IC 9212

BUREAU OF MINES
INFORMATION CIRCULAR/1989

Material Handling Devices for Underground Mines

By Ernest J. Conway and Richard L. Unger

UNITED STATES DEPARTMENT OF THE INTERIOR

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. BuMines IC 9212	2.	3. Recipient's Accession No.

4. Title and Subtitle
Material Handling Devices for Underground Mines

5. Report Date
1989

6.

7. Author(s)
Ernest J. Conway and Richard L. Unger

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
U.S. Bureau of Mines
Washington, DC 20241

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
Same

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

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17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Unlimited release	Unclassified	48
	20. Security Class (This Page) Unclassified	22. Price

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UNITED STATES DEPARTMENT OF THE INTERIOR
Manuel J. Lujan, Jr., Secretary

BUREAU OF MINES
T S Ary, Director

Library of Congress Cataloging in Publication Data:

Conway, Ernest J.
Material handling devices for underground mines.

(Information circular / United States Dept. of the Interior, Bureau of Mines; 9212)

Supt. of Docs. no.: I 28.27:9212.

1. Coal mining machinery. I. Unger, Richard L. II. Title. III. Series: Information circular (United States. Bureau of Mines); 9212.

TN295.U4 [TN813] 622 s [622'.6] 88-600243

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

in	inch	min	minute
lb	pound	psi	pound per square inch
lb/ft	pound per foot		

MATERIAL HANDLING DEVICES FOR UNDERGROUND MINES

By Ernest J. Conway[1] and Richard L. Unger[2]

ABSTRACT

This report presents engineering drawings for six material handling devices for underground coal mines. The devices were designed under a U.S. Bureau of Mines program to reduce injuries from material handling during mine and equipment maintenance. The six devices are (1) scoop-mounted lift boom, (2) swing-arm boom, (3) heavy-component lift-transport, (4) mine mud cart, (5) container-workstation vehicle, and (6) timber car. Each device is described briefly, and recommendations are made concerning the design of new devices.

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[2]Civil engineer, Pittsburgh Research Center, U.S. Bureau of Mines, Pittsburgh, PA.

INTRODUCTION

Manual material handling represents a critical and persistent source of personnel injuries in underground coal mining operations. On an annual basis, such injuries represent the largest category of nonfatal, lost-time injuries, accounting for 35% of all lost-time injuries in 1983 and 1984, according to U.S. Mine Safety and Health Administration data. Approximately 26% of all injuries related to manual material handling are associated with the performance of mine maintenance or equipment maintenance tasks (fig. 1).

As part of its program to improve health and safety conditions in mines, the Bureau of Mines recently completed a research program that addressed the material handling problems of mine maintenance and equipment maintenance. Under contract H0113018 with Monterey Technologies, Inc., a detailed analysis of mine- and machine-related tasks was completed and sources of injuries were identified. Concepts for simple material handling devices that could replace manual handling were then developed and evaluated. Six of these devices were fabricated and delivered to operational underground coal mines for testing and evaluation.

This report presents a brief discussion of the six devices, along with associated engineering drawings. The report is intended for mine operators who wish to make use of the design concepts to manufacture similar devices for use in their mines.

Figure 1.—Manual material handling in underground coal mine. Manual material handling is the leading cause of injuries year after year.

SUMMARY OF DESIGN RATIONALE

This project specifically addressed material handling tasks related to mine maintenance and equipment maintenance performed in underground coal mines. Surface material handling tasks and the transporting of supplies or materials from the surface to the operating section were outside the scope of this effort.

MINE AND EQUIPMENT MAINTENANCE

Representative mine maintenance tasks included

1. Installation or removal of ventilation, electrical, communications, or compressed-air systems.

2. Installation of timbers, cribbing, and other supplemental materials used in roof or rib control.

3. Track installation, repair, and retrieval.

4. Rock dusting, installation of air control screens, electrical wiring, installation of warning or other systems.

Typical machine maintenance tasks falling within the scope of this project included

1. Removal or replacement of belt drives, heads, pumps, drive motors, and other major machine parts on stationary equipment.

2. Assembly, installation, and repair of mine equipment, including mobile face equipment.

3. Routine servicing of mining equipment.

All underground coal mine seam heights were included in this study. However, emphasis was placed on mid to lower seam coal mines (under 58-in seam height), because preliminary data suggested that the highest risks of manual material handling injuries were to be found in those seam heights. The study included a review of relevant material handling literature and past Bureau programs, visits to six operating coal mines, and an extensive analysis of the Mine Safety and Health Administration's accident data base.

The mine maintenance and equipment maintenance tasks investigated involved, by their very nature, the manual handling of supplies and equipment components. Individual modules of the items handled might range in weight from a few to several thousand pounds. Because of the operational constraints in underground coal mines, these materials and components often have to be manhandled from the supply dropoff point to the place where they will actually be used or installed.

Components used in equipment maintenance are typically hoisted onto a railroad car, scoop bucket, or maintenance jeep on the surface. They are then transported to the section where the disabled machine is located. At that point, they are manually lifted off the rail car or jeep or ejected out of the scoop bucket and manually carried to the installation position. Occasionally, hoists or come-alongs are attached to roof bolts in order to aid in this process. Replaced components are then manually loaded into the transport vehicle for shipment to the surface.

Mine maintenance materials (e.g., timbers, rock dust bags, roof bolts, etc.) are typically loaded in bales or via pallets onto railcars or into scoop buckets for shipment to or near the working section. At the end of the rail line, the bales or pallets are broken down for manual loading into scoops or onto other transport vehicles for delivery to work locations. (One mine visited had rubber-tire-equipped railcars that could be detached at the end of the rail line and towed by battery-powered vehicle to the work locations or section supply area.) Once the materials are dumped near the work locations, miners manually carry them to the maintenance point for use. These maintenance personnel may lift materials weighing 50 to 100 lb continually on a daily basis. They handle materials weighing 1,000 lb or more (sections of rail or steel arches) on a monthly or more frequent basis.

Analyses of material handling injuries in the six mines visited indicated that

1. 39% of all mine maintenance and 32% of all machine maintenance injuries involved the lower back,

2. 45% of all mine and 39% of all machine maintenance accidents were the result of overexertion, and

3. 68% of mine maintenance injuries involved the handling of timbers, posts, caps, and cribbing materials, while 32% of the machine-related accidents involved the handling of metal machine components.

MECHANIZATION REQUIREMENTS

The design implications of these and other findings revealed during studies of material handling tasks related to mine and equipment maintenance can be summarized by the following mechanization needs:

1. Devices to lift or lower and rotate machine components weighing up to 3,000 lb, for removal from and replacement on mining equipment.

2. Devices to lift or lower components of up to 500 lb in and out of scoops, off railcars and on or off other mobile vehicles.

3. Carts or other devices to transport small quantities of materials weighing up to 500 lb from storage areas or railheads to working sections.

4. A device to raise and support crossbeams for temporary roof support while permanent roof supports are installed.

Six material handling devices were developed to fulfill these needs. Particular attention was focused on making the designs practical, low cost, and easily fabricated so as to be broadly applicable in underground operations. Where possible, the designs were simplified and off-the-shelf components used to permit fabrication of the devices by mine personnel on-site.[3]

The devices discussed in this report are not intended to be final designs. Rather, they are working prototypes that have been field evaluated and are presented herein in the hopes of stimulating other innovative designs on the part of mine personnel.

The six devices include

1. Scoop-mounted lift boom.

2. Swing-arm boom.

3. Heavy-component lift-transport.

4. Mine mud car.

5. Container-workstation vehicle.

6. Timber car.

Functions performed by, and design specifications for each of these devices are discussed in the following section.

PROTOTYPE MATERIAL HANDLING DEVICES

SCOOP-MOUNTED LIFT BOOM

One of the major identified needs was for a simple boom device to lift and transport components weighing up to 3,000 lb in the underground environment. The device had to be mounted on a powered mobile machine and had to be installed and removed quickly to minimize production downtime for the machine. This tool would be used for transporting and maneuvering heavy machine components such as a continuous miner head.

A quick mount-dismount lift boom device was developed for installation on the front of a small scoop with its bucket removed (figs. 2-3).

The design features of the scoop-mounted lift boom include

1. A 3,000-lb lift capacity.

2. Manual or powered lift capability.

3. Installation and removal in 5 min or less.

4. Ready storage in working sections or on mobile machinery.

Four attachment points secure the lift boom to the scoop lift mechanism by means of four pins. The pins correspond in size and location to the pins used to secure the scoop bucket. The overhead design of the lift boom permits lifting or lowering of components being handled. The bucket tilt mechanism provides up and down maneuvering of the components, while the scoop's normal steering permits lateral and forward and reverse maneuvering.

Appendix A provides details on the fabrication of the lift boom device, including a summary of the materials and components needed.

[3]Specific products are identified in the appendixes as the materials used in fabricating the prototypes; however, comparable materials may also be used. Reference to specific products does not imply endorsement by the Bureau of Mines.

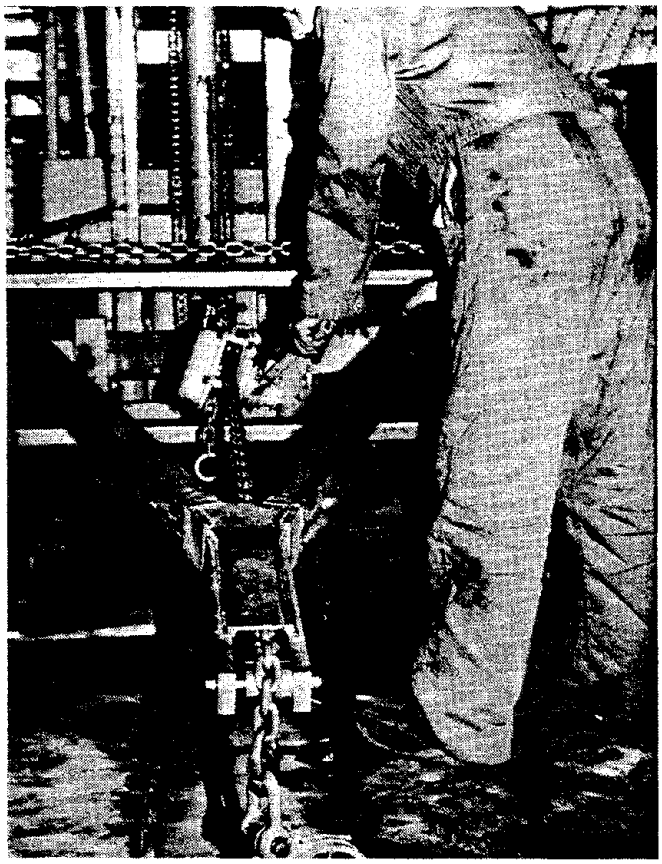


Figure 2.—Testing the scoop-mounted lift boom.

SWING-ARM BOOM

Accident and biomechanical analyses suggested the need for a simple swivel crane or boom device to lift components on and off transport vehicles and to assist in maneuvering heavy machine components in confined spaces.

To address these requirements, a lightweight, removable, stowable lift boom was designed (figs. 4-5). This boom can be installed at various locations on maintenance carts or on mining machines themselves. The height of the boom can be varied by quickly changing the boom leg. The inexpensive mounts can be permanently welded at various locations on the machine frame and are designed to resist damage during normal machine operation. Two or more quick mounts can be installed on the same machine to permit access to all machine locations.

Design features of the swing-arm boom include

1. Load capacity of 500 lb.

2. Boom height range from 24 to 68 in, depending on leg length.

3. Arm radius of 24 to 48 in.

4. Mounting and stowing without tools.

5. Light weight for carrying by one person.

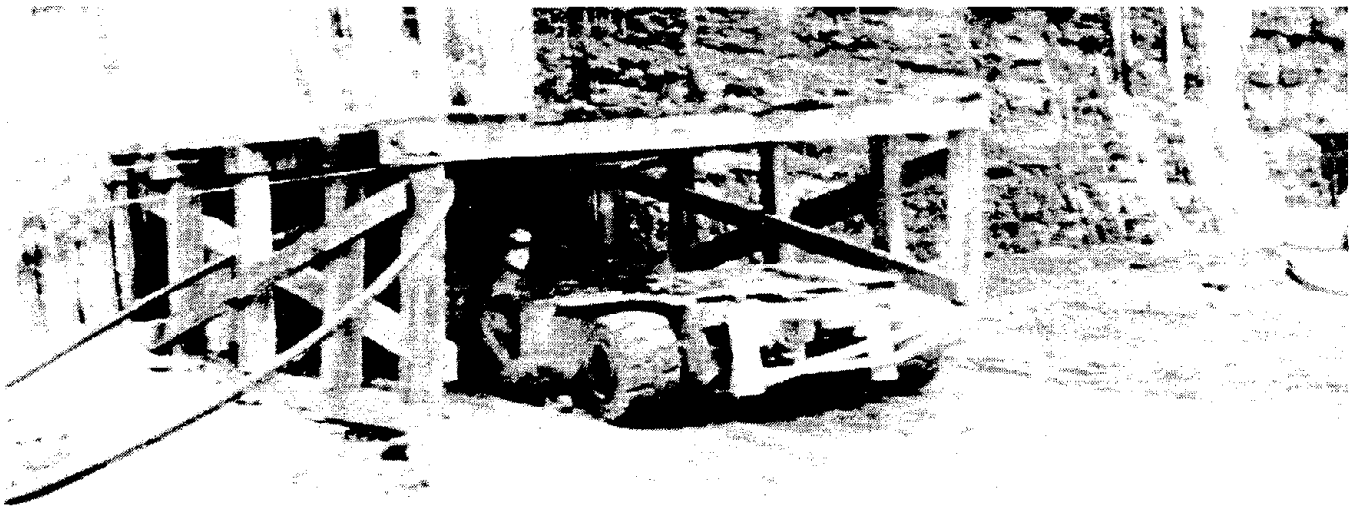


Figure 3.—Scoop-mounted lift boom during surface tests.

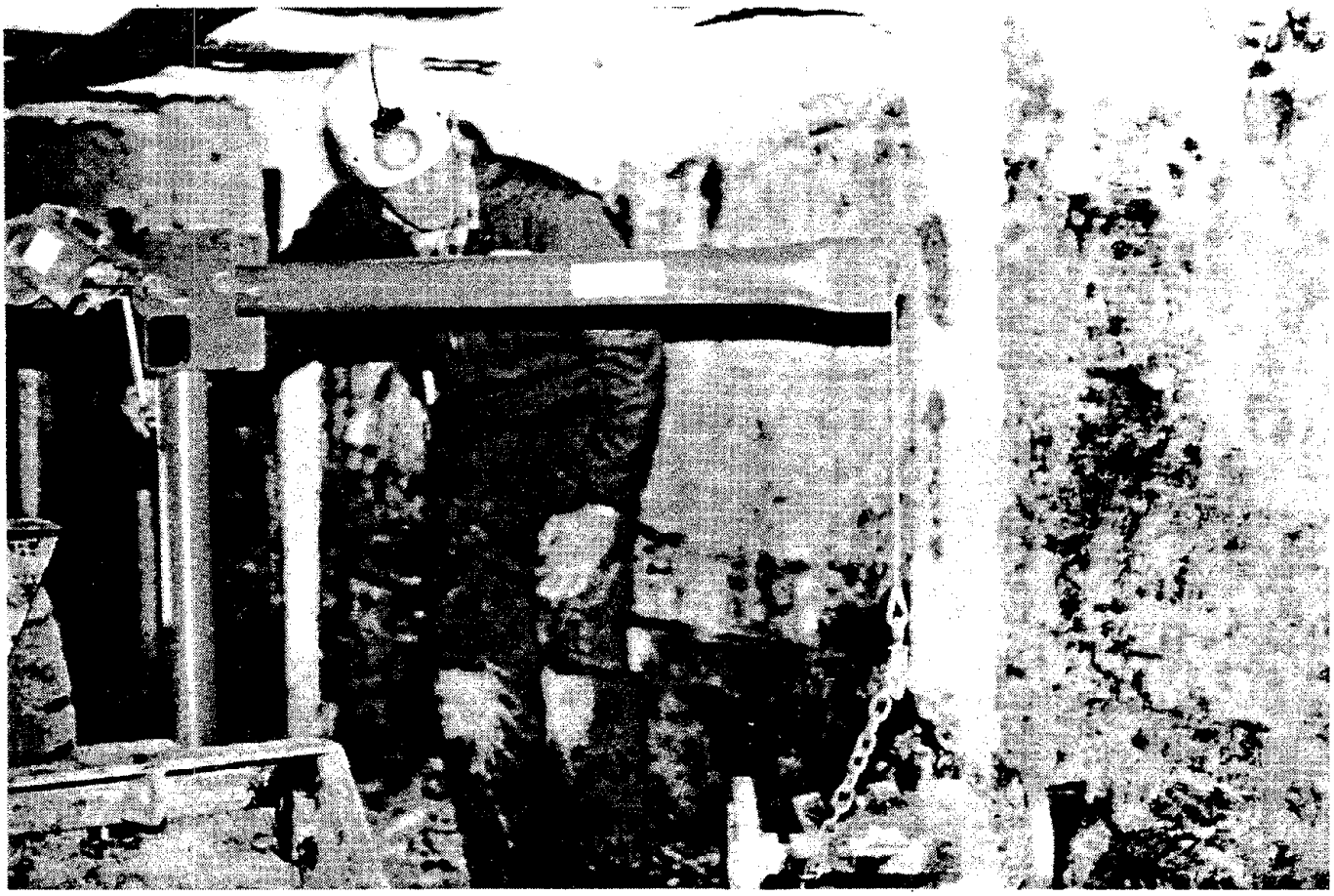


Figure 4.—Swing-arm boom during underground tests.

Appendix B provides detailed drawings of the boom and the materials required for its fabrication. Several commercially available swing-arm cranes could be readily adapted for the same purpose.

HEAVY-COMPONENT LIFT-TRANSPORT

Another identified need was for a floor-type maintenance jack that could be used to lift heavy machine components from the bottom, transport them over short distances, and lift them into position for installation. Saddles on the lift point could be designed to permit additional maneuvering of the component during actual installation. This type of device could be used, for example, to install drive motors under the nonremovable fenders in shuttle cars.

This prototype is shown in figures 6 and 7. The device utilizes a standard hydraulic floor jack to provide the lift mechanism. The jackhead itself is tiltable and rotatable to permit close-in maneuvering. The jack mechanism travels along the device frame by means of a sump drive mechanism. This motion permits forward-backward movement of handled components and balancing of components over the lift-transport device wheels during travel. The long handle permits the user leverage by which to maneuver loads up and down or sideways, as required. Dual tires or oversized balloon tires increase the device's stability and permit easy movement over uneven floors.

Figure 5.—Boom being mounted in removable base.

The design features of the heavy-component lift-transport include

1. Up to 1,000 lb lift capacity.

2. Balloon tires for ease of transporting manually.

3. A standard automotive floor jack for the lift mechanism.

4. Ability to lift and maneuver a heavy component as it is being removed or replaced on a mining machine.

5. Jackhead that can be trammed forward or back on the frame for close-in maneuvering or for load balancing.

Appendix C presents detailed drawings of the lift-transport mechanism and lists materials and components required for its fabrication. Note that single balloon tires could be substituted for the tandem tires illustrated in these drawings.

MINE MUD CART

One of the basic problems faced by all miners is that of moving machine components or supplies such as concrete blocks from the supply storage area to the point of use. If a powered vehicle is not available, the task must be accomplished manually. The intent of this concept was to design a small, manually pulled cart that could transport up to 900 lb of materials over a short distance.

The mine mud cart has the following design features:

1. Narrow width to permit passage by a parked mining machine.

2. Tandem design to prevent tipover if one unit is loaded and the second is empty.

3. Balloon tires for transit through mud or water and over mine floors.

4. Handle designed for pulling by one or two people.

Figure 8 illustrates a tandem cart concept using eight wheels. The vehicle can also be fabricated as a single cart. Appendix D provides design details for a tandem cart with four wheels and its major components and materials.

CONTAINER-WORKSTATION VEHICLE

Tools and supplies required for many maintenance tasks performed in a section can be mounted on a transportable container. This concept is for a device that allows a single, manually powered mechanism to lift and transport such containers (figs. 9-10). There are many uses for the containers themselves, such as tool station, lubrication module, rock dust unit, fire and safety equipment storage, repair workstation, cable-splicing module, etc.

To move the container around the working section, the transporter is positioned around the container and a lift mechanism raises it off the floor and positions the load slightly ahead of the axle. The load is carried by the wheels while the operator controls motion by pulling, steering, and balancing the unit on its axle.

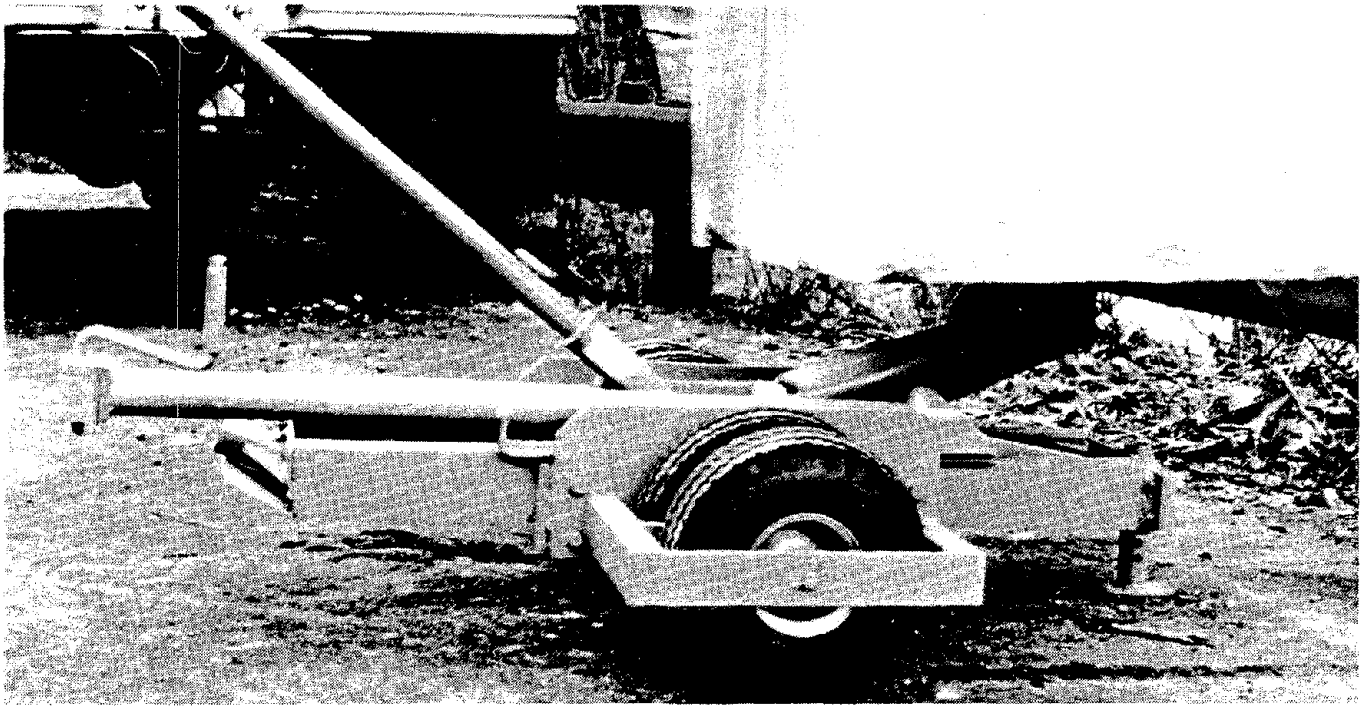


Figure 6.—Heavy-component lift-transport during testing with 1,500-lb concrete block.

