envisioned a flat-bottomed saucer, 8 ft in diameter, that would accommodate a wide variety of conveyor components on a single skid. However, it was soon realized that a skid of that size (that is, approximately 900 lbs) would be far too heavy for two people to handle easily and would be too large to be readily maneuvered for positioning accessibility. A unit 5 ft in diameter was finally chosen since it could be easily handled by two persons, was small enough to facilitate movement around equipment in cramped conditions, was large enough to carry the smaller size conveyor on a single skid, and could be used in twos, threes, or even fours should the load warrant. A standard, noncode, 1/4-inch steel tank head was used for the basic structure for both the full radiused and flat-bottomed units. The reinforcing ribs were also made from 1/4-inch steel plate. Prototyped manufacturing is shown in Figures 17 through 21.

During the in-mine testing, the theories were proven when two men quickly and easily placed a flat-bottomed skid under a small head unit, chained it fast, and hooked it to a towing vehicle which then moved the unit rapidly to its new position about 1800 feet away. The relocation was accomplished more easily and with less damage to the road surface than had previously been experienced. The conveyor unit was left on the skid at its destination so that its final positioning could be accomplished with the assistance of the skid. Using the skid obviously lessened the amount of physical effort required to move the unit. A testimonial to this fact was presented in letter form from the Brushy Creek Mine. In-mine testing is illustrated in Figures 22 though 28.

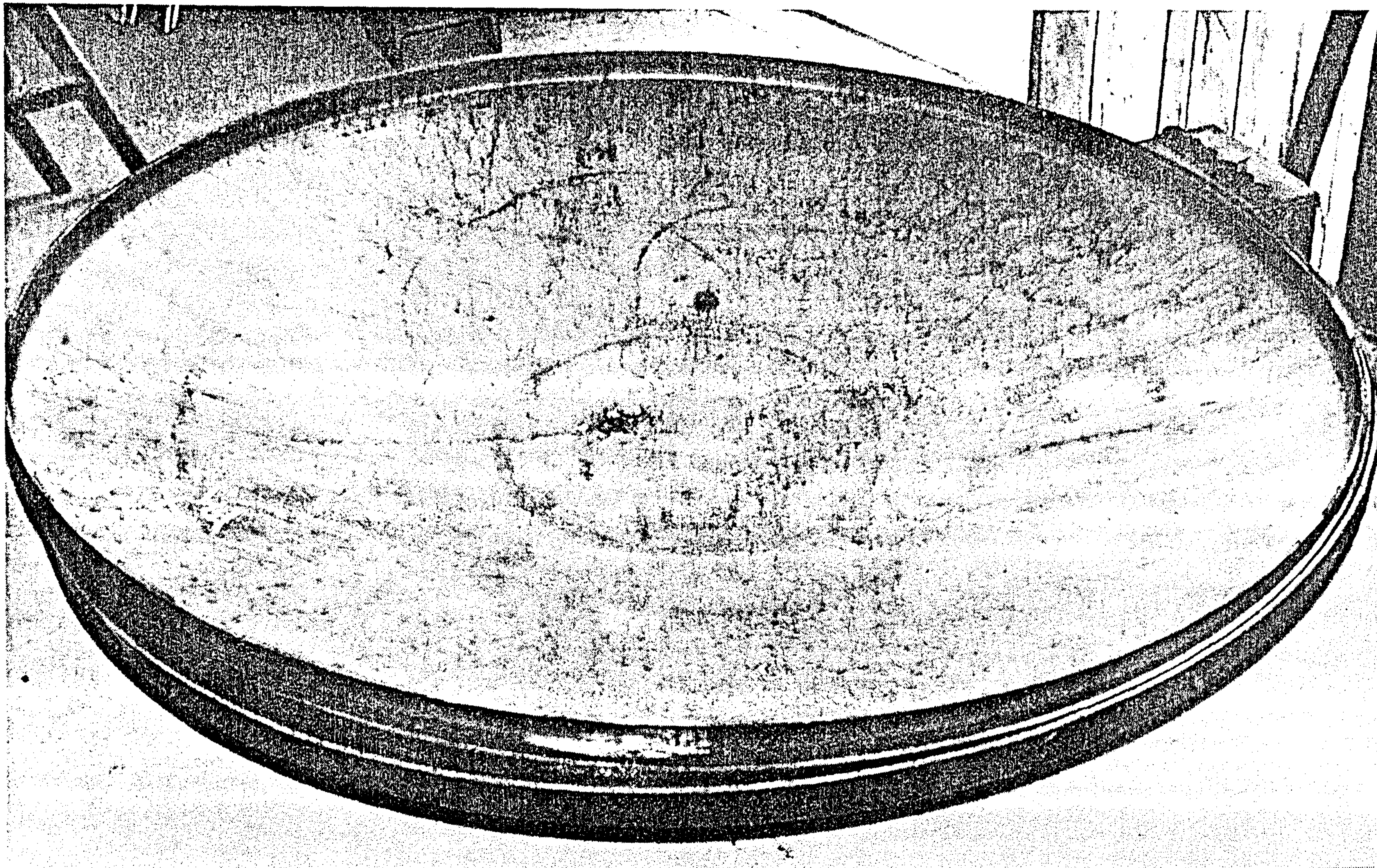


FIGURE 17. - Saucer Skid Manufacture, Noncode Tank Ends.

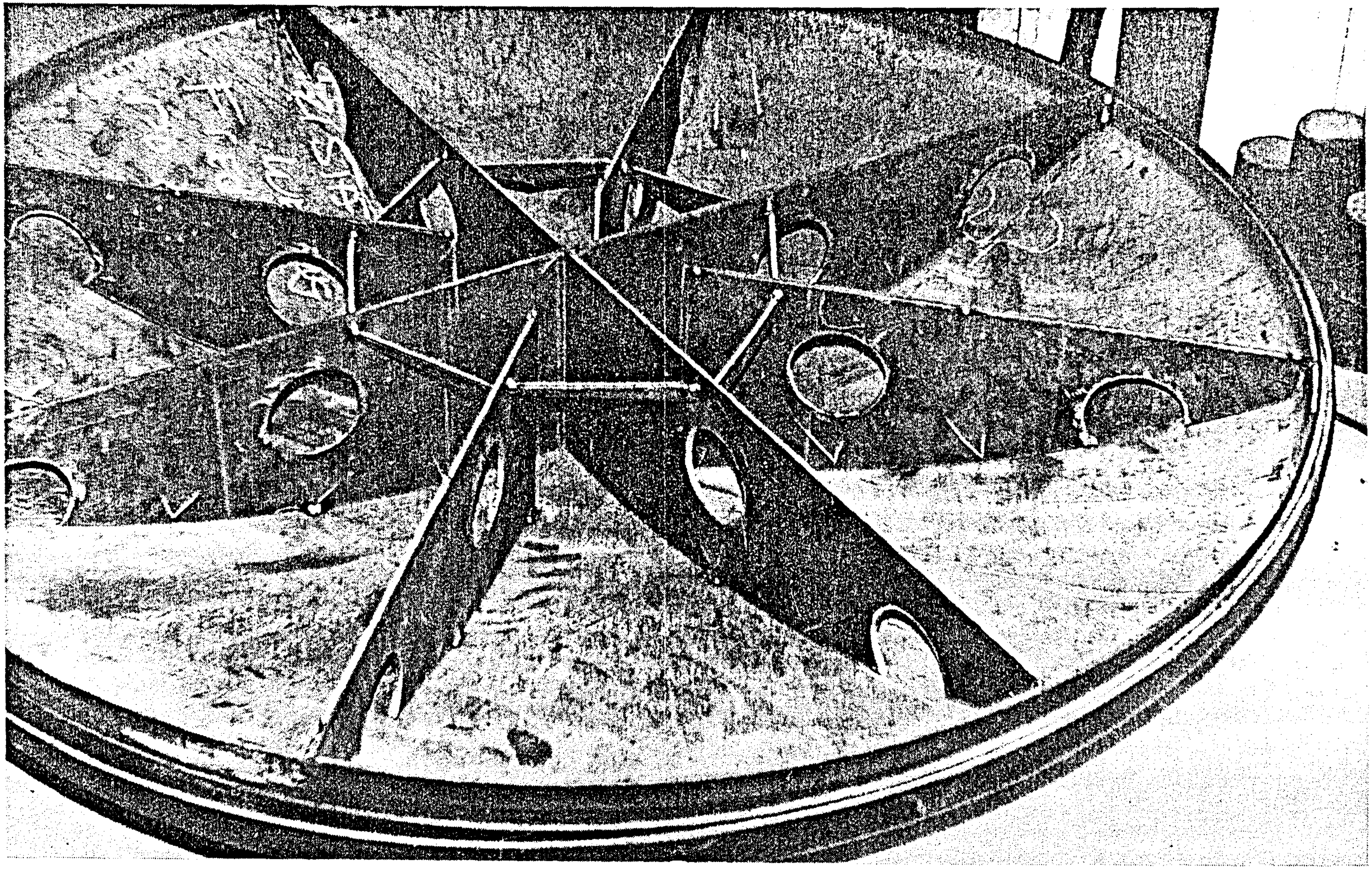


FIGURE 18. - Saucer Skid Manufacture, Radiused Bottom Skid—In Process.

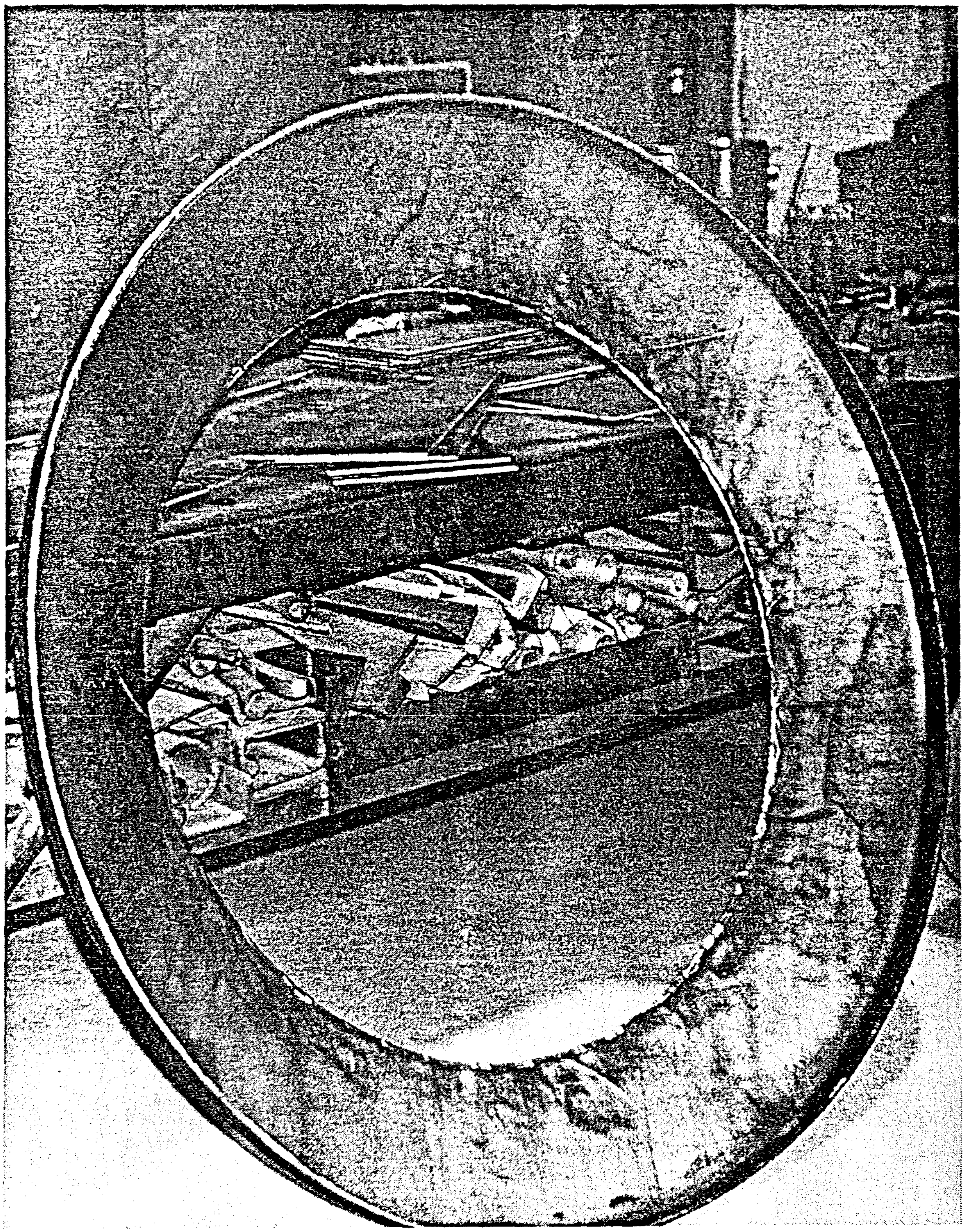


FIGURE 19. - Saucer Skid Manufacture, Flat Bottom Skid—In Process.

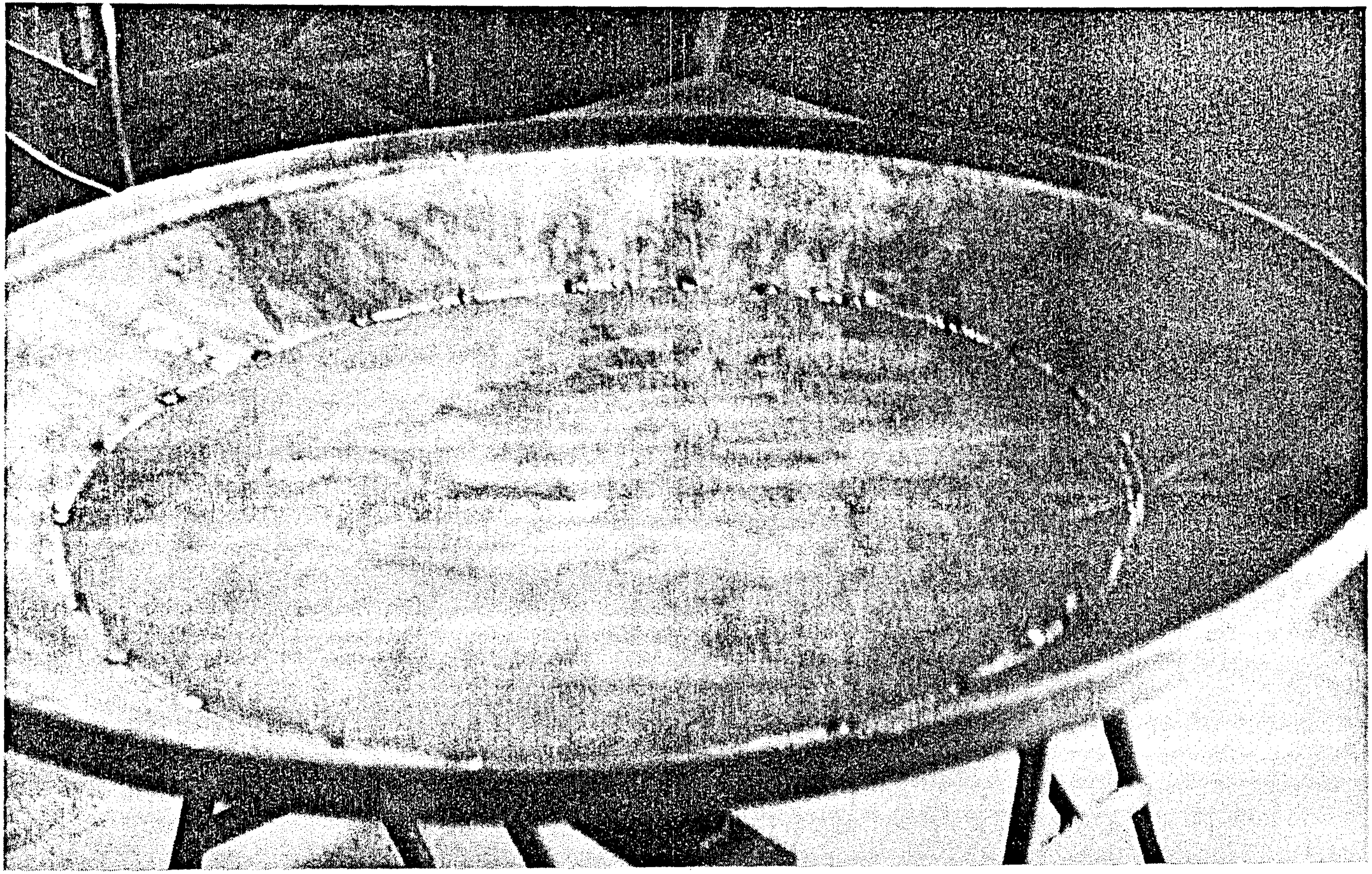


FIGURE 20. - Saucer Skid Manufacture, Flat Bottom Skid--Welded Bottom.

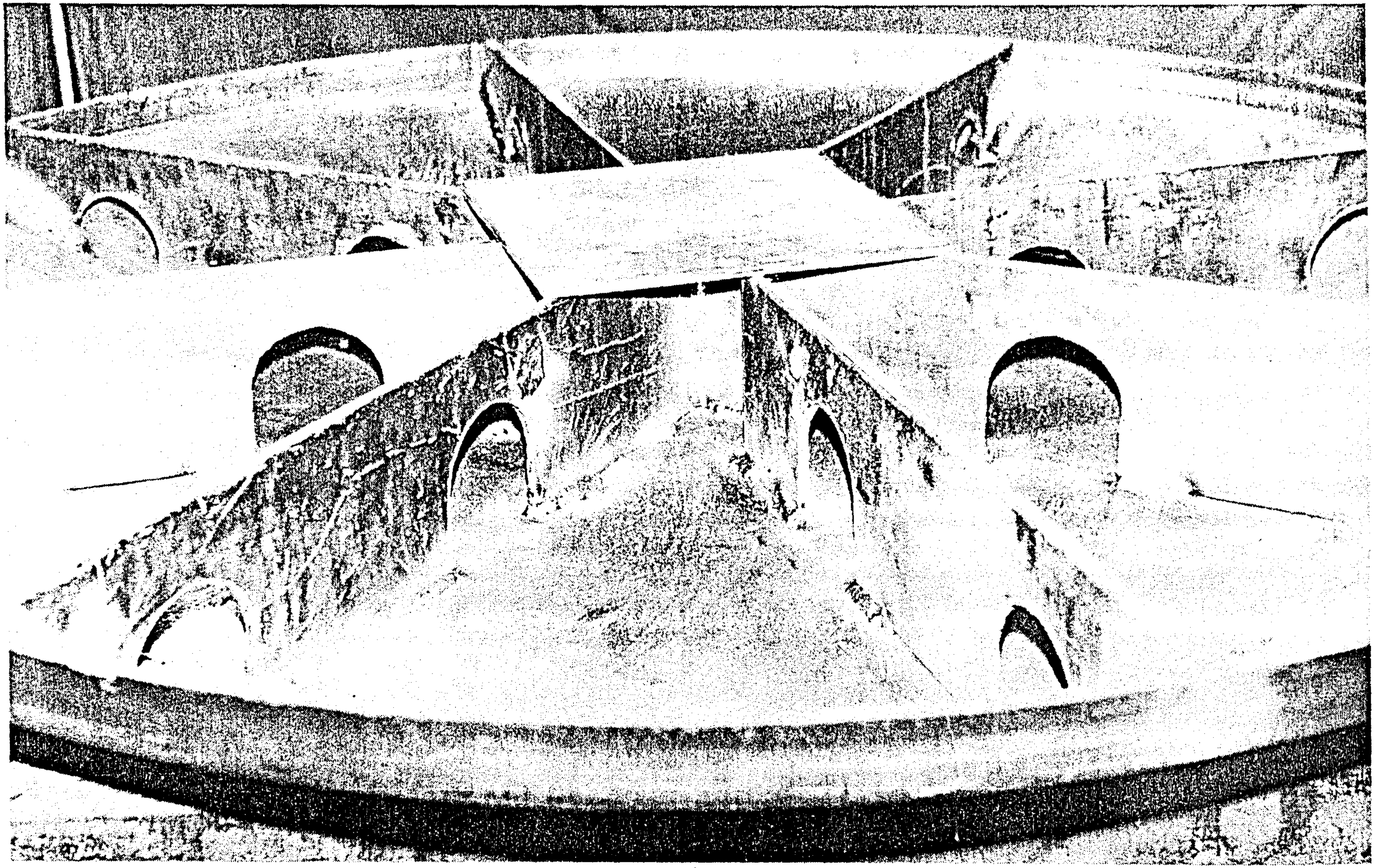


FIGURE 21. - Saucer Skid Manufacture, Flat Bottom Skid Complete with Ribs.

