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U. S. ARMY
TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

TRECOM TECHNICAL REPORT 63-53

GEM JACK CONEX MOVER: COST, RELIABILITY, OPERATION, AND MAINTENANCE CONSIDERATIONS

Task 1D021701A04815
(Formerly Task 9R99-01-005-15)
Contract DA 44-177-TC-752

October 1963

prepared by:

HILLER AIRCRAFT COMPANY
Palo Alto, California

HEADQUARTERS
U S ARMY TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

The usefulness of the air-bearing principle in moving heavy loads over relatively smooth surfaces has been demonstrated. The ability of a flexible seal to permit movement over significant obstacles, such as a 4-inch lower-hold brow, with adequate stability and acceptable efficiency was investigated by the Hiller Company under Contract DA 44-177-TC-752.

Two experimental 5-ton CONEX container jacks were constructed to permit seal evaluation under operational conditions. Since the air requirements fell in a pressure/volume range for which few sources were available, the expedient of employing a roots-type blower to satisfy the requirements introduced inordinate noise problems which are now the subject of investigation before operational tests are conducted.

The attached report describes the operation, maintenance, and construction details of the device, including some cost information for producing a device of this sort.

Data covering the operational aspects and seal effectiveness will be included in a subsequent report.

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Cost, Reliability, Operation, and Maintenance Considerations
ARD-306

Prepared by
ADVANCED RESEARCH
DIVISION OF HILLER AIRCRAFT COMPANY

For
U. S. ARMY TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

FOREWORD

This report is submitted in compliance with the requirements of Contract DA 44-177-TC-752.

Mr. L. A. Burdick, Jr. conducted the development of the GEM JACK Conex Mover under the direction of Mr. M. F. Gates, Project Engineer, Propulsion Research Department.

Substantial contributions to the success of the development were made by Mr. E. R. Sargent, Manager, Propulsion Research Department; D. A. Graber, Head Propulsion Lab. Technician; and G. B. Holcombe, President, Industrial Covers, Inc., manufacturers of fabric components.

The counsel of TRECOM GEM Task Group personnel is gratefully acknowledged.

CONTENTS

1. SUMMARY

The unit cost of the first 500 GEM JACKs in quantity production is estimated to be $9,500. A follow-on procurement of 500 units would lower the unit cost to approximately $7,000.

Based on known factors, the reliability of the GEM JACK should be excellent. One unknown in the prognostication is the expected service-operating conditions; therefore, the durability of the bearing bag is difficult to assess.

The report also discusses the proper operation, maintenance, and storage of the GEM JACK.

2. INTRODUCTION

Hiller Aircraft Company has been investigating the ground-effect phenomenon for many years in connection with their helicopters and other VTOL aircraft concepts. Since 1959, the study of ground-effect machines of unique concept has been actively pursued. In January 1961, investigations of the application of ground-effect (and/or air-bearing) principles to the simplification of cargo handling problems began. These were based on the earlier Hiller research programs in this field, and led to the development of the GEM JACK to meet specific Army requirements for handling the Conex container.

This report applies specifically to the GEM JACK (see Figure 1) as delivered to the U. S. Army under this contract. Figure 2 shows the GEM JACK partially installed beneath the Conex. Figure 3 shows the GEM JACK operating. The Appendix lists the drawings applicable to the GEM JACK.

GENERAL CHARACTERISTICS

Dimensions		
Overall Length	--	130 in.
Overall Width	--	57.3 in.
Lift Section Length	--	102 in.
Lift Section Width	--	53 in.
Lift Section Collapsed Height	--	4.25 in. max.
Weight and Load Capacity		
Jack Weight	--	1,000 lbs.
Weight Distribution		
Caster Wheels	--	200 lbs./two wheels
Fixed Wheels	--	800 lbs./two wheels
Maximum Design Payload	--	11,000 lbs.
Operational		
Design Base Pressure	--	365 psf
Maximum Base Pressure	--	435 psf (off-center load condition)

3. ESTIMATED COST OF GEM JACK IN QUANTITY PRODUCTION

There is very little cost information presently available on this type of equipment. The estimate of direct man-hours and material cost elements is based on the specification weight of 1,000 pounds and consultation with vendors regarding major subcontract items.

On this basis the estimated unit cost for the first 500 units is $9,500, if they are produced at a rate of 20 units per month. This figure includes amortization of additional production engineering and tooling. In a follow-on procurement of 500 units, the unit cost would be approximately $7,000, if the production rate were maintained.

The estimated reduction in unit cost for the follow-on procurement is due to the deletion of production engineering and tooling costs and to the learning curve process, which should reduce both the direct man-hours and material costs.

The estimated costs quoted above are believed to be realistic. Any engineering changes required by revised performance specifications would, however, necessitate revised cost estimates.

4. EXPECTED RELIABILITY OF GEM JACK

4.1 Hardware Components:

In order to meet the Army requirement of a design service life of 1,000 hours without the replacement of major components, durable off-the-shelf industrial components were used wherever possible. The blower, manufactured by M. D. Blowers, Inc., of Racine, Wis., was originally designed for pneumatic conveying and is their standard-duty industrial unit. This blower has ductile iron rotors and aluminum housings, and the drive gears are lubricated by an oil bath. Its average life is far in excess of the design requirement, since it is shown by industrial experience to have service life in excess of 5,000 hours. The electric motor, manufactured by Electra Motors Inc., of Anaheim, California, to NEMA design B, Frame 286U standards, has a ventilated, drip-proof aluminum housing and permanently lubricated ball bearings. This squirrel-cage motor is rated for continuous duty and is equipped with class B insulation, which is adequate for use at ambient temperatures to 167°F. The average life for motors of this design greatly exceeds the requirements of this contract. The relief valve and the control cables are also standard industrial products, and their average life exceeds contract requirements. The other mechanical components that have been designed and fabricated for the GEM JACK have been carefully considered to insure reliability and adequate life.

4.2 Fabric Components:

The reliability of the bearing bag is difficult to assess. During development of the GEM JACK, no appreciable wear that could be traced to operation on a level floor was noted. Operation over irregular surfaces, as represented by traversing a brow plate, produced some localized wear. It was found that this localized wear could be kept from damaging the basic integrity of the bearing bag by proper maintenance. This maintenance consisted of recoating the wear points with liquid Hypalon as required. As it is not known at this time what the eventual work cycle of the GEM JACK will be, it is difficult to predict an expected life for the bearing bag. It is believed, however, that with proper maintenance its life can be extended indefinitely. This, of course, excludes damage which would occur because of improper or careless handling of the unit. The bearing bag is fabricated of Hypalon-Coated nylon fabric. Hypalon elastomer, a chlorosulfonated polyethylene rubber, has excellent abrasion resistance, second only to polyurethene, and is superior in other important coating properties, such as flexibility at low temperature, adherence to

nylon, weather resistance, and resistance to common fuels and lubricants. The base nylon fabric is 12 oz/yd material. The coated fabric has a weight of 32 oz/yd. This coated fabric has the following properties:

Test	Warp		Woof
grab tensile	1000 lb/in		925 lb/in
adhesion-Hypalon to nylon	20 lb/in		20 lb/in
tongue tear	125 lb/in		135 lb/in
Mullen hydrostatic		1000 psi	
Mullen burst		1000 psi	

The jack bag, by nature of the construction of the GEM JACK, is protected from all abrasive contact by the metal structure and by the bearing bag. The life of this component should be well in excess of the design requirement of 1,000 hours, excluding puncture damage that can result from careless handling.