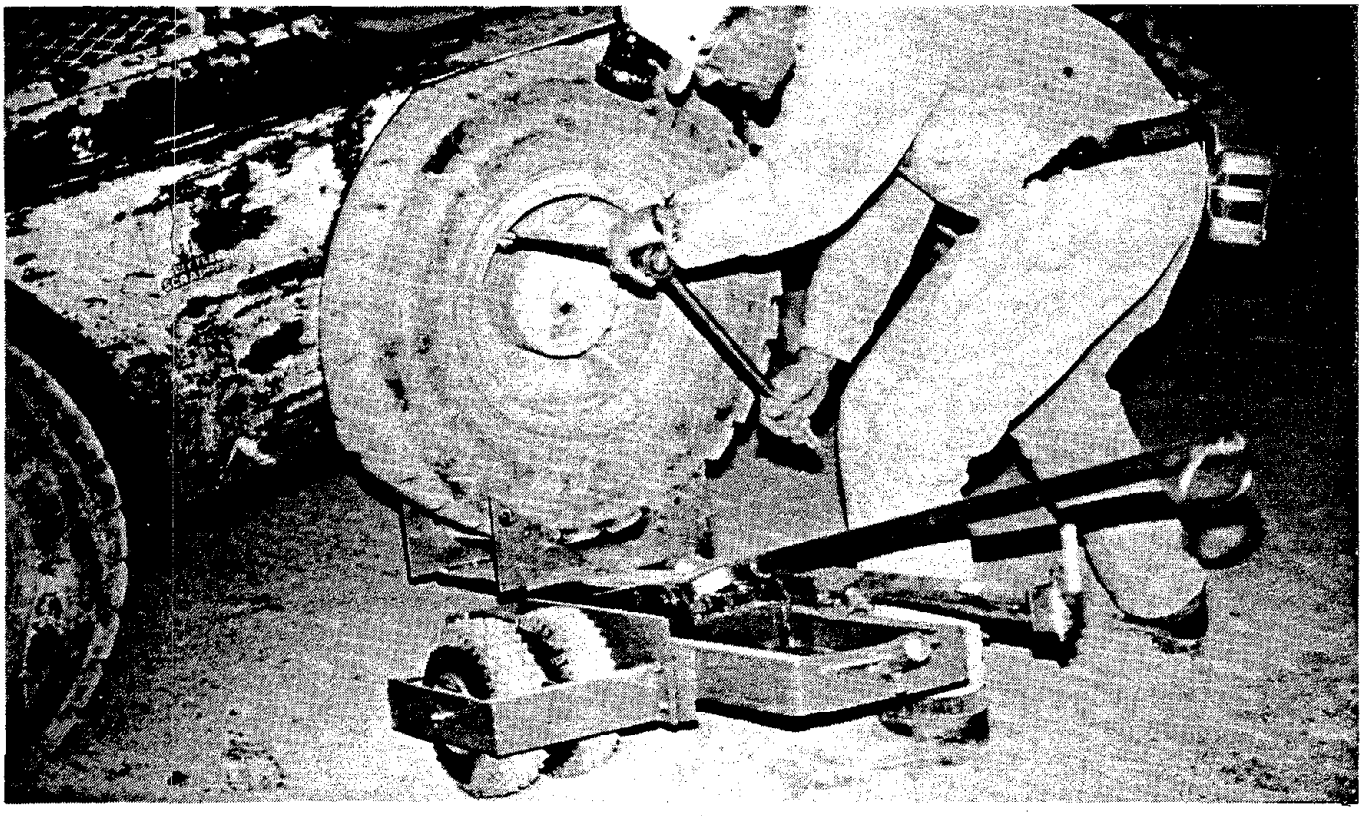


Figure 7.—Tire-changing attachment to eliminate manual handling of heavy wheels during replacement.

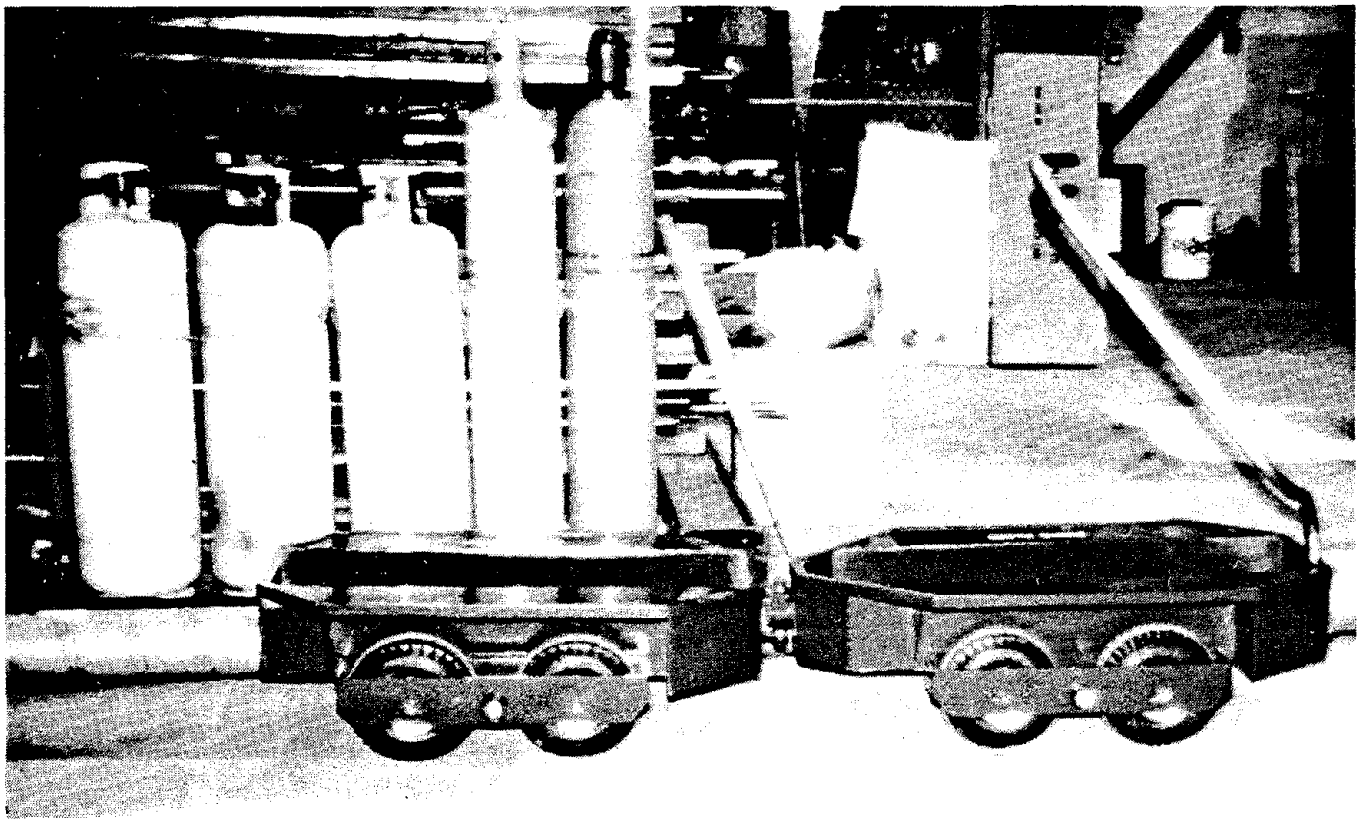


Figure 8.—Mine mud cart.

Design features of the container-workstation include

1. Rapidly interchangeable containers that can be picked up or dropped off as required.

2. Containers that can be used as secured storage units when dismounted from the vehicle.

3. Up to 1,000-lb load capacity.

4. Adjustable ground clearance.

5. Balloon-type tires for easy transporting on unimproved mine floor.

6. A towbar that can be adapted for towing behind utility vehicles.

Detailed drawings and a list of materials and components for the device are provided in appendix E.

TIMBER CAR

One of the most hazardous material handling tasks in underground mining is that of installing crossbeams for roof support. A need was identified for a mechanism to lift beams weighing up to 500 lb to the roof, where they could be held in place until permanent supports could be installed (figs. 11-12). The device shown utilizes a modified hydraulic floor jack to provide the lift. The jack mechanism is moved manually along a track down the center of the car. This forward-backward movement permits easy positioning of the load. In addition, the jackhead rotates to ease positioning of extra-long members.

Design features of the timber car include

1. Up to 500-lb lift capacity with a 60-in lift height (suitable for low- to medium-seam mines).

Figure 9.—Container-workstation vehicle.

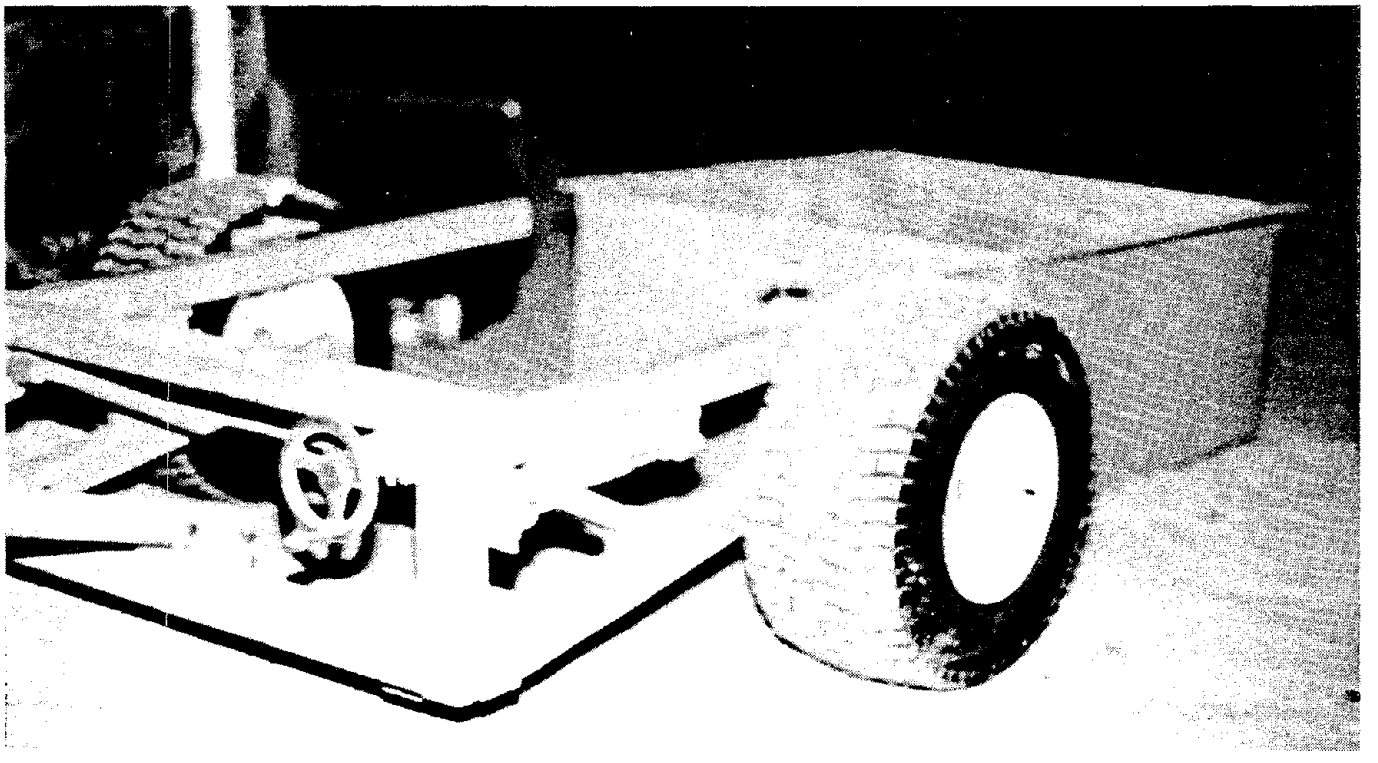


Figure 10.—Container removed from frame of vehicle. Containers with specialized functions may be attached.

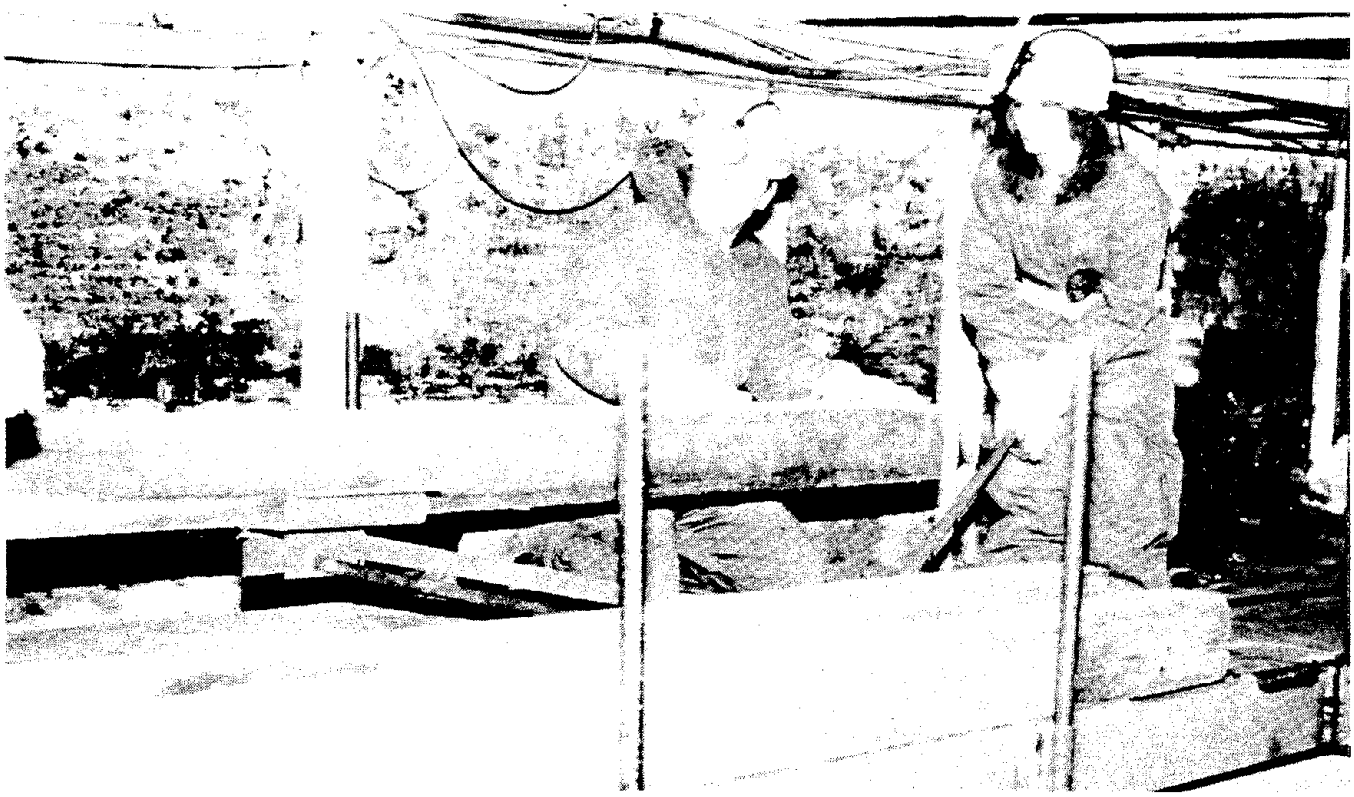


Figure 11.—Timber car during underground tests at Bureau's Safety Research Coal Mine.

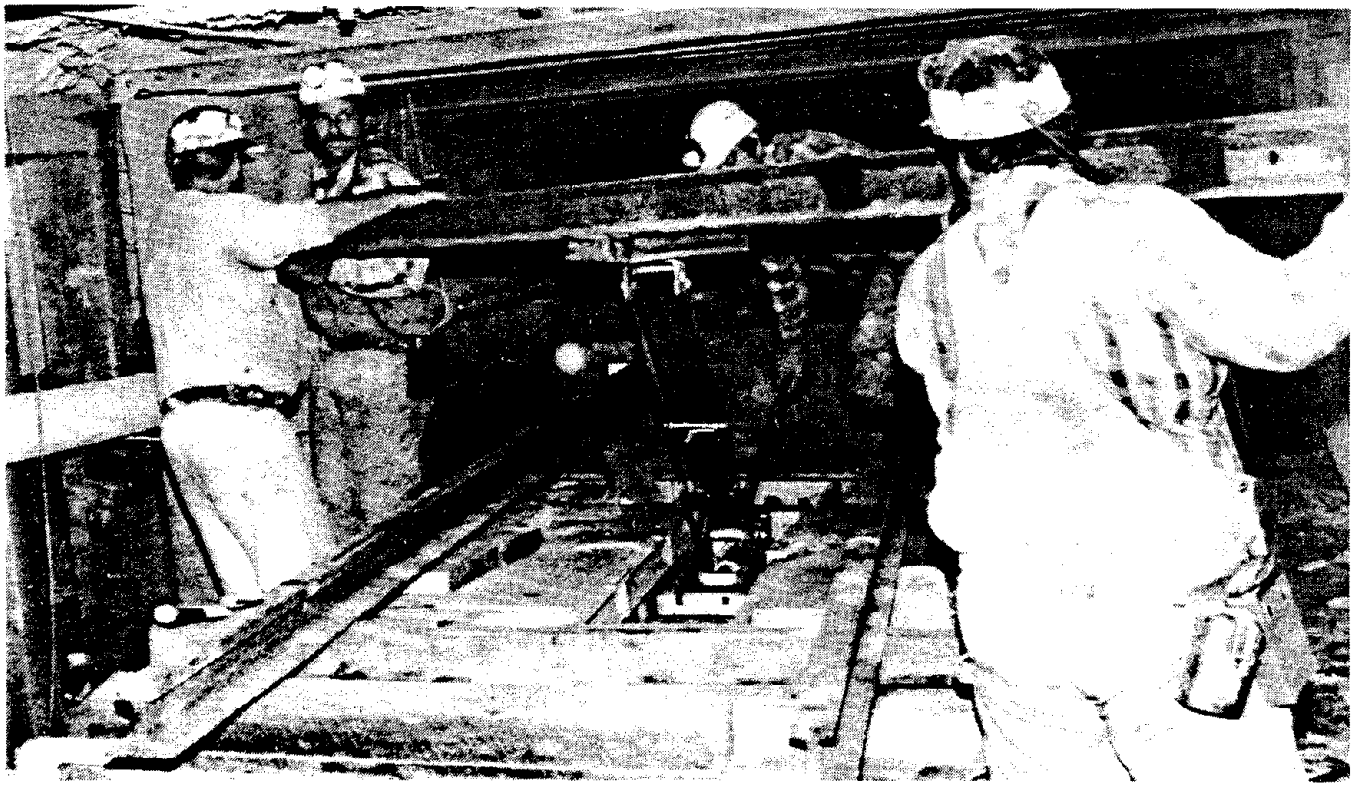


Figure 12.—Miners using timber car to raise 85-lb rail for roof support in eastern Ohio coal mine.

2. Mounting on a low-profile flatcar, which serves double duty as a 40-ton-capacity supply car.

3. A modified automotive floor jack for the lift mechanism.

4. Jack that can be maneuvered forward or back in its track for close-in maneuvering.

Appendix F presents detailed drawings of the track and jack assemblies for the timber car. Note that the components could be mounted on any suitable flatcar rather than be built as part of the car.

CONCLUSIONS AND RECOMMENDATIONS

On-site visits, task analyses, and interviews suggest that the majority of the risk exposure associated with material handling in underground coal mines results from the lack of properly designed and easily accessible material handling tools, devices, and vehicles. Mine personnel traditionally rely on a "couple of extra hands" or on crowbars, come-alongs, and other makeshift tools to manhandle even the largest components of mining machinery. Similarly, lacking appropriate tools, carts, and other handling devices, mine personnel manually move timbers, posts, beams, and other heavy materials on a continual basis. In most instances, tools are simply not available for these heavy lifting, transporting, and positioning tasks.

These investigations also revealed that what is needed is not another complex, powered vehicle designed to perform any and all maintenance jobs. Rather, what is required is a series of simple, task-specific tools, aids, and devices to be housed and used in the working sections and maintenance areas. Mine personnel tend not to wait 30 to 60 min while a special vehicle or tool is brought in from another area of the mine. The material handling hardware should be relatively easy to fabricate and should, where possible, utilize off-the-shelf components. It should be relatively inexpensive and designed for fabrication in mine shops. The prototypes of six such devices that were developed and tested by the Bureau are described in this report.

There appears to be a sincere interest on the part of mine management and safety and production personnel in reducing injuries related to material handling. There is also a need for exposure to new ideas, products, and material handling mechanization concepts to assist mine personnel in identifying their own unique handling requirements and in coming up with appropriate mechanical solutions to these problems. The concepts presented here were designed to stimulate the development of other mechanization concepts to address mine-specific material handling problems.