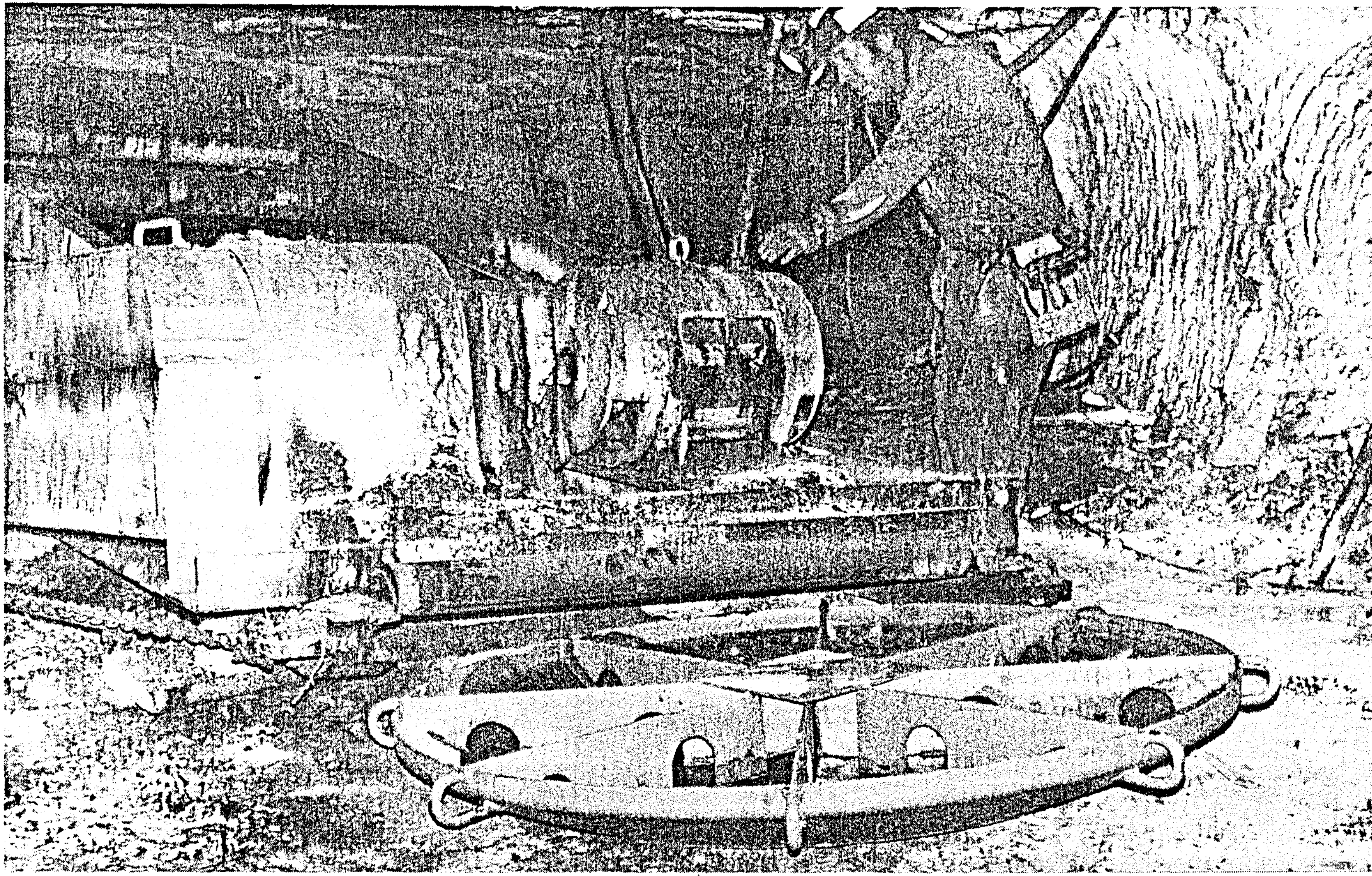


FIGURE 22. - Saucer Skid In-Mine Test, Skid Ready to Use.

FIGURE 23. - Saucer Skid In-Mine Test, Jacking up Discharge.

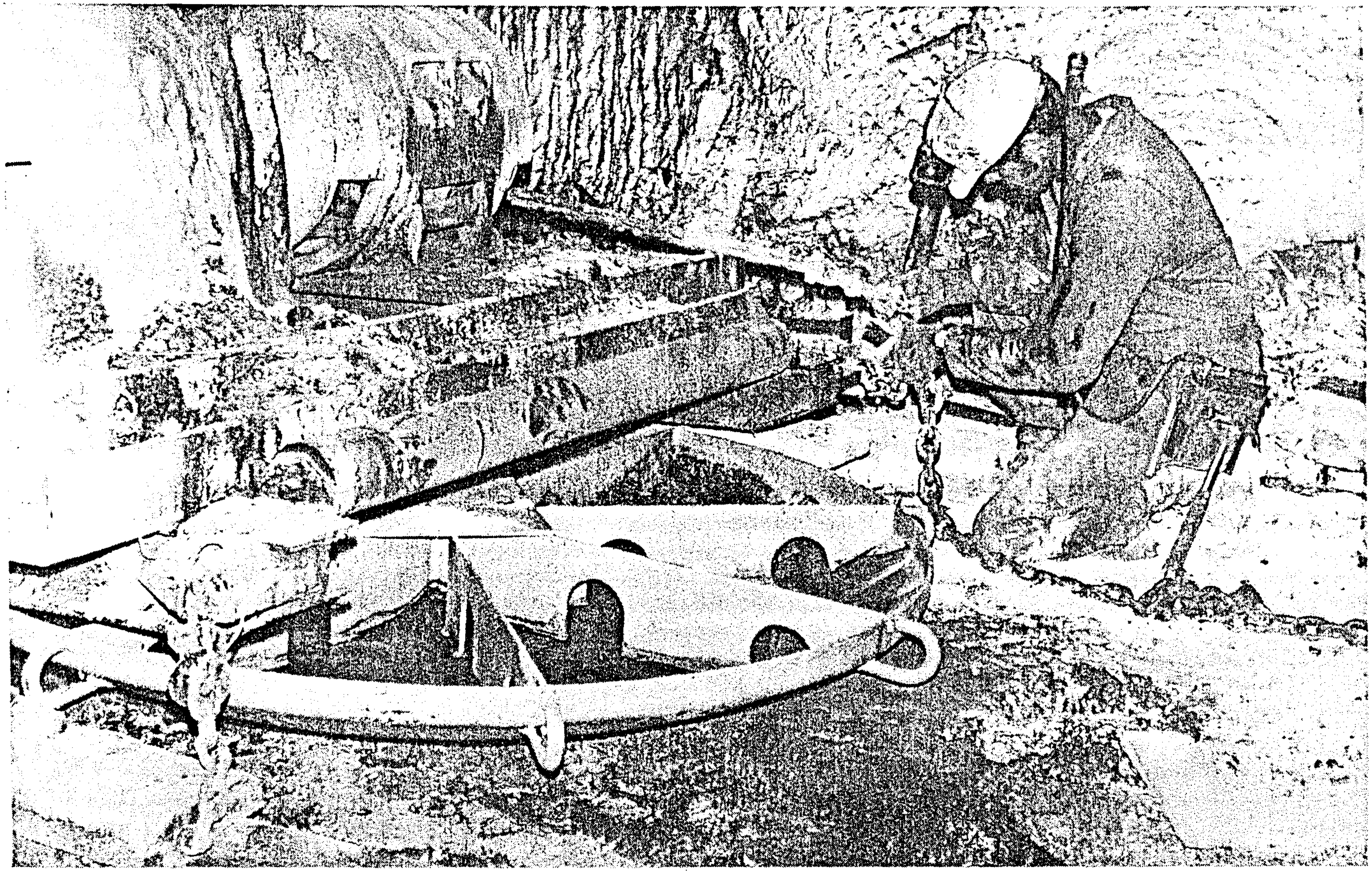


FIGURE 24. – Saucer Skid In-Mine Test, Skid Partially Under Discharge.

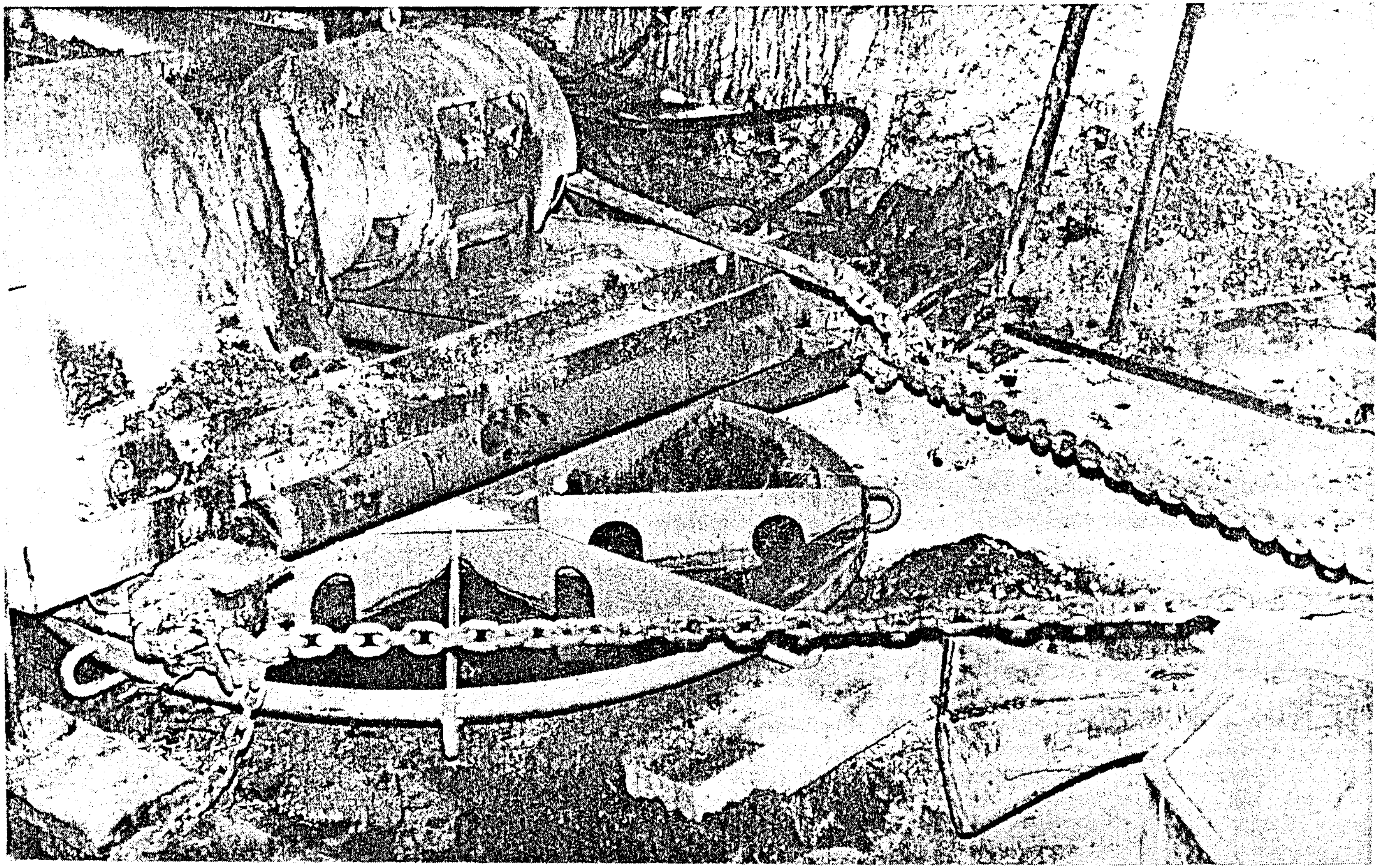


FIGURE 25. – Saucer Skid In-Mine Test, Pulling Discharge Onto Skid.

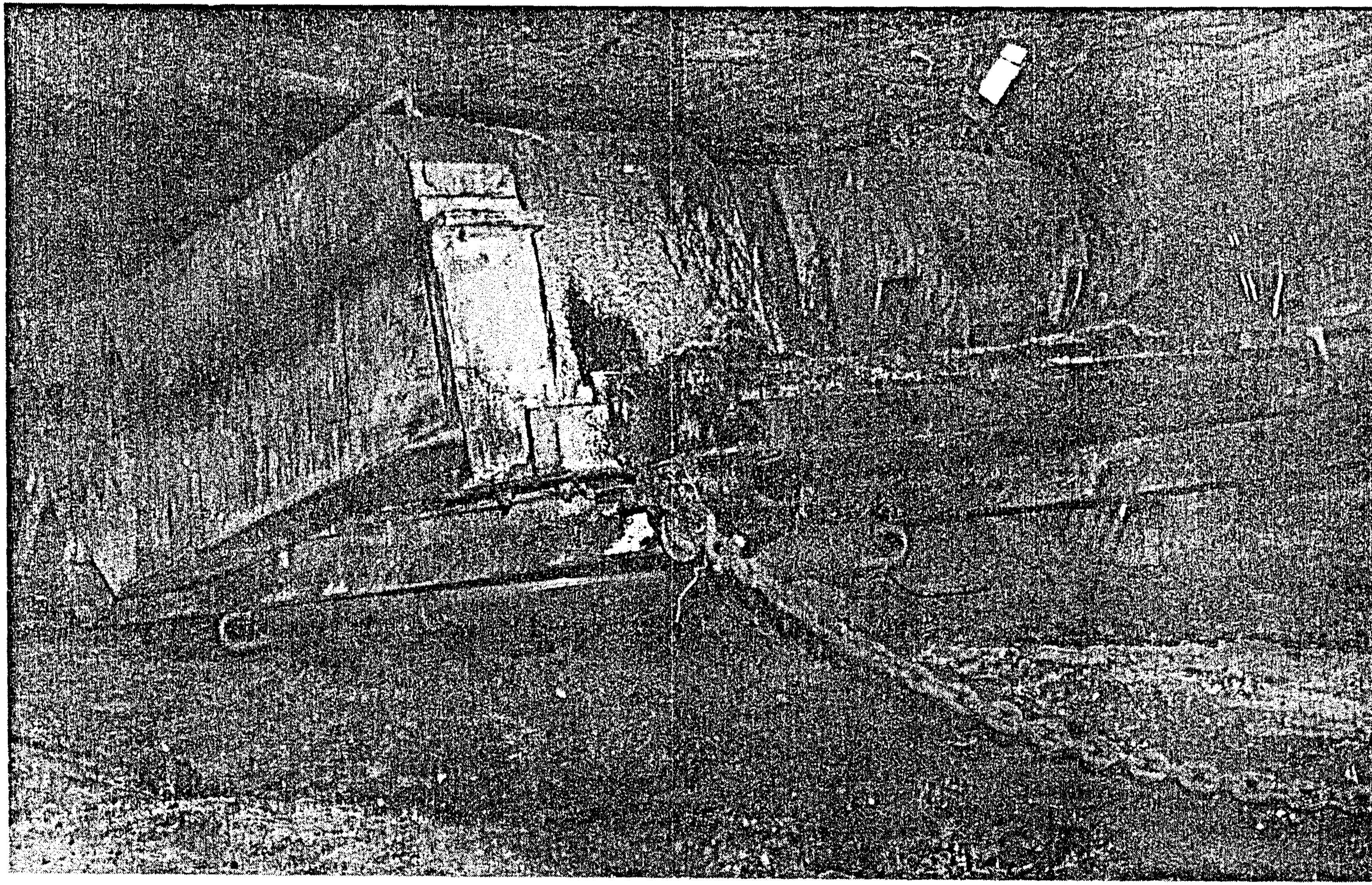


FIGURE 26. - Saucer Skid In-Mine Test, Discharge Balanced onto Skid.

FIGURE 27. - Saucer Skid In-Mine Test, Discharge Chained to Skid.

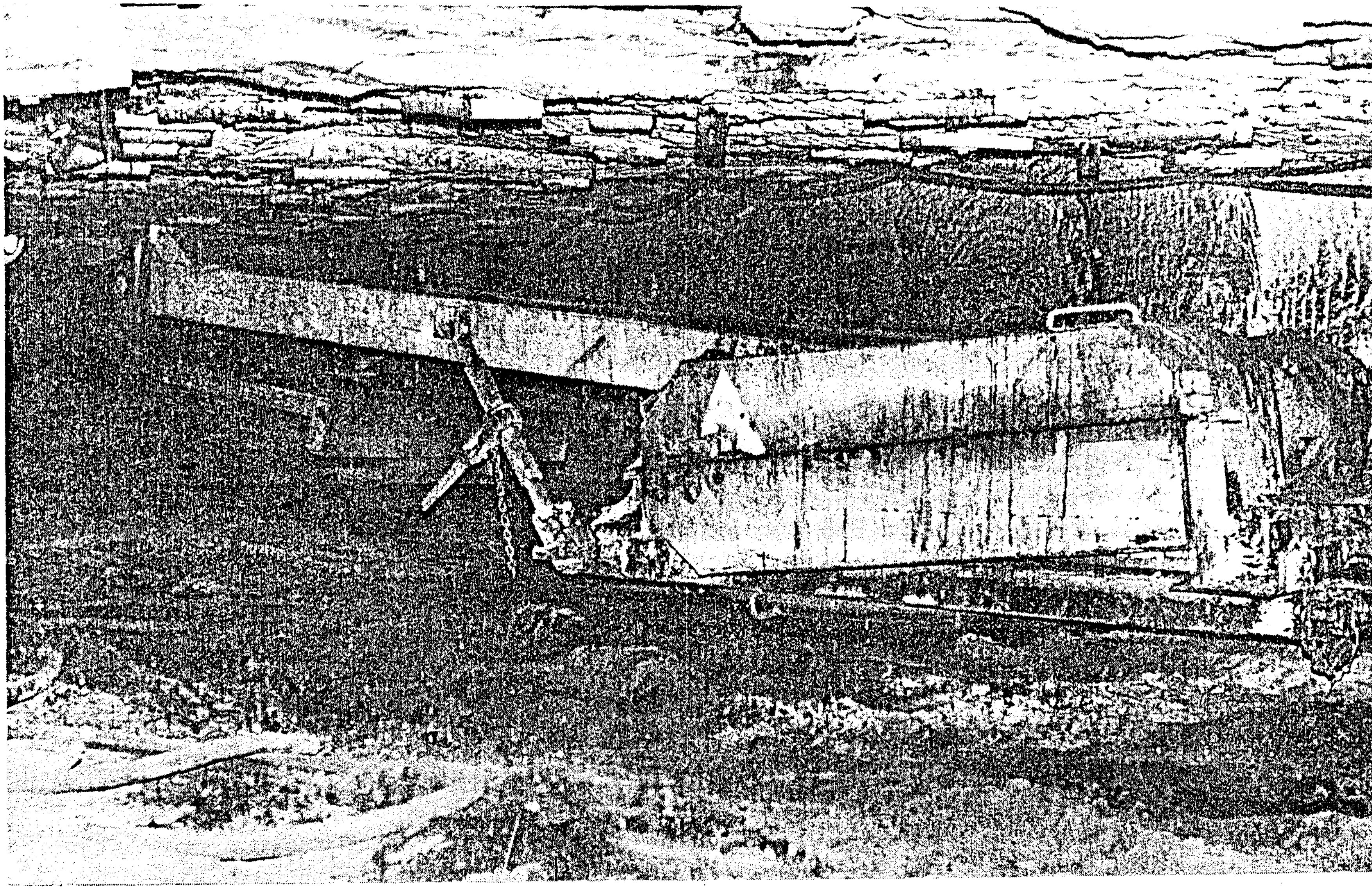


FIGURE 28. - Saucer Skid In-Mine Test, Towing Discharge Into Crosscut.

Controlled Load Tensioning Device (CLTD)

In discussions with conveyor equipment design engineers, the need was stressed for uniformity in the tension of lashings or anchoring ropes in order to have quality installations and properly operating systems. During the early stages of conceptualizing a method for torque limiting binders, careful research led to the selection of the "Tensor" unit which was chosen for the following three reasons: 1) once tightened, it would not loosen due to vibrations, shocks, or tension stress; 2) it employed a fully enclosed, lubricated, multiple-thread screw which ensured an easy and quick operation; and 3) it was easily adaptable to the use of a selected standard torque limiting device. Prototype manufacturing and laboratory testing are shown in Figures 29 through 35.

The unit as prototyped (Figure 35) has performed exceptionally well--particularly in lashing (or anchoring) tailpieces that are moved frequently. It replaces the commonly used ratchet jack tensioning device. Results are substantiated by the testimony given in letters from Brushy Creek and Inland Steel. In-mine testing is shown in Figures 36 through 44.

One change that would tend to improve the unit would be substitution of a driving lug (square) in place of the 1/2-inch square socket which has a tendency to become clogged with debris and dirt from the mine floor. Also, several models could be designed where each would have special hook characteristics best suited for particular functions as opposed to having a universal hook which would not be as convenient for various applications.