5. OPERATION OF GEM JACK

5.1 General:

The operating procedures presented here are based on the experience gained during development and acceptance testing of the GEM JACK. The procedures outlined may require augmentation and modification as experience is gained during Army evaluation tests. Prior to operating GEM JACK, operation instructions should be read completely.

5.1.1 Electrical System and Requirements:

Adequate electrical power capacity must be provided to supply the 25-horsepower squirrel-cage motor. The motor requires 220-volt, 3-phase, 60-cycle power, and draws 62 amperes under full load. The maximum starting current is 150 amperes; breakdown current is 200 amperes. The motor is capable of operation on 440 volts, 3 phase; however, rewiring of motor is required. Replacement of operating-time indicator with a 440-volt unit is also required.

5.1.1.1 An across-the-line starter box must be used and wired as shown in Figure 4. The starter box shall be equivalent to Allen Bradley part number Bull 709 DAA, size 3, 200 volts, with 62-ampere heaters.

5.1.1.2 Care must be taken to insure proper rotation of the blower when the starter box is wired prior to the jack's being placed in service. Proper rotation, clockwise when viewed from the shaft end of the blower, is noted on the blower case. When rotation is checked, power should be applied to the motor for the minimum possible time. Prior to rotating the blower, the manufacturer's instructions should be checked for lubrication.

5.1.1.3 The power supply cable connector which matches the GEM JACK power receptacle is Killark part number W-P-1004-F34,3W,4P.

5.1.1.4 The motor control cable connector which matches the GEM JACK motor control receptacle is Hubbell part number 7484.

5.1.2 Pneumatic Controls:

5.1.2.1 All control valves are fully open when the control rods are fully depressed. Vernier (twist) controls should not be forced into closed position, as the high loads developed will damage control rods and valves. The control panel is shown

in Figure 5.

5.1.3 Fork Lift Co-ordination:

5.1.3.1 If the fork lift is used to propel or control the loaded or unloaded GEM JACK over a brow plate or a listing surface, the GEM JACK should be secured to the fork lift as shown in Figures 6, 7, or 8. Fork tines should not be inserted into receptacles. (These receptacles are for convenience in transporting the unloaded GEM JACK and are not designed to withstand the weight of a loaded container.)

5.1.3.2 When the fork lift is used, tine height must be coordinated with GEM JACK height. This is most important when operating over a brow plate. Fork tine height should never be less than that which occurs during level floor operation.

5.1.4 Starting Procedure:

5.1.4.1 Power supply and motor control cables are attached.

5.1.4.2 All control valves (control rods fully depressed) are opened.

5.1.4.3 Start button is depressed.

5.2 Unloaded GEM JACK Operation:

5.2.1 Operation of the unloaded GEM JACK with the aid of a fork lift may be accomplished by two methods. The fork lift must be attached as described in paragraph 5.1.3.1.

5.2.1.1 The recommended method with fork lifts is, with manifold valves open, to close the dump-bypass valve sufficiently to inflate the jack and bearing bags. (This does not require complete closing of the dump-bypass valve.) The aft end of GEM JACK is lifted with the fork lift and moved to the desired location. For placement of the jack under a Conex, it will then be necessary to deflate the jack and bearing bags by opening the dump-bypass valve fully.

5.2.1.2 Another method of operation is to propel the GEM JACK on the self-contained casters without inflating the bearing or jack bag and with or without motor and blower operation. It is recommended that the blower be operated to reduce bag wear through air lubrication.

5.2.2 Operation of the unloaded GEM JACK without the aid of a fork

lift is possible on the self-contained casters, but is not recommended without motor and blower operating. Motor and blower operation with all control valves open provides air lubrication and reduces bag wear.

5.3 Loaded GEM JACK Operation:

GEM JACK centering beneath Conex is not critical under normal Conex loadings. In extremely unsymmetrical loadings, repositioning may be required to achieve satisfactory operation. All valves should be fully open during loading. Refer to "Loading", Figure 9.

5.3.1 With the motor running and with manifold and divider valves fully closed, the jack valve is opened; then the dump-bypass valve is closed gradually until the jack bag pressure reaches 10 psi. (The relief valve is set for 10 psi.) Fork lift tine height is adjusted accordingly. Refer to "Jacking", Figure 9.

5.3.2 The jack valve is closed, and then the dump-bypass valve is opened.

5.3.3 The manifold and divider valves are opened fully, and the dump-bypass valve is closed gradually to pressurize the bearing bag. Refer to "Operation-Center C.G.", Figure 9.

5.3.3.1 Closing the dump-bypass too severely can result in heave instability. In this event, the dump-bypass is opened sufficiently to correct. This instability can also be corrected for local floor conditions by manually opening the relief valve.

5.3.3.2 Manifold valves are trimmed for load leveling. Only light or "high side" manifold valves need be adjusted. Heavy or "low side" manifold valves should remain full open.

5.3.4 In the event that extreme C.G. loadings are encountered, as indicated by inability to level the load by the procedure specified in paragraph 5.3.3 (ref. paragraph 5.3), the following procedure, which will suffice for 9,000-pound Conex loads up to 9 inches off Conex centerline, should be used.

5.3.4.1 From the previous procedure, "light" or "high side" should be noted.

5.3.4.2 With all control valves open and with jack bag inflated to 10 psi, light side manifold control valve is closed. Refer to "Operation-Off-Center C.G.", Figure 9.

5.3.4.3 Dump-bypass valve is closed to inflate bearing bag.

5.3.4.4 Light side-manifold valve is trimmed for level attitude. It is possible that it will be necessary to close the heavy side manifold valve slightly to achieve level attitude.

5.3.4.5 If level attitude is not attained, repositioning of GEM JACK (ref. paragraph 5.3) can be resorted to.

5.4 Shutdown Procedure:

5.4.1 The dump-bypass valve is opened and then the jack valve is opened gradually.

5.4.2 The jack is now free to be wheeled from under the Conex container, and the motor may be stopped at this point if required. It is recommended that the motor not be shut down between each successive loading.

5.5 Emergency Shutdown Procedure:

5.5.1 The dump-bypass valve is opened fully, the jack valve is opened, and the stop button is depressed.

6. MAINTENANCE OF GEM JACK:

6.1 The bearing bag may be repaired by using the repair kit. Instructions are included. If wear or damage is extensive, the bag should be returned to the manufacturer for repair.