Three major recommendations are suggested with respect to development of material handling devices:

1. Systems Approach to Material Handling. Many larger mines have developed so-called systems for moving huge quantities of supplies and materials from surface storage areas to in-mine drop points or supply depots. These systems, however, have many missing elements and built-in problems. For example, pallets are utilized to load quantities of 90-lb cement blocks or 100-lb bags of rock dust from the storage onto the supply train. Forklifts or hoists may be used to offload the pallets at the dropoff points. However, personnel must manually load these supplies onto battery-powered vehicles or physically lug them to the point of use. This systems-approach thinking has failed to account for the fact that the blocks still weigh 90 lb and the bags 100 lb apiece when they get into the mine. These loads are too heavy for personnel working in confined workspaces and on unimproved mine floors. If a systems approach is to be used, it should start with the end user or task and work backward from there.

2. Task-Specific Tools. As in any industry, the design of special tools to perform specific tasks is often overlooked. In underground mining, few if any tools or devices have been developed to cope with specific material handling tasks. Exposure to high-risk tasks could be substantially reduced if appropriate task-specific tools were available. For example, the transporting of materials through a 3- by 3-ft man door requires the miner to lift a 50- to 100-lb (or heavier) object, rotate his or her body, and heave the object through the man door opening. Exposure to overexertion-type injuries is very high. If a simple slide or materials conveyor were available, the miner could simply pass the material through the opening. Similar aids and mechanical tools are required for handling rail sections, timbers, posts, cribbing materials, etc.

3. New Technologies. The search for new technologies is an ongoing process in any industry. In underground mining, however, it is even more important since so little completely new technology has been introduced to this sector. With respect to material handling, this search should focus on new, low-cost, reduced-weight materials for mine maintenance and safety applications. It should address improved designs and packaging for manual handling in operational environments. It should cover improved methods of installation and maintenance of the mine and the mining equipment. It should focus on ways of reducing mine maintenance (e.g., cleaning up along belt lines) and machine maintenance (e.g., autolubing systems). It should attempt to replace muscle power (particularly back muscles) with mechanical or hydraulic power.

APPENDIX A.–SCOOP-MOUNTED LIFT BOOM

The scoop-mounted lift boom is illustrated in figure A-1. Table A-1 lists the parts and their specifications. Details of individual parts and assemblies are shown in figures A-2 through A-7. The italic letters on the drawings correspond to the letters used in table A-1. All dimensions shown in the drawings are in inches.

TABLE A-1. - Scoop-mounted lift boom parts list

Item	Quantity	Description	Material
A	1	Roller	Bar, round, AISI Type 1035, 2-in diam.
B	1	Pin	Shafting, AISI Type 1025, 0.5-in diam (0.499 - 0.501).
C	1	Plate joint	Plate, ASTM A36, 0.5 in thick.
D	2	Bar, rib	Cold-forged bar, AISI Type 1018, 0.75 by 2 by 18 in.
E	1	Plate, filler	Plate, ASTM A36, 2.5 by 6.75 by 0.25 in.
F	2	Angle	Steel, M1020, 3 by 2 by 0.25 in.
G	1	Tube	Square pipe, hot-rolled steel, 2 by 2 by 0.145 in.
H	1	.. do	Do.
J	1	.. do	Do.
K	1	.. do	Do.
L	2	Plate, mount	Plate, ASTM A36, 5.5 by 20 by 0.75 in.
M	4	Plate, clevis	Plate, ASTM A36, 1 in thick.
N	1	Plate, hoist	Do.
O	1	Beam, upper	Rolled steel, ASTM A500B, 5 by 2 by 1/4 in.
P	1	Beam, lower	Rolled steel, ASTM A500B, 3 by 2 by 3/16 in.
Q	2	Washer, flat	Steel, 1/2-in ID, 0.109 in thick.
R	2	Cotter pin	Steel, 1/8 by 2 in.
S	1	Cover	Channel, ASTM A36, 3 by 5 by 6 in.

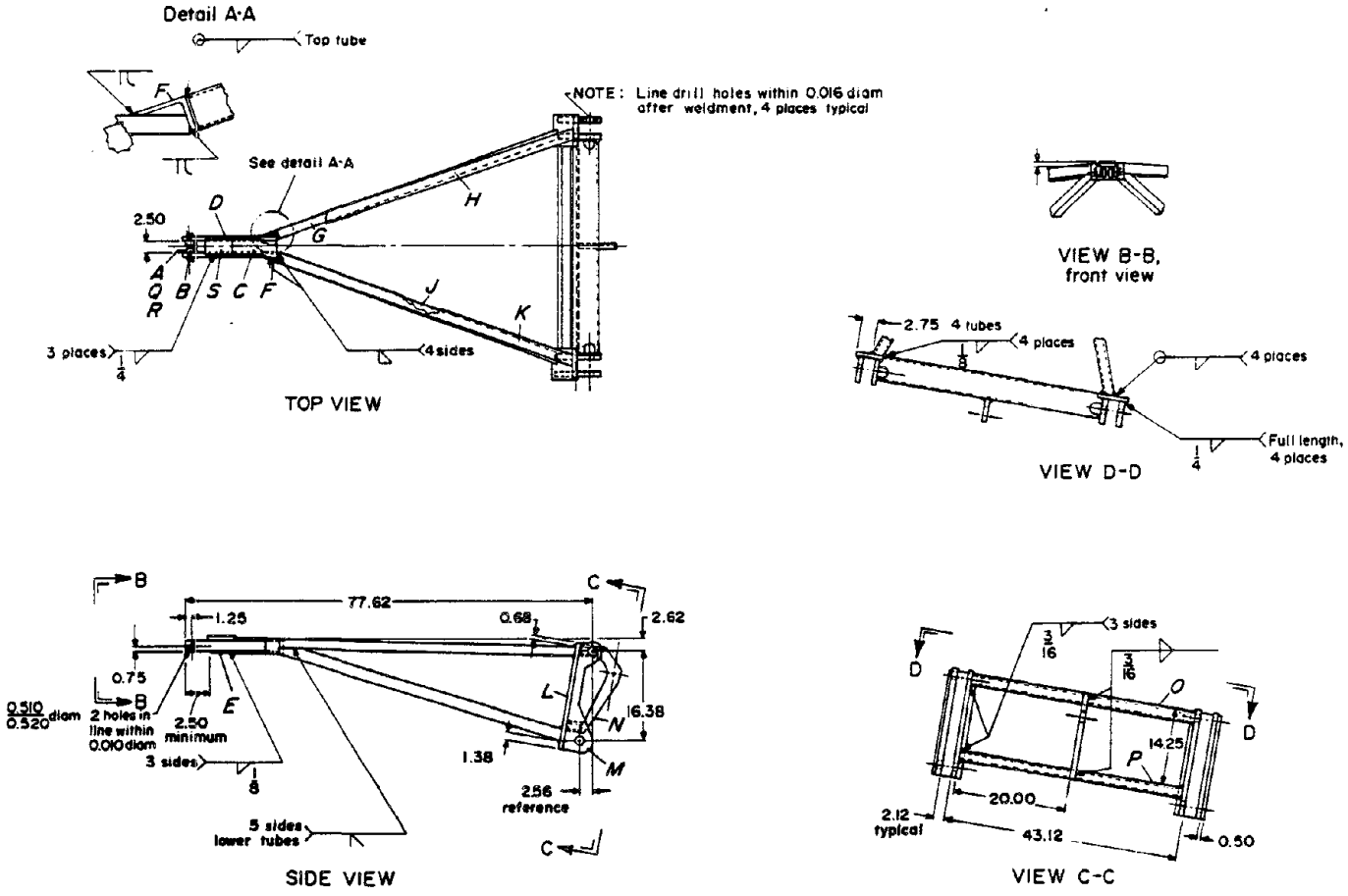
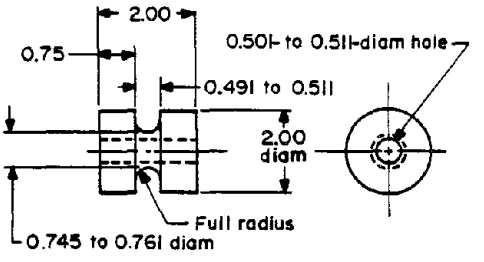
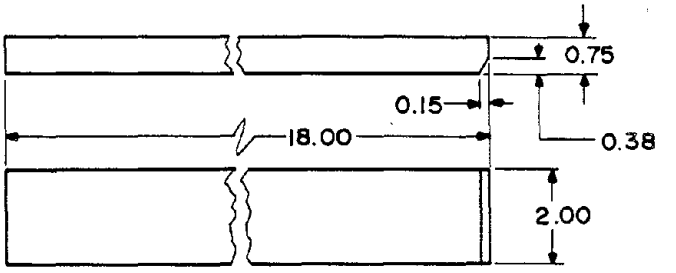


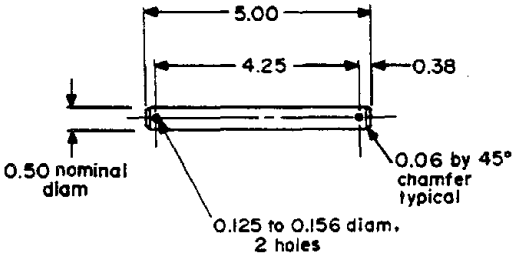
Figure A-1.—Scoop-mounted lift boom. See figures A-2 through A-7 for details of parts and assemblies.



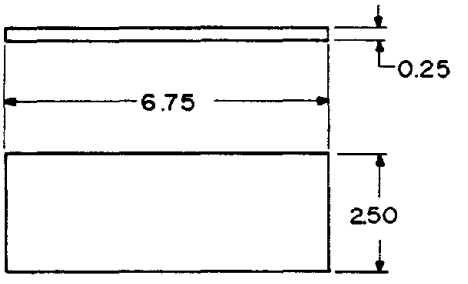
A Roller



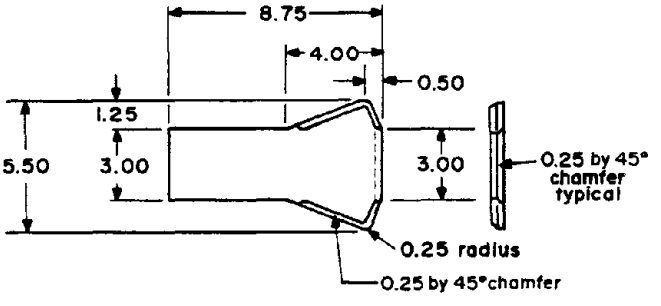
D Bar, rib



B Pin

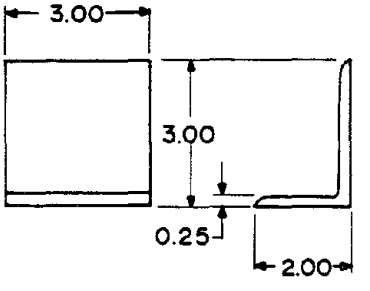


E Plate, filler



C Plate joint

Figure A-2.—Roller, pin, and plate joint used in lift boom.



F Angle

Figure A-3.—Rib bar, plate filler, and angle.

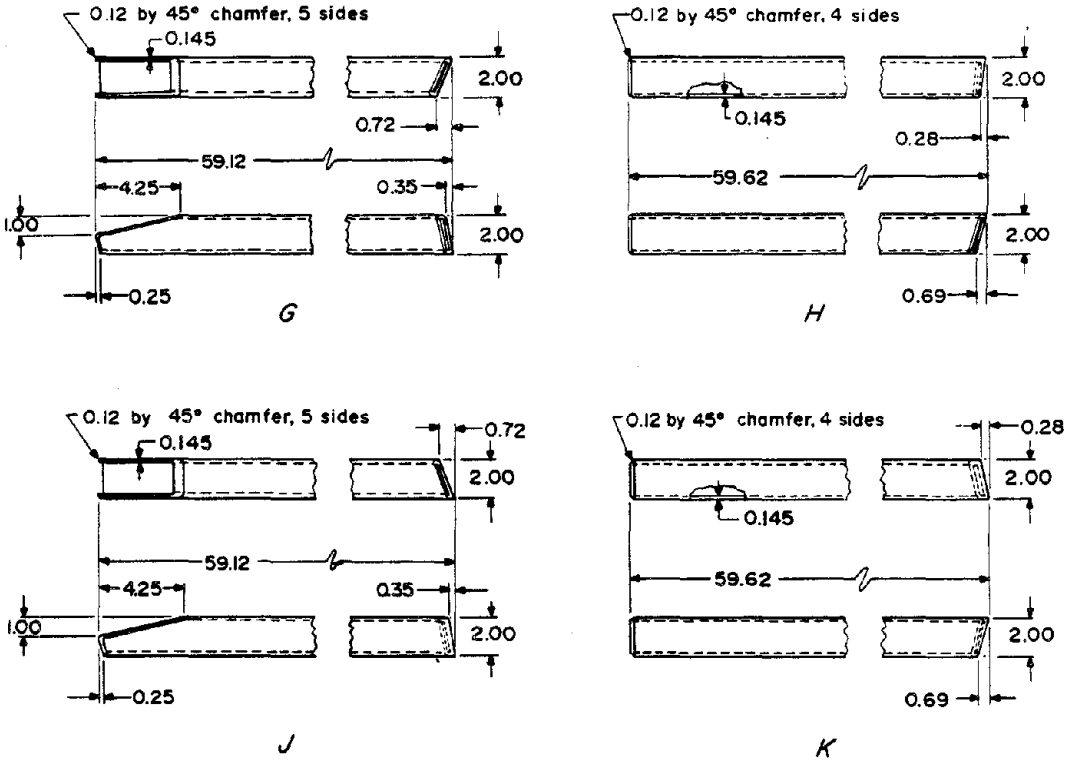


Figure A-4.—Tubing.

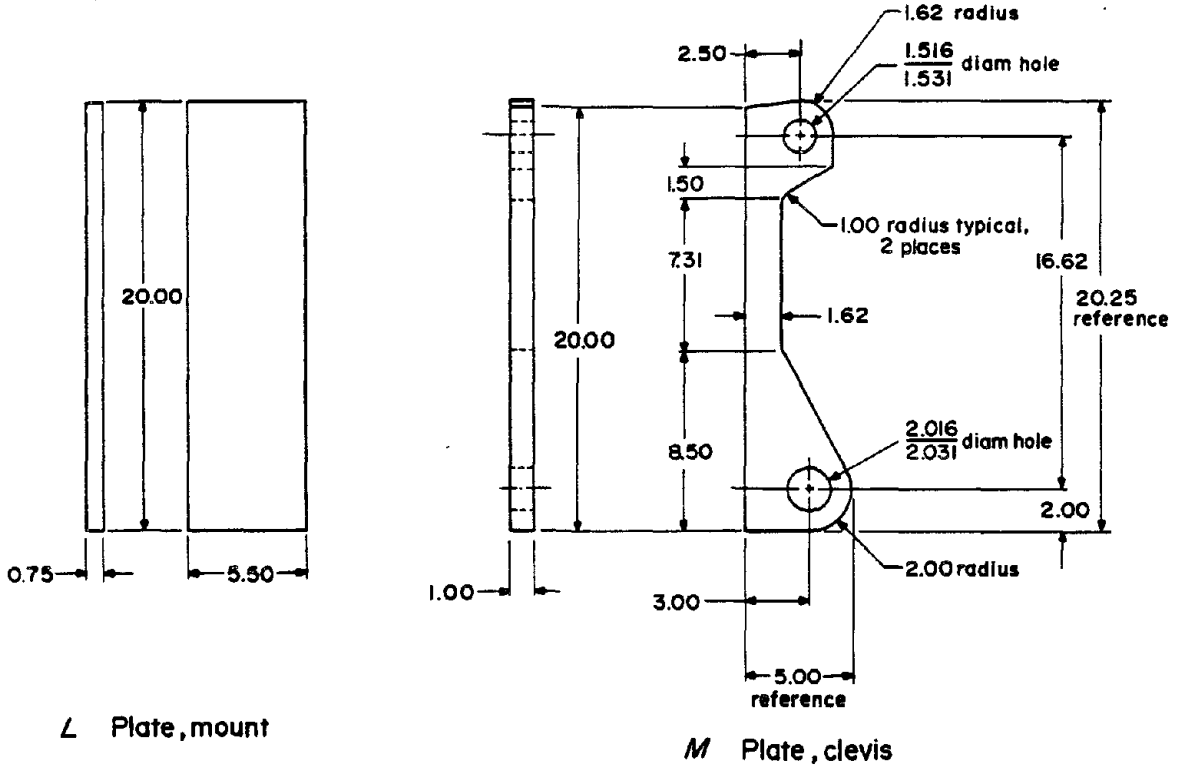


Figure A-5.—Mount and clevis plates.

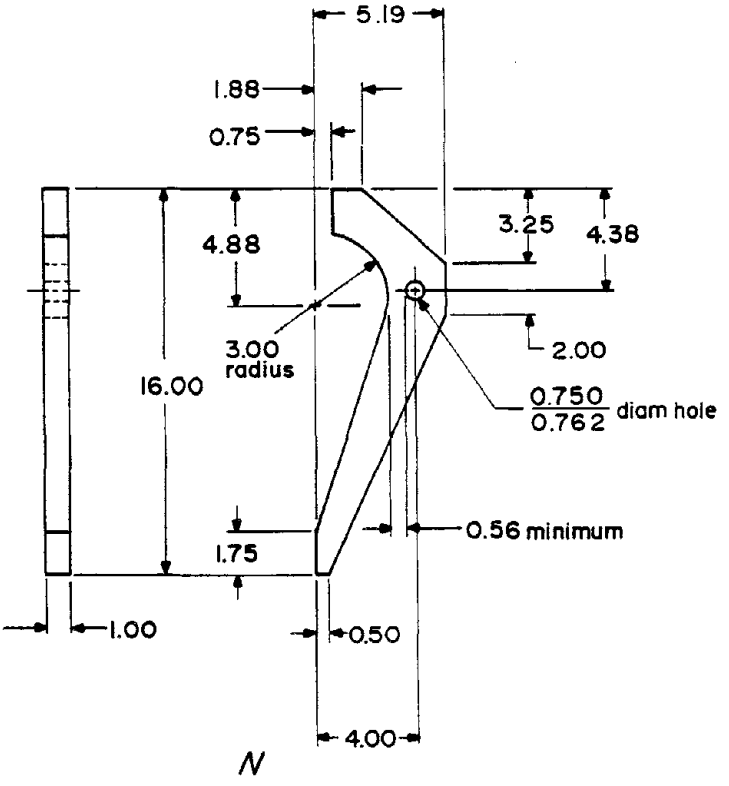
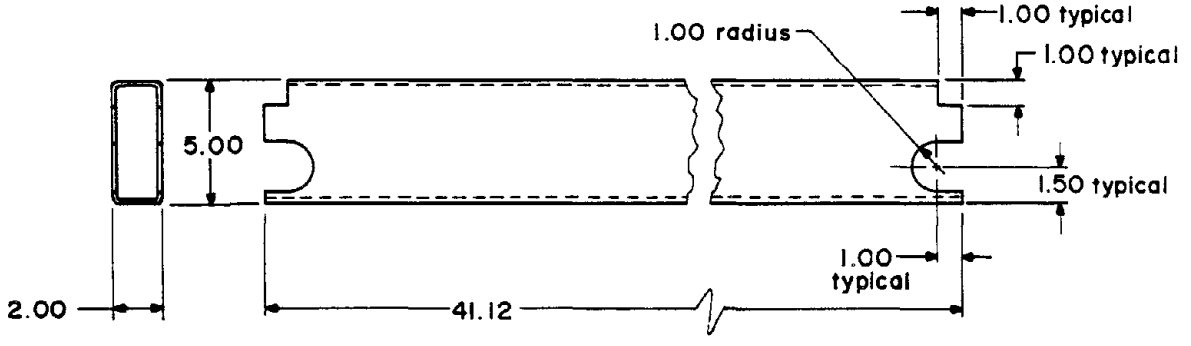
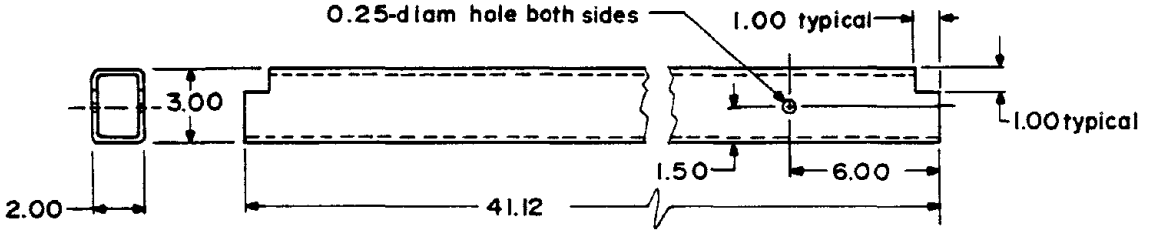


Figure A-6.—Hoist plate.



O Beam, upper



P Beam, lower

Figure A-7.—Upper and lower beams.

APPENDIX B.–SWING-ARM BOOM

The swing-arm boom is illustrated in figure B-1. Table B-1 lists the parts and their specifications. Details of individual parts and assemblies are shown in figures B-2 and B-3. The italic letters on the drawings correspond to the letters used in table B-1. All dimensions shown in the drawings are in inches.

TABLE B-1. - Swing-arm boom parts list

Item	Quantity	Description	Material
A	4	Bar	Steel, M1020, 1.5 by 1 in.
B	1	Plate	Steel, AISI Type 1010, 0.5 in thick.
C	1	..do	Steel, ASTM A36, 0.5 in thick.
D	1	..do	Do.
E	1	Swivel base	M/C 3276T16, winch crane.[1]

[1]M/C = McMaster Carr catalog No. 88.