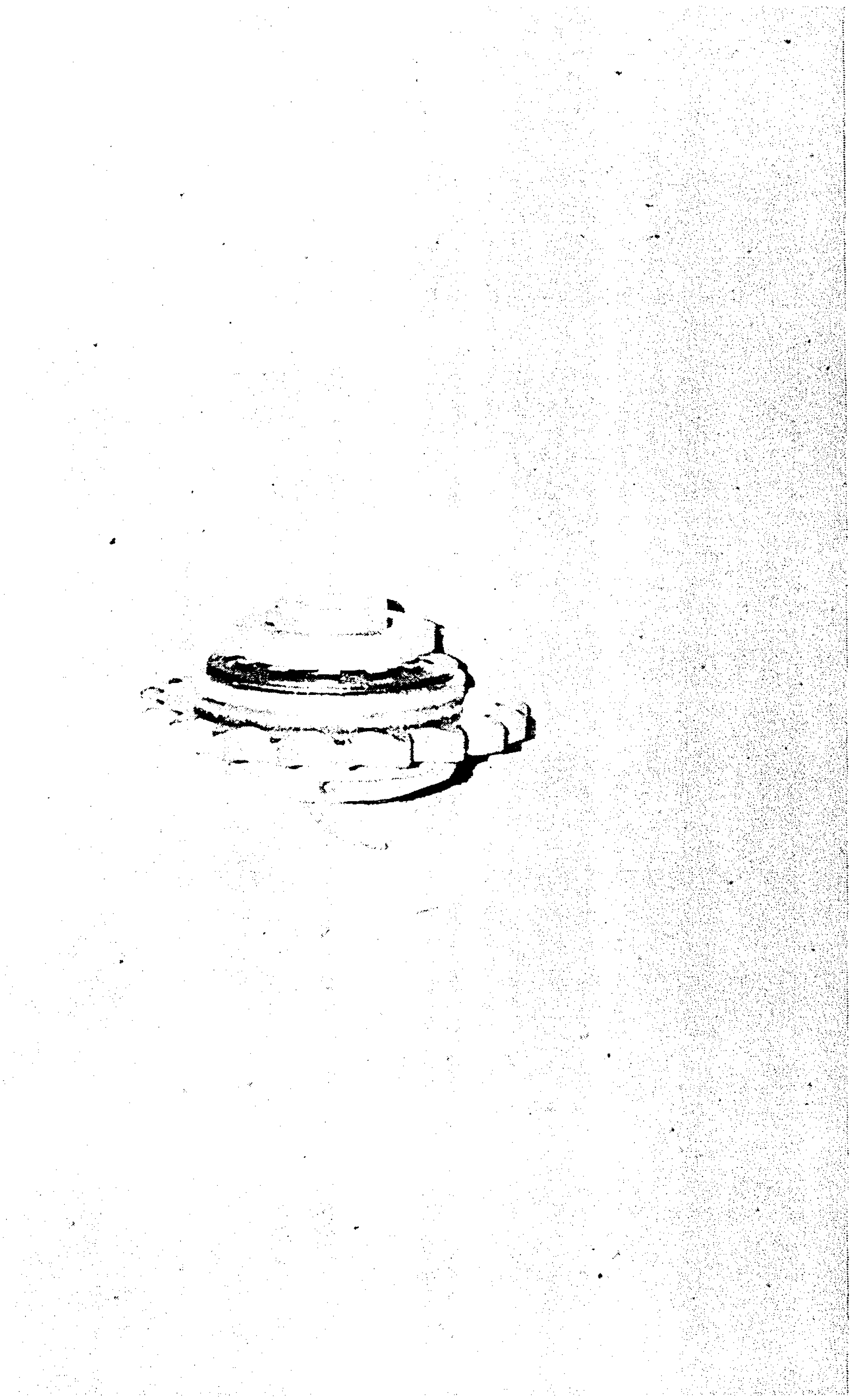


FIGURE 29. - CLTD Manufacture, Standard Torque Limiter With Sprocket.

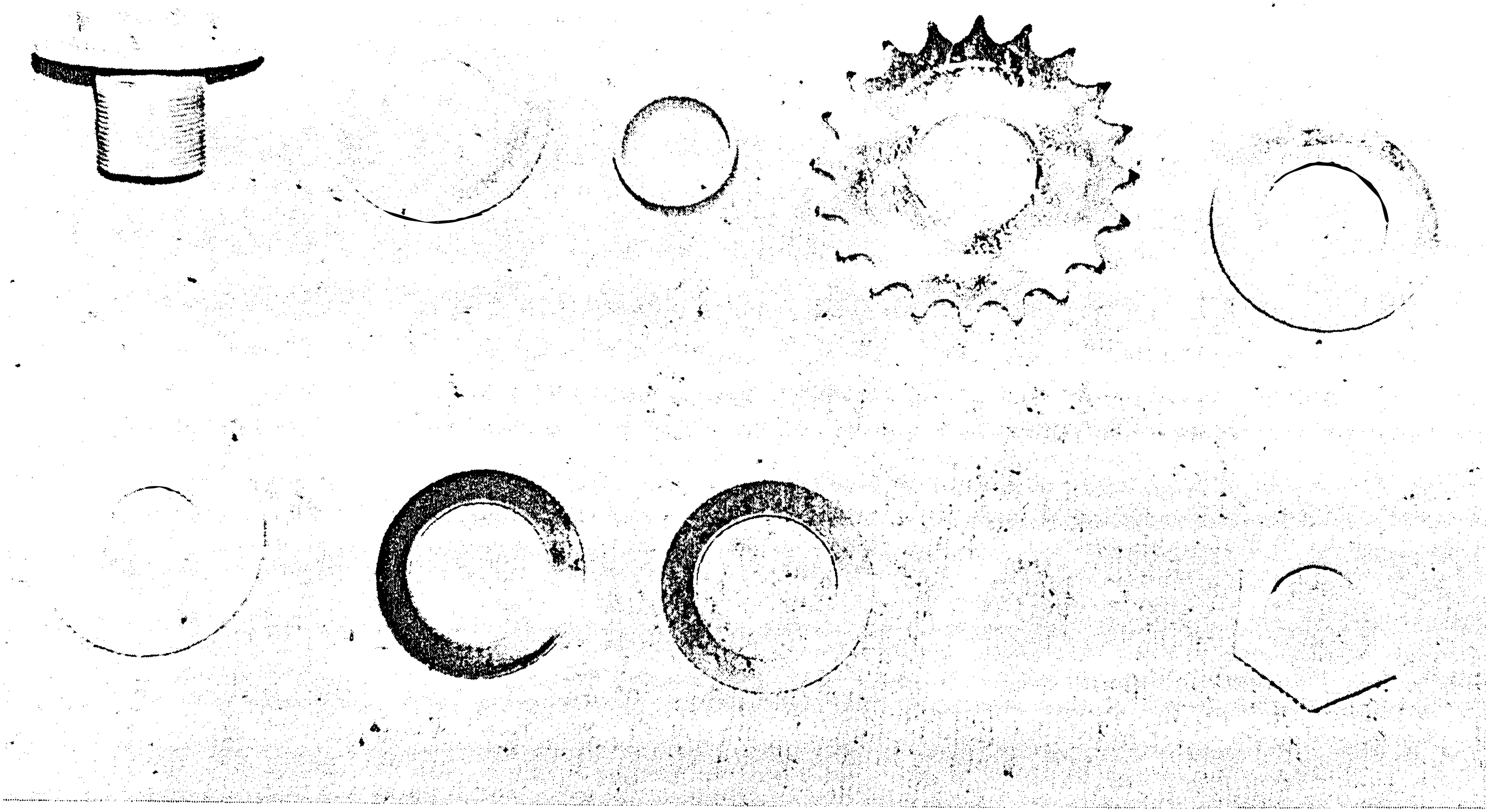


FIGURE 30. – CLTD Manufacture, Disassembled Torque Limiter.

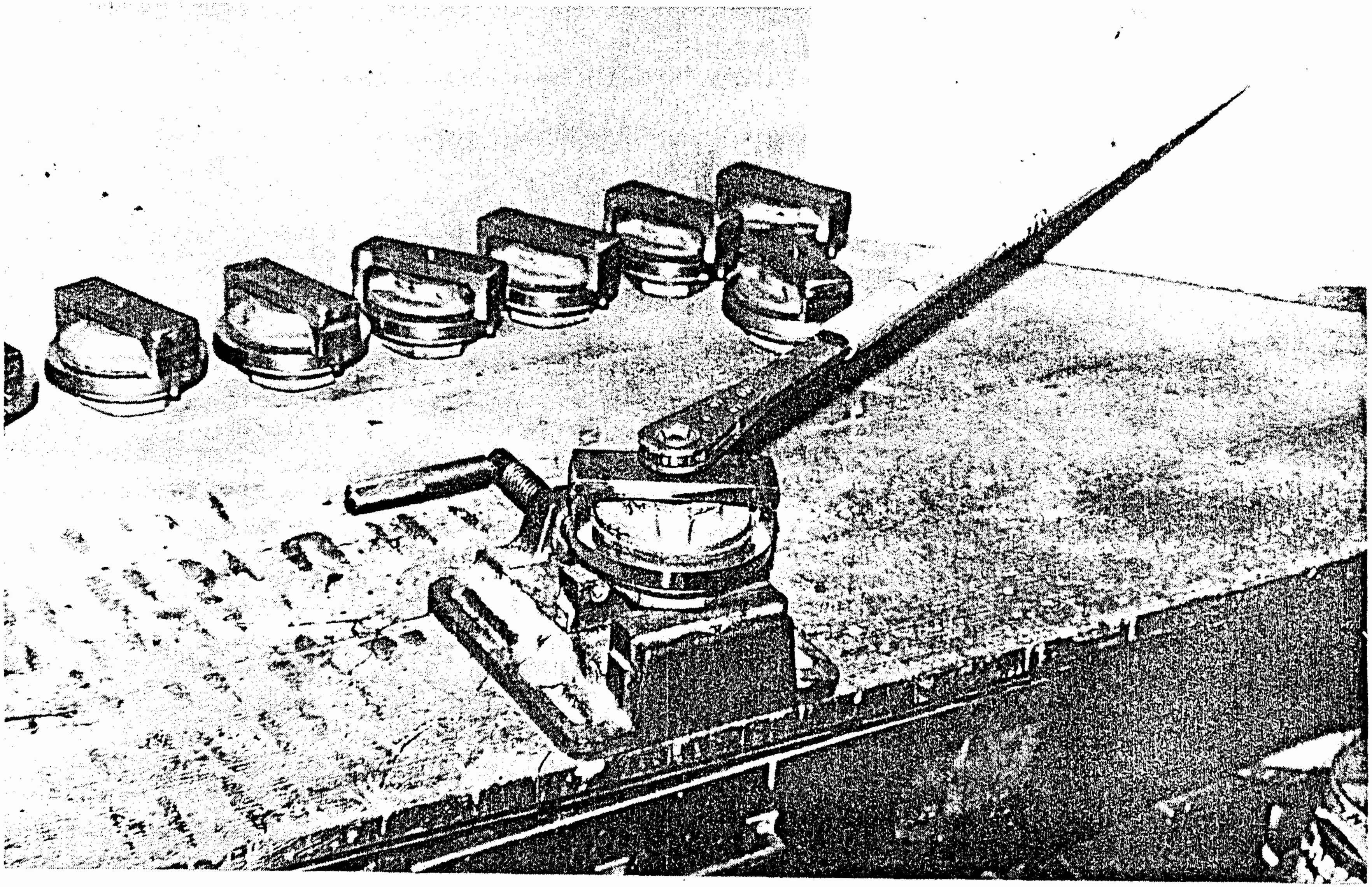


FIGURE 31. - CLTD Manufacture, Running-In Modified Torque Limiter.

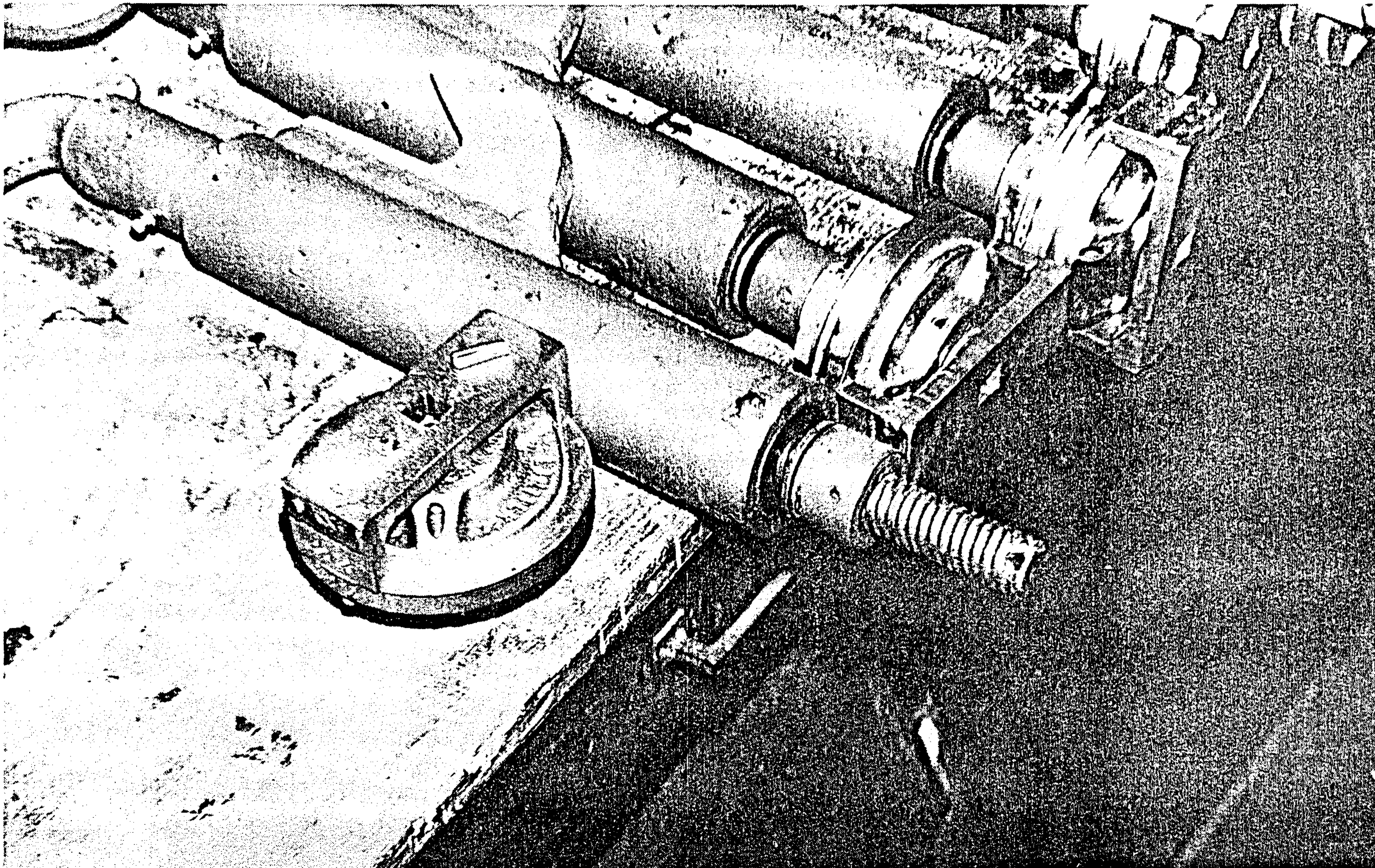


FIGURE 32. - CLTD Manufacture, Assembly.

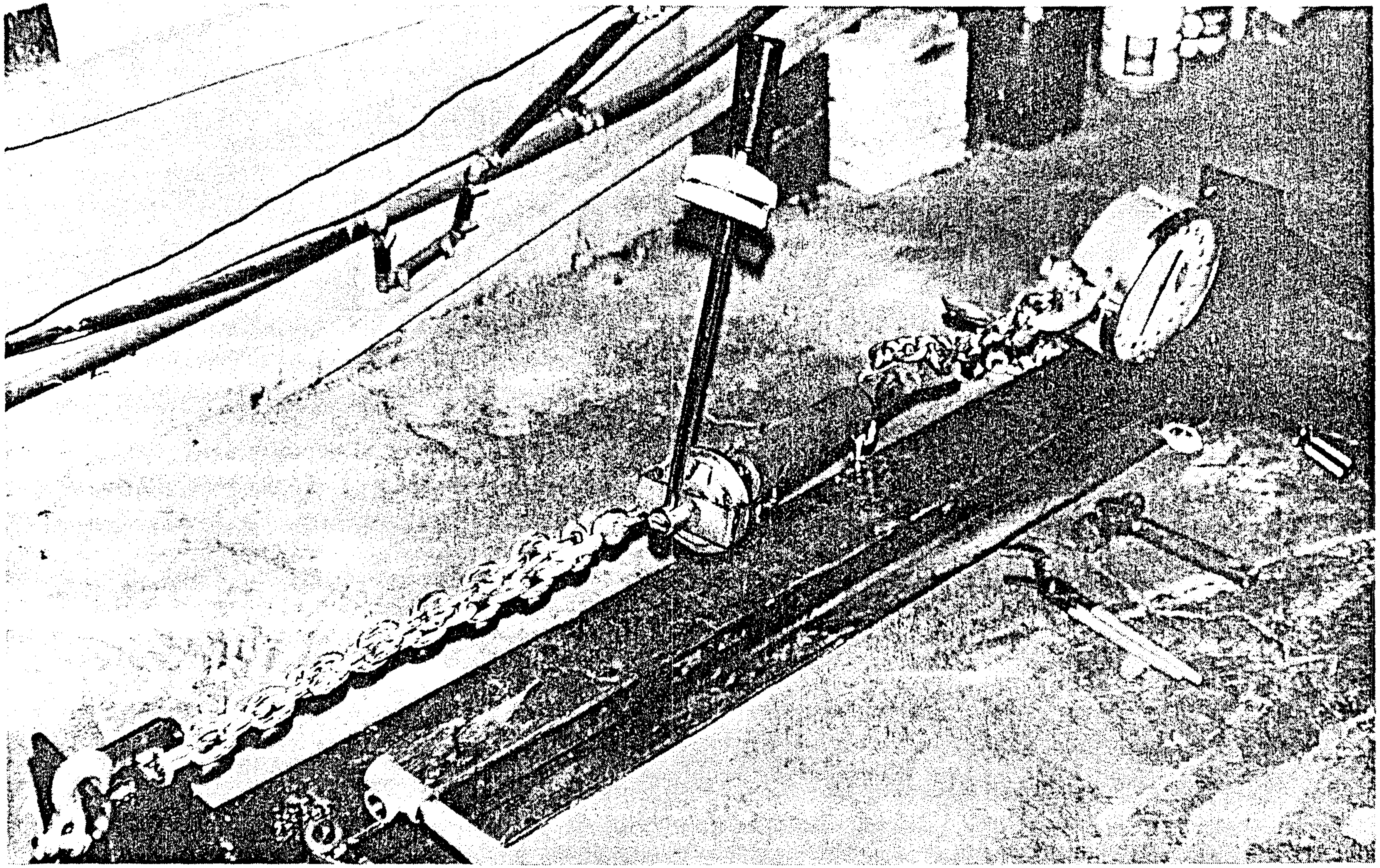


FIGURE 33. – CLTD Manufacture, Calibration Test.

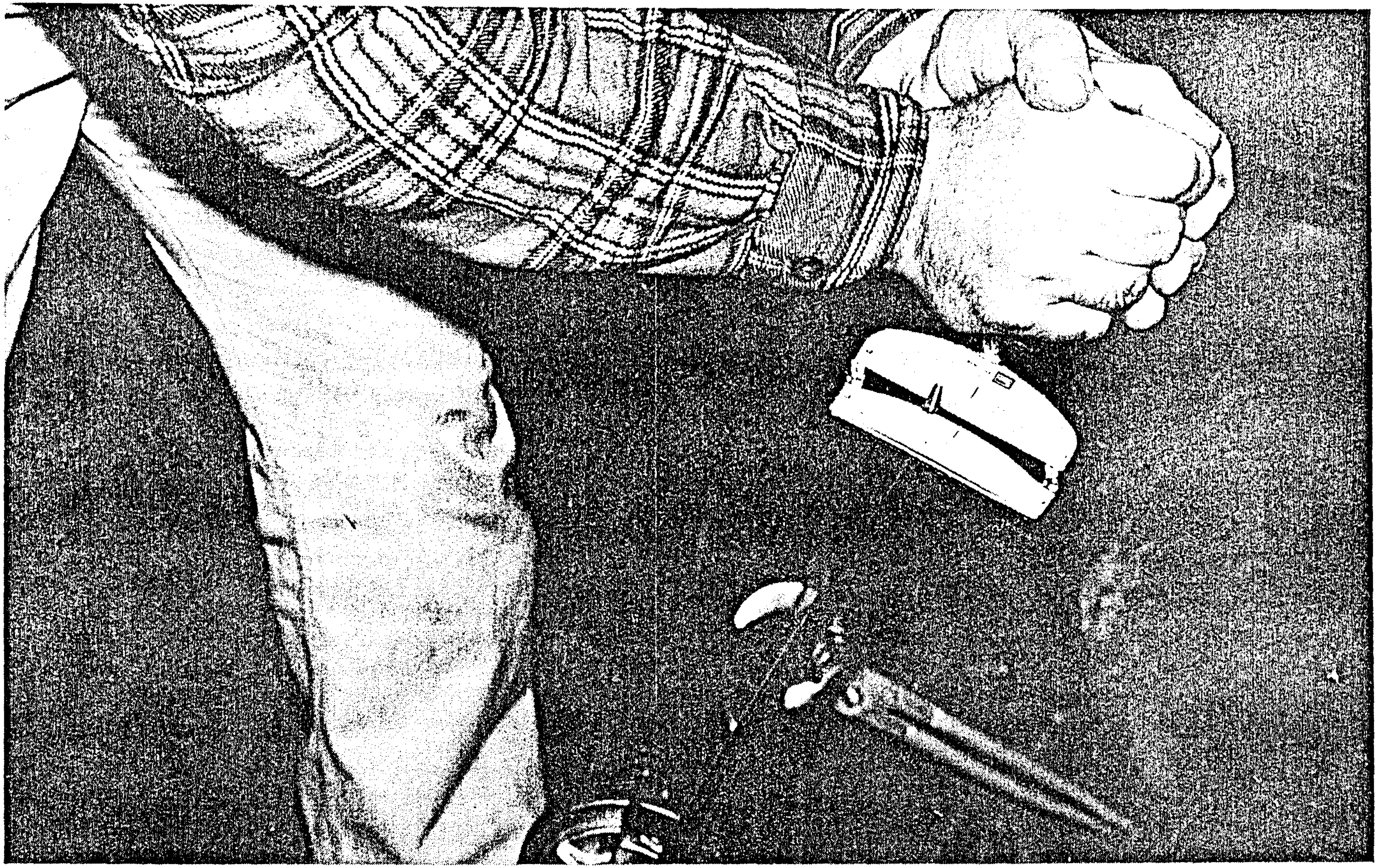


FIGURE 34. - CLTD Manufacture, Torque Testing Close-up.