6.2 Bypass Valve:

The rubber valve liner should be lightly lubricated every 20 operating hours with Dow Corning Number 33 medium grease or equivalent.

6.3 Jack Valve:

The rubber valve liner should be lightly lubricated every 40 operating hours with Dow Corning Number 33 medium gresse or equivalent. This valve liner can be reached through the open bypass valve.

6.4 Bypass Valve Control:

An alemite fitting is provided on the control terminal. This should be lubricated with MIL-G-3278 grease or equivalent every 40 operating hours.

6.5 Blower:

The manufacturer's maintenance instructions are described in Reference 1*. Refer to instructions for the series 16, Model 4000 Blower.

6.6 Pressure Relief Valve:

The manufacturer's maintenance instructions are described in Reference 2**. Refer to instructions for the series 1352 valve.

6.7 Motor:

No maintenance is required.

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*Anon, "Maintenance Instructions 3-Lobe Rotary Positive Blowers", Bulletin M16-51, M-D Blowers, Inc., Racine, Wisconsin.

**Anon, "Pressure Relief Valve 1351/1352 Maintenance Bulletin", V135, S-11, M-D Blowers, Inc., Racine, Wisconsin.

7. STORAGE OF GEM JACK

7.1 Blower:

7.1.1 For storage, lube vents should be replaced with pipe plugs.

WARNING: Lube vents must be reinstalled before the blower is operated.

7.2 Motor:

7.2.1 It is recommended that the ventilation ports on the motor be sealed if the jack is turned upside down in an area in which contaminants may be introduced to the motor.

WARNING: The seal must be removed from the motor vent ports before the motor is operated.

7.3 GEM JACK:

7.3.1 After lube vents are plugged, the jack may be overturned, if desired, by inserting forks of a modified 4,000-lb.-capacity lift truck (forks mounted on turntable with a 180° turning capability) into the tine channels provided for lifting.

7.3.2 When the jack is stored in an upside down condition, blocks (4 x 4 timbers) should be placed between the guard rails and the surface on which the jack is placed to prevent damage to controls.

7.3.3 The front end (or lift section) of the jack should be supported to hold the pan assembly relatively level while the jack is stored in the upside down condition.