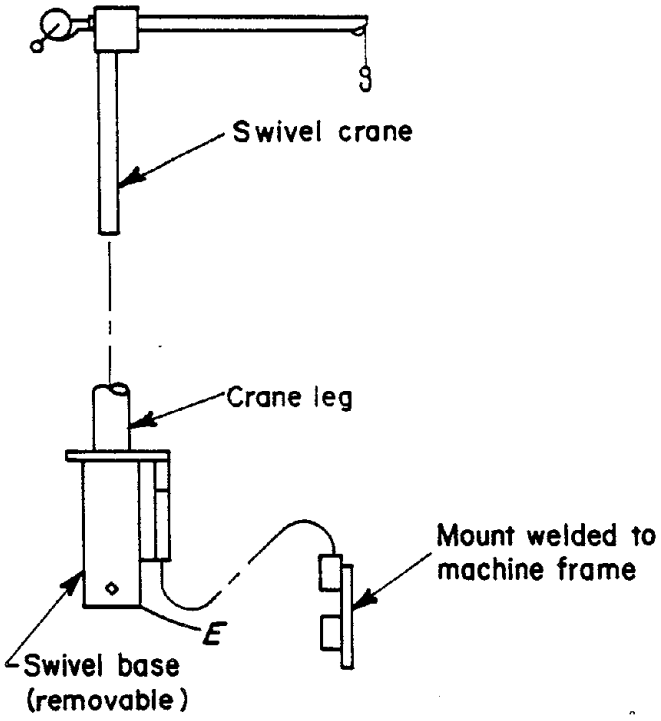


Figure B-1.—Swing-arm boom. See figures B-2 and B-3 for details of parts and assemblies.

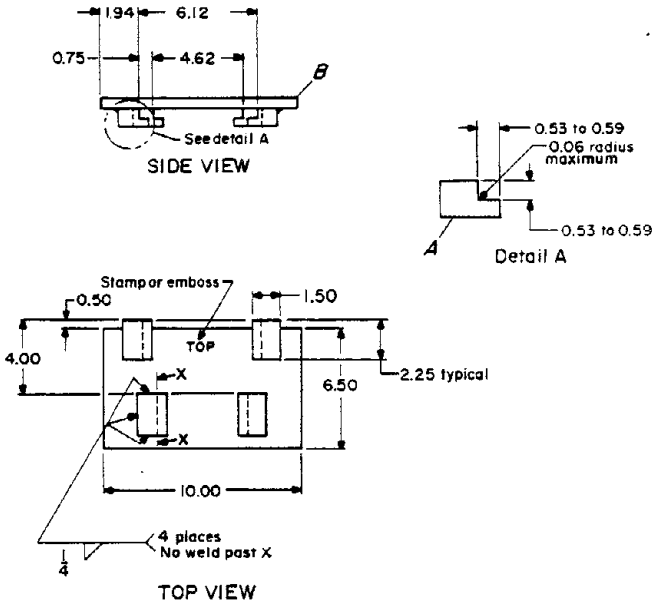


Figure B-2.—Bar and plate used in swing-arm boom, with assembly details.

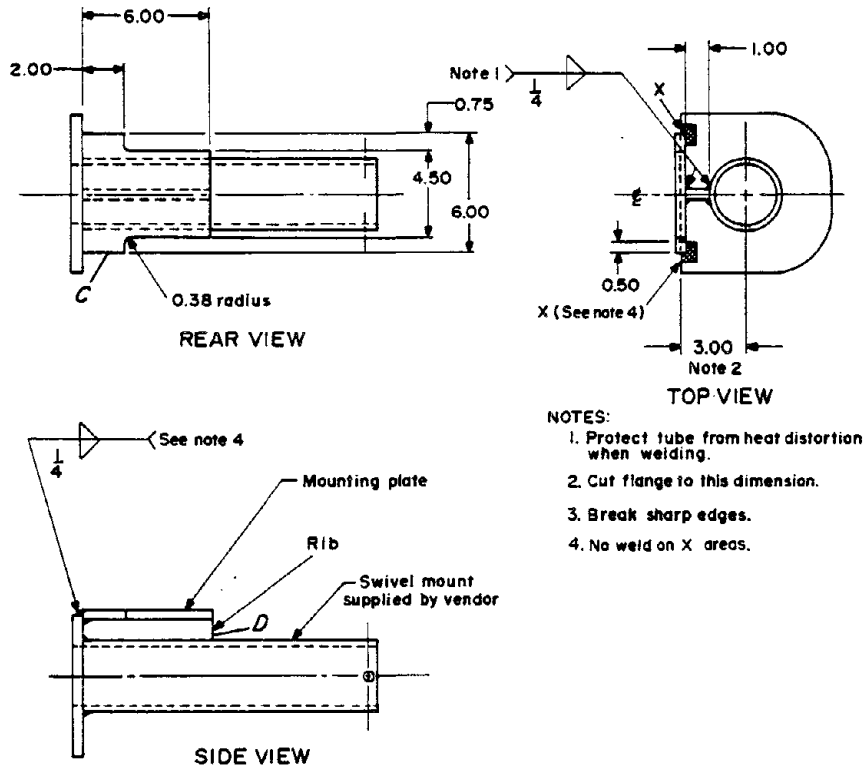


Figure B-3.—Plates and assembly details.

APPENDIX C.–HEAVY-COMPONENT LIFT-TRANSPORT

The heavy-component lift-transport is illustrated in figure C-1. Table C-1 lists the parts and their specifications. Details of individual parts and assemblies are shown in figures C-2 through C-10. The italic letters on the drawings correspond to the letters used in table C-1. All dimensions shown in the drawings are in inches.

TABLE C-1. - Heavy-component lift-transport parts list

Item	Quantity	Description	Material
A	2	Side channel	ASTM A36.
B	2	Plate	ASTM A36, 0.25 by 2.5 by 10.25 in.
C	1	..do	ASTM A36, 0.25 by 1 by 10.25 in.
D	1	End plate	ASTM A36, 0.25 by 1.5 by 13.25 in.
E	2	Bar	Steel, 0.25 by 0.375 by 2.5 in.
F	2	Mounting block	Steel, 0.5 by 1.25 by 2.5 in.
G	1	Pipe	Schedule 40, 1-1/4 by 2.5 in.
H	1	..do	Schedule 40, 1-1/4 in.
J	1	Nut	Steel, 1/4-20 UNC.
K	4	Capscrew	Steel, 3/8-16, 1 in long.
L	12	Lockwasher	3/8-in ID.
M	2	Gusset	ASTM A36, 0.25 in thick.
N	4	Mounting plate	ASTM A36, 1 by 3 by 3.5 in.
O	2	Axle	Cold-forged, AISI Type 1040 round, 0.625 by 11.5 in.
P	4	Plate	ASTM A36, 6.5 by 12 by 0.25 in.
Q	4	..do	ASTM A36, 6.5 by 10 by 0.25 in.
R	2	..do	ASTM A36, 6.5 by 16.5 by 0.375 in.
S	8	Spacer	AISI Type 1025, DOM, 1-in OD, 3/16-in wall.
T	1	Pipe	Schedule 40, 1-in ID.
U	1	Plate	ASTM A36, 2 by 4.25 by 0.25 in.
W	1	..do	ASTM A36, 3 by 3 by 3/8 in.
X	4	Washer, flat	3/8-in ID.
Y	4	Cotter pin	1/8 by 1-1/4 in.
Z	2	Capscrew	Grade 8, 3/4-20 UNEF, 2 in long.
AA	2	Lockwasher	3/4-in ID.
AB	8	Capscrew	Grade 5, 3/8-16 UNC, 1-1/4 in long.
AC	1	..do	Grade 5, 3/8-16 UNC, 3/4 in long.
AD	1	..do	Grade 5, 3/8-16 UNC, 2 in long.
AE	1	Nut, self-locking	3/8-16 UNC.
AF	1	Plate	ASTM A36, cut to fit.
AG	2	Leg	M1020, 2 by 2.5 in.
AH	1	Leg	Do.
AJ	1	Leg	Do.
AK	1	Screwjack	M/C 879H453C, crank-type trailer jack.[1]
AL	1	Floor jack	M/C 8802T14.[1]
AM	4	Wheel	M/C 8353T22, light-duty pneumatic.[1]

[1]M/C = McMaster-Carr catalog No. 88.

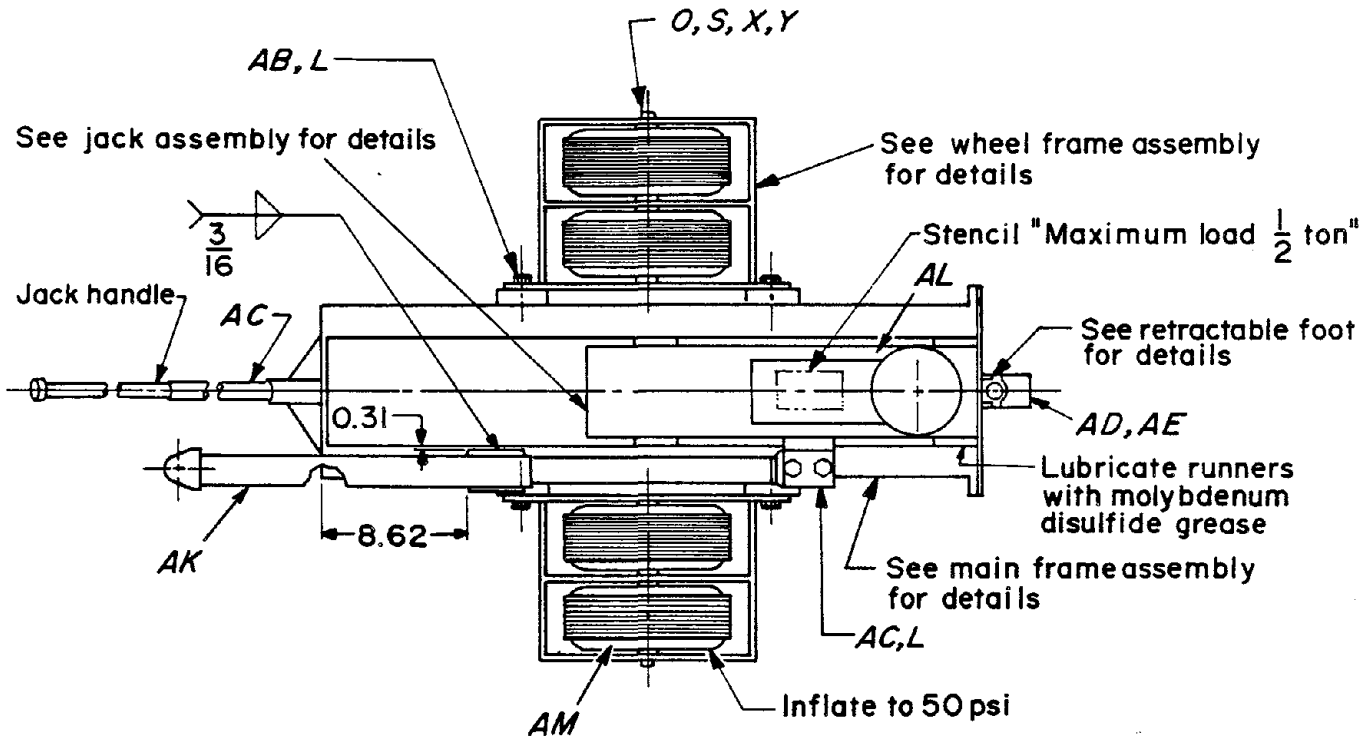


Figure C-1.—Heavy-component lift-transport. See figures C-2 through C-10 for details of parts and assemblies.

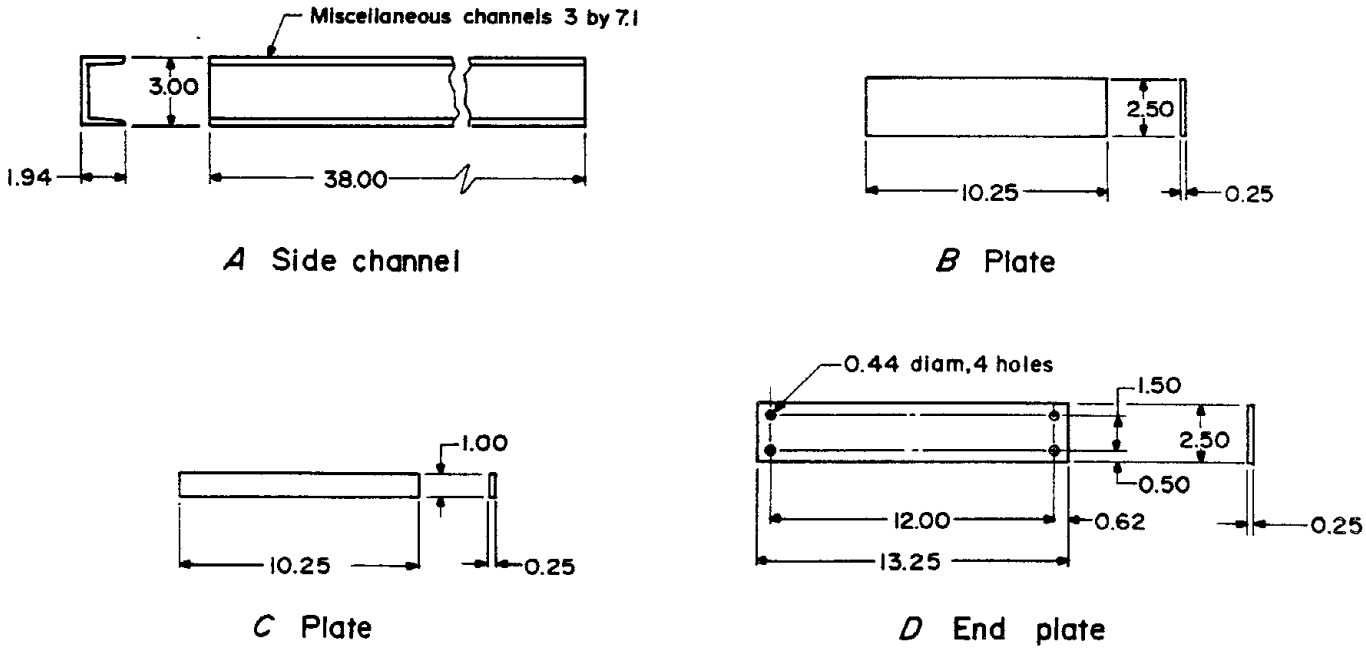
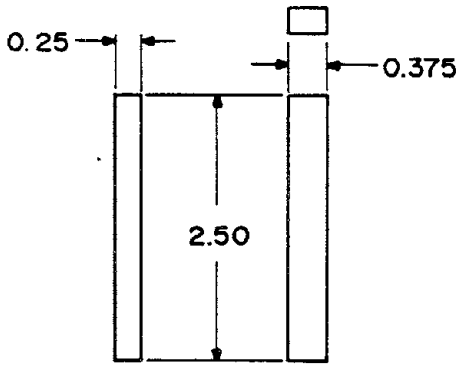
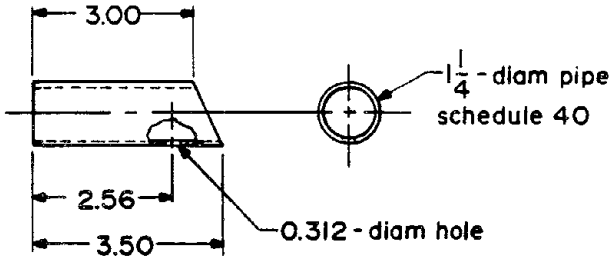


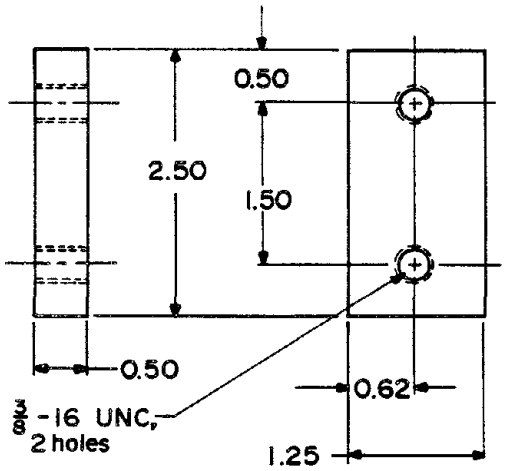
Figure C-2.—Channel and plates used in heavy-component lift-transport.



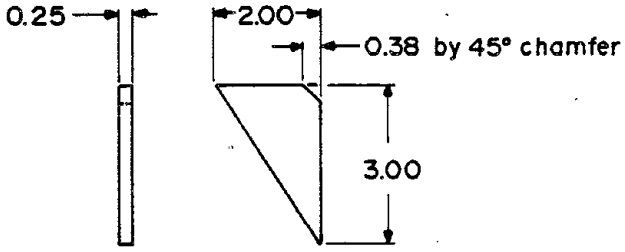
E Bar



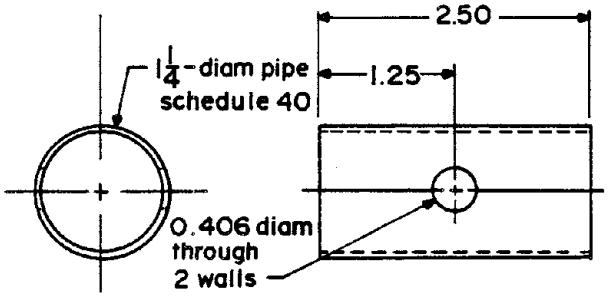
H Pipe



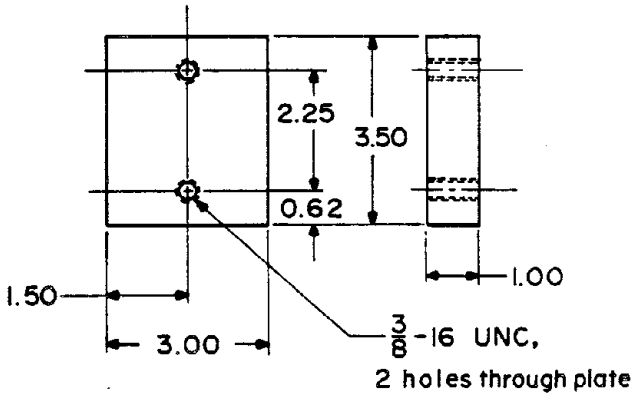
F Mounting block



M Gusset



G Pipe



N Mounting plate

Figure C-3.—Bar, mounting block, and pipe.

Figure C-4.—Pipe, gusset, and mounting plate.

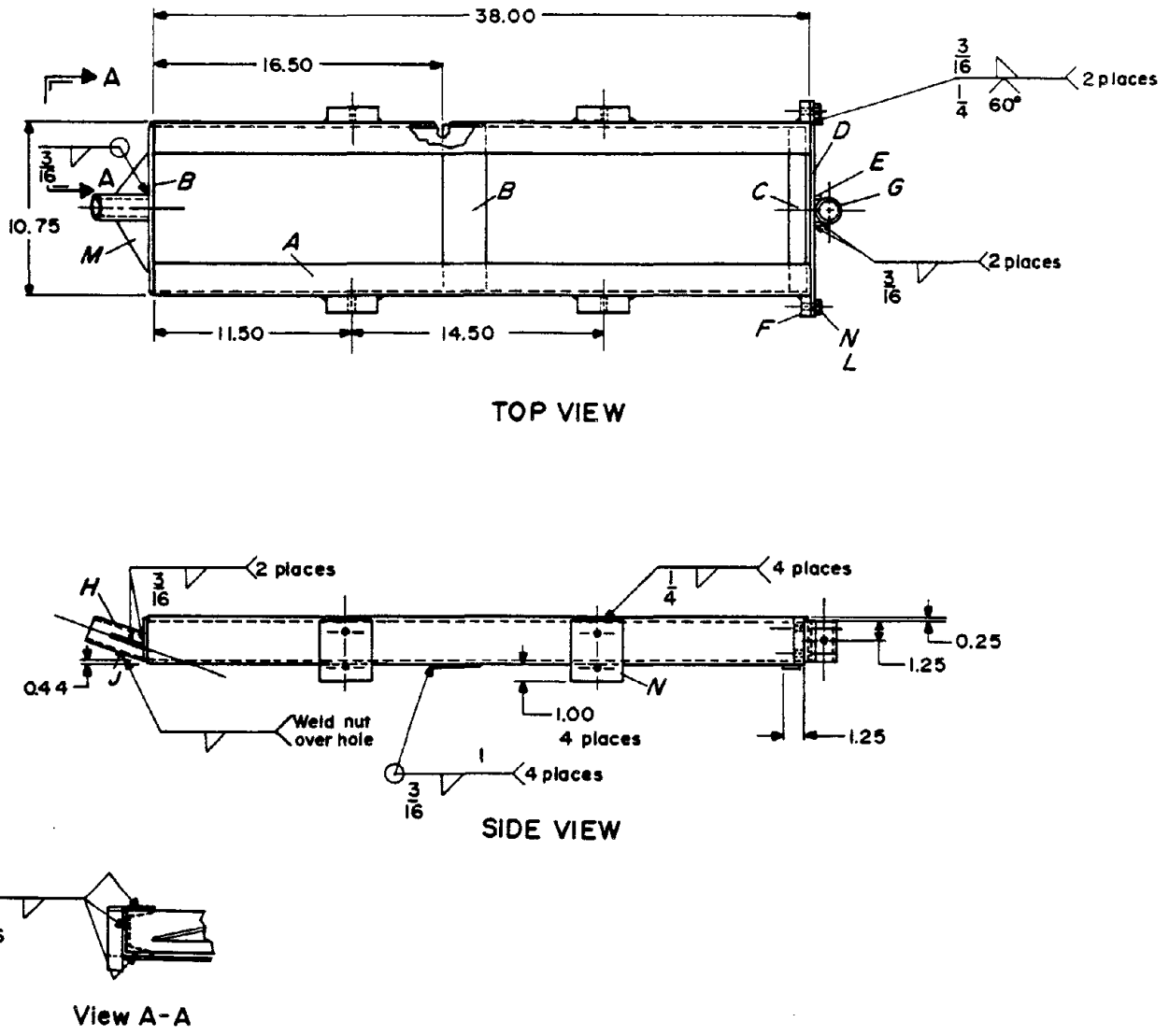


Figure C-5.—Main frame assembly for heavy-component lift-transport.