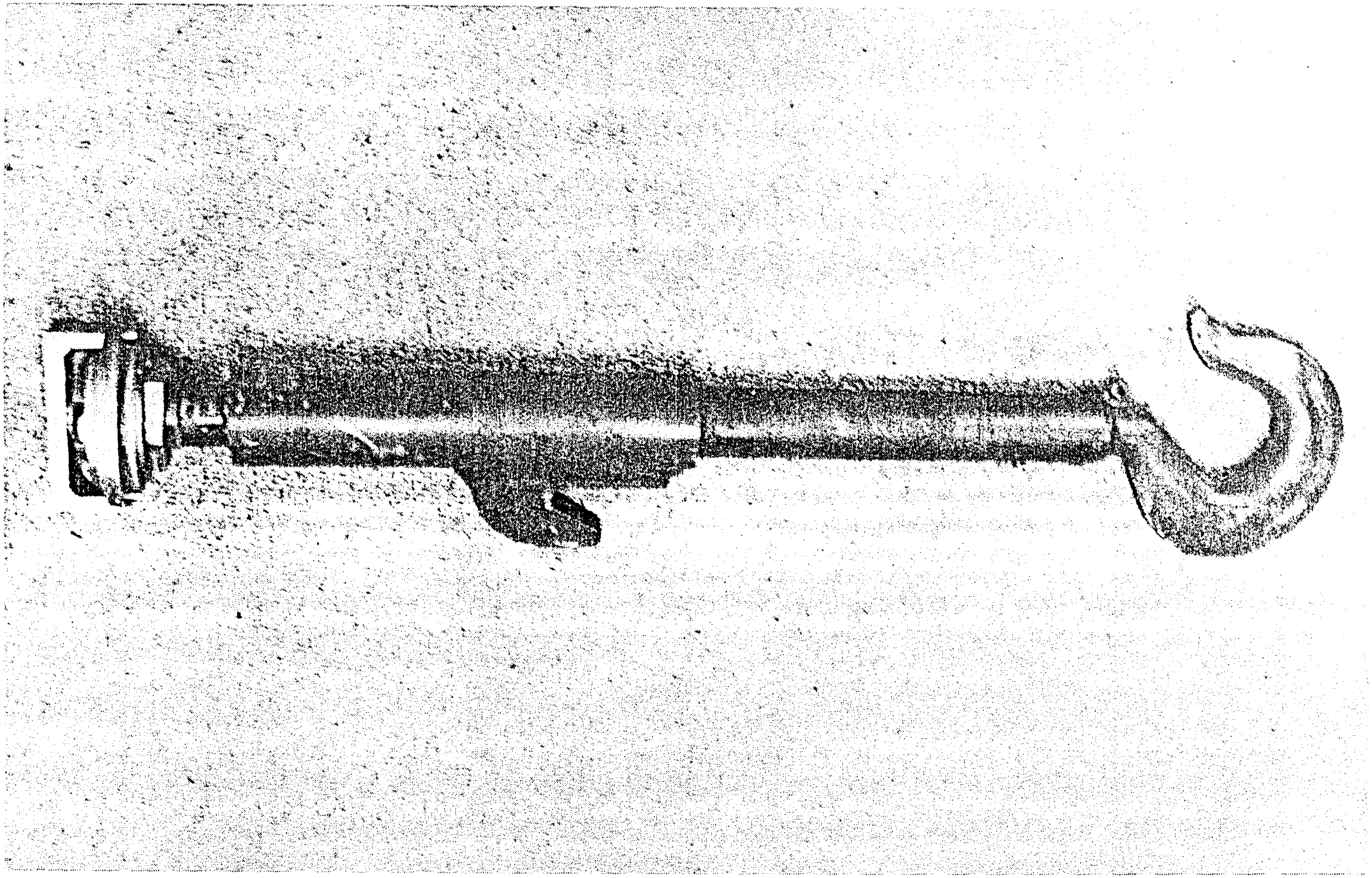


FIGURE 35. – CLTD Manufacture, Completed Unit—Fully Extended.

FIGURE 36. - CLTD In-Mine Test, Unit with 1/2 Square Drive Socket Wrench and Jack Pipe.

FIGURE 37. - CLTD In-Mine Test, Unit With Lashing Chain.

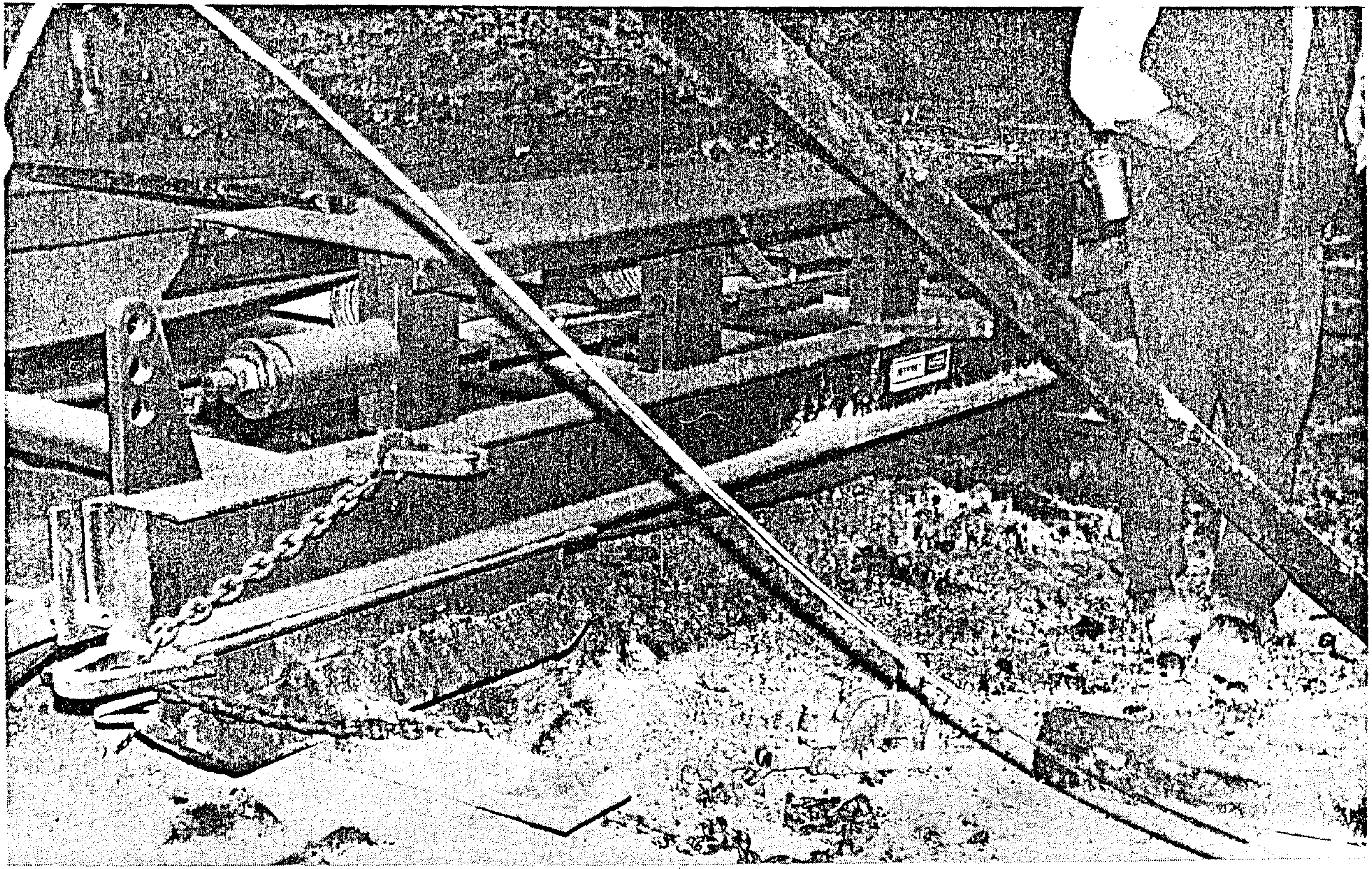


FIGURE 38. - CLTD In-Mine Test, Tailpiece to be Lashed.

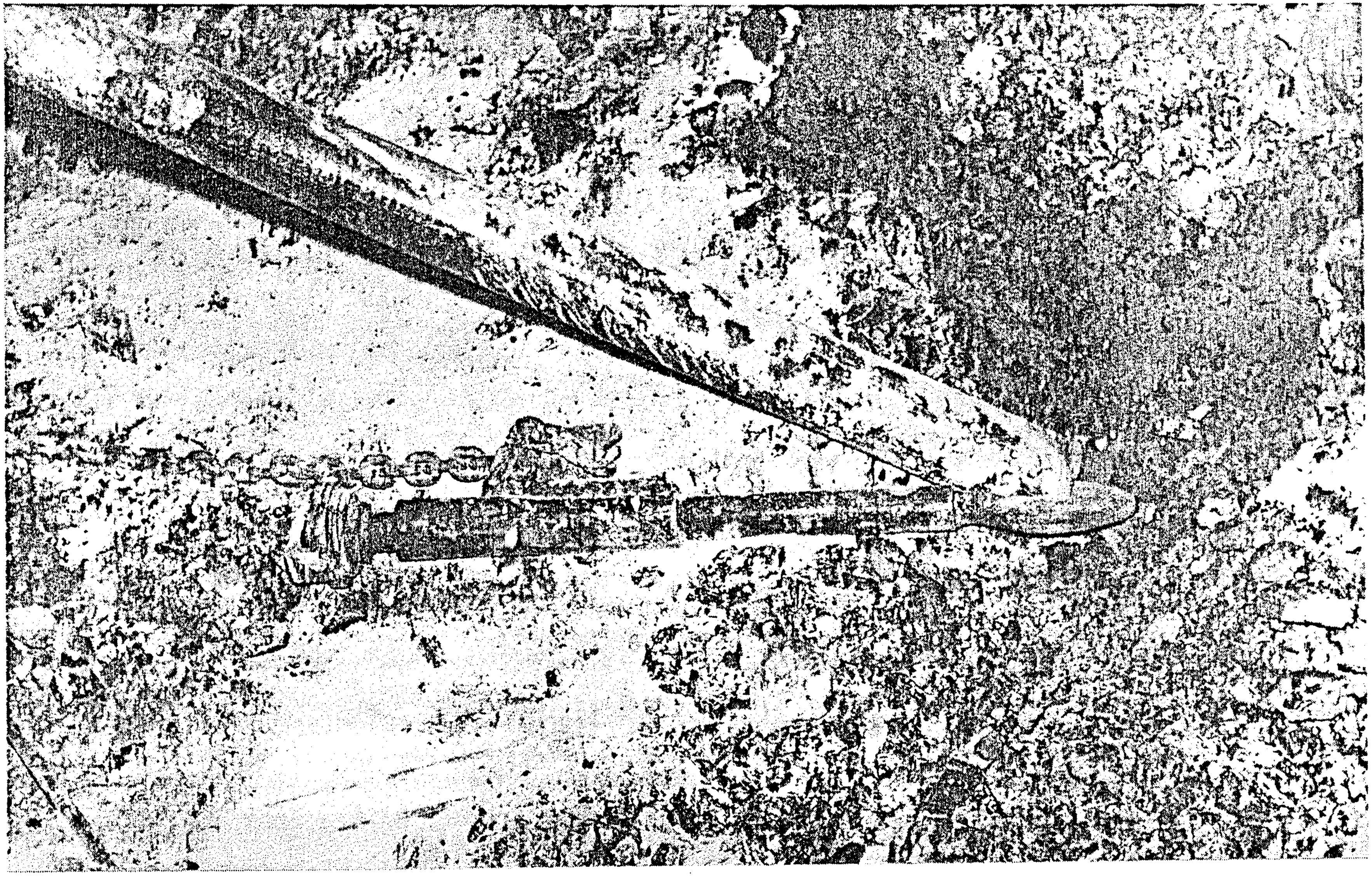


FIGURE 39. - CLTD In-Mine Test, Unit Anchored in End of Jack Pipe.

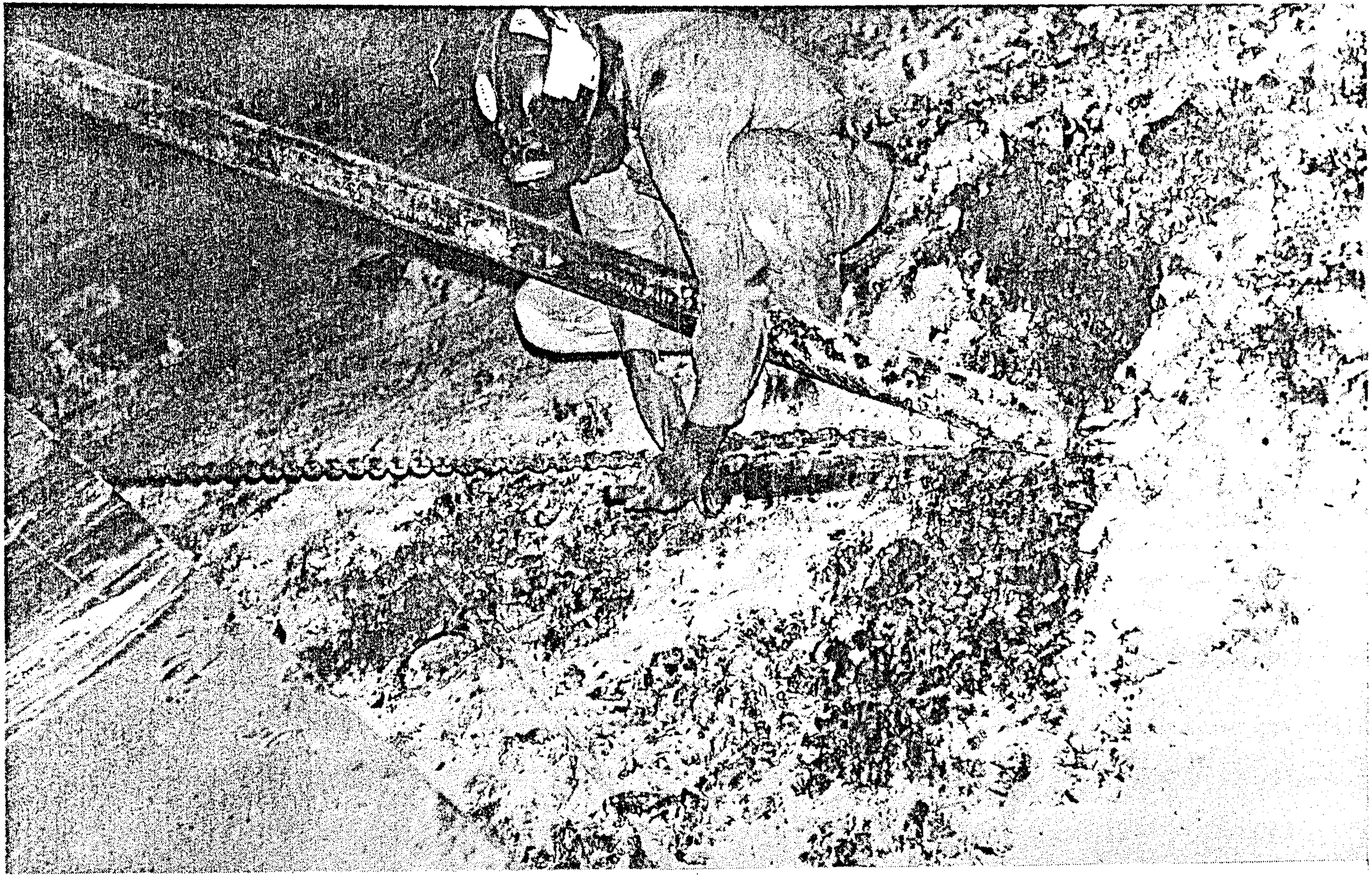


FIGURE 41. - CLTD In-Mine Test, Tensioning Unit.

FIGURE 42. - CLTD In-Mine Test, Tension Force Limit Reached.

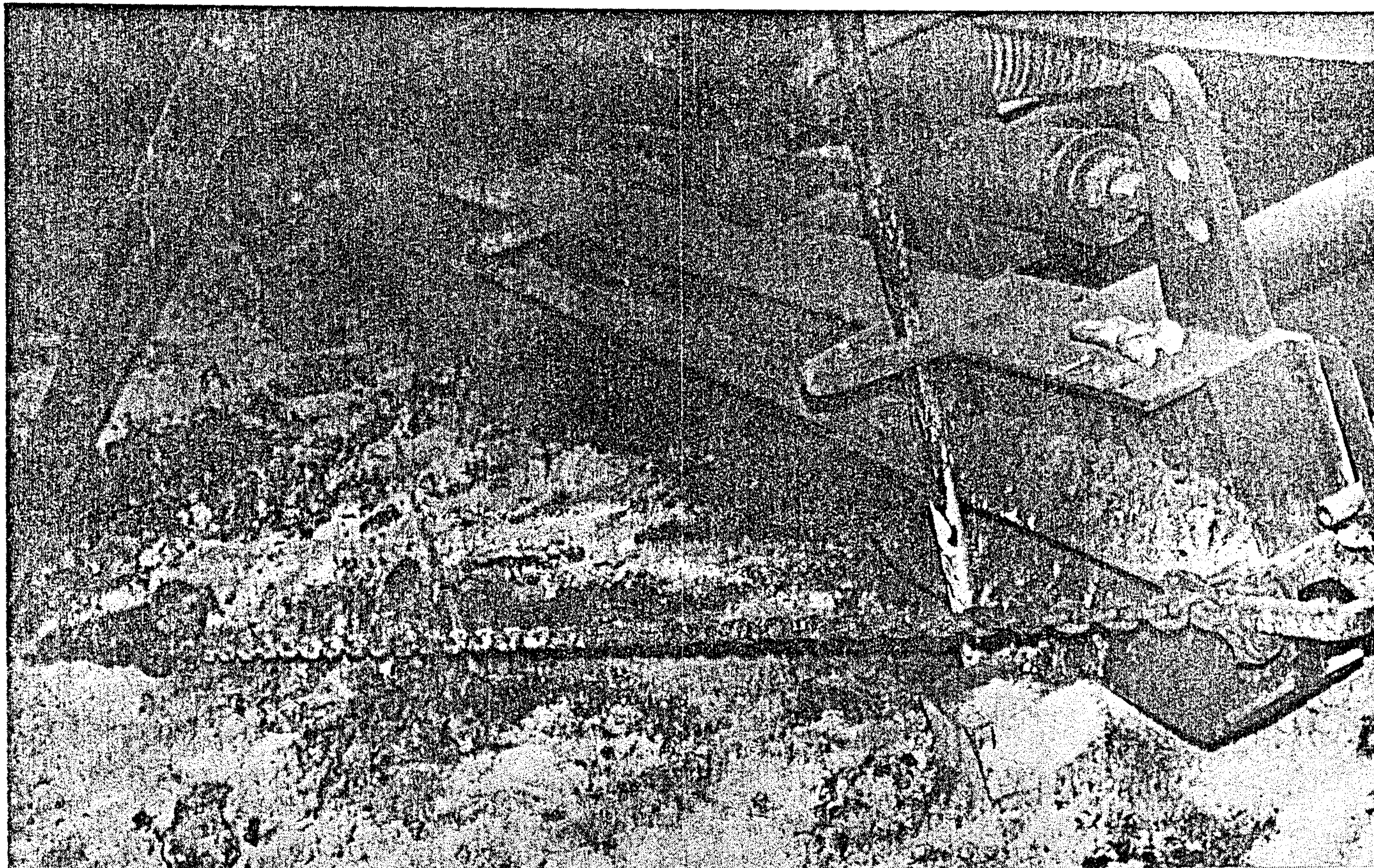


FIGURE 43. - CLTD In-Mine Test, Lashing Fully Tensioned.

FIGURE 44. - CLTD In-Mine Test, Unit Hooked to Screw Jack Base.

Turnbuckle Tensioning Wrench (TTW)

When the CLTD was first conceived and business factors were considered, it was surmised that the anticipated selling price of a CLTD would be such that it would be very unfavorable when compared with a standard 1-inch forged turnbuckle. The thought then developed that perhaps a device could be made that would not be retained as part of the system but would be used in conjunction with a turnbuckle to tighten it to a specified tension load. This led to the development of the Turnbuckle Tensioning Wrench which was simply the application of a standard uniform deflection-beam torque wrench to the tang of a double-jawed open-end wrench as shown in Figures 45 through 47. An MEI market test sample is described in Figures 48 and 49. The scale of the TTW has been calibrated directly to reflect the pounds of force in tension created through the standard 1-inch by 8-pitch thread system of the turnbuckle.

The TTW makes it possible to use standard turnbuckles for lashing conveyor components and anchoring wire ropes for conveyor supports and ensures a reasonable degree of accuracy with respect to the pounds tension imparted to the system. There is nothing else in the field at this time which is truly mine compatible and will perform this function.

Three prototype wrenches were made and two of them were placed in mines for testing. Both gained accolades for their handy performance. One had a problem initially--the jaws were not long enough and the wrench would slip off the turnbuckle. The wrench was altered in the field and performed excellently following the repair. This design defect was corrected in the finalized design presented in this report.