7.3.4 Do not stack over 4 units high.

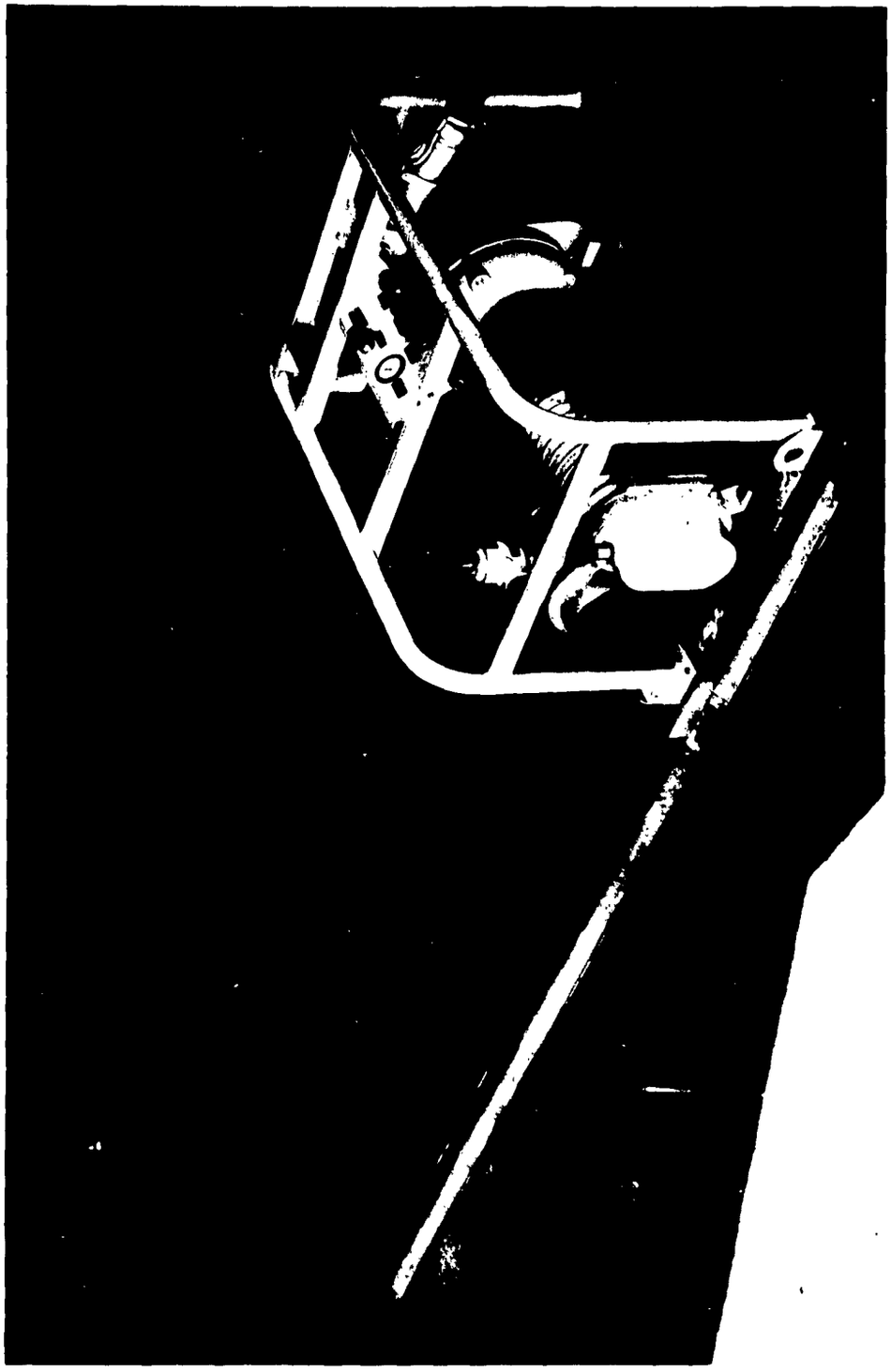

FIGURE 1: GEM JACK

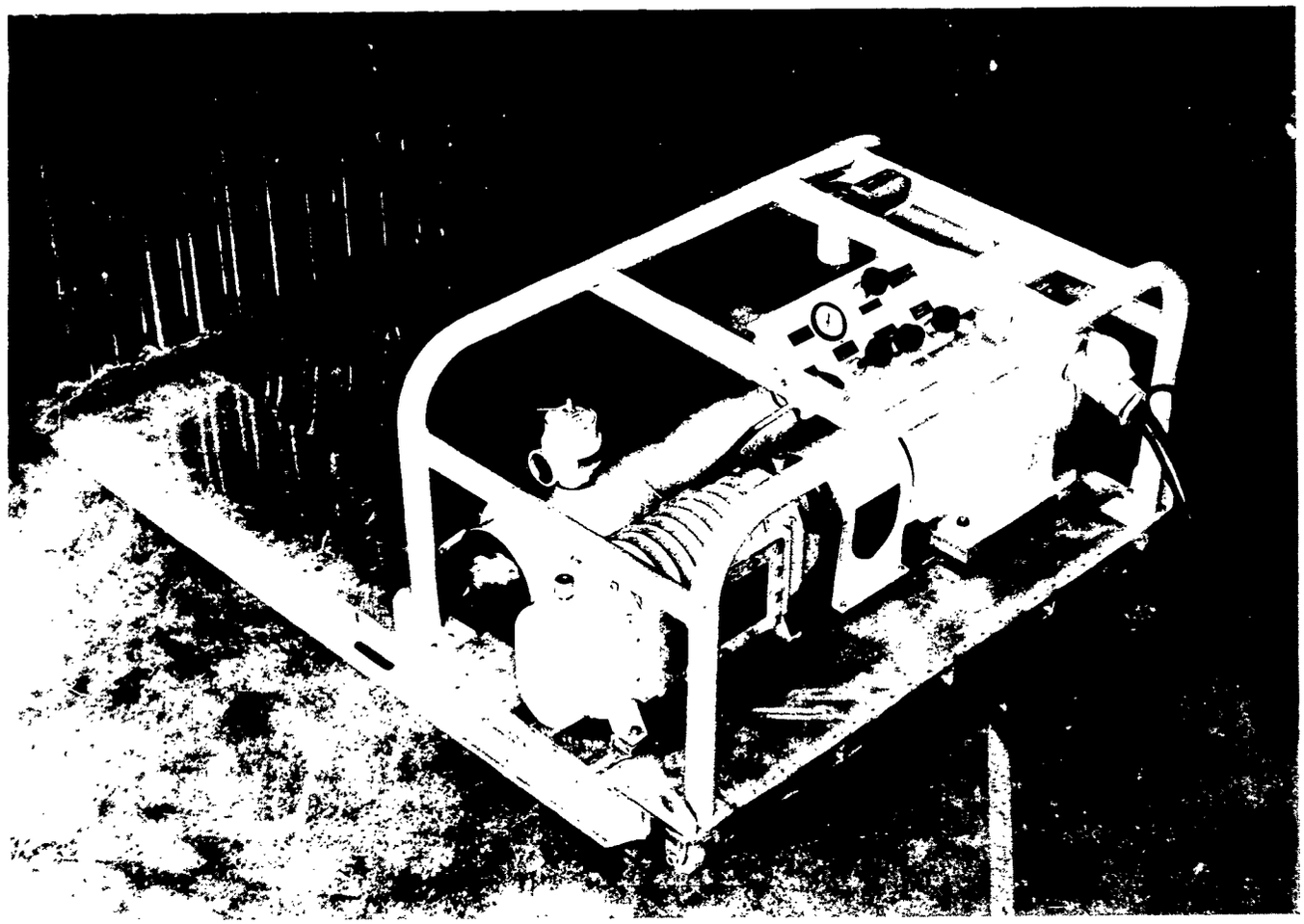

FIGURE 2: GEM JACK PARTIALLY INSERTED BENEATH CONEX

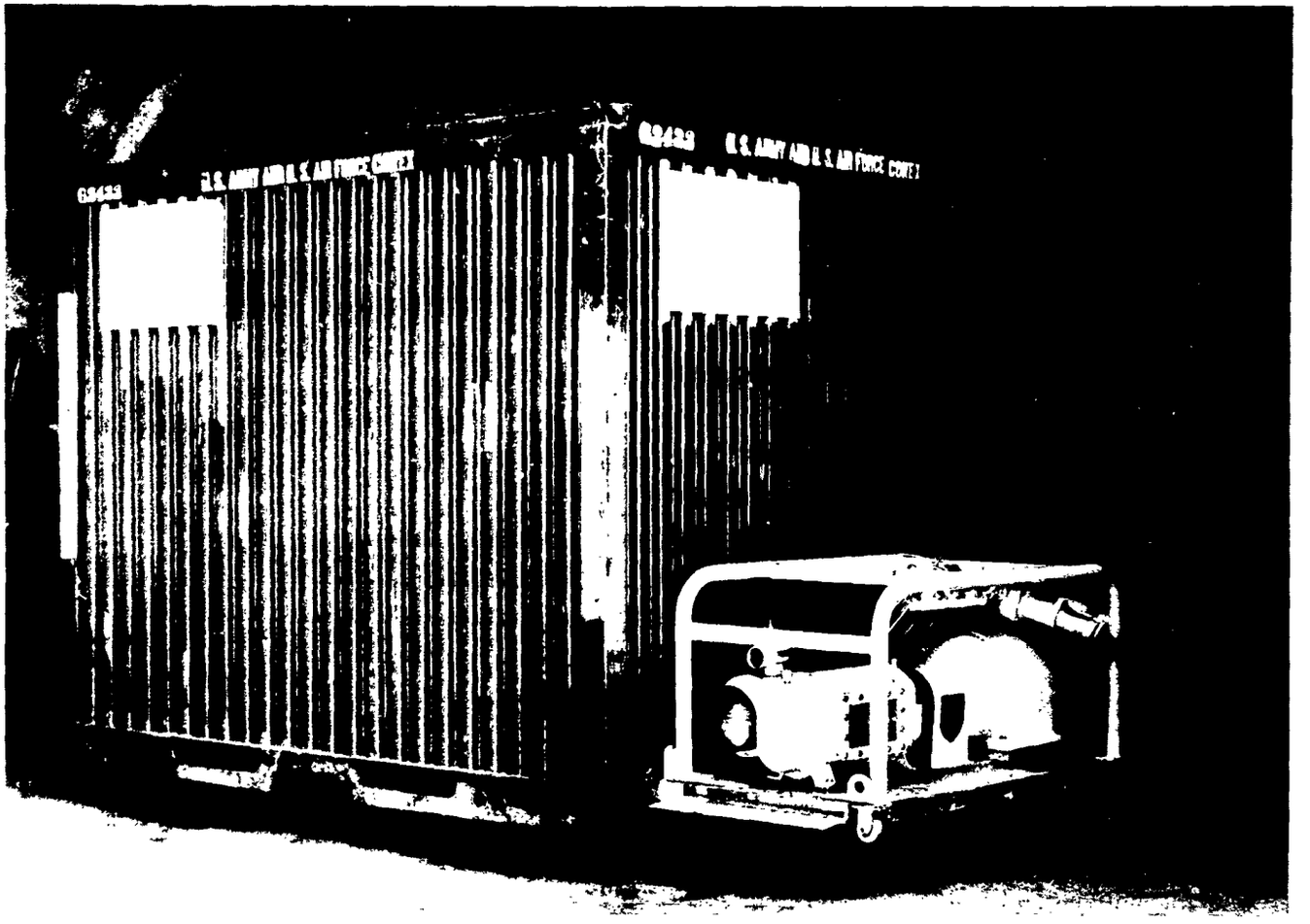

FIGURE 3: GEM JACK OPERATING

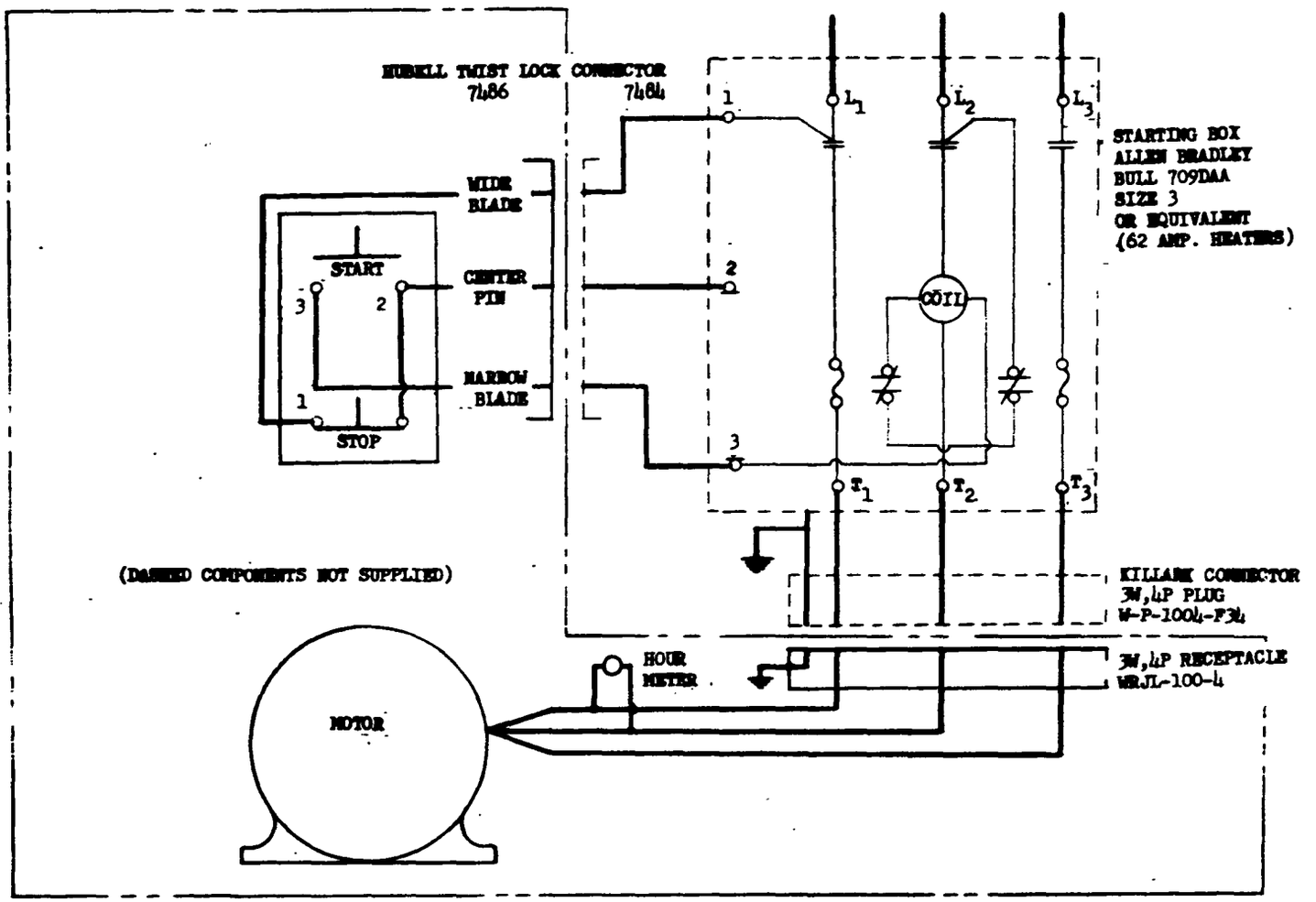

FIGURE 4: ELECTRICAL SCHEMATIC

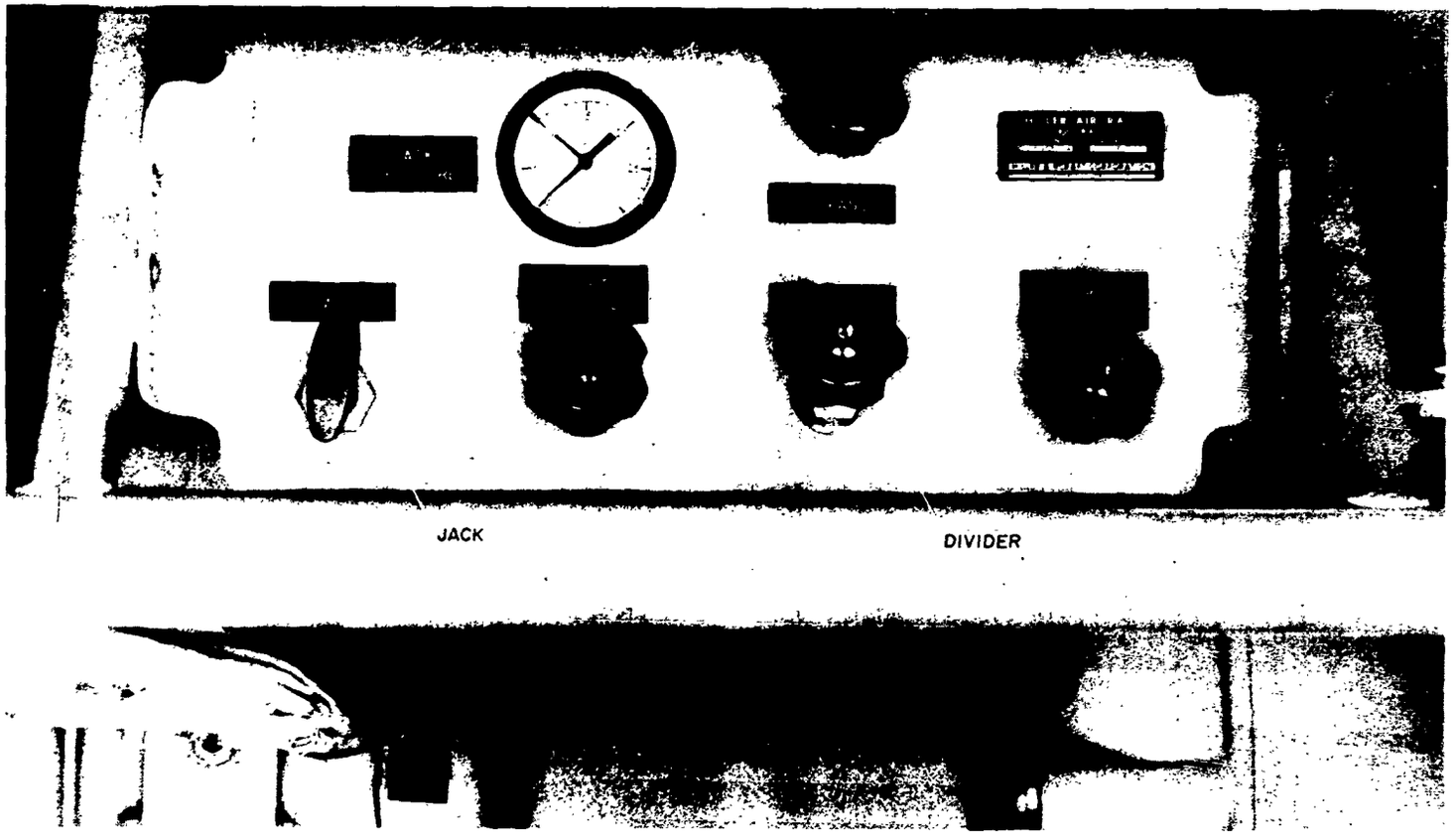

FIGURE 5 CONTROL PANEL

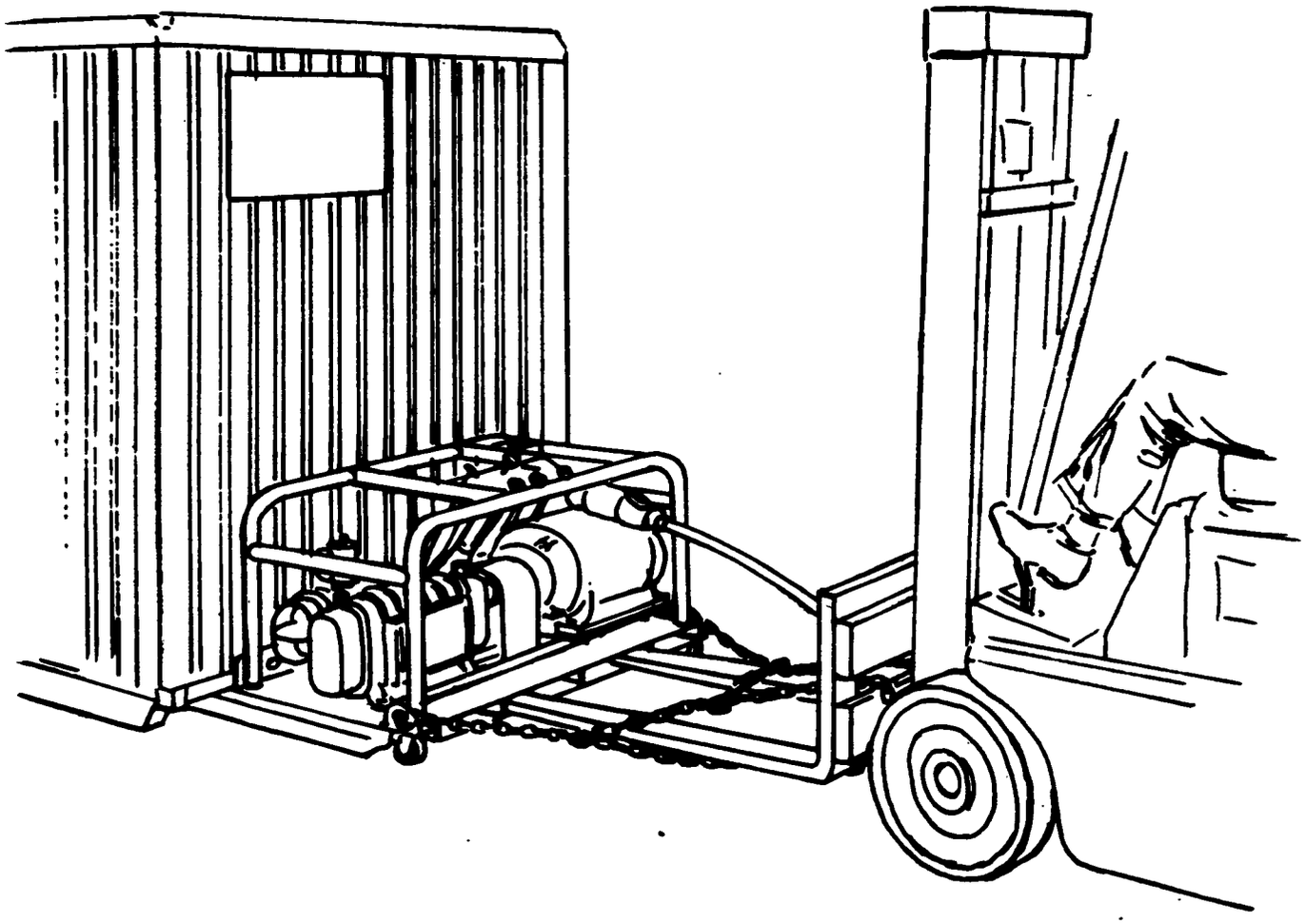

FIGURE 6: LIFT TRUCK SECURED TO AFT END OF GEM JACK

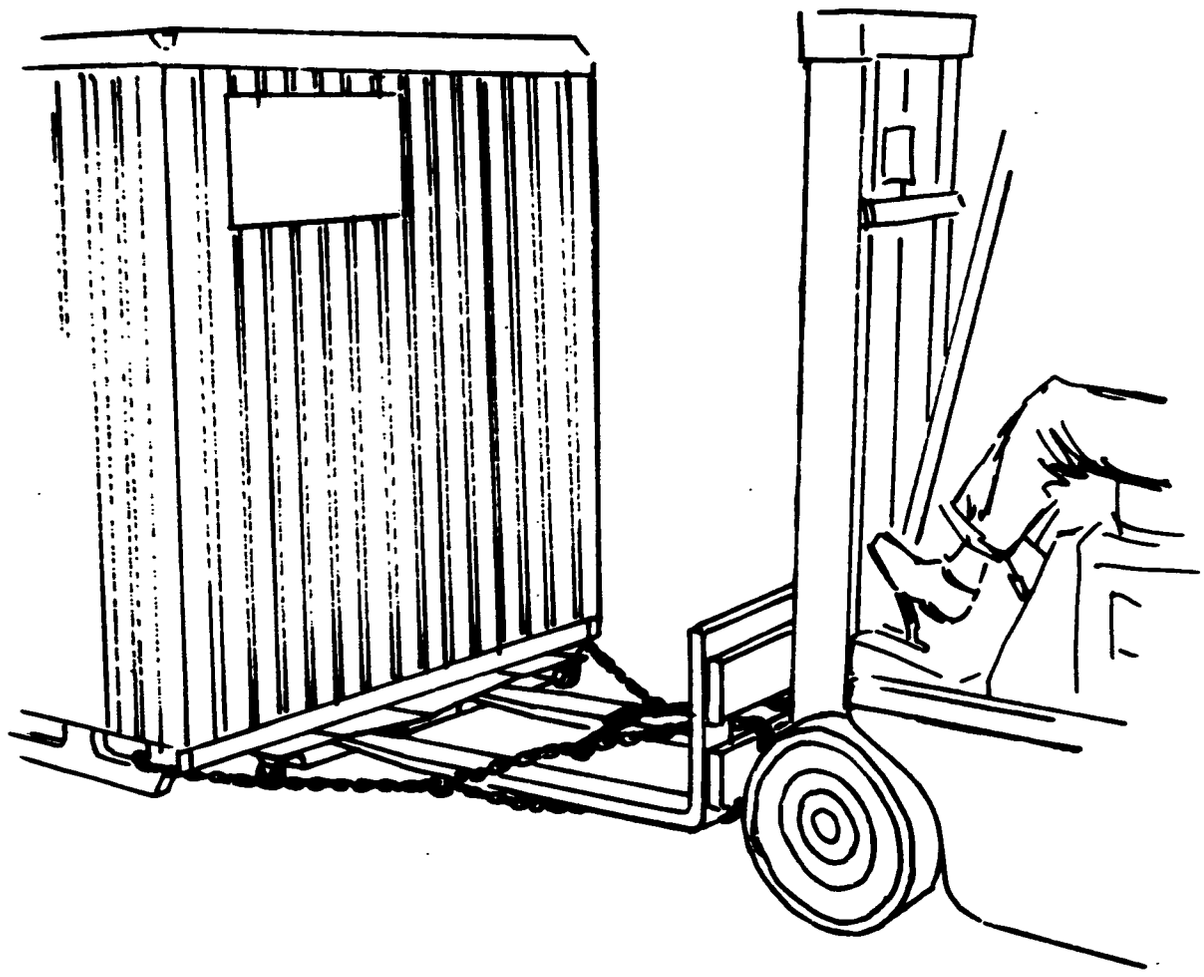

FIGURE 7: LIFT TRUCK SECURED TO FORWARD END OF GEM JACK

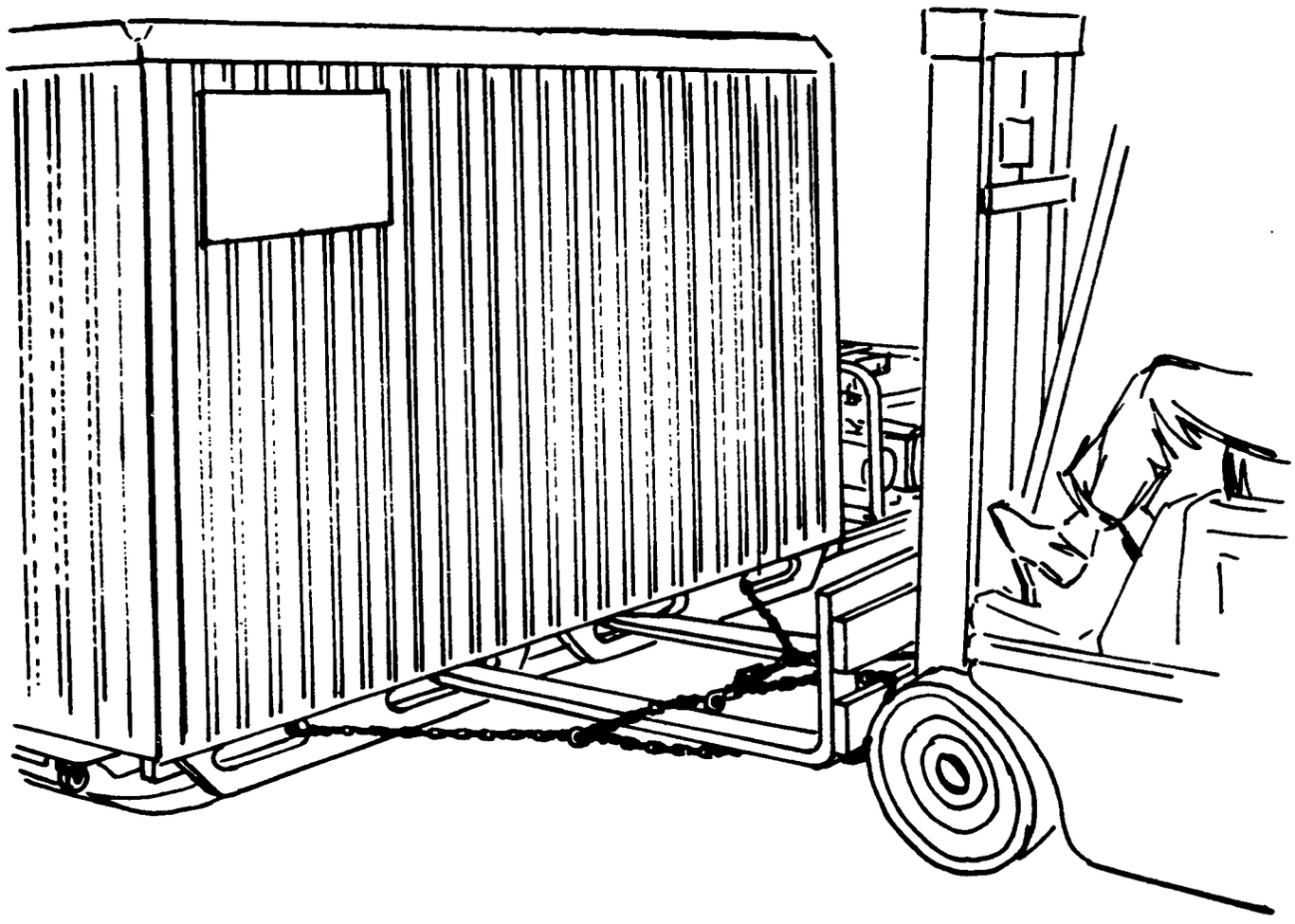

FIGURE 8: LIFT TRUCK SECURED TO SIDE OF GEM JACK

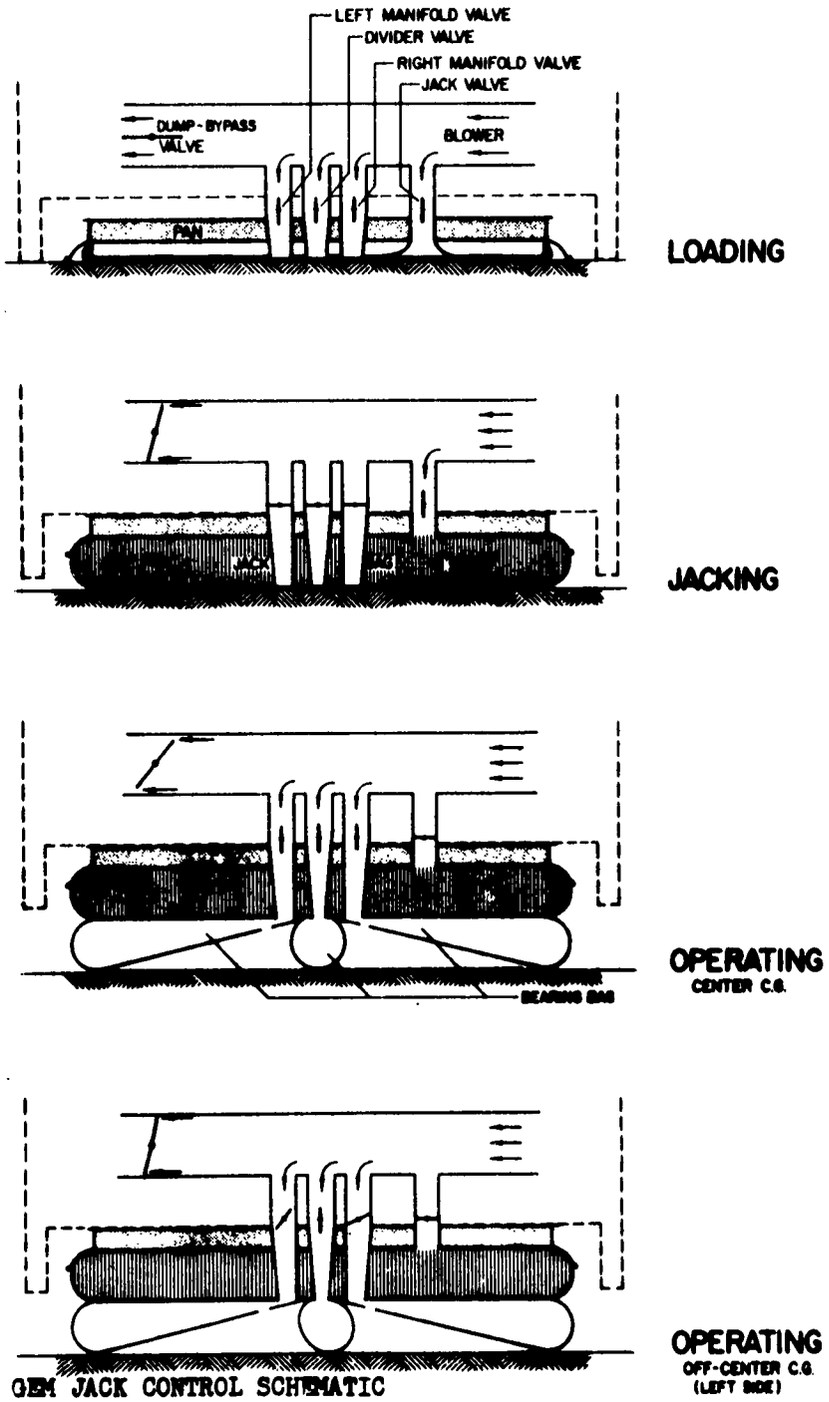