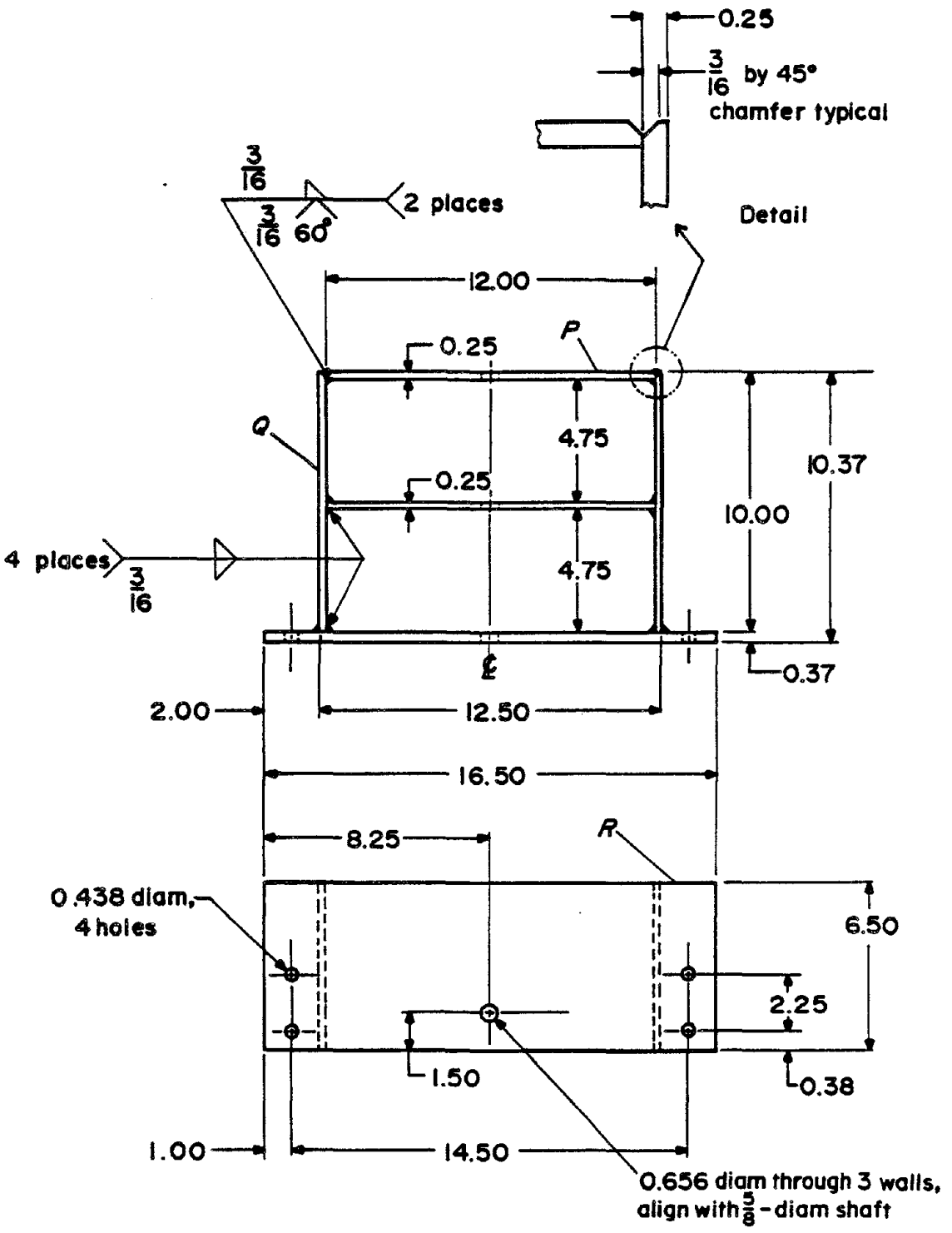


Figure C-6.—Wheel frame assembly.

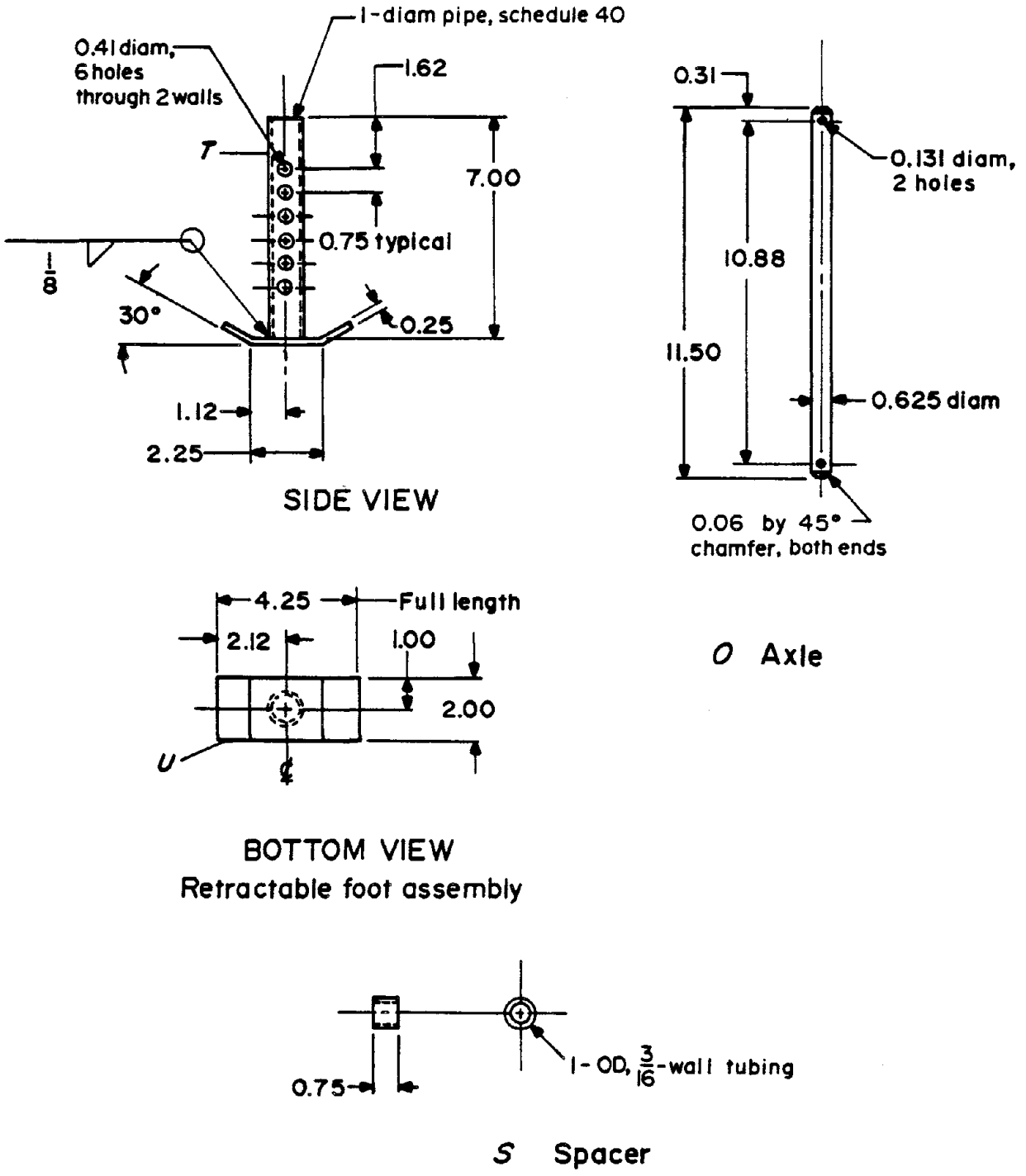


Figure C-7.—Axle and spacer and retractable foot assembly.

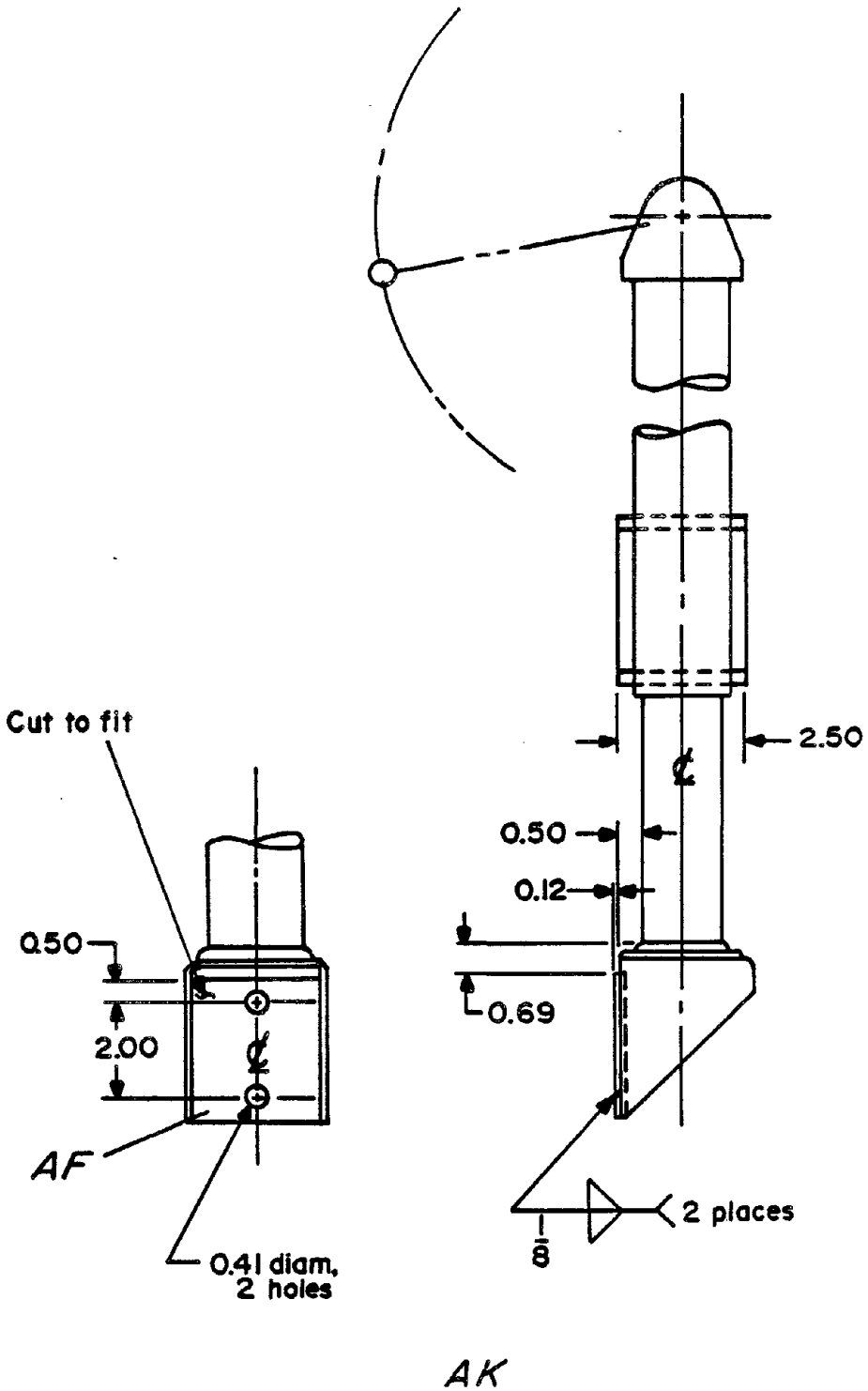
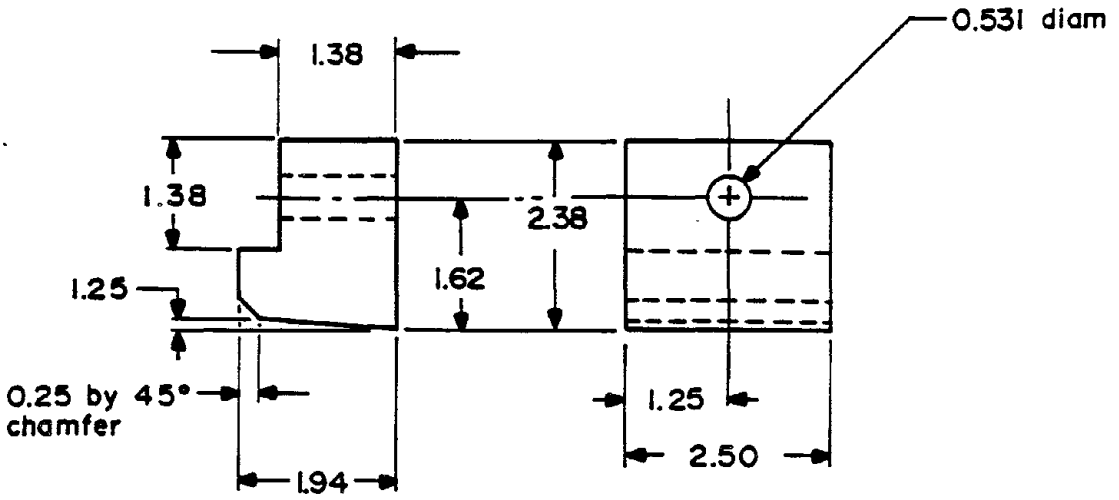
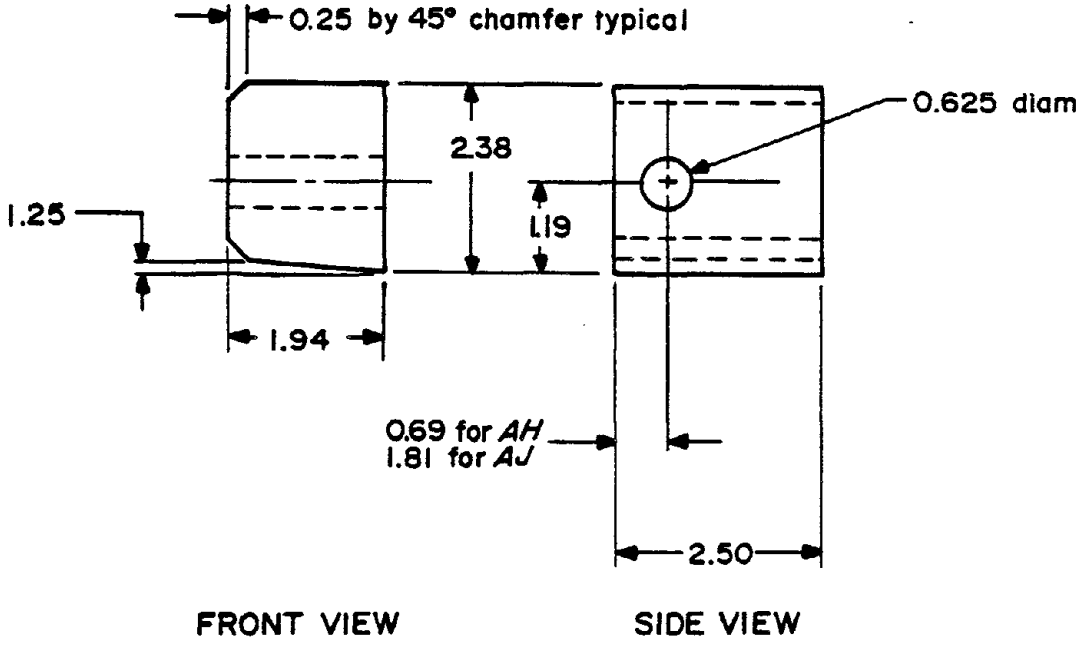


Figure C-8.—Crank jack assembly.

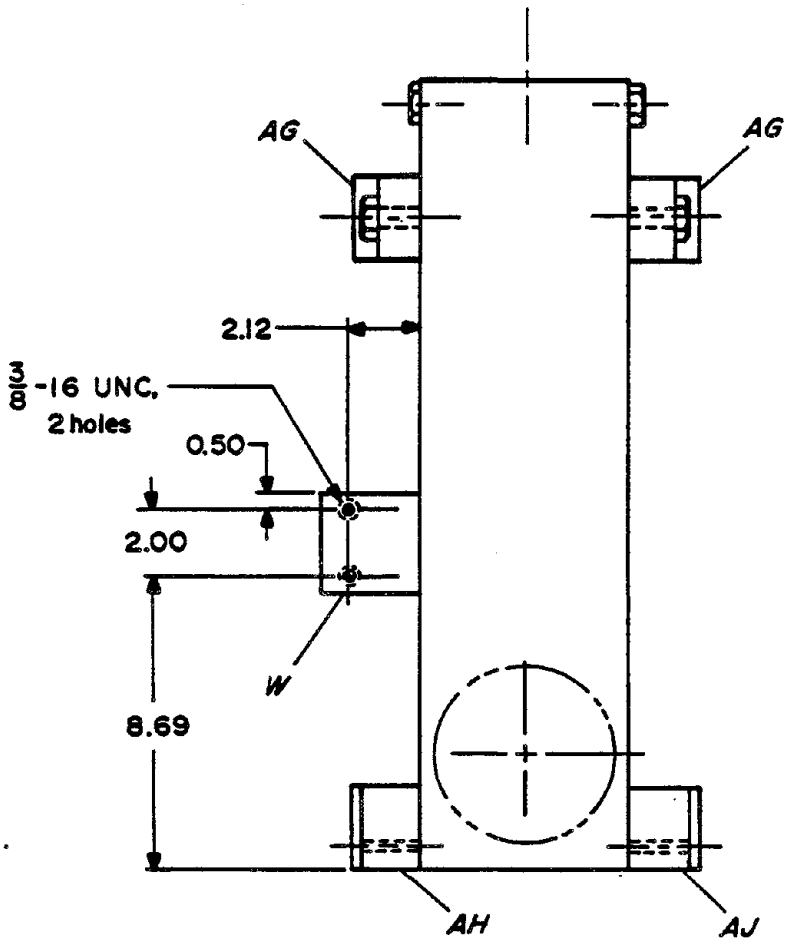


AG Leg

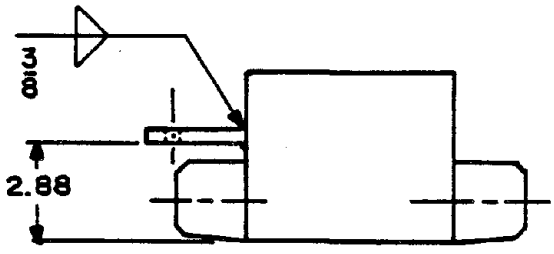


AH, AJ Leg

Figure C-9.—Legs.



TOP VIEW



FRONT VIEW

Figure C-10.—Floor jack leg assembly.

APPENDIX D.–MINE MUD CART

The mine mud cart is illustrated in figure D-1. Table D-1 lists the parts and their specifications. Details of individual parts and assemblies are shown in figures D-2 through D-8. The italic letters on the drawings correspond to the letters used in table D-1. All dimensions shown in the drawings are in inches.

TABLE D-1. - Mine mud cart parts list

Item	Quantity	Description	Material
A	1	Mount	Steel plate, 0.25 in thick.
B	1	Pivot	Cold-forged, AISI Type 1045, 2.0-in diam.
C	1	Yoke	Steel plate, 1.0 in thick.
D	4	Deck	Steel sheet, 14 gauge.
E	4	Rib	Do.
F	4	Fender	Do.
G	4	Gusset	Do.
H	3	End	Steel sheet, 10 gauge.
J	2	Support	Do.
K	3	End	Do.
L	4	Side	Do.
M	1	Bottom	Steel sheet, 14 gauge.
N	1	. . do	Do.
O	1	Edging	Steel tube, AISI Type 1025, 0.75-in OD by 0.035-in wall.
P	1	. . do	Do.
Q	2	Axle	Steel channel, 1.5 by 1.5 by 3/16 in.
R	4	Shaft	Steel bar, cold-forged, AISI Type 1045, 1.25-in diam by 8 in long.
S	1	Pivot	Steel plate, 1.25-in OD by 1.125 by 3 in.
T	1	Pull bar	Steel tube, AISI Type 1025, 1.25-in OD by 1/16-in wall.
U	7	Jab nut	M/C 91079A035, 5/8-18.[1]
V	2	Washer	M/C 90126A035, 5/8-in ID, SAE.[1]
W	2	Spring	M/C 92161A035, 5/8-in ID, SS.[1]
X	3	Ball joint	M/C 6072K25, 5/8-in bore, 5/8-in stud.[1]
Y	2	Capscrew, hex head	Grade 8, 5/8-18 UNF by 1.5 in.
Z	5	Lockwasher	Split type, 5/8-in ID.
AB	1	Grease fitting	Steel head, 1/8 in NPT.
AC	1	Bearing	M/C 6391K295, 1.5-in OD by 1.25-in ID by 1 in long.[1]
AD	2	Washer	M/C 90126A040, 1-1/4-in bore.[1]
AE	1	Shaft collar	M/C 6436K19, 1-1/8-in bore.[1]
AF	4	Screw, hex head	Grade 8, 5/8-18 UNF by 3.5 in.
AG	4	Lockwasher	Split type 3/8-in ID.
AH	1	Screw, hex head	Grade 8, 5/8-18 UNF by 3.5 in.
AJ	4	Tire	13 by 6.5-6.[2]
AK	4	Hub	6 by 4.50, 3/4-in bore, 3.0-in hub.[3]
AL	4	Washer, hardened	M/C 980232A036, 3/4-in ID.[1]
AM	4	. . do	M/C 98023A035, 5/8-in ID.[1]
AN	4	Nut, self-locking	M/C 94828A035, 5/8-11.[1]

[1]M/C = McMaster-Carr catalog No. 88.
[2]Armstrong Rubber Co., Ultra Trac.
[3]Armstrong Rubber Co.