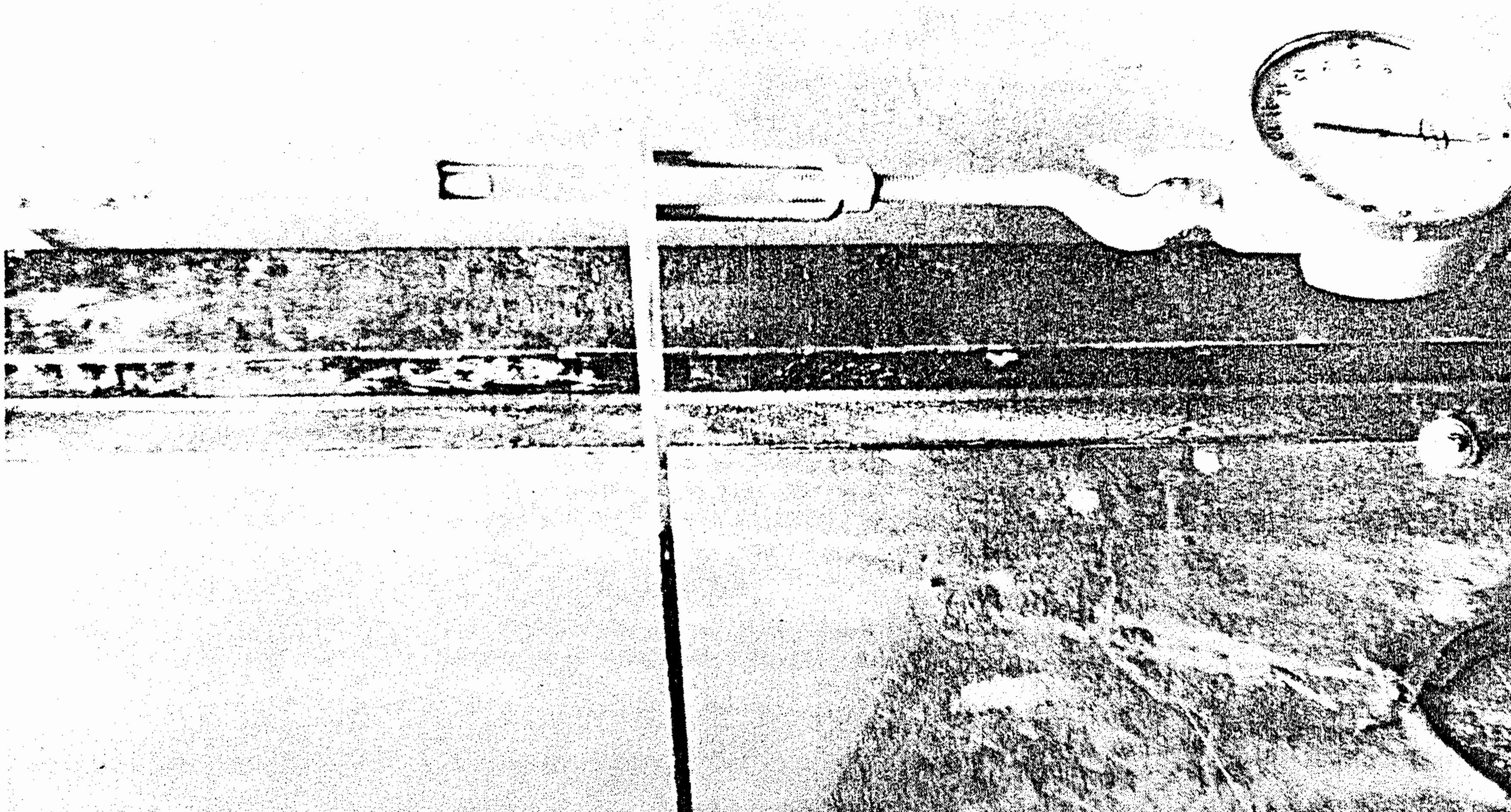


FIGURE 45. – TTW Development, Turnbuckle Tensioning Analysis.

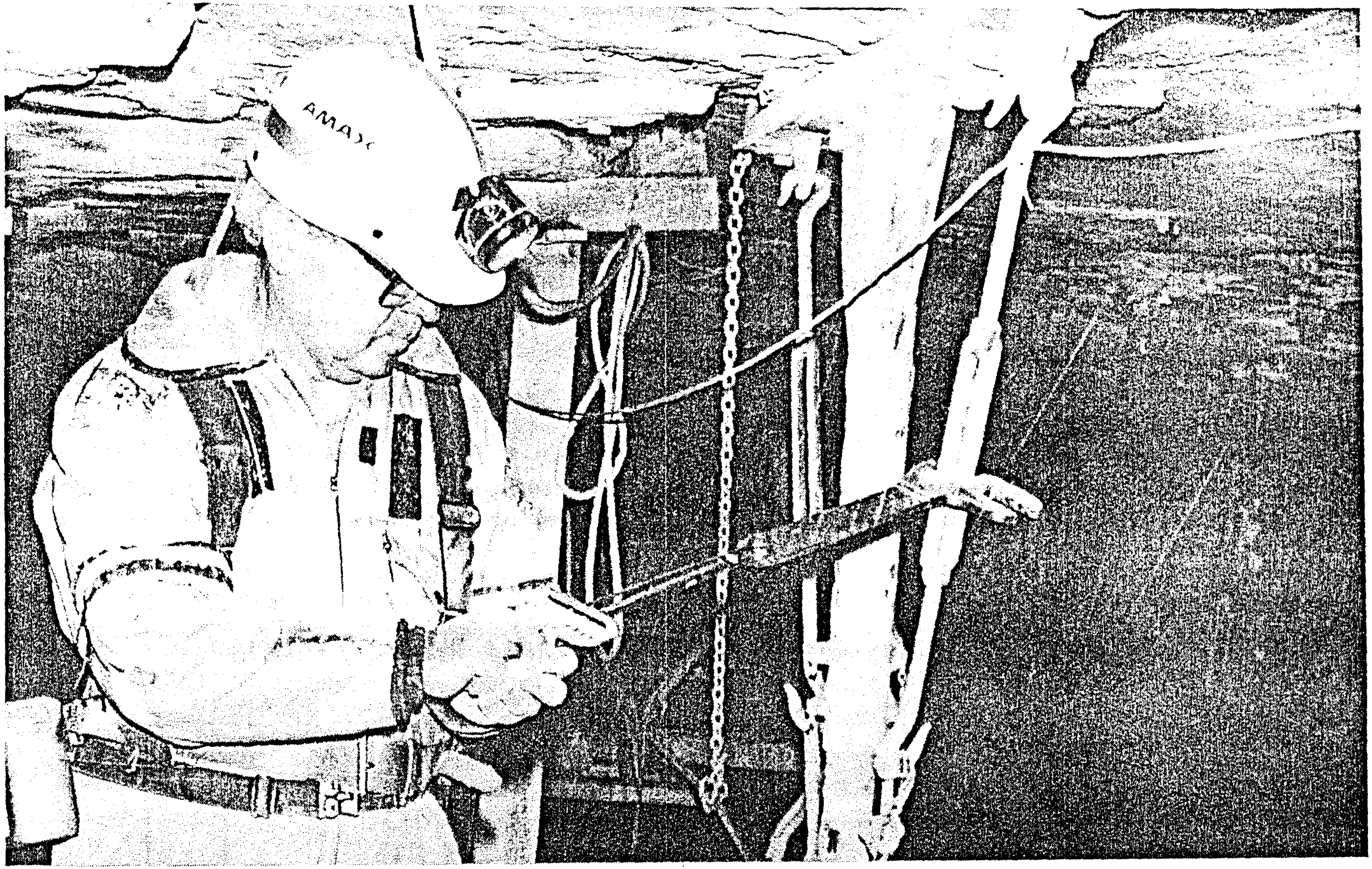


FIGURE 46. - TTW In-Mine Test, Sailboat Anchored Wire Rope Tensioning.

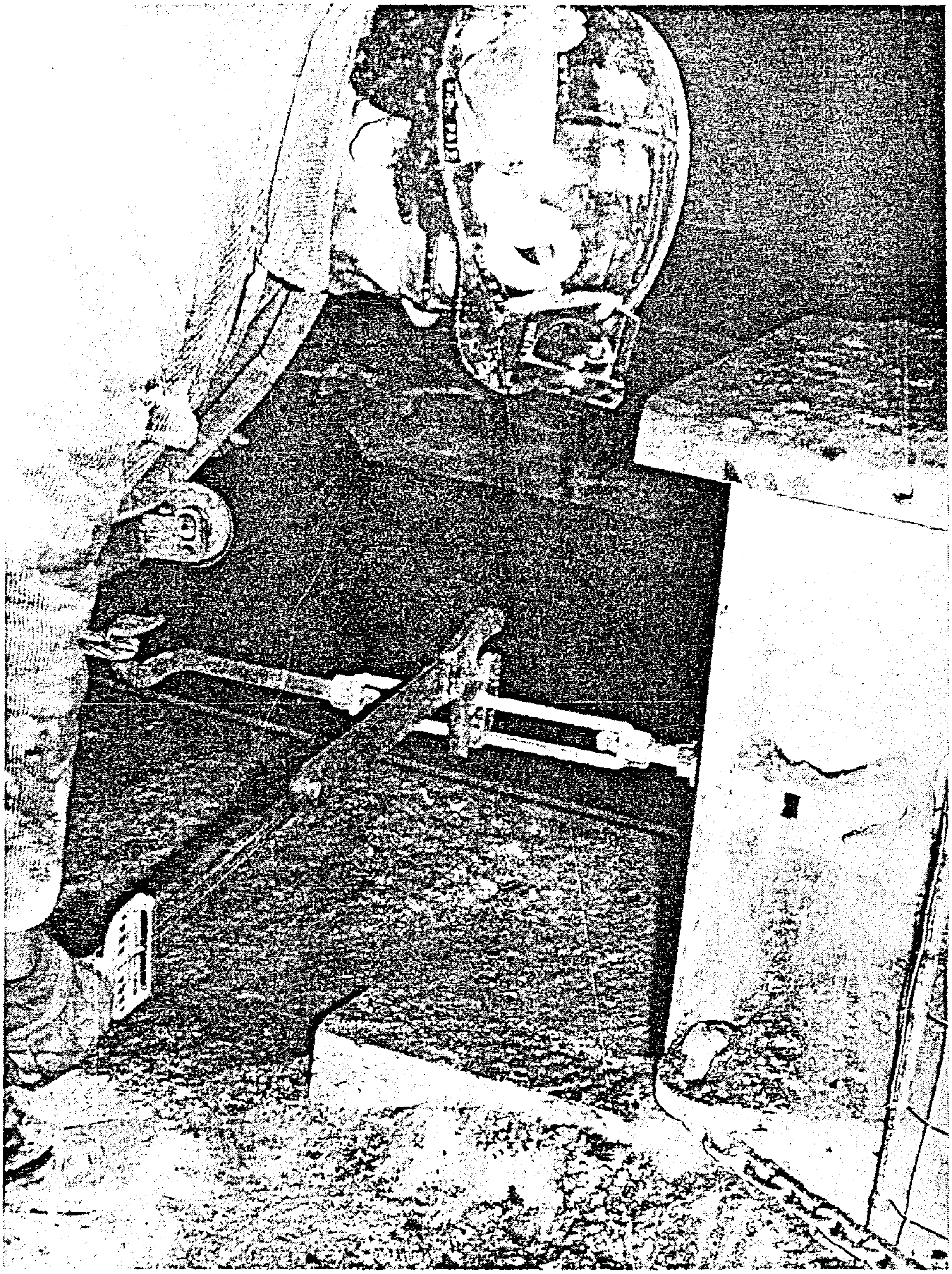


FIGURE 47. - TTW In-Mine Test, In-Line Anchored Wire Rope Tensioning.

Management
Engineers
Incorporated

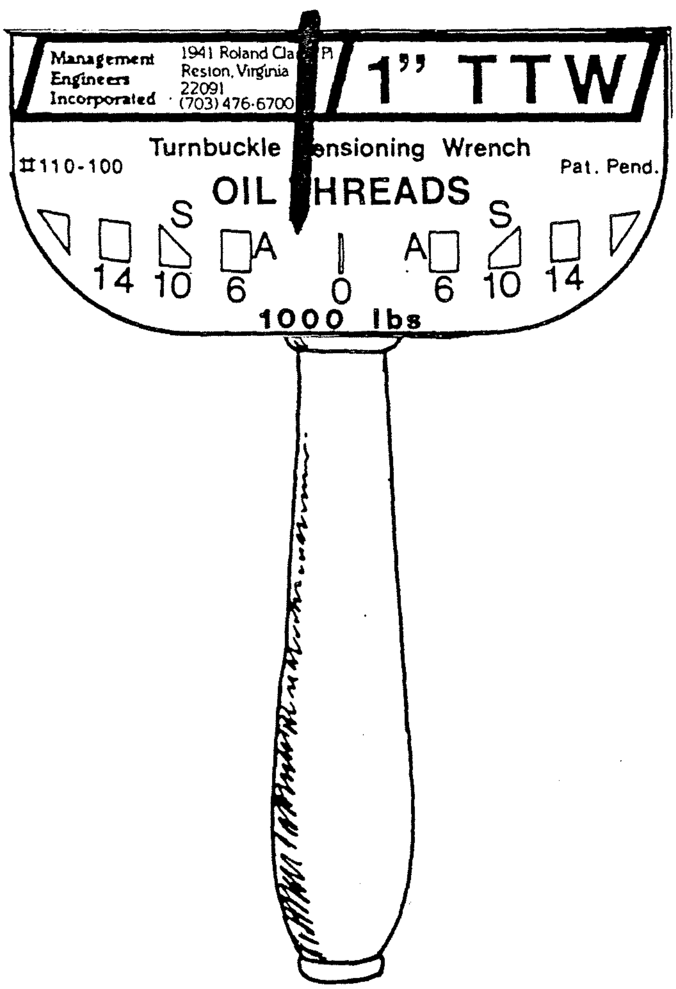
1941 Roland Clarke Place
Reston, Virginia
22091

(703) 476-6700

1" TURNBUCKLE

TENSIONING WRENCH

DESCRIPTION



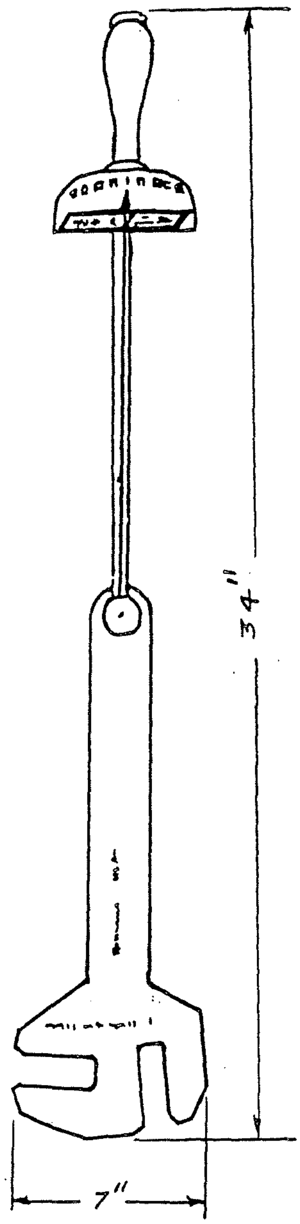


FIGURE 48. - TTW Advertisement Sheet, Page 1.

1" T T W

WHAT IT IS

The 1" TTW Model 110-100 is specifically designed for use with 1-inch by eight thread, forged steel turnbuckles having oiled threads. Models for other applications are available. Model 110-100 is designed for use in less than perfect conditions as typically found in underground coal mines. Therefore, the scale has been calibrated in bands of approximation that are easy to use under difficult conditions. While the wrench does not yield a finitely accurate tension force value, it does yield a close approximation sufficiently accurate for the application. There is no other simple means readily available to attain an equal degree of accuracy. Remember, obtaining an accurately finite tension load value is not as important as obtaining reasonable uniformity between two or more members. The 1" TTW can give you that uniformity.

HOW TO USE IT

- Extend the turnbuckle's threaded members to their maximum distance and squirt some oil on the threads.
- Hook up turnbuckle and tighten by hand.
- Place appropriate wrench jaw over the turnbuckle at a convenient point and tighten further by applying force at the handle grip only. Continue to tighten until the indicator points to the desired tension load shown on the scale.
- The scale has been calibrated to indicate increments of tension loads approximating 1000 lbs. The associated band number theoretically represents the tension load attained when the indicator points to the center of that band. The edges of the band represent a value of 1000 lbs. above or below the center value. The midpoint between bands represents a value 2000 lbs. above or below the center value.

CAUTION

Periodically check the accuracy of the indicating pointer. It should always point to zero when the wrench is unloaded. It if does not, simply bend it until it does.

EXAMPLE 1

Where the turnbuckle is used to anchor a conveyor terminal unit and is directly in line with the wire rope, tighten until the indicator points to letter A which should yield an approximate 4000-lb. tension load.

EXAMPLE 2

For setting the initial tension for wire ropes (e.g., where the turnbuckle is at an angle in a sailboat anchor), tighten until the indicator points to the letter S on the scale. This should create an approximate 6000-lb. tension in the running rope.

FIGURE 49. - TTW Advertisement Sheet, Page 2.

Armored Levels

Since one of the keys to a quality installation is the creation and maintenance of level component positioning, it seemed natural and obvious that a relatively inexpensive level should be attached to the equipment at the factory. Thus, when the components were delivered to the field, the level would assist in ensuring that the installation would be made correctly and could be easily monitored afterward.

Researching the spirit levels currently available in the market turned up a bubble vial that could be used in any position about its longitudinal axis and was constructed of plastic, making it much more shock and break resistant than glass. A common piece of 3/4-inch, schedule-40, black iron pipe was used as a protective housing for the bubble as shown in Figures 50 and 51. Several levels were placed on a tailpiece and head boom (Figures 52 through 55) in the Jeffrey Division factory in Belton, South Carolina. These units were shipped to their purchaser, moved underground, installed, and operated. None of the levels were broken or disturbed in any way throughout the above described events. In-mine testing is shown in Figures 56 through 59. Other levels were subsequently installed on components while above ground and used underground during installation and operation at Brushy Creek mine. The levels have performed successfully as planned.

They appear to be utilized best on panel belt tailpieces (which are moved frequently) where the device is used to indicate the levelness at right angles to the run of the conveyor. It also serves well on head-mounted booms to indicate levelness at right angles to the conveyor run. This level has the only known bubble vial that will work regardless of the vertical angle of the boom which makes it unique and most helpful.

Even though the levels have performed successfully in two mines, neither mine has shown any great admiration or enthusiasm for them. This is puzzling but perhaps indicates that people are not fully aware of the benefits of quality installations even though they give lip service to the philosophy.

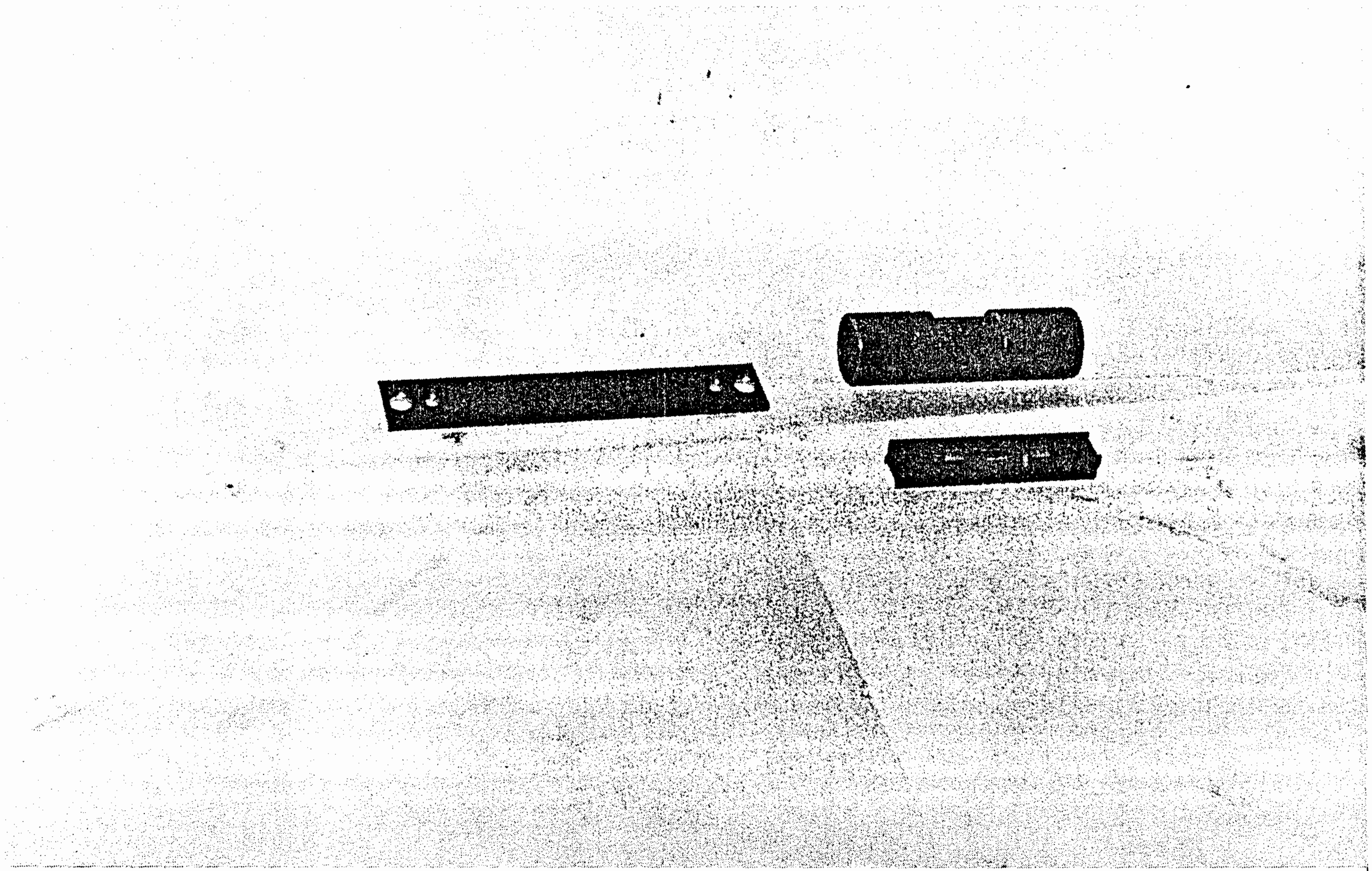


FIGURE 50. - Armored Level Manufacture, Basic Components.