FIGURE 9: GEM JACK CONTROL SCHEMATIC

APPENDIX

GEM JACK DRAWINGS

DRAWING NUMBER	DRAWING TITLE
15062-001	GEM Cargo Handling Jack
15062-002	Blower
15062-003	Motor
15062-004	Manifold Ass'y
15062-005	Manifold
15062-006	Body, Valve, Butterfly
15062-007	Body, Valve, Divider
15062-008	Flange
15062-009	Plate, End Jack Valve
15062-010	Flange, Blower Outlet
15062-011	Boss-Coupling
15062-012	Flange, Jack Valve
15062-013	Doubler, Coupling
15062-014	Bracket, Control Rod, Manifold
15062-015	Skin, Upper
15062-016	Skin, Lower
15062-017	Core, H'Comb
15062-018	Block, Closure
15062-019	Bracket
15062-020	Brace
15062-021	Plate
15062-022	Stiffener
15062-023	Conex Bumper
15062-024	Closure
15062-025	Brace
15062-026	Closure, Ass'y
15062-027	Tab Keeper
15062-028	Closure
15062-029	Skin
15062-030	Block
15062-031	Core, H'Comb
15062-032	Closure Ass'y
15062-033	Aft Support Ass'y
15062-034	Pan Ass'y
15062-035	Bracket, Control Rod, Jack Valve
15062-036	Guard Rail
15062-037	Valve, Bypass Pump
15062-038	Valve, Jack

APPENDIX

GEM JACK DRAWINGS Continued

DRAWING NUMBER	DRAWING TITLE
15062-039	Duct, Jack Valve
15062-040	Bracket, Mounting
15062-041	Blade Ass'y
15062-042	Shaft, Valve
15062-043	Lever, Butterfly
15062-044	Blade, Bypass
15062-045	Boss, Butterfly
15062-046	Transition, Flared
15062-047	Bearing, Plane
15062-048	Bearing, Seal
15062-049	Brace, Guard Rail
15062-050	Panel Ass'y, Timer
15062-051	Jack Bag
15062-052	Bearing Bag
15062-053	Keeper Rod
15062-054	Shims
15062-055	Shaft Guard