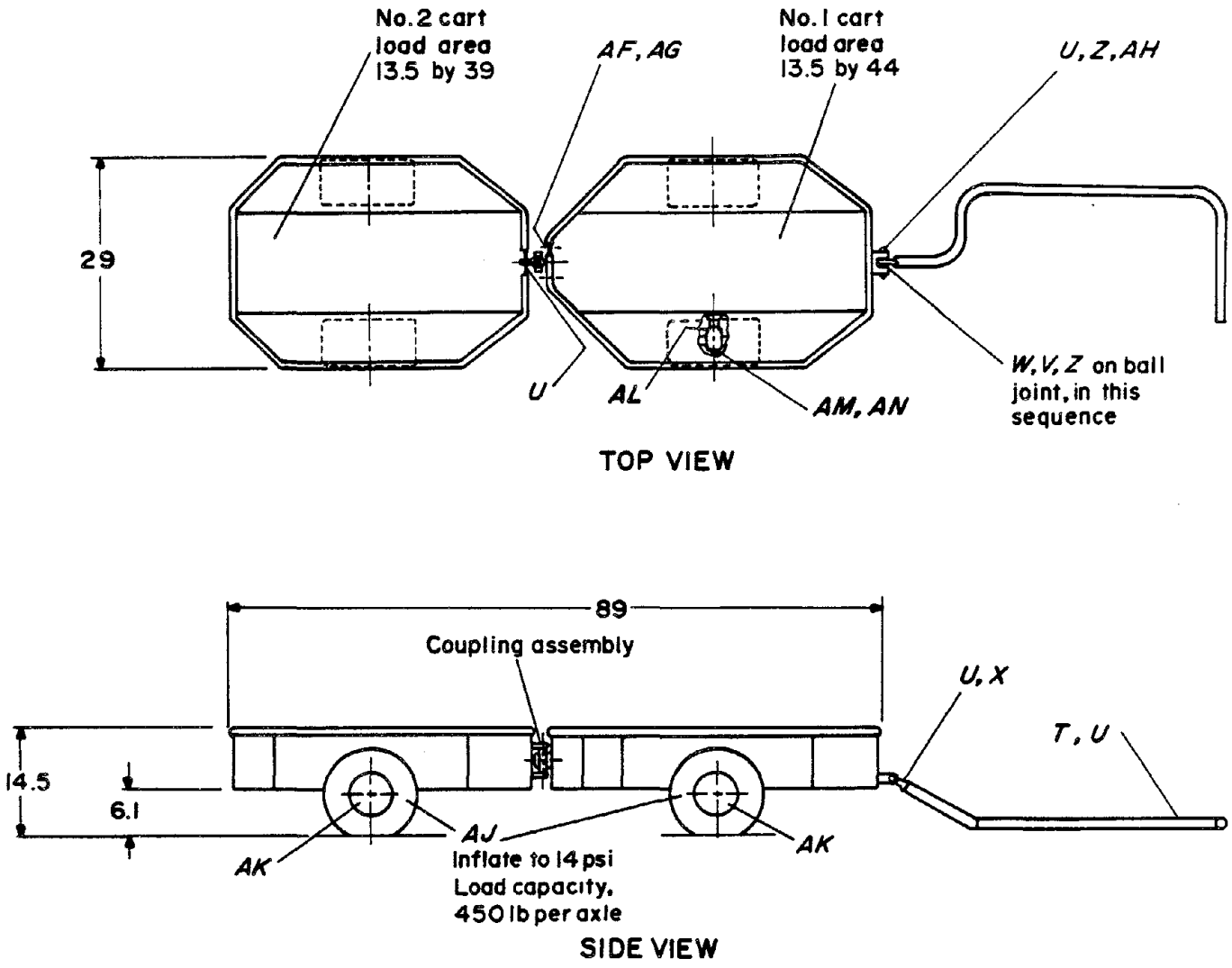


Figure D-1.—Mine mud cart. See figures D-2 through D-8 for details of parts and assemblies.

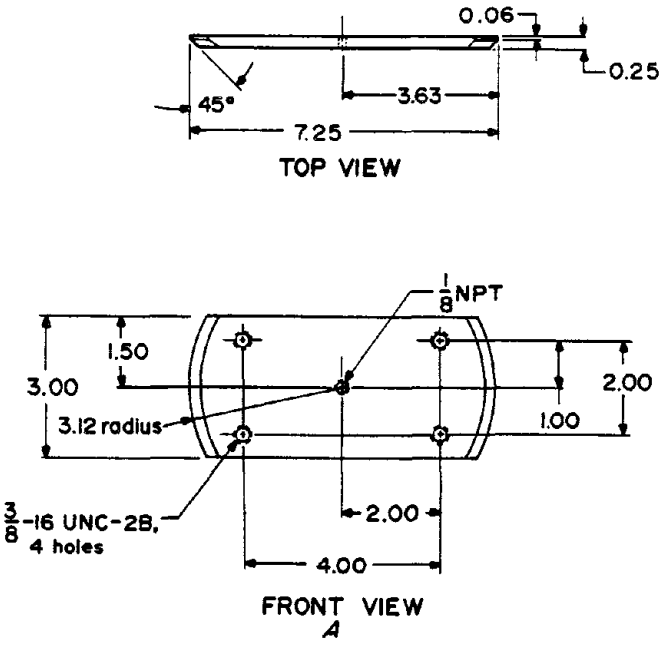
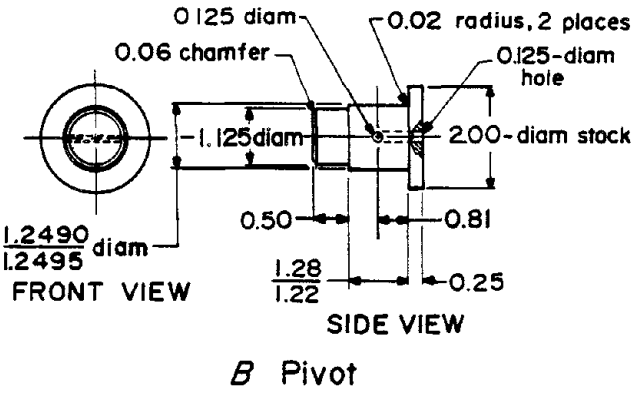


Figure D-2.—Mount.



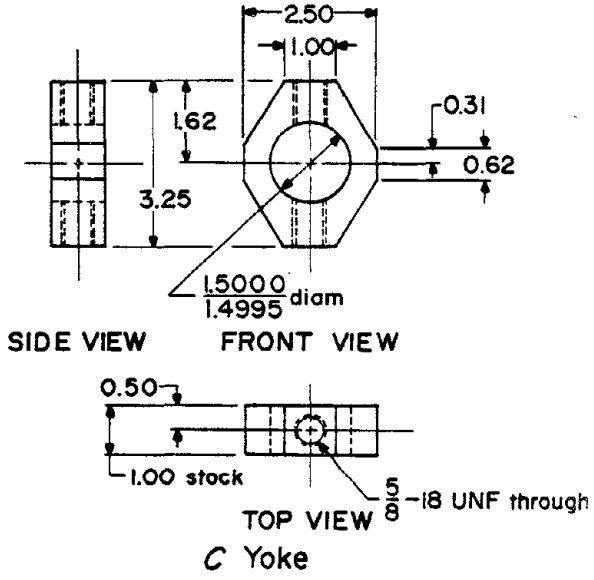


Figure D-3.—Pivot and yoke.

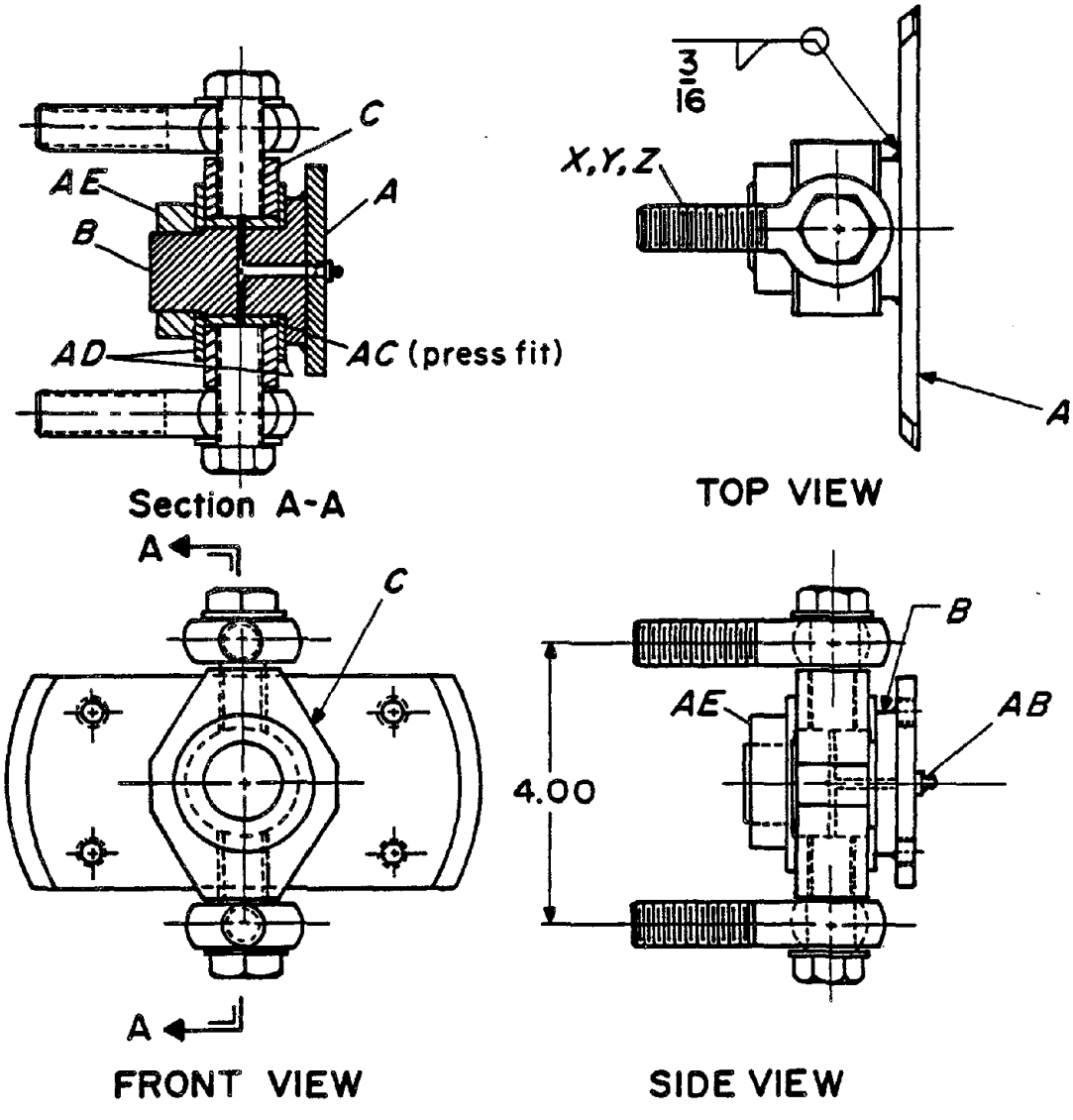


Figure D-4.—Coupling assembly.

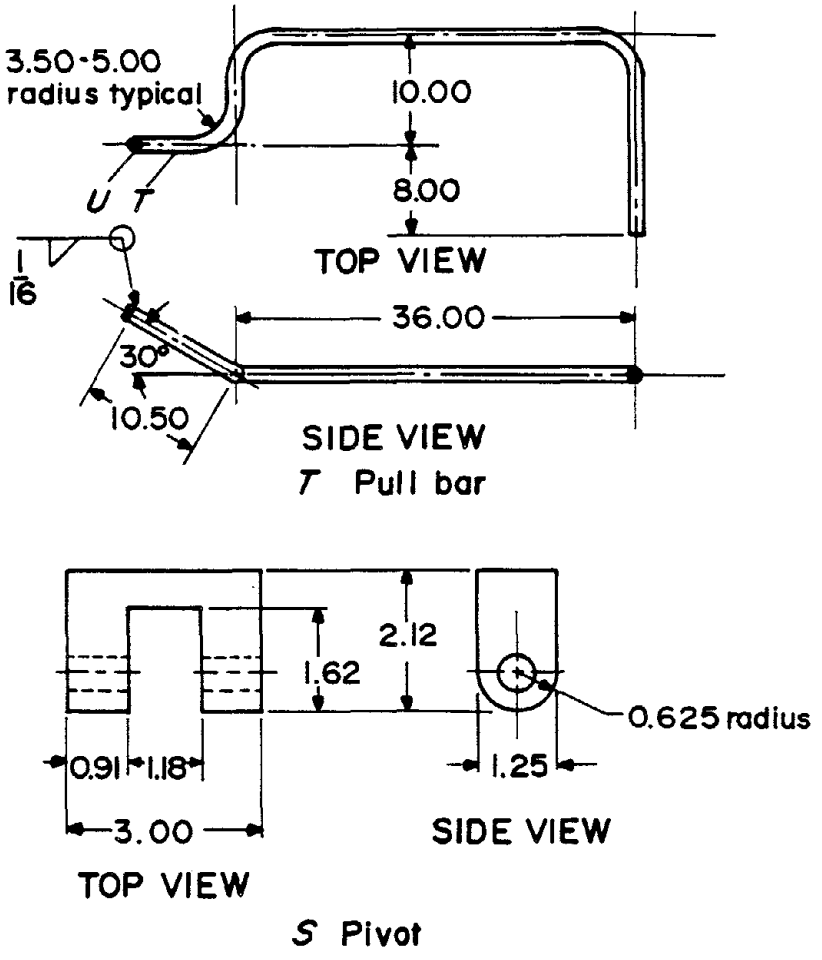


Figure D-5.—Pull bar and pivot.

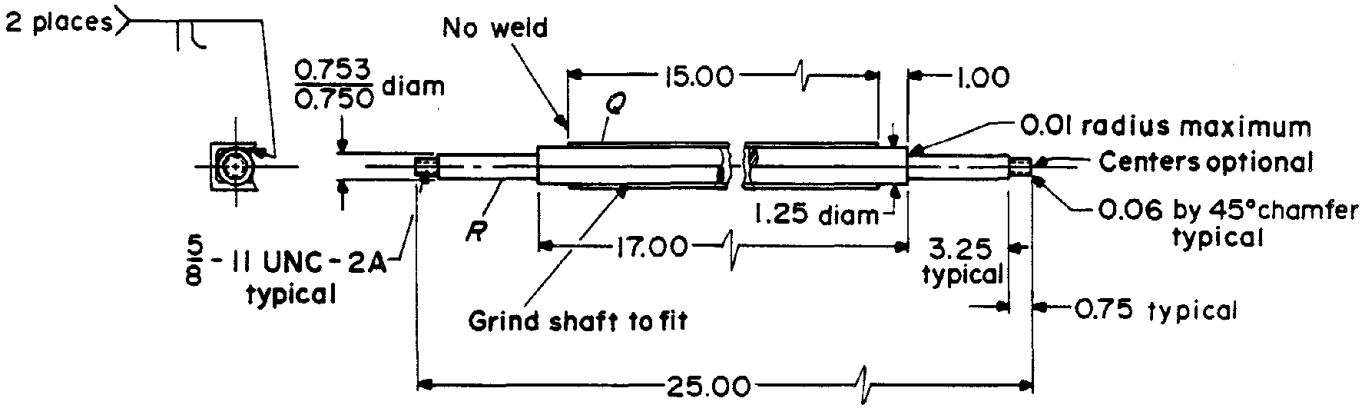


Figure D-6.—Shaft and axle assembly.

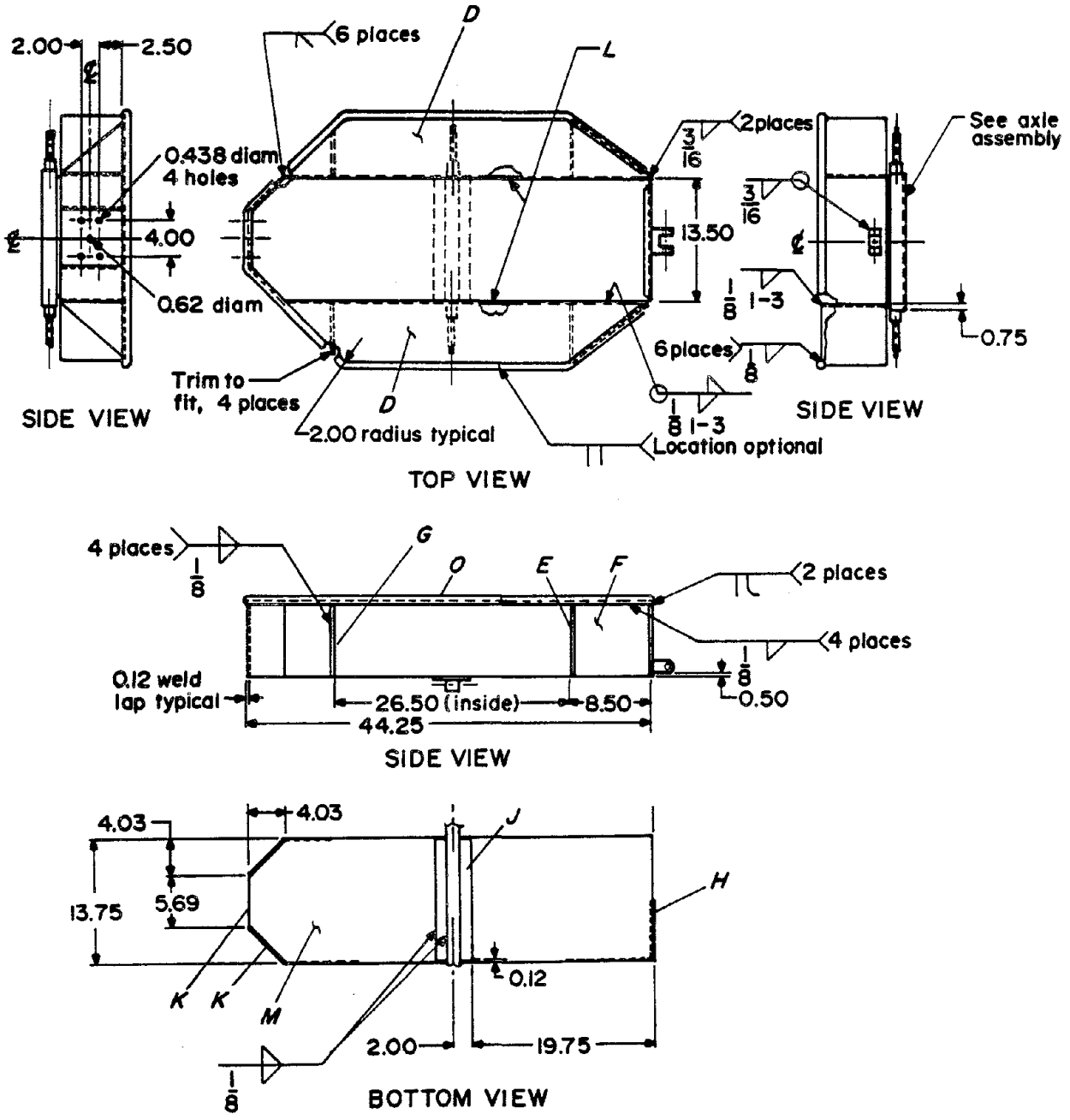


Figure D-7.—No. 1 cart assembly.

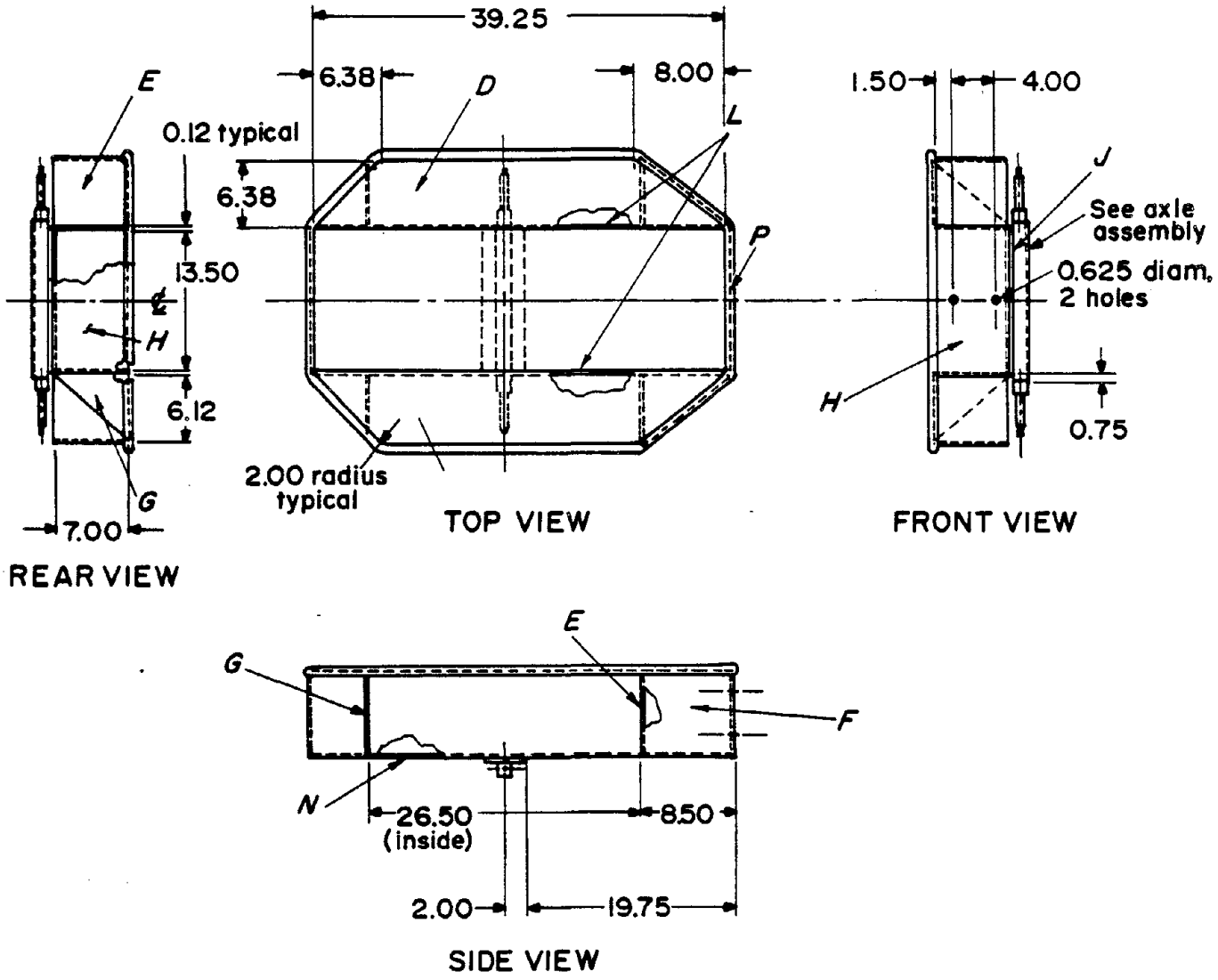


Figure D-8.—No. 2 cart assembly.