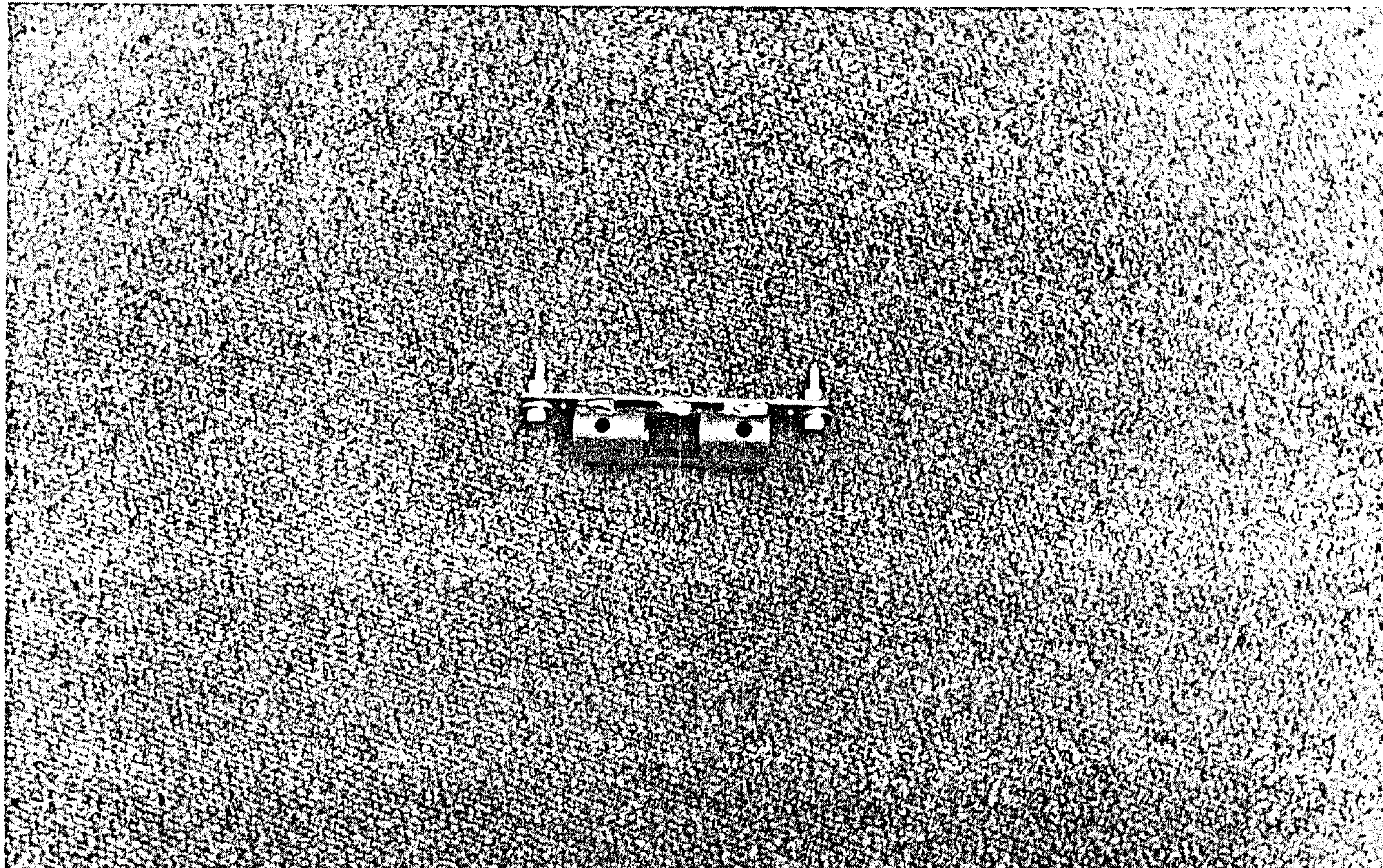


FIGURE 51. – Armored Level Manufacture, Fully Assembled.

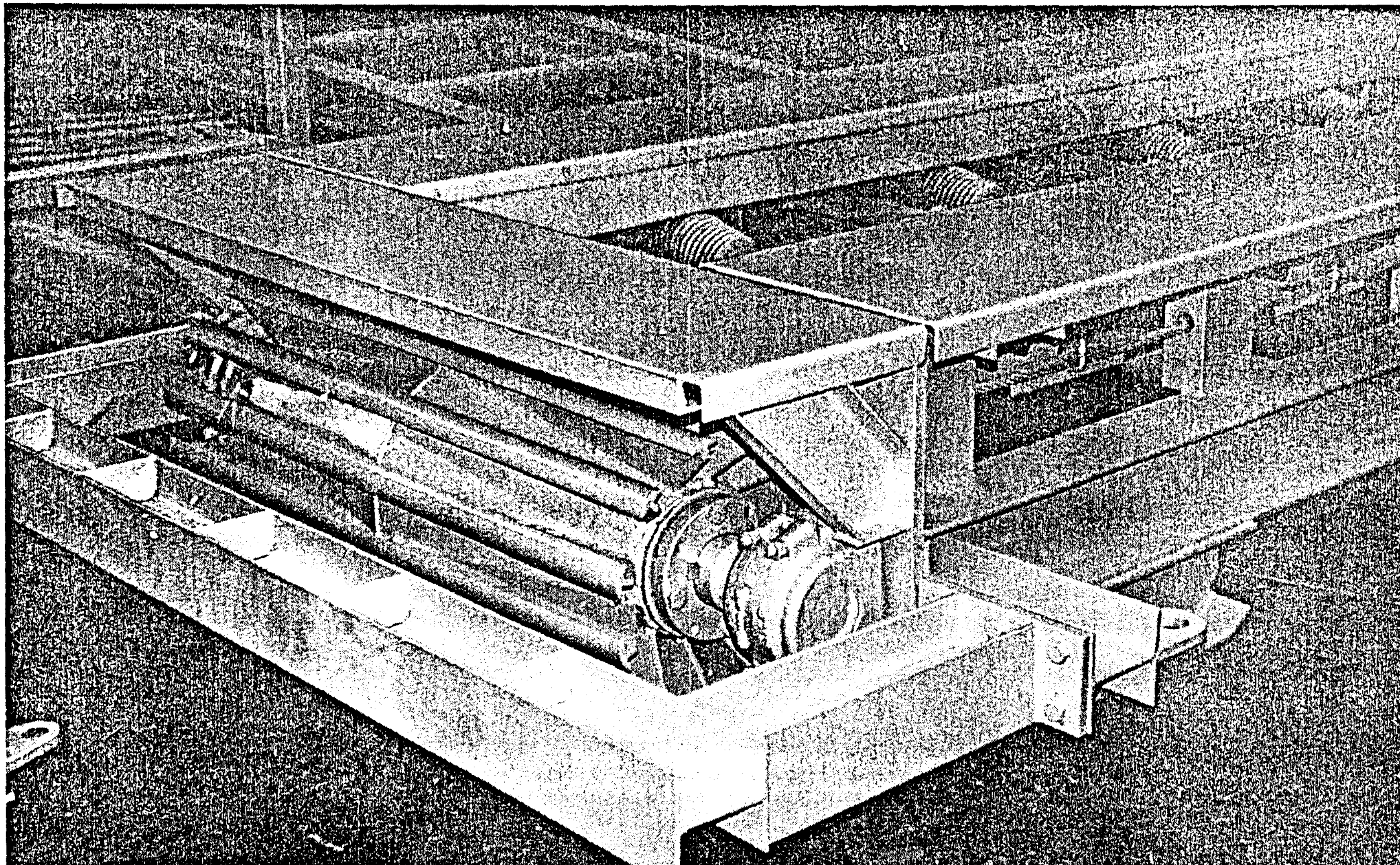


FIGURE 52. - Armored Level Installation.

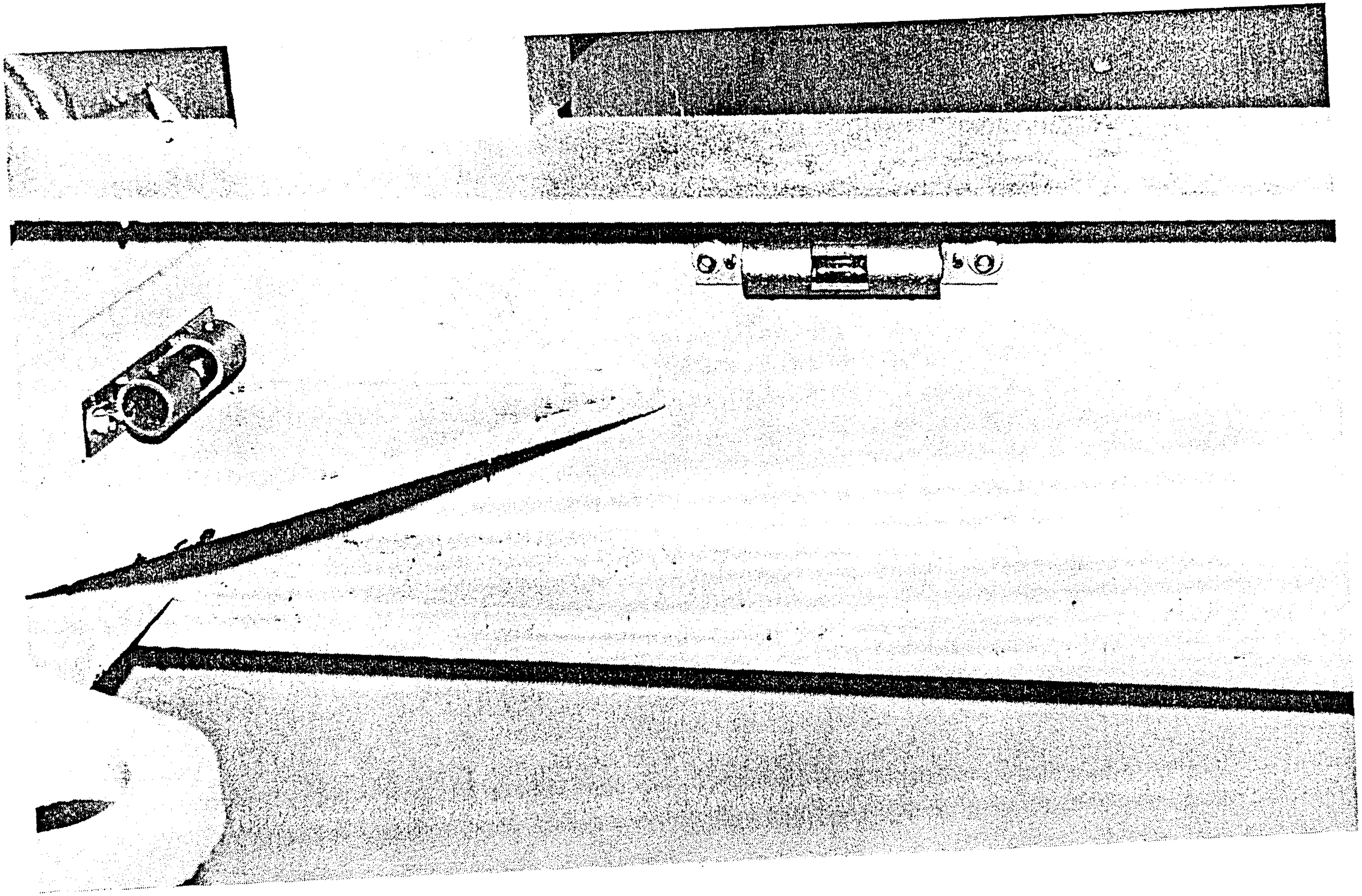


FIGURE 53. – Armored Level Installation, Mounted Levels.

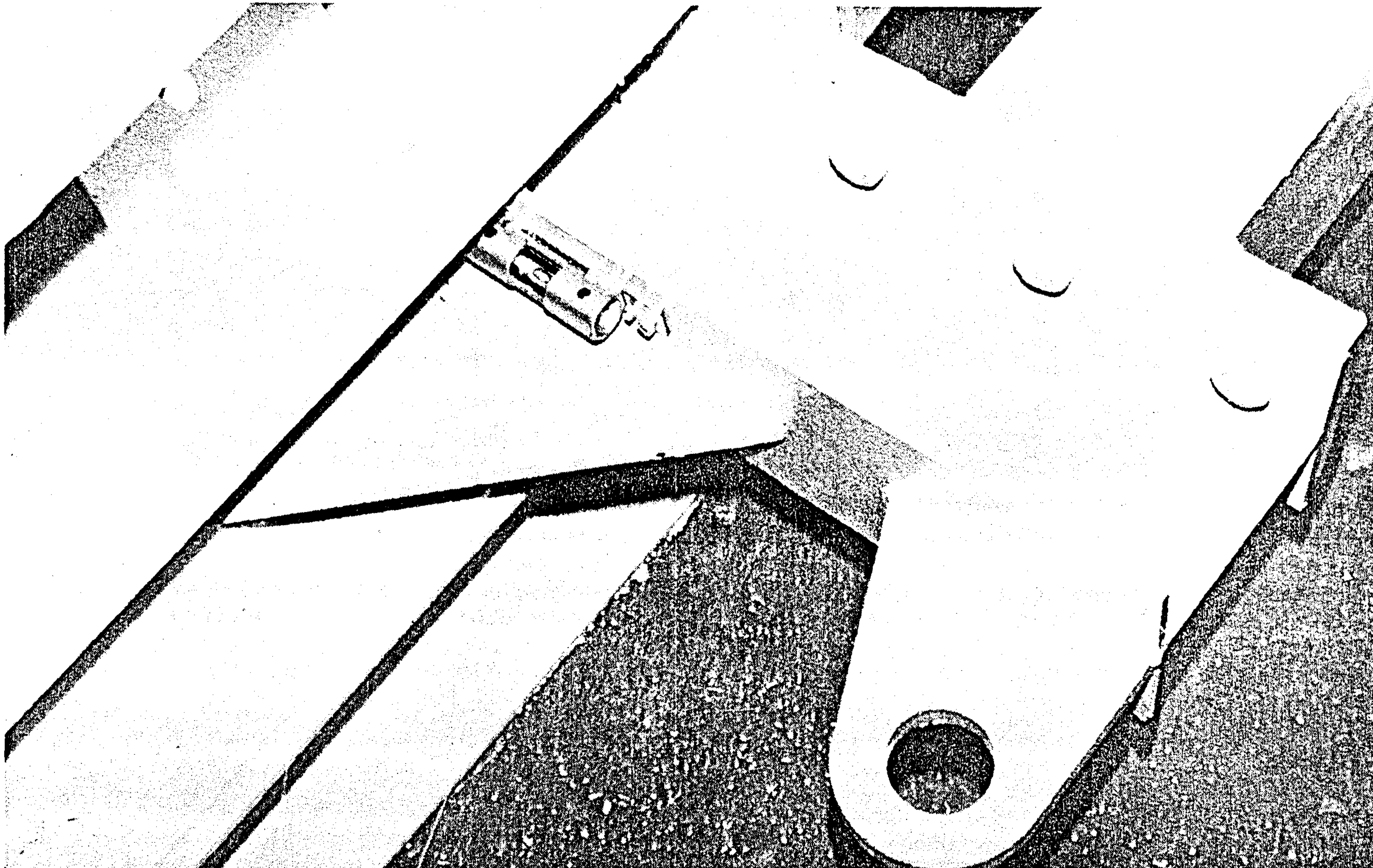


FIGURE 54. - Armored Level Installation, Protected Yet Visible.

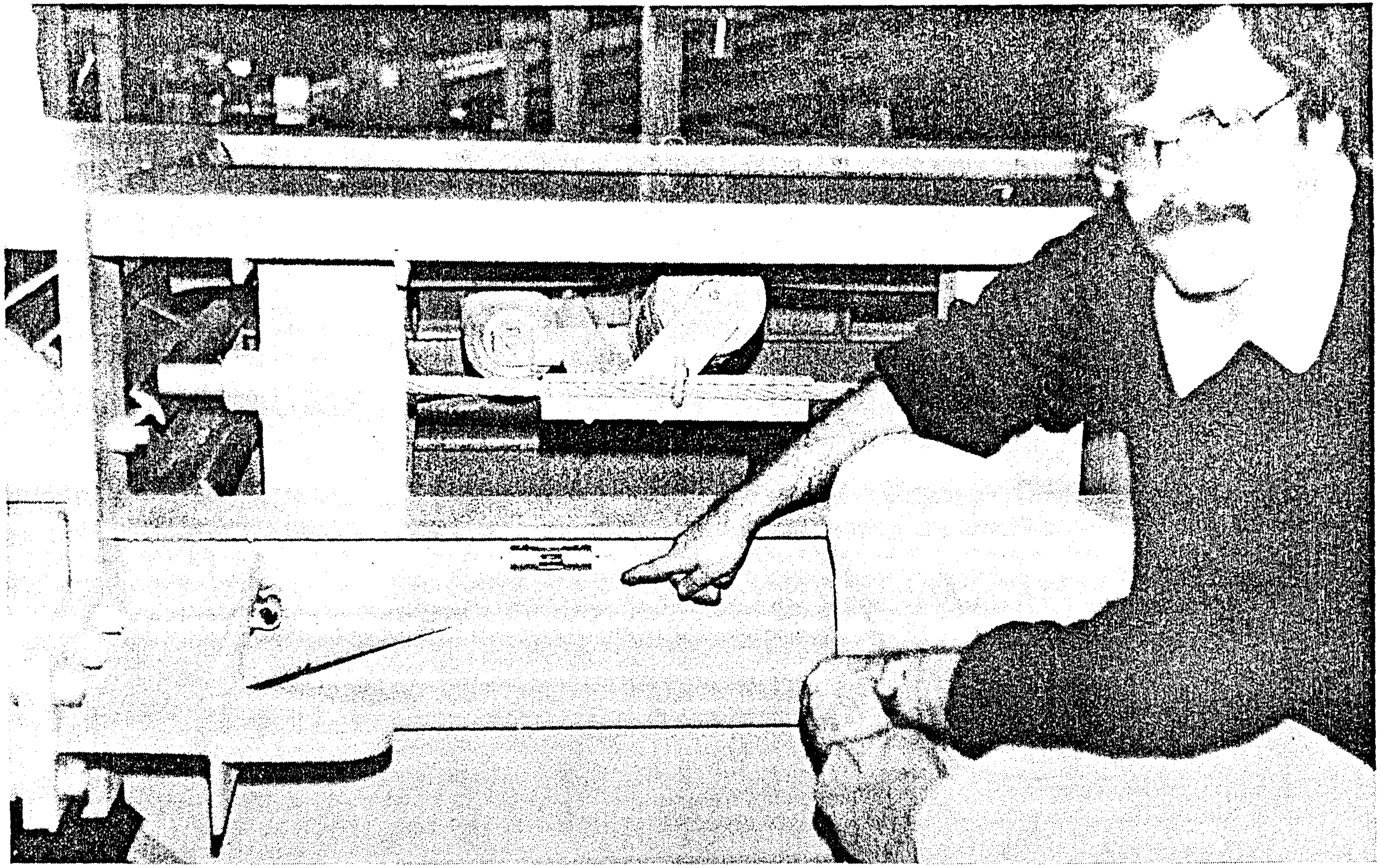


FIGURE 55. – Armored Level Installation, Ready for Shipping.

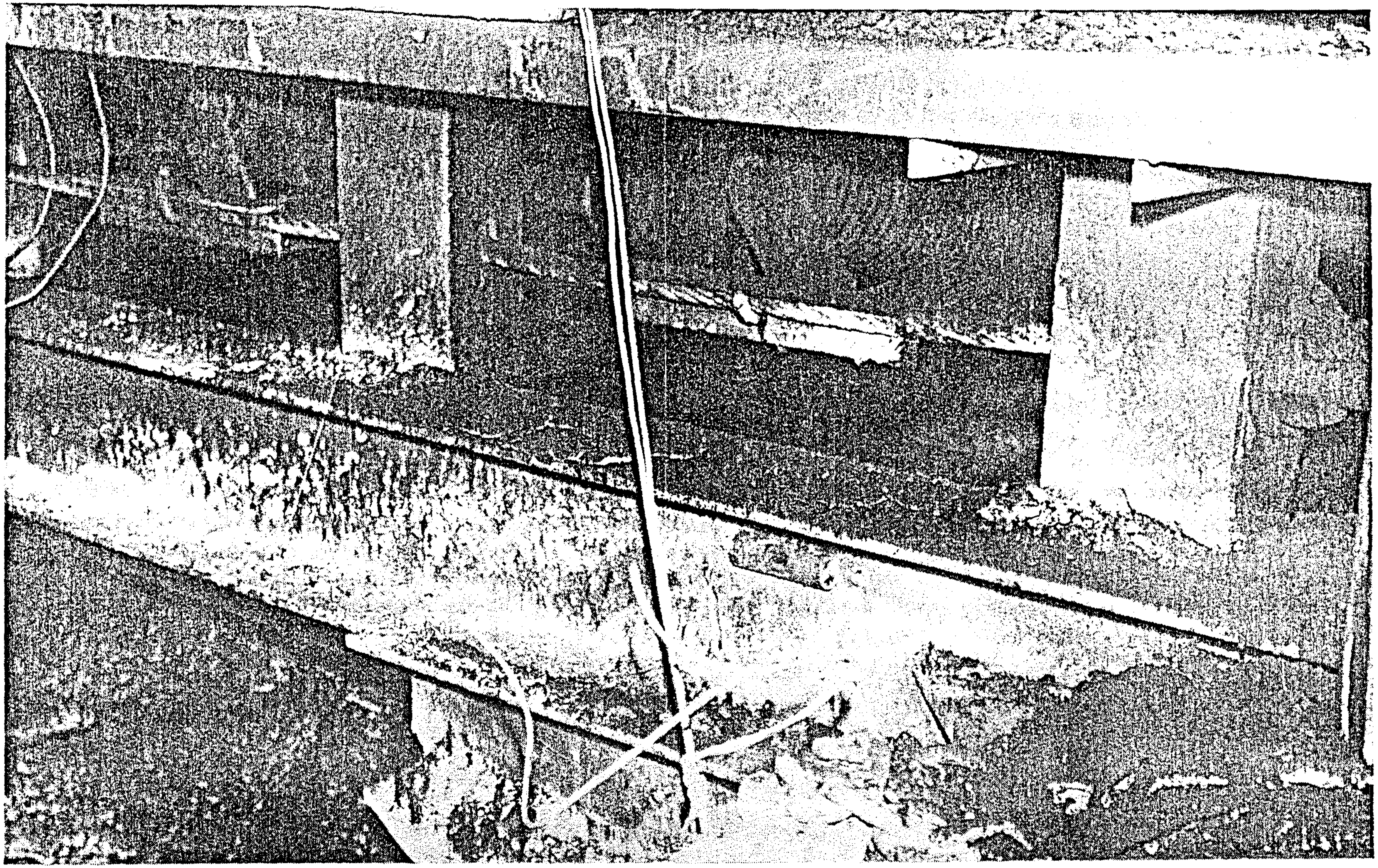


FIGURE 56. - Armored Level In-Mine Test, Typical Mine Conditions.