15062-056	Pressure Line
15062-057	Switch, Start-Stop
15062-058	Bracket, Bypass Valve
15062-059	Support, Motor Mount
15062-060	Block, Blower Mount
15062-061	Caster, Swivel
15062-062	Caster, Rigid
15062-063	Panel, Control
15062-064	Duct, Jack Bag
15062-065	Motor
15062-066	Coupling, Fabric
15062-067	Timer
15062-068	Electrical Schematic
15062-069	Screen Intake
15062-070	GEM Cargo Jack Arrangement
15062-071	Valve, Jack
15062-072	Switch, Start-Stop
15062-073	Control, Push-Pull, 42 inch
15062-074	Control, Push-Pull, 82 inch
15062-075	Control, Push-Pull, Lockhead
15062-076	Gage, Pressure
15062-077	Body, Manifold
15062-078	Valve, Pressure Relief
15062-079	Panel, Junction Box

APPENDIX

GEM JACK DRAWINGS-Continued

DRAWING NUMBER	DRAWING TITLE
15062-080	Receptacle
15062-081	Junction Box
15062-082	Caster, Swivel

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U. S. Strike Command	1
U. S. Army Mobility Command	3
U. S. Army Materiel Command	6
Human Engineering Laboratory	1

Hiller Aircraft Co.,Division of ELTRA Corp., Palo Alto, Calif.,GEM JACK CONEX MOVER: Cost,Reliability, Operation,and Maintenance Considerations - M.F.Gates,L.A.Burdick,Jr., TREC Technical Rept 63-53,October 1963, 24 pp. (Contract DA 44-177-TC-752) USATRECOM Task 1D021701A04815

Unclassified Report

This report discusses the anticipated production cost, expected reliabil-

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1. GEM
2. Cargo Handling
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