APPENDIX E.–CONTAINER-WORKSTATION VEHICLE

The container-workstation is illustrated in figure E-1. Table E-1 lists the parts and their specifications. Details of individual parts and assemblies are shown in figures E-2 through E-5. The italic letters on the drawings correspond to the letters used in table E-1. All dimensions shown in the drawings are in inches.

TABLE E-1. - Container-workstation parts list

Item	Quantity	Description	Material
A	1	Eye ring	M/C 3024526.[1]
B	1	Handwheel	M/C 6022K37, 5-in diam.[1]
C	3	Coupling	M/C 6410K38, 3/8-in shaft.[1]
D	1	Setscrew	M/C 91375A242, 10-24 by 0.5 in.[1]
E	2	Guide	ASTM A36, 0.25 in thick.
F	2	Screw, hex head	Grade 5, 3/8-16 by 3 in.
G	6	Nut, self-locking	Steel, 3/8-16.
H	1	Gear drive	M/C 6456K13, 3-way.[1]
J	3	Screw, hex head	Grade 5, 10-24 by 1.5 in.
K	3	Lockwasher	Steel, 3/16-in OD.
L	2	Screwjack	Keyed for traveling nut.[2]
M	8	Screw, hex head	Grade 5, 1/4-20 by 1.0 in.
N	4	Nut, self-locking	Steel, 1/4-20.
O	2	Hand knob	M/C 6085K17, trim to 1 in.[1]
P	2	Nut, plain	Steel, 1/2-13.
Q	2	Bearing, split	M/C 6259K36, 15/16-in shaft.[1]
R	4	Screw, hex head	Grade 5, 3/8-16 by 1.5 in.
S	2	Nut, self-locking	Steel, 3/4-10.
T	2	Washer, hard	M/C 98029A036, 3/4-in ID.[1]
U	2	Wheel	8 by 7 in.[3]
V	2	Tire	18 by 8.50-8.[4]
W	4	Snap ring	M/C 98410A122, external.[1]
X	2	Pin, clevis	M/C 98306A387, 0.5 by 1-27/32.[1]
Y	2	Pin, cotter	Steel, 5/32 by 1.0 in.
Z	2	Standoff	ASTM A500 grade B, 2 by 2 by 3/16-in tube.
AA	2	Carry arm	Do.
AB	2	Crossbeam	Do.
AC	2	Trailing arm	Do.
AD	1	Cross shaft	Cold-forged bar, AISI Type 1018, 0.93-in diam.
AE	2	Axle shaft	Cold-forged bar, AISI Type 1018, 1.25-in diam.
AF	1	Gusset	ASTM A36, 0.25 in thick.
AG	2	Guide	Do.
AH	1	Mount	ASTM A36, 3/16 in thick.
AJ	1	Pipe	Schedule 40 steel, 1.5-in pipe.
AK	4	Link	ASTM A36, 0.25 in thick.
AL	2	Runner	ASTM A36, as required.
AM	2	Track	Do.
AN	2	End plate	ASTM A36, 0.375 in thick.
AO	2	Lug	ASTM A36, 1.0 in thick.
AP	2	Mount	ASTM A36, 0.25 in thick.
AQ	2	. . do	Do.
AR	2	Brace	Steel angle, 2 by 2 by 1/4 in.
AS	2	Rail	Do.
AT	1	Bottom	Steel sheet, 10 gauge.
AU	2	Side	Do.
AV	2	End	Do.
AW	8	Washer, flat	1/2-in ID, SAE.
AX	4	Lockwasher	Split type, 1/4-in ID.
AY	1	Shaft	Cold-forged bar, AISI Type 1018, 3/8-in diam.

[1]M/C = McMaster-Carr catalog No. 88.
[2]Joyce Dayton Corp., model WJ1000, worm gear screwjack, 9-in travel.
[3]Armstrong Rubber Co., ARCO wheel part 70886.
[4]Armstrong Rubber Co., Ultra Trac, part 429331, with rim shown in footnote 3.

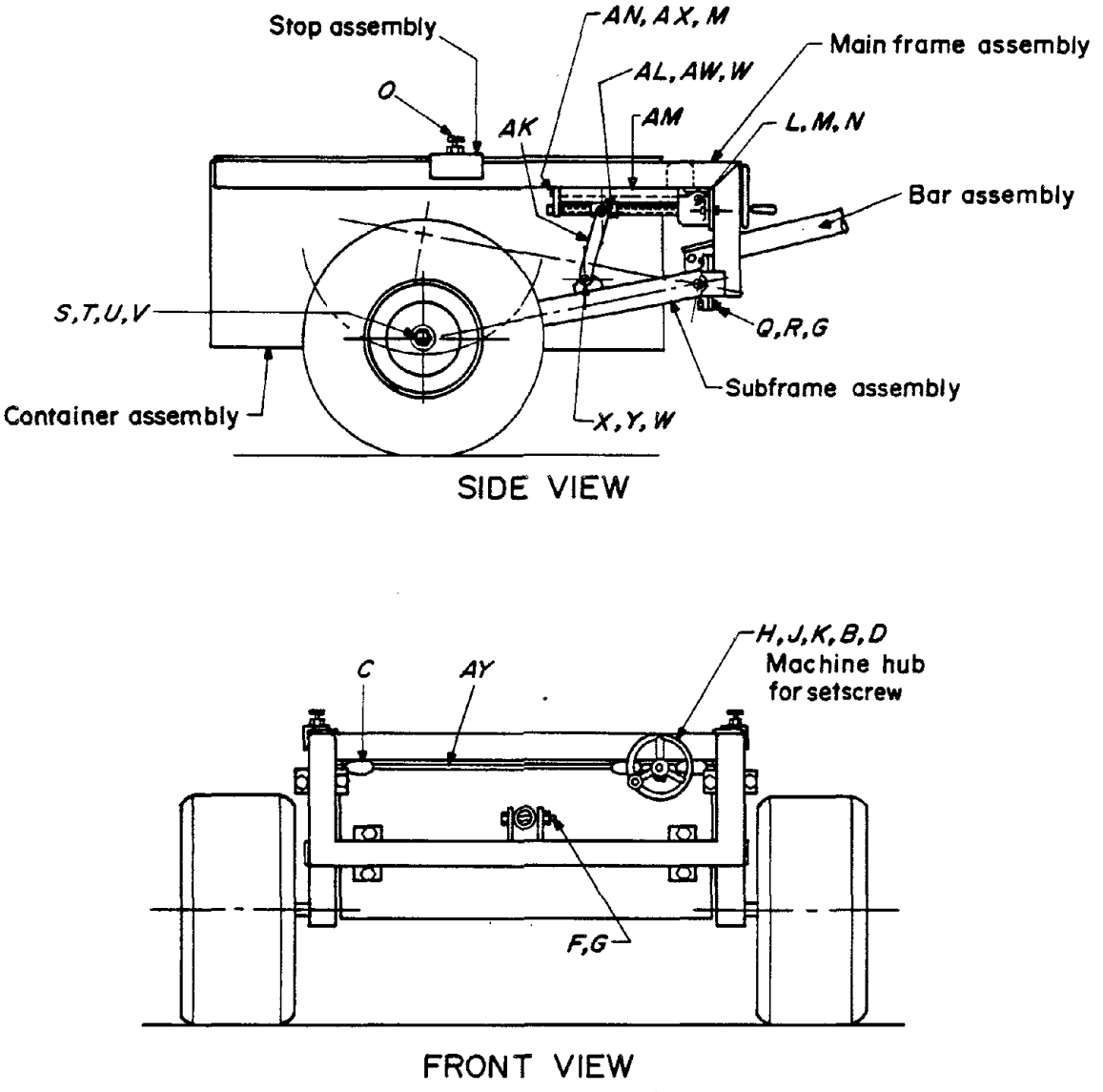


Figure E-1.—Container-workstation. See figures E-2 through E-5 for details of parts and assemblies.

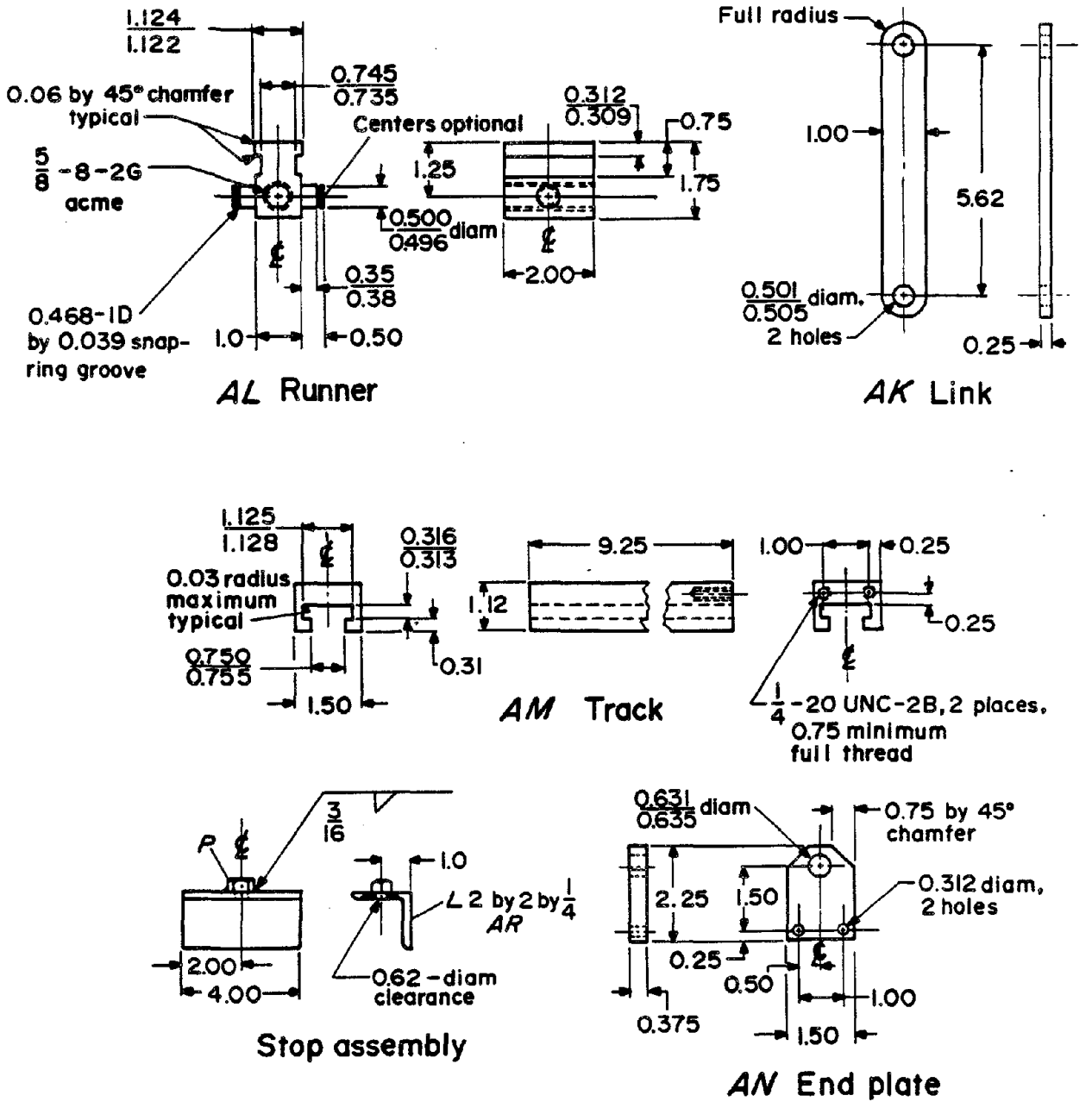


Figure E-2.—Runner, link, track end plate, and stop assembly for container-workstation.

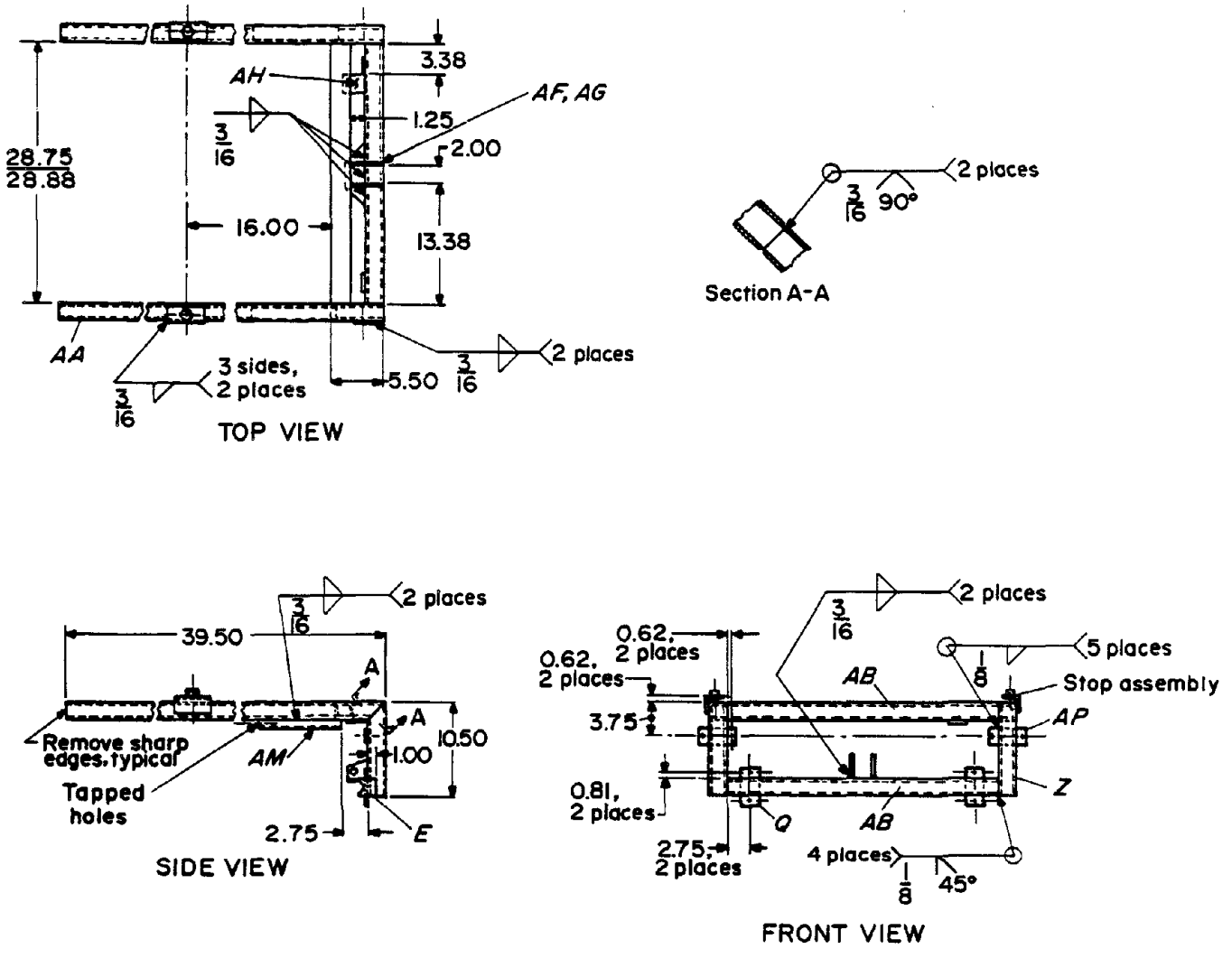


Figure E-3.—Main frame assembly.

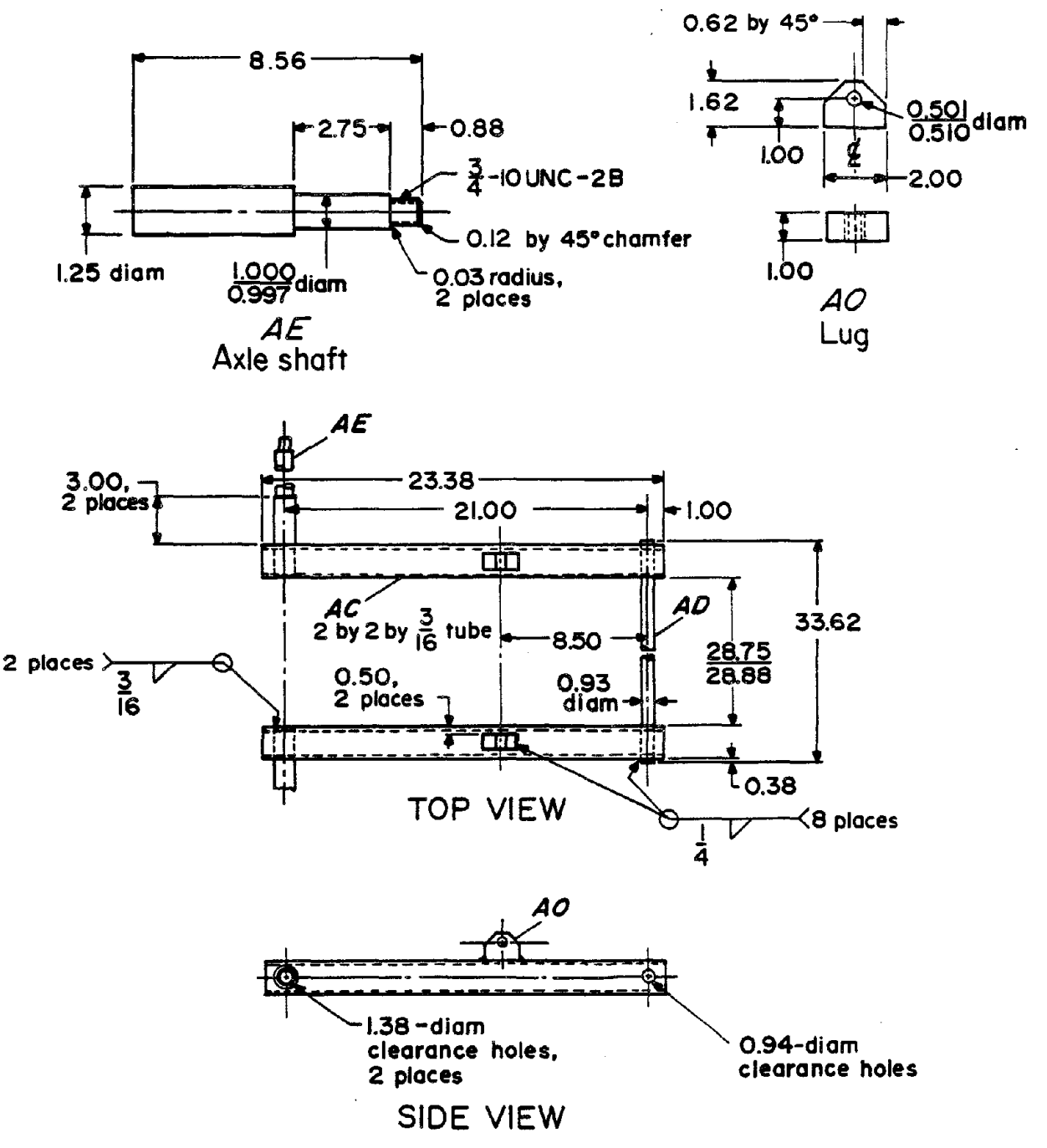


Figure E-4.—Axle shaft, lug and subframe assembly.

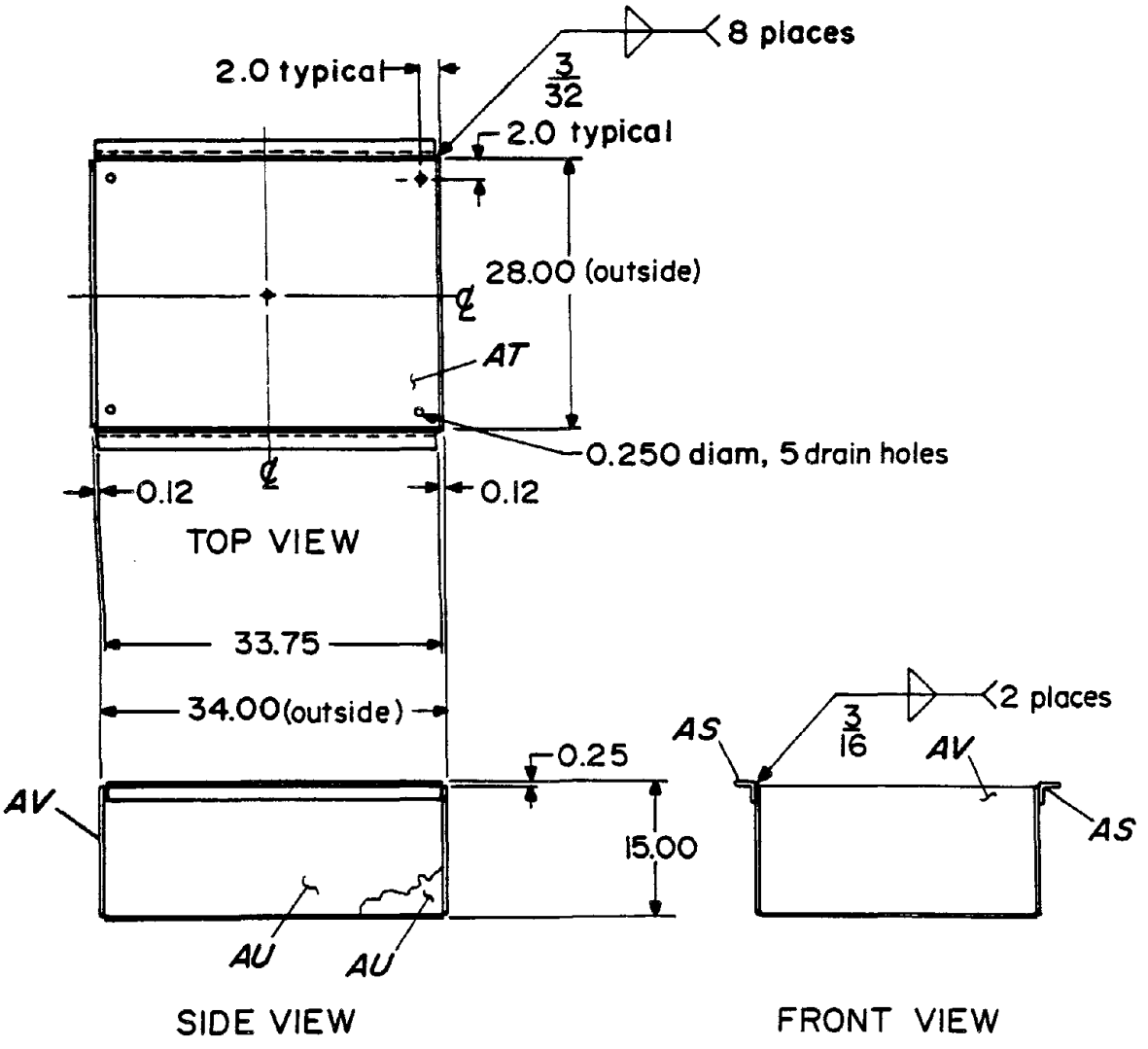


Figure E-5.—Container assembly.