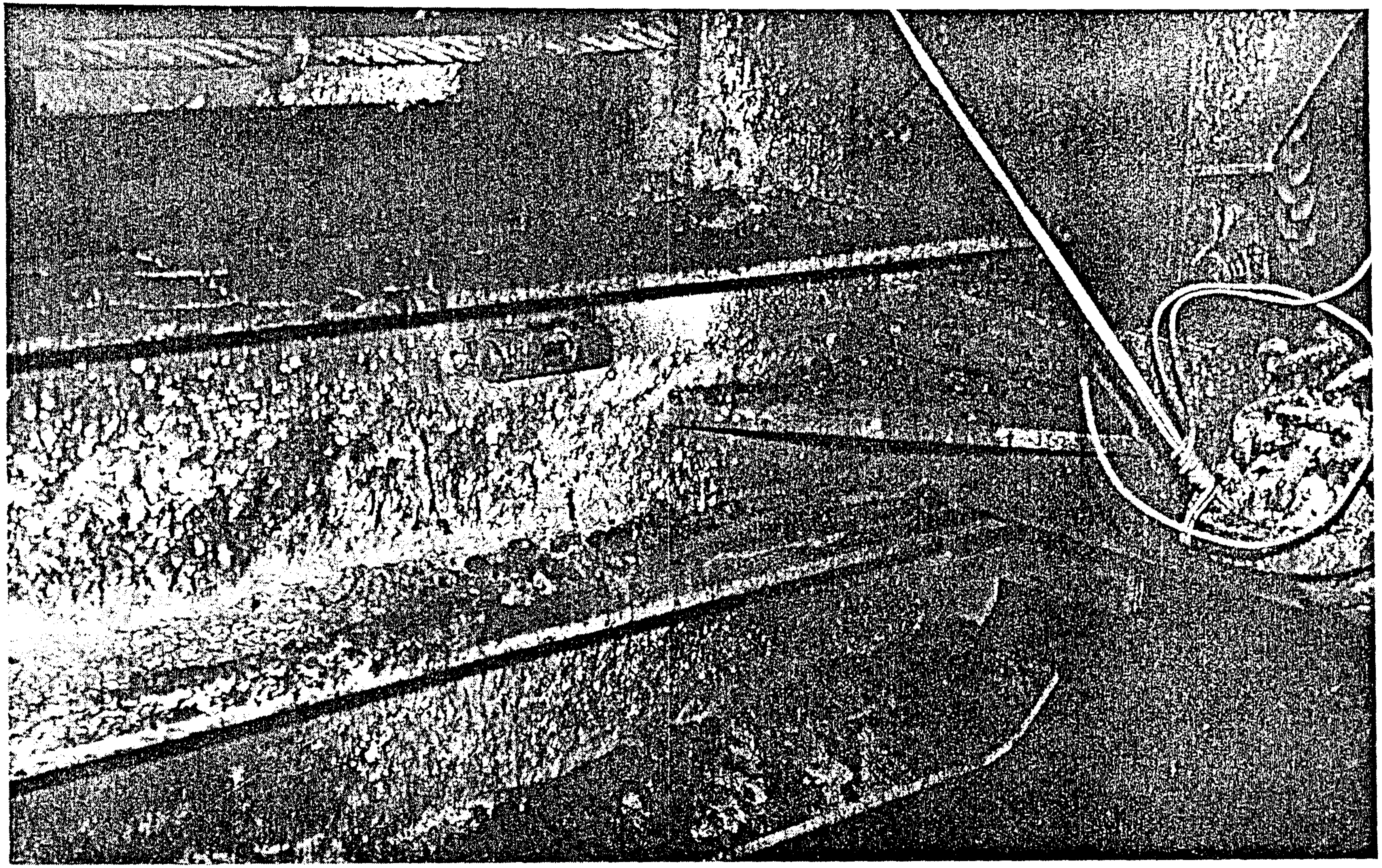


FIGURE 57. - Armored Level In-Mine Test, Same Tailpiece and Same Levels.

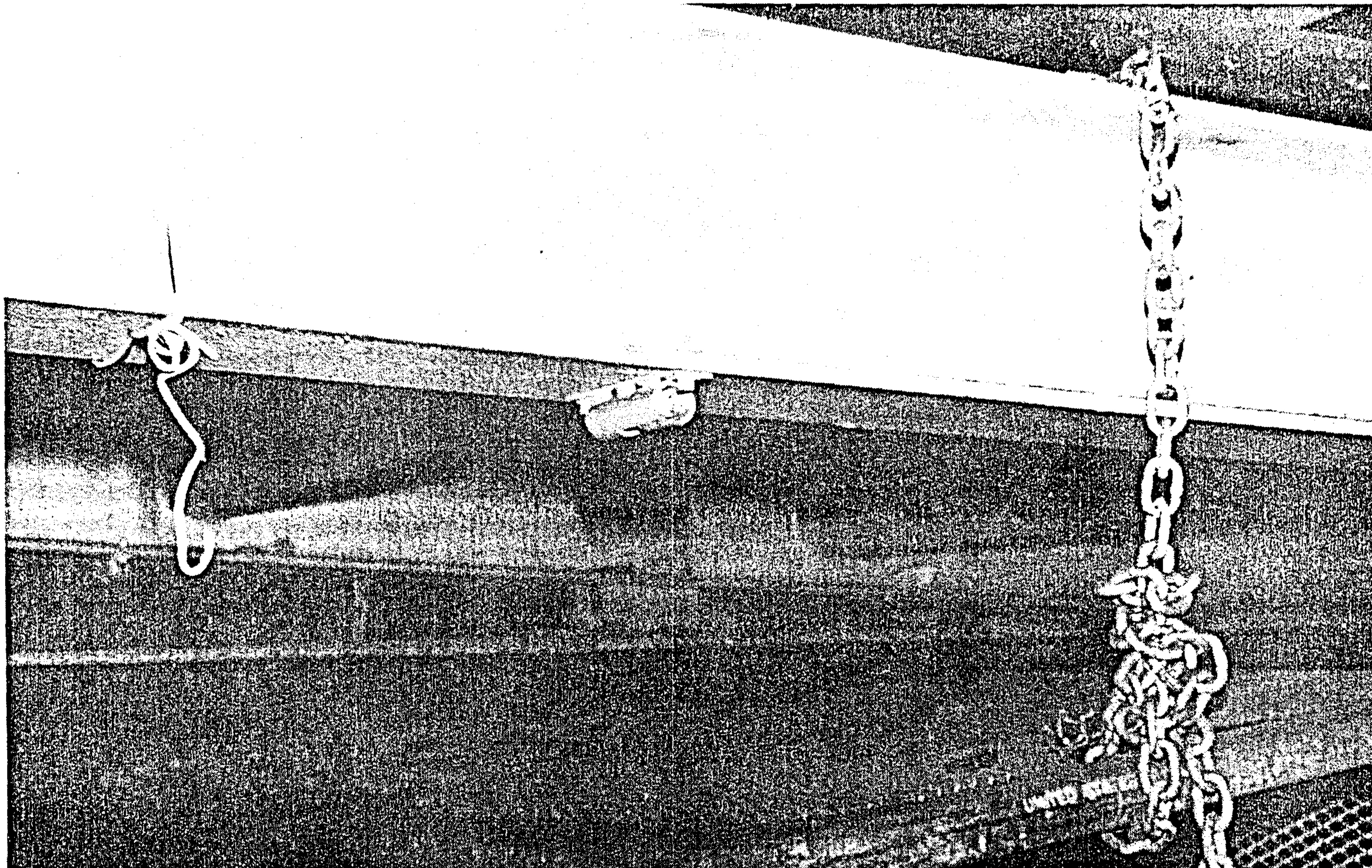


FIGURE 58. - Armored Level In-Mine Test, Discharge Boom-Mounted Unit.

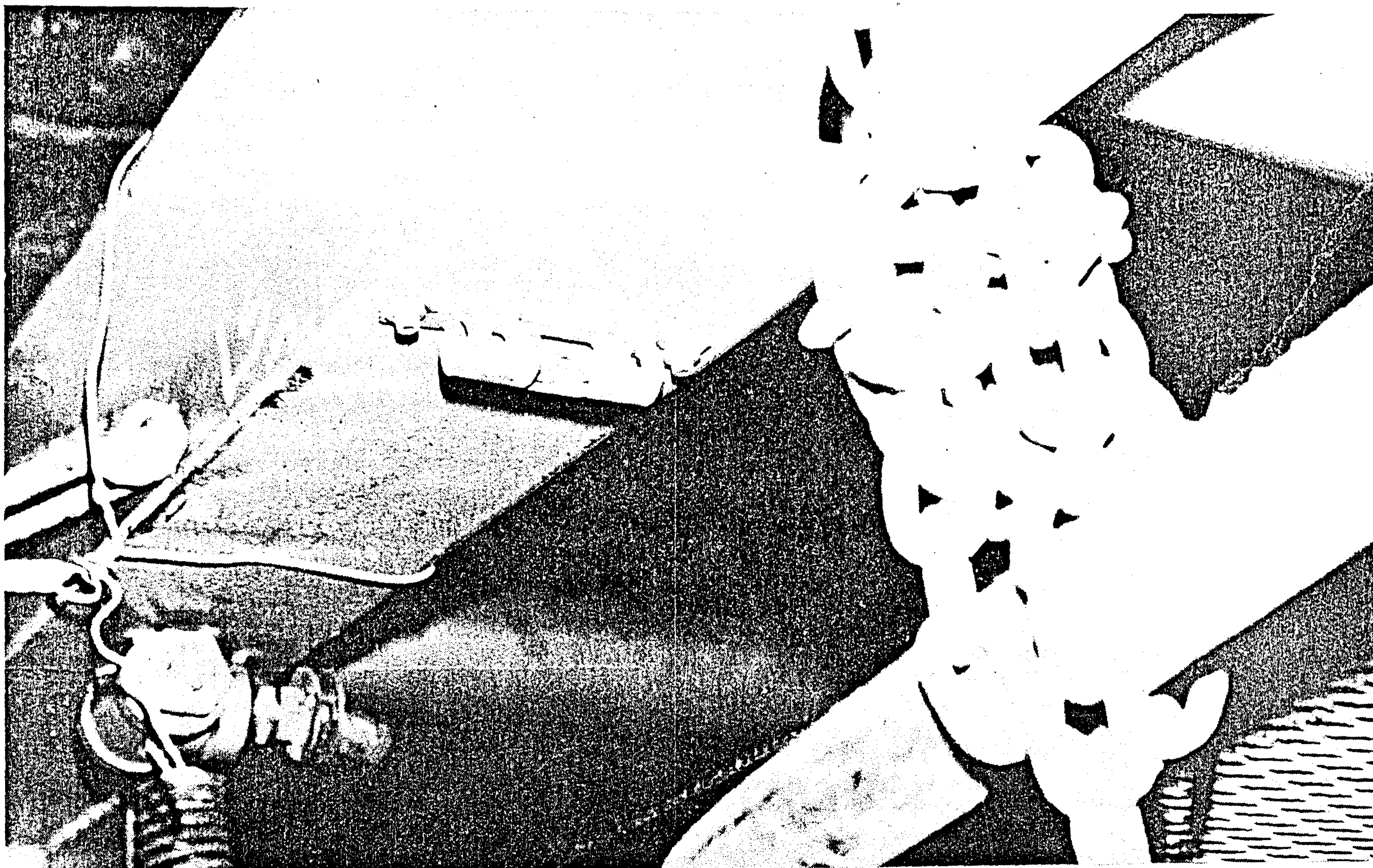


FIGURE 59. - Armored Level In-Mine Test, Boom's Level.

Power Driving Belt Splicing Rivets

During the mine visits, it became obvious that the belt splicing requirements occupied a very important area in the overall installation and maintenance activity. It was observed that all of the mines visited used splicing hardware from only one manufacturer, the Flexible Steel Lacing Company (Flexco). The combination rivet nail that is a patented item from Flexco (see items in Figure 60) is used because of its obvious convenience and quality performance. It is used almost exclusively underground with rare exceptions which usually prove to be slope or very long main haul belts using a vulcanized splice.

It was found that even though Flexco has designed and produced rivet holding and driving tools (Figure 60) at a nominal cost, none of the mines visited used this special tooling. Instead, the person doing the splicing (that is, a splicer) simply held the nail rivet in his fingers as a carpenter would hold a nail and then drove it with a 2-lb ball peen hammer. On occasion, due to carelessness, a splicer would hit his fingers with the hammer much as a carpenter does. In an attempt to overcome this minor finger-bruise problem, MEI suggested the use of a nail-holding device when driving the rivet nails. The idea was presented at the first oral briefing but was not chosen for prototyping.

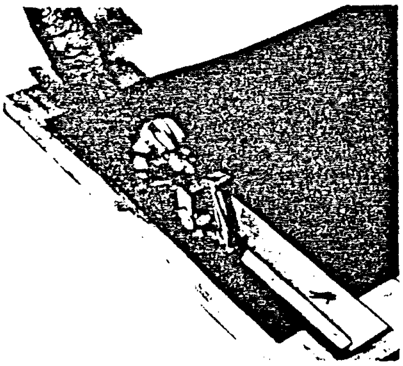
Convenience and speed explain the reasons for not using the special rivet nail-setting tools. There are an average of 250 rivets used per splice which would prove very time-consuming to drive using the special tools when compared with hand dispensing, guiding, and holding during driving. In actual practice, it was found that the splicer would take several rivet nails, hold them in his hand and roll out individual rivets between his thumb and index finger in a very rapid and efficient manner.

During the briefing discussion of this subject, MEI mentioned that Flexco had made a prototype "air gun" to power drive the rivets, but its development had been stopped. TPO Williams made a verbal request of MEI to check into the status of the power driving tool if such could be arranged within the scope of the current contract. MEI subsequently made a cursory investigation and found that a more penetrating review of the problem of power driving Flexco rivets could be included in the contract at no additional cost and then, authorized verbally by TPO Williams, MEI proceeded. An in-depth analysis of the problem of power driving Flexco rivets was documented as an interim report which was forwarded to TPO Williams on August 4, 1981.

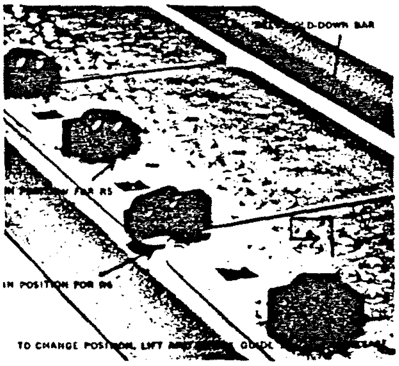
The cost analysis indicated that it would cost approximately $4000 for a power driving system to perform the required function safely. There are some unique characteristics related to the splice hardware, rivet nail, and power driving that preclude the use of ordinarily available staccato-type nail driving power tools. Power driving requirements would consist of a pneumatically-powered gun (shown in Figure 61) which would be large and cumbersome, a portable power source (tanks), and special fixturing to support and guide the tool for accurate positioning during the actual driving cycle. Under these circumstances, there would be considerable transportation as well as handling inconvenience and time delay in "setting up" prior to its productive use. This would tend to offset the theoretically gained speed and efficiency of the system. Therefore, when all factors were considered and compared to the efficiency and extremely low cost of a common 2-lb ball peen hammer, there were no takers among the mine operators surveyed.

Installing FLEXCO® Rivet Fasteners on SRT Applicator

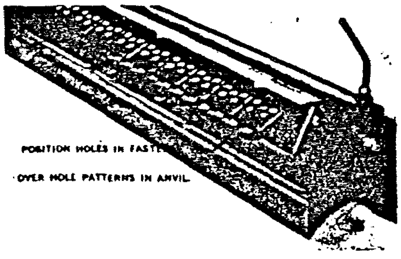
Bulletin FSR-961C



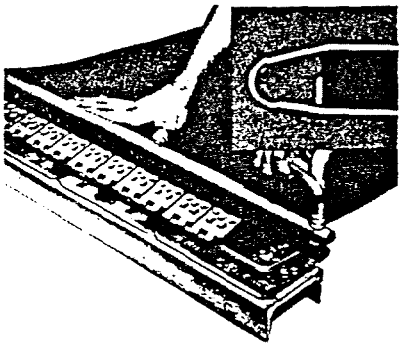
1. Cut the belt square using a straight cut 300 series Alligator® wide belt cutter.



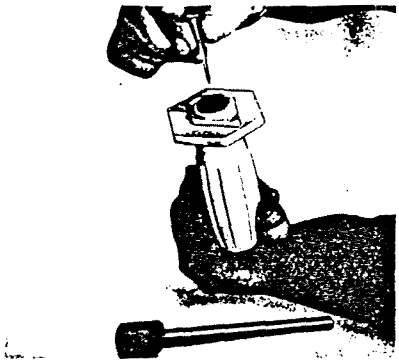
2. Set gauge pin guides in position for R5 or R6 fastener as shown above.



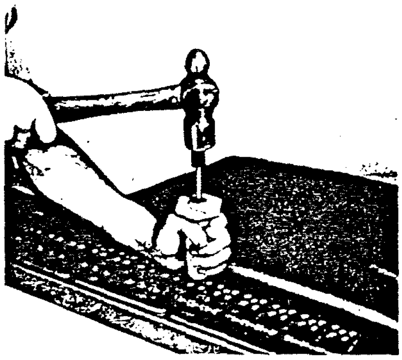
3. Center fastener strip in tool with R5 or R6 number up, connected plates down. Gauge pin guides go between fastener plates. Hole patterns in fastener should now be positioned over hole patterns in anvil. Insert gauge pin through guides and fastener loops.



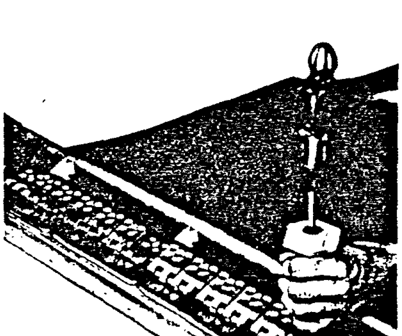
4. Center belt in fastener strip. Be sure belt end is butted against all belt-stop lugs in fastener. Tighten hold down bar until belt is just held in place. Do not overtighten. With hammer lightly pre-set fasteners.



5. Select correct size SR rivet nail assemblies for belt thickness. Do not use unassembled rivets and nails. Remove drive rod, drop rivet assembly into tool and replace drive rod. Use this for starting rivets.



6. Center rivet driver in center hole of center plate. Drive rivet out of tool into belt. Remove tool and set rivet with hammer. Be careful not to overdrive rivets as this can cause distortion of fastener plates.



7. Next drive rivets into center hole of both end plates. Continue to drive rivets into all center holes of remaining plates. This will anchor fastener strip in position.

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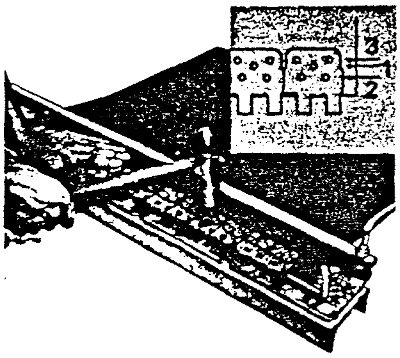
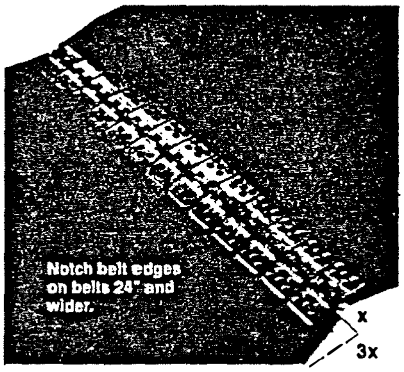
2525 WISCONSIN AVE. DOWNERS GROVE, IL 60515



8. Complete driving the other two rows of rivets in the sequence shown above. Finish rivets with firm blows being sure fastener edges are down flush on the belt. When joining new belt to old, it may be necessary to break up the bridges in the fastener strip (after installation) to make it spread uniformly with old belt end. This will make hinge pin insertion much easier.

9. Remove gauge rod and belt clamp bar. Lift belt off tool. Knock off any pilot nails still stuck in rivets.

10. Turn tool over and be sure all nails are removed before making next splice.



11. Repeat entire sequence on the other belt end. Bring both ends together and insert hinge pin. Notch belt edges as shown. Joint is completed.

12. To remove hinge pin which has been in use, release tension on belt, dislodge material binding pin and twist pin simultaneously at both ends ¼ turn (in the same direction). A hammer and vice grip pliers are recommended.

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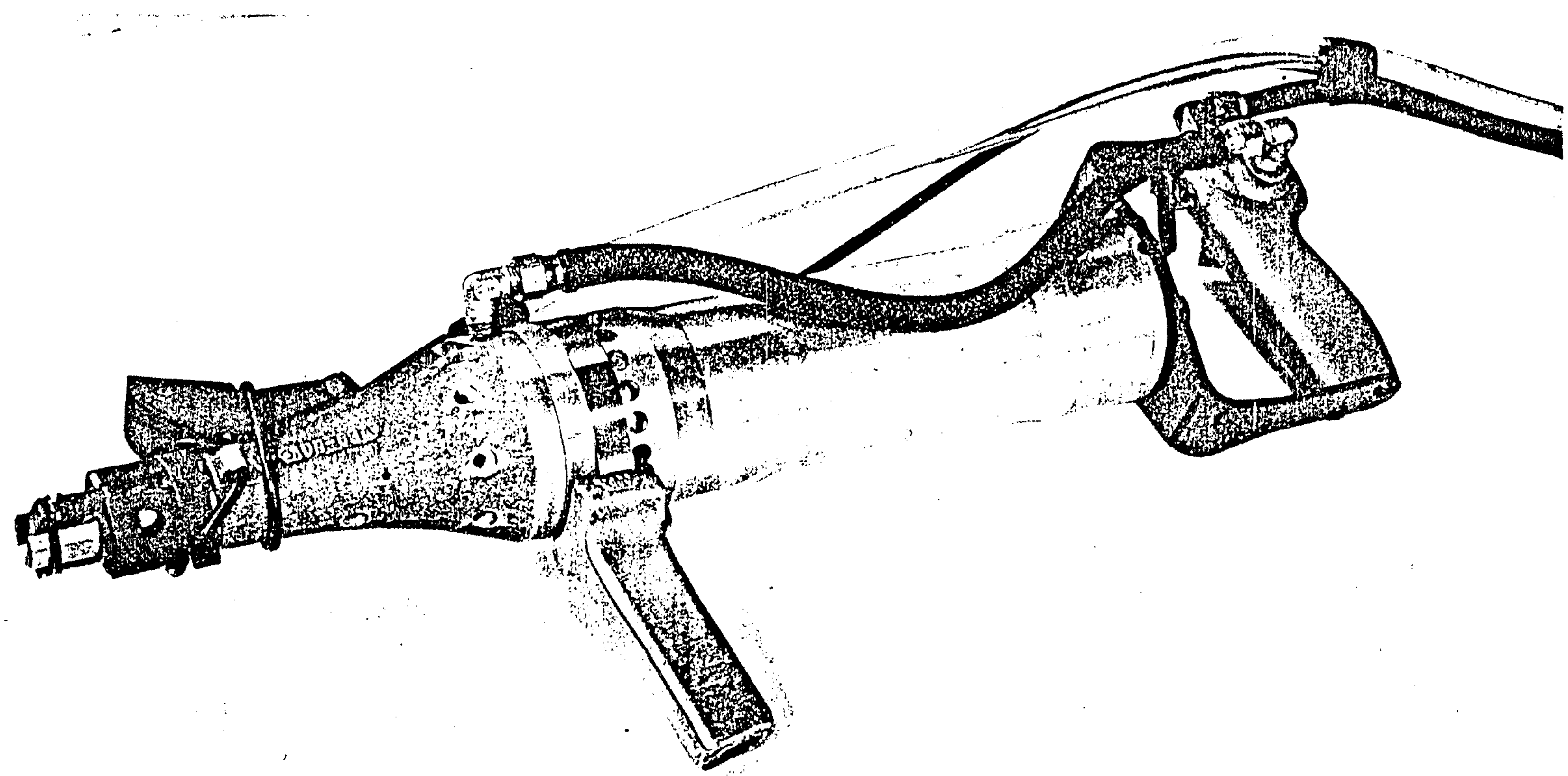
FIGURE 60. - Flexco Splicing.



The 3/8" driving unit, Model G, is 23 inches long and 3-1/4 inches in diameter through the body, with a nose diameter of approximately 1 inch. It weighs about 10 pounds. It is designed to operate on air pressure of 90 pounds per square inch of clean dry air at 21 cubic feet per minute, with an air supply hose of 1/2 inch (minimum) inside diameter.

FIGURE 61. - Candidate Gun for Driving Flexco Rivet Nail.

Subject Inventions

In accordance with the requirements related to "Subject Inventions and Patent Applications" contained in the Patents and Inventions article provision, Exhibit C, of the contract, the necessary documentation was properly executed. On May 6, 1982, Management Engineers Incorporated forwarded to Ms. Sandra Schlesier, Contract Specialist, in Denver, Colorado and to TPO T. Williams, disclosure documentation with information sufficiently descriptive and complete so that a person knowledgeable in the art may ascertain whether or not the subject inventions are patentable.

Manual Development

Philosophy

From direct experience in underground coal mines and in recognition of "real world" factors, the overriding philosophy generic to this manual may be summed up as follows. The manual must generate a desire to be used. It must place emphasis on the positive and should not picture negatives that may be remembered. It should be directed at belt-knowledgeable supervisory level personnel to successfully assist them in better planning of safe belt activities and also be usable as a readily understood training aid for their belt crews.

The predominant philosophical logic of generating a reduction of accidents by promoting quality in installations is well accepted in the industrial world. It is obvious that the amount of exposure to a hazard directly affects the opportunities for injury. Therefore, the better the installation, the less personal attention is required to keep it operating properly. This quality-means-safety axiom is employed as the dominant theme in the manual.

The old adage stating, "You can lead a horse to water but you can't make it drink" holds true. However, there is an obvious and simple solution. All one has to do is to make the horse thirsty and it will want to drink when it gets to the water. Making a horse thirsty is not difficult. Making people want to read and use a book is not so easy; on the contrary, it is difficult and complex, and it requires new and interesting techniques and concepts.

Concepts

The means for best implementing the above philosophy was conceptualized in the following manner. An early decision for enhancing the use of the manual was to make it convenient to handle. Therefore, it was made mine-friendly by being sized to fit a miner's pocket and printed in easy-to-read type. Another means to attain reader interest settled on the use of cartoons. The use of cartoons is not new but certainly is as attractive to mining as to any other industry. Holding reader interest after it is attained is another problem which has to do with the manner in which the technical material is presented. MEI made a concerted effort not to use language that would be unusual and/or lofty yet would accurately present the material.

A unique feature of this manual is the three cartoon characters and the manner in which they are treated in the text. This has produced a unique and unusual style that promises to obtain and hold reader interest. The cartoon messages were constructed specifically not only to create interest but to sell ideas through repetitious cryptic messages to be remembered through rhyme. Some of the cartoons can be used on a stand-alone basis as a safety message in any industry, some can be used as stand-alones in any mining industry, and others can be used on a stand-alone basis only in underground coal mines using conveyor haulage. Also, there are some that can only be used in conjunction with the manual since they tie in directly with the narrative.

After it was decided to use cartoons, the development of suitable characters to carry the messages was hit upon by adopting two sculptures that occupied the author's office. Being his previous creations (Figures 62 and 64), he was quite familiar with them and felt they would lend themselves admirably to the cause. Ms. LaRue Wells, the artist, was engaged to give them character and life-like personalities. The progenitor of the gob louse* is shown in Figure 63 and the splice worm* in Figure 65. Billy Beltz*, Figure 66, was created entirely by Ms. Wells based on many discussions of a personality envisioned by the author.

The problem of how best to present the technical material was the subject of considerable thought, analysis of the real world conditions in which it was to be used, and creative approaches to implementing the philosophic logic discussed above. Since it is obvious that no conveyor can be maintained adequately unless is is installed properly, it was felt that the logic of discussing installation through the vehicle of an example was self evident. A wire rope supported conveyor was chosen because it represents the most popular type of conveyor support system used in the underground coal mine industry today.

Since the manual was to be directed at the supervisory level to help plan their belt work as well as to assist in training their crews, the format and context of the material was given considerable study. Another early decision was that the text should not be a basic primer for belt work. Also, it was assumed that even the most inexperienced person would at least be a mechanic of sorts and would be under the supervision of experienced belt supervisors. The result of the study, therefore, was to present detailed discussion of how to make a quality installation and then provide checklists of sequential highlights for the same installation. The more experienced persons can quickly review these sequential requirements and then refer to the details if necessary. The inexperienced persons start by studying the detailed procedures.

It was felt that a few very basic but extremely important factors be presented, developed, and repeated and repeated to the point where they would be driven home unforgettably. The cardinal point is that the way to improve safety around conveyors is to improve the efficiency of the system through practicing the "3-D KEY TO SUCCESS" which embodies installing a conveyor that is in alignment, is square and level, and is made to stay that way. Every industry person acquainted with conveyor operations, when queried, has agreed that more than 95 percent of operational problems are eliminated when a conveyor system is installed according to this rule.

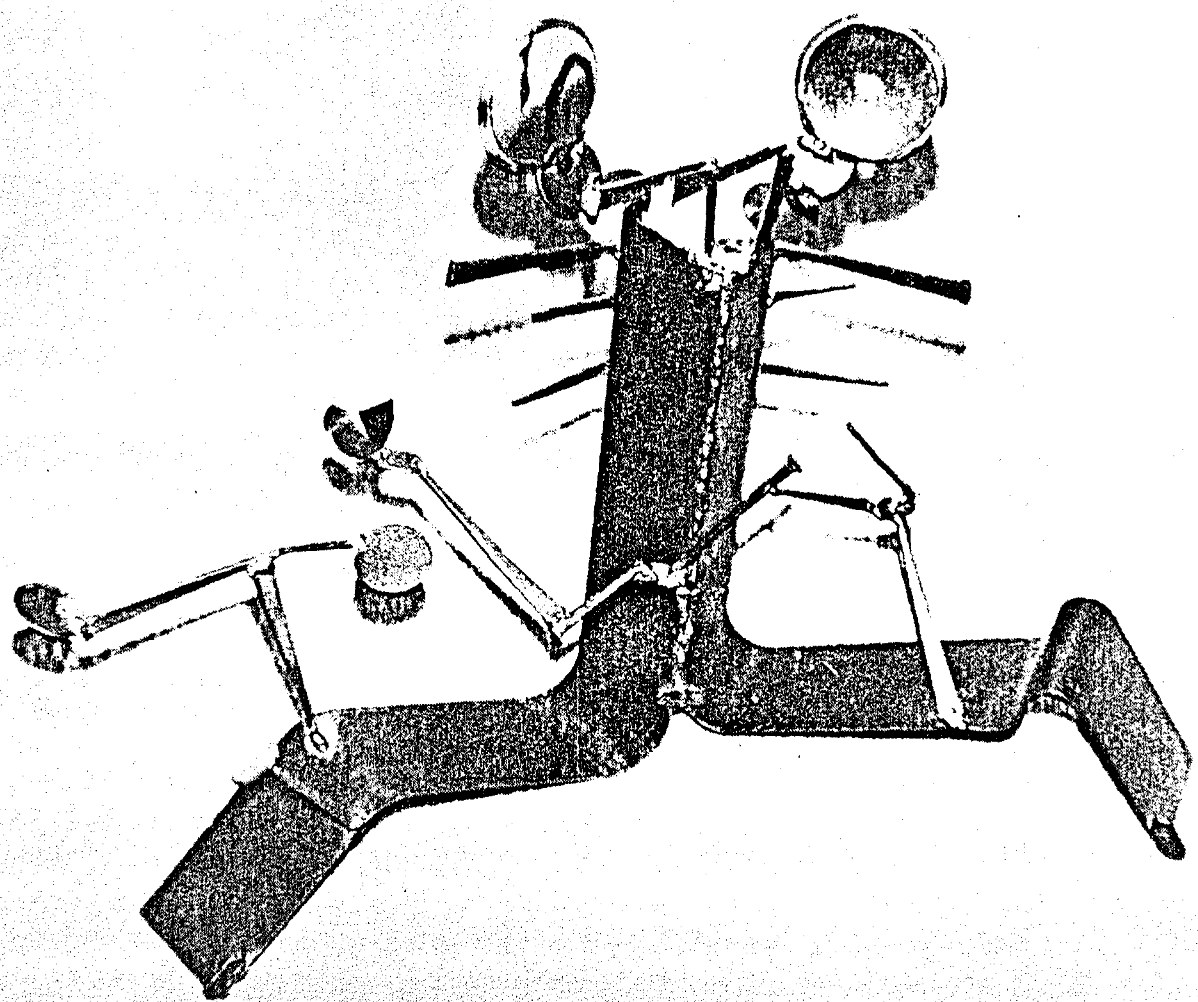


FIGURE 62. - "Mantis."

This piece of sculpture by Svend Bue Rondum was used as the progenitor of the manual's gob louse cartoon character.

GOB LICE PRODUCE LOUSY WORK. THEY ALSO CAUSE THE SHORTCUT ITCH CAUSING CARELESS FEVER WHICH TENDS TO CAUSE ACCIDENTS.

FIGURE 63. - Gob Louse.

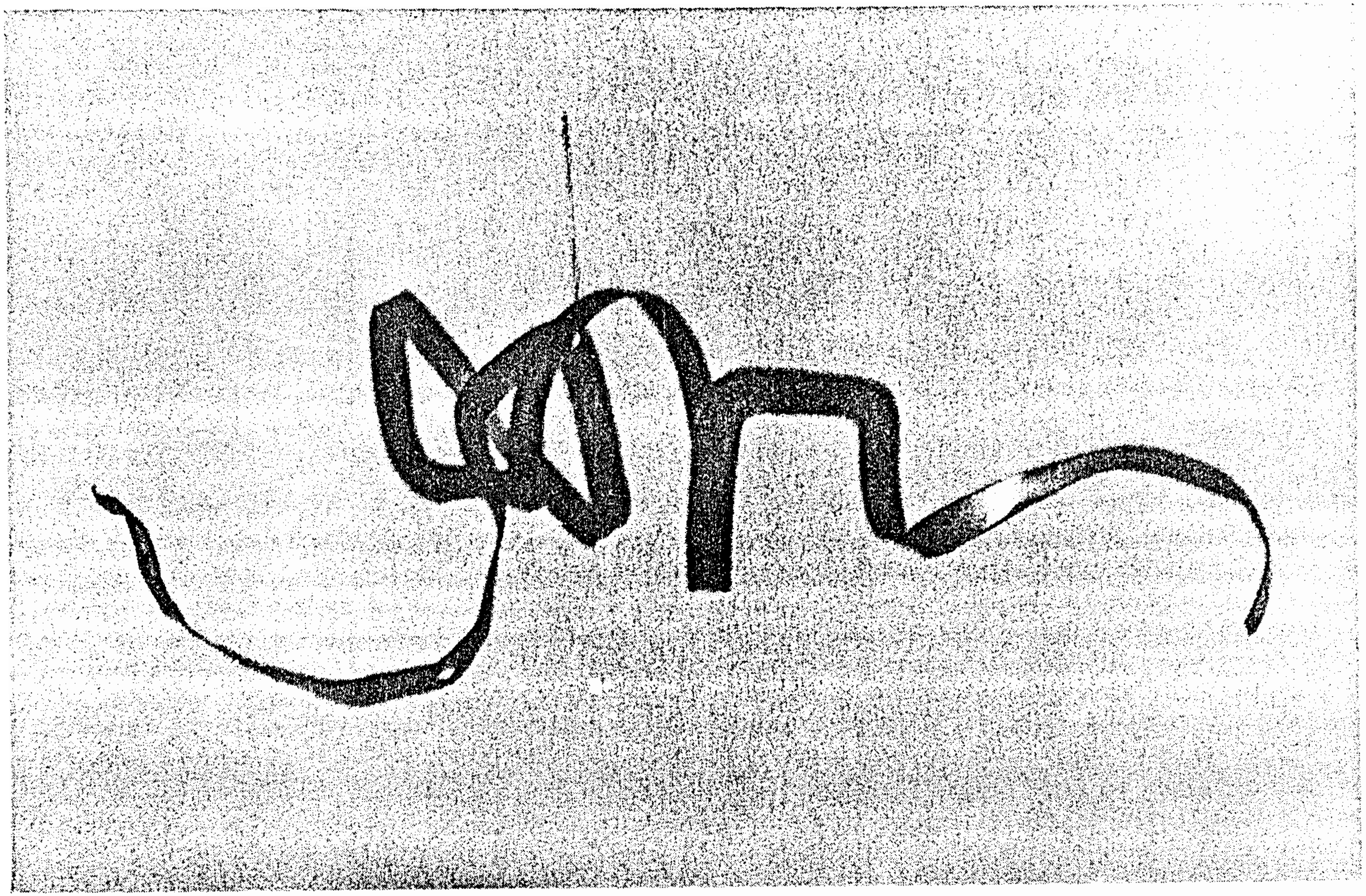
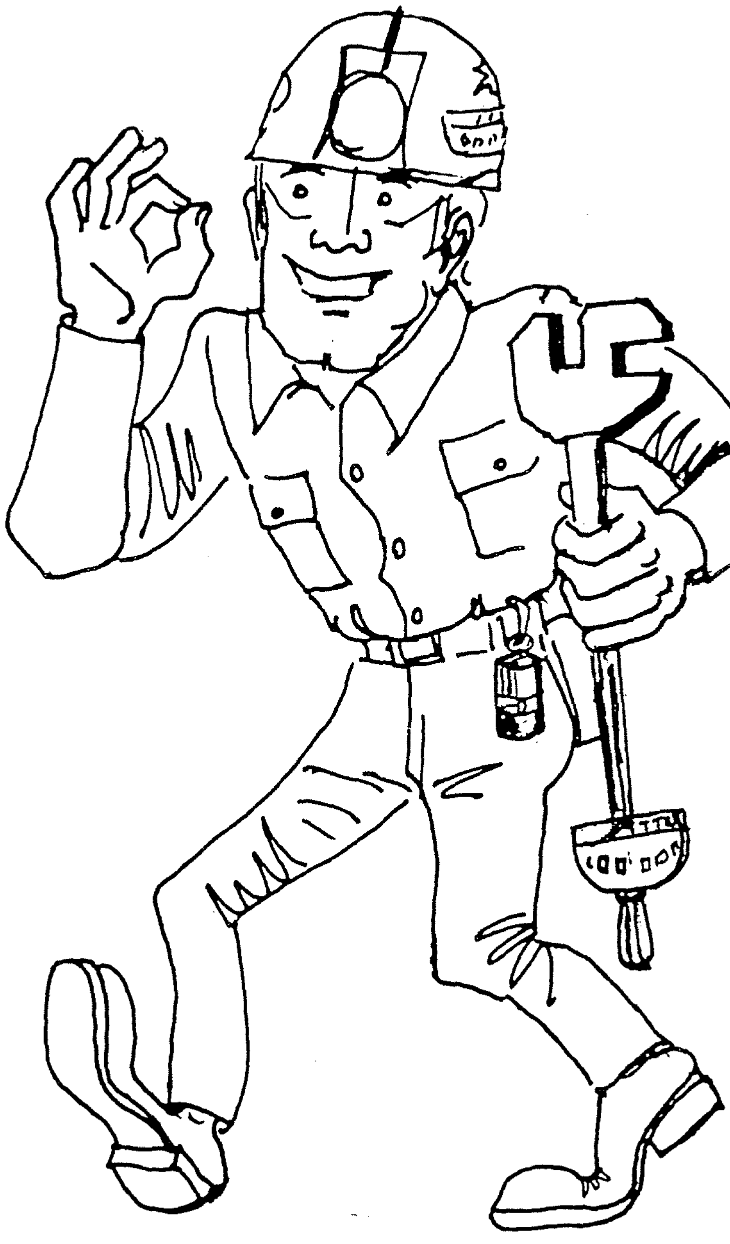


FIGURE 64. - "Form and Void."

This piece of sculpture by Svend Bue Rondum was used as the progenitor of the manual's splice worm cartoon character.



INTRODUCING BILLY BELTZ WHO CHEWS SUNFLOWER SEEDS,
IS SKILLED AT HIS WORK, AND PLANS AND PRACTICES BELT SAFETY.

FIGURE 66. - "Introducing Billy Beltz."

Training and Use

Much work was done to develop the philosophy underlying the manual, and even more effort has been expended to conceptualize its successful implementation. Now that the product has been completed and is ready for use, the problem must be considered of how to best introduce it to the industry in order to obtain maximum results. There are two basic ways this can be accomplished. One approach requires a formal introduction using detailed instructions and procedures for its evaluation in the mine environment. The other way would be to simply make it readily available on an informal basis with casual feedback requirements.

The formal approach for manual use was addressed in comprehensive detail in task reports that have been forwarded to TPO Ted Williams. Task 12 covered a suggested training strategy to be followed on a formal basis. Task 13, In-Mine Evaluation, included a list of cooperative mines and a cost estimate for implementing this activity.

The informal approach would entail a direct mailing campaign that would provide safety directors of a number of mines with two copies each of the manual and a brief letter of introduction which would indicate that more copies are available and where to get them. All requests for more manuals would be tallied. At the end of a suitable period (e.g., 30 days), a feedback request letter would be sent to the recipients. The next step would be based on the results of the initial mailing response. Should the manual be favorably received, as is anticipated, then a larger mailing could be made. Additionally, an advertising campaign could be initiated to acquaint mining companies and mines with the availability of the manual through the production of some stand-alone cartoons in poster form, introducing the characters at trade shows, and by direct mailing to the mines.

Once announced to the industry, the real indicator of its success will, of course, be its popularity as indicated by the number of volumes requested. A more accurate measure of success will be the uninhibited use by mine personnel of the names and quotations of the cartoon characters. Incorporation of these concepts in a casual, daily usage will indicate that some of the lessons for safe installation and maintenance activity for underground belt conveyors will have been learned and are probably being practiced. This, in turn, should result in reduced accidents.