APPENDIX F.–TIMBER CAR

The jack components of the timber car are illustrated in figure F-1. Table F-1 lists the parts and their specifications. Details of individual parts and assemblies are shown in figures F-2 through F-6. The italic letters on the drawings correspond to the letters used in table E-1. All dimensions shown in the drawings are in inches.

TABLE F-1. - Timber car parts list

Item	Quantity	Description	Material
A . .	1	Lift jack	M/C 8802T15, 1.5 ton.[1]
B . .	4	Cam follower	1.75-in diam.[2]
C . .	1	Extension	Channel, 4 in, 6 in long.
D . .	2	Upper track guide	Steel angle, 2 by 1.25 by 0.25 in.
E . .	2	Lower track guide	Steel angle, 2 by 2 by 0.25 in.
F . .	2	Extension arm support	Steel angle, 1 by 1 by 1/8 in, 3 in long.
G . .	2	Track	Channel, 3 in.
H . .	2	Leveler arm	Plate, steel, 0.25 by 1 in.
I . . .	1	Jack leveler head	Plate, steel.
J . .	1	Jackhead	Do.
K . .	4	Mounting block	Plate, steel, 3 by 4 by 0.50 in.
L . .	1	Jackhead pin	Cold-forged bar, AISI Type 1018, 1.5-in diam.
M . .	2	Leveler pivot pin	Cold-forged bar, AISI Type 1018, 0.5-in diam.

[1]M/C = McMaster-Carr catalog No. 88.
[2]Torrington bearings, CRS-28, 2.75 in, cam follower.

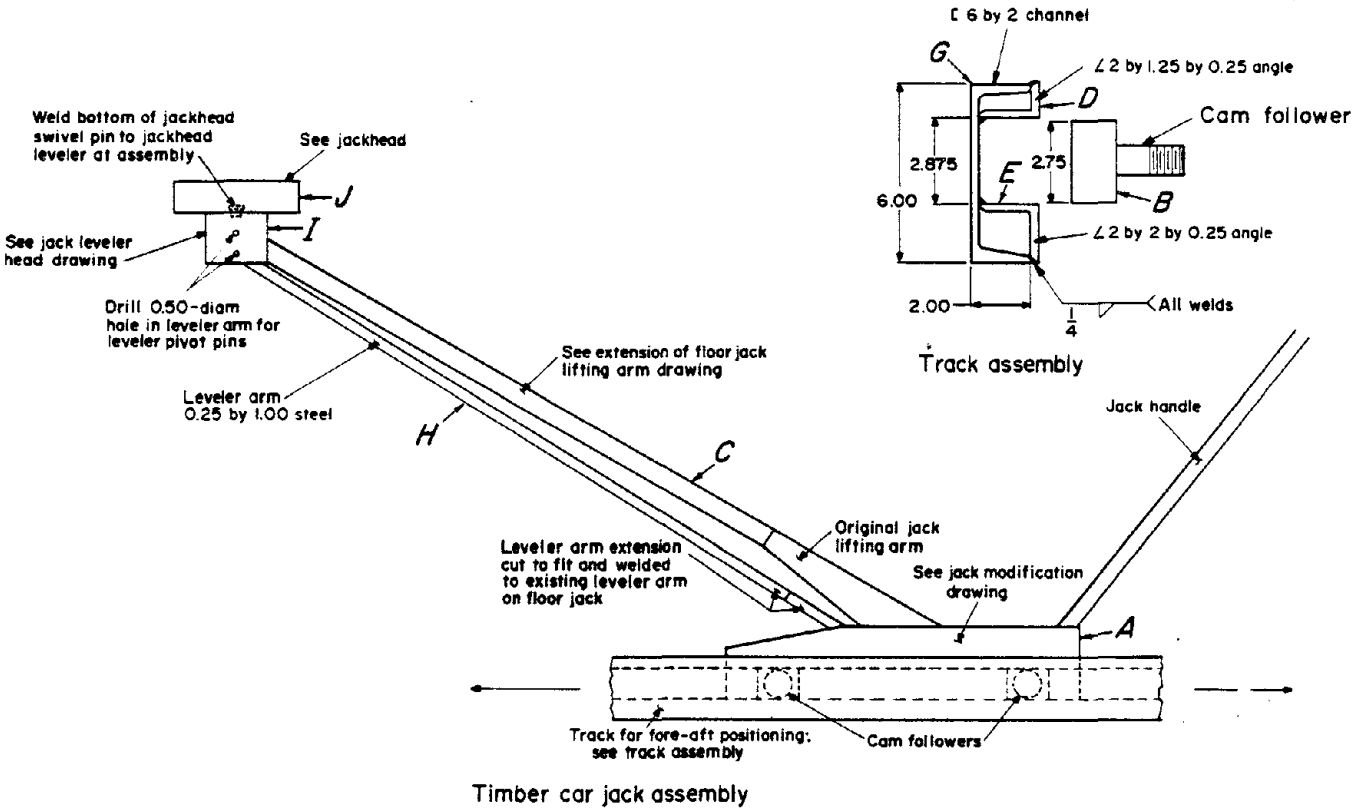
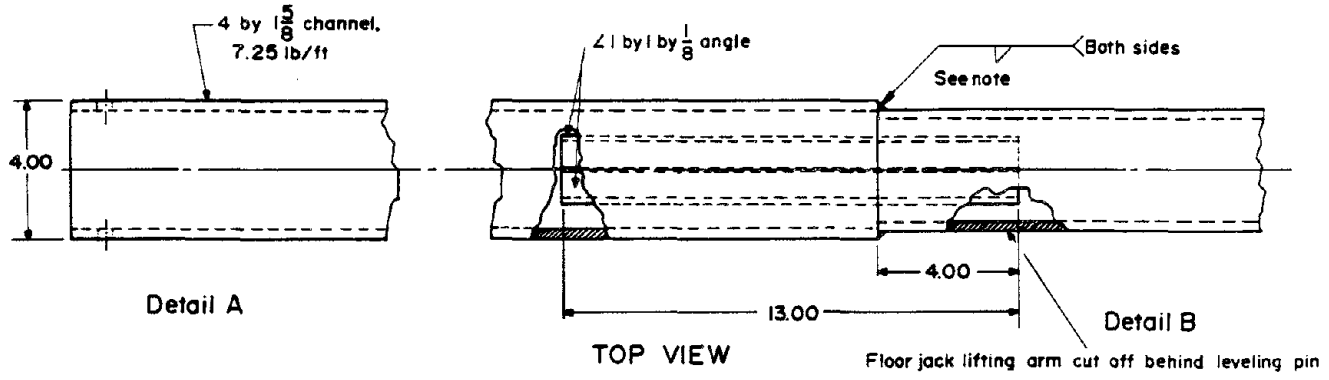


Figure F-1.—Timber car. See figures F-2 through F-6 for details of parts and assemblies.



NOTE: Size of weld not to exceed minimum material thickness

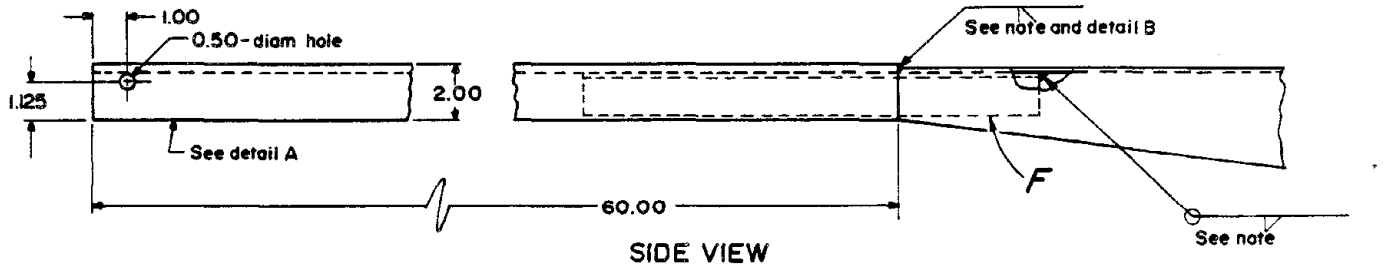


Figure F-2.–Extension details.

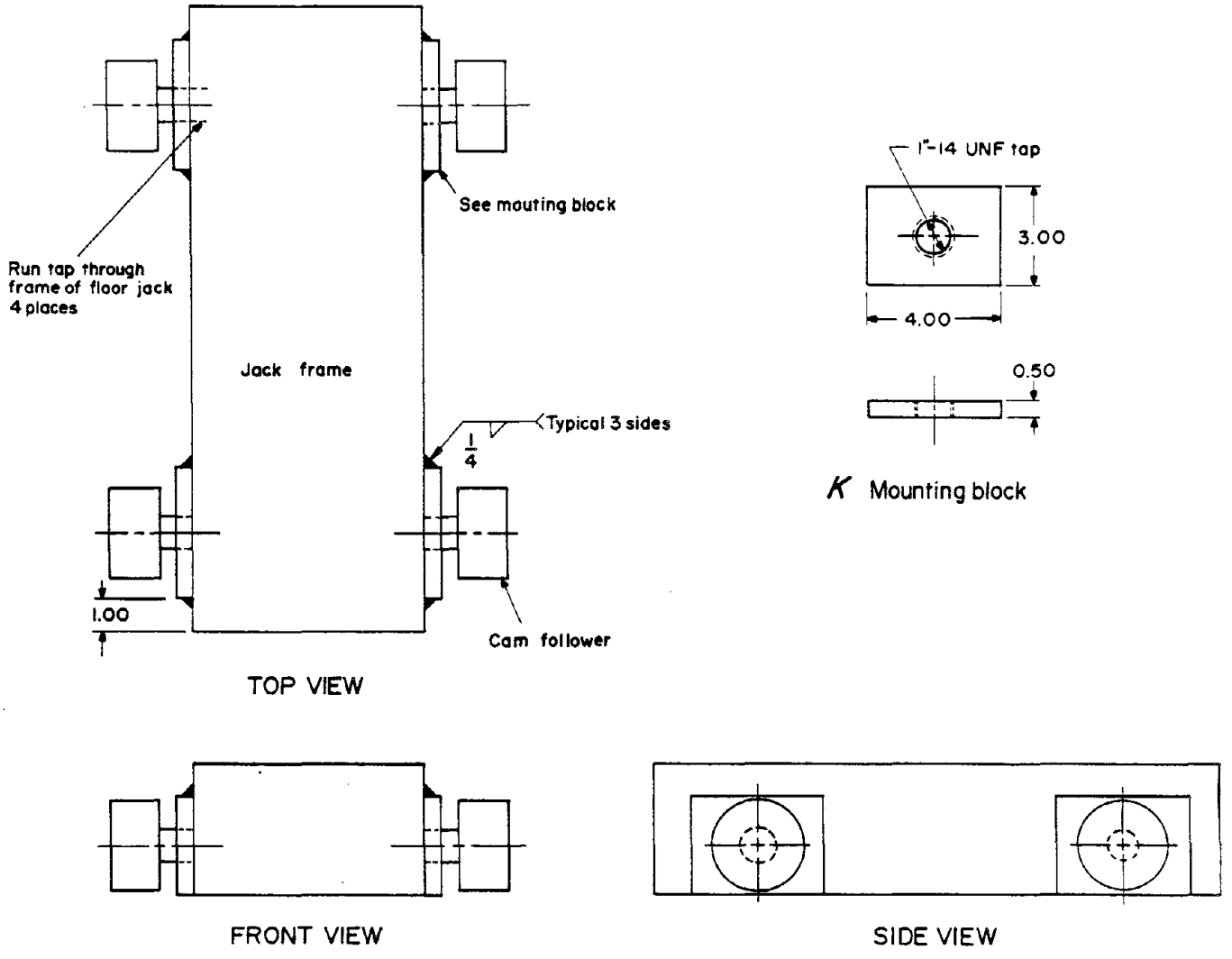


Figure F-3.—Mounting block and mounting block cam follower assembly.

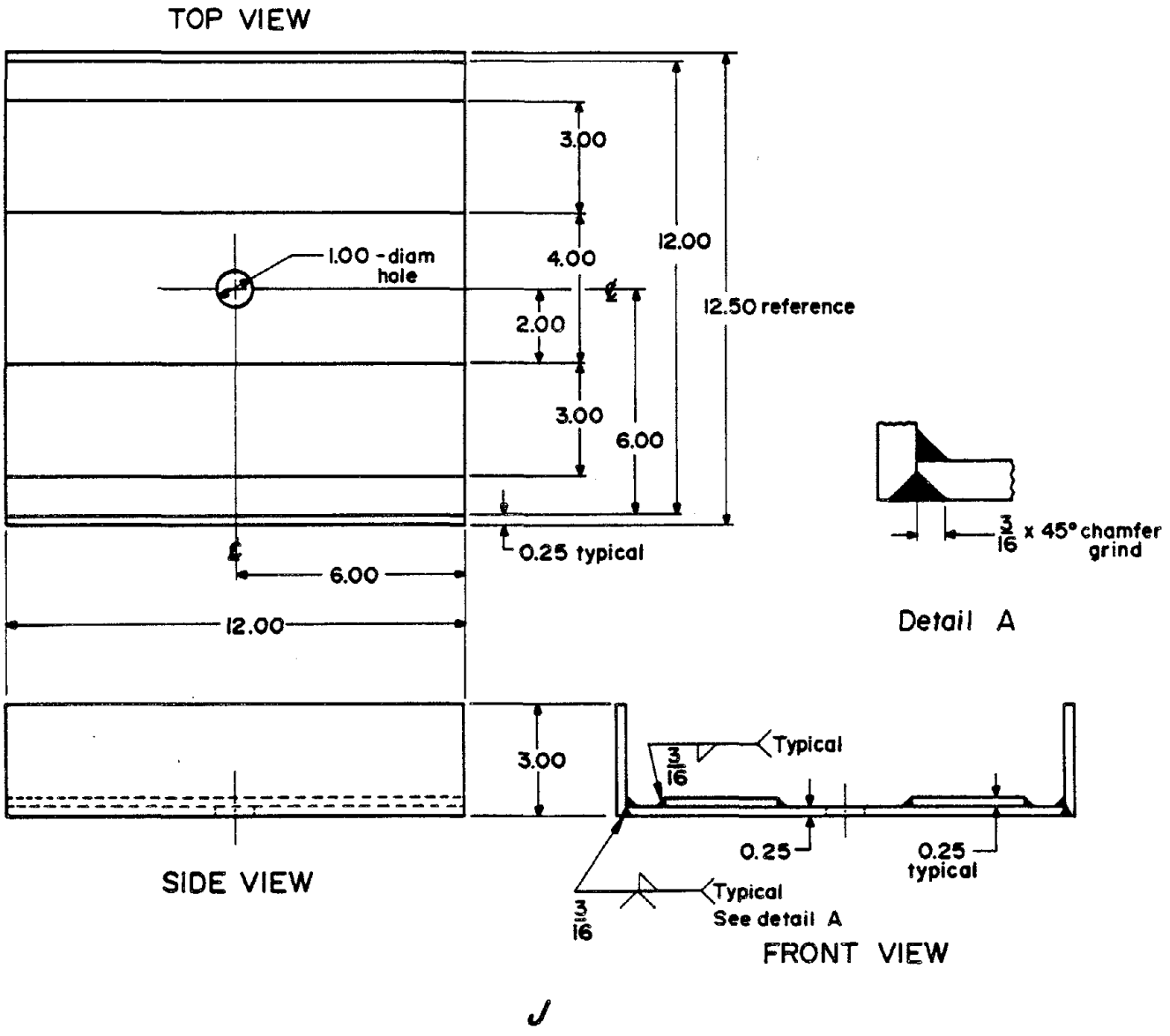
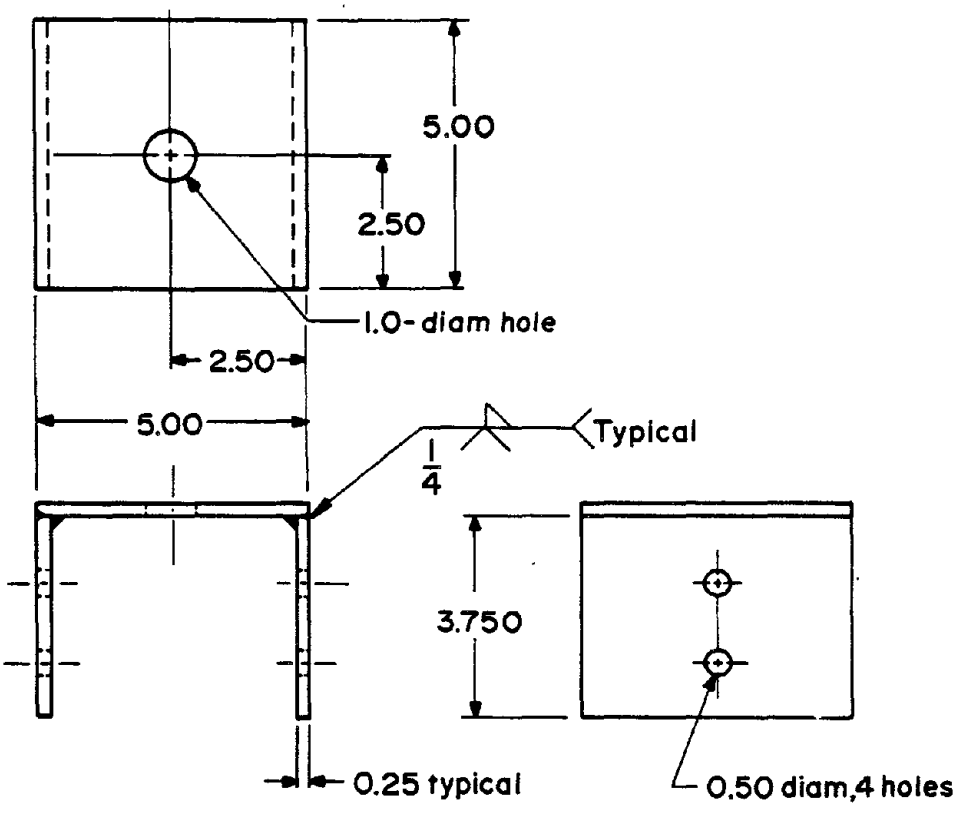
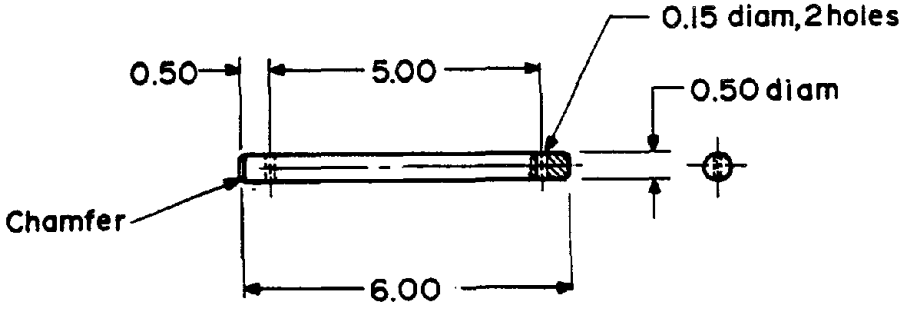


Figure F-4.—Jackhead assembly.



NOTE: The location of these holes is dependent on the type of floor jack being used. See text for details.

I Jack leveler head



M Leveler pivot pin

Figure F-5.—Jack leveler head assembly.

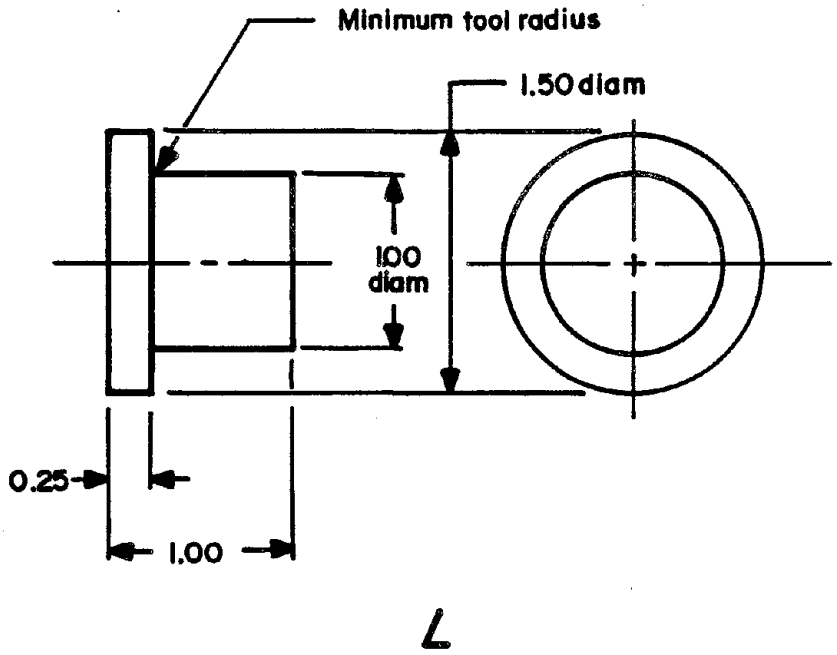


Figure F-6.—Pin.

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