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NUCLEAR SAFETY EVALUATION FOR THE USAF MHU-83/E MUNITIONS HANDLING/LOADING LIFT TRUCK

Cameron W. Hyde, IV
Lt USAF

TECHNICAL REPORT NO. AFWL-TR-68-149

April 1969

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Air Force Systems Command
Kirtland Air Force Base
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Lieutenant USAF

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FOREWORD

This research was performed under Engineering Service Number 02280. There is no Program Element number for this document. Inclusive dates of research were 20 September 1968 through 4 December 1968. The report was submitted 5 January 1969 by the Air Force Weapons Laboratory Project Officer, Lt Cameron W. Hyde, IV (WLAS).

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This technical report has been reviewed and is approved.

CAMERON W. HYDE, IV
Lieutenant, USAF
Project Officer

JAMES P. HEBERT
Lt Colonel, USAF
Chief, Safety Branch

DANIEL L. SCHMUCKER
Colonel, USAF
Chief, Nuclear Safety and Weapons Division

ABSTRACT

(Distribution Limitation Statement No. 2)

The MHU-83/E Munitions Handling/Loading Lift Truck was evaluated against nuclear safety criteria. Results show that the MHU-83/E is well designed with respect to safety features and will adequately withstand intended loads.

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ILLUSTRATIONS

SECTION I

GENERAL

The MHU-83/E Lift Truck, Figure 1, is mounted on a low-slung, heavy-duty frame supported by six small high-capacity wheels. The vehicle has rear-wheel drive, powered by a gasoline engine mounted on the rear of the frame. The two rear wheels are steerable using a conventional steering wheel located in the mid-section of the power unit. The Lift Truck consists of five functional components: the engine, cantilever lifting boom, bomb cradle or manipulator head, hydraulic system, and mechanical traction component. All power is supplied by a 25-horsepower gasoline engine.

From the standpoint of nuclear safety it is important to consider four major functional components of the MHU-83/E Lift Truck. These components are hydraulic system, cantilever lifting boom, bomb cradle, and mechanical traction component.

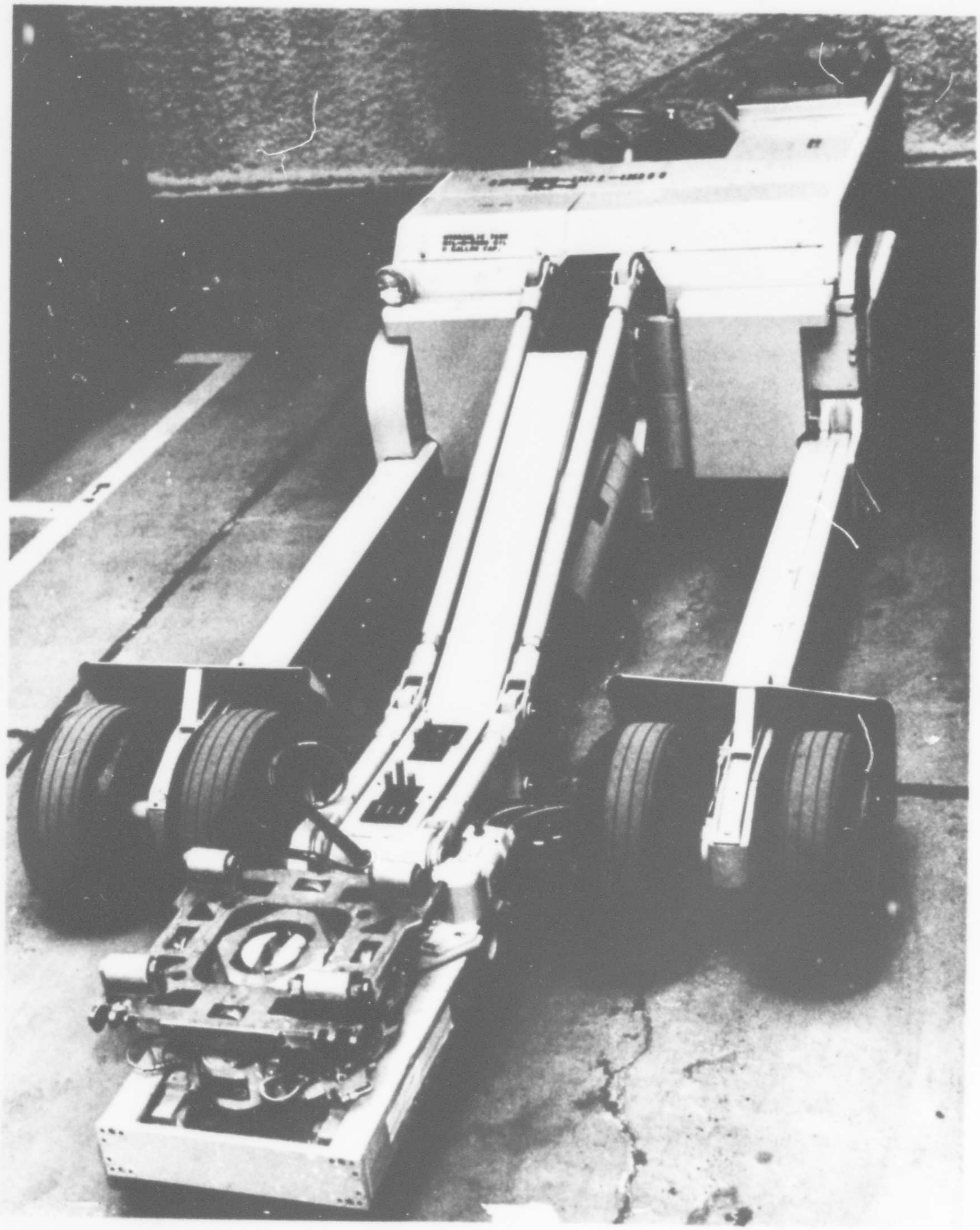

Figure 1. MHU-83/E Lift Truck

SECTION II

THE HYDRAULIC SYSTEM

1. GENERAL

a. The cradle movements, cantilever lift boom, power steering, power brakes, and side frame width adjustment are hydraulically operated. The principal components of the hydraulic system are the hydraulic fluid tank, gear-type pump, piston-type pump, control valves, cantilever lift cylinder, azimuth cylinder, accumulator, power steering unit, hand pump, cradle cylinders, unloader valve, counter-balance valves, relief valves, pressure reducing valves, side frame width adjustment cylinders, and the hydraulic lines. (Figures 2 and 3.)

b. Hydraulic controls for operating all parts of the lift truck are located at the driver's position, with the exception of the longitudinal positioning adjustment which is located on the boom to the rear of the bomb cradle. The left and right frame width controls are located at the driver's position. Duplicate hydraulic controls are provided for operating the bomb lift and azimuth, cradle tilt, roll, and yaw.

2. SAFETY ANALYSIS

a. Control valves used on the MHU-83/E are "dead man" spring center-type which return to the closed position when released, stopping all motion.

b. A hand pump which can be used to operate any part of the hydraulic system in the event of engine or pump failure is incorporated into the system.

c. Two relief valves are provided in the circuit to protect components from excessive hydraulic pressure. The relief valve in the main control valve is set at 1750 psi and protects the lift boom pump and lift cylinder from excessive pressure. Operating pressure for the cantilever lift boom system is 1000 psi and the maximum operating pressure for the relief valve is 4000 psi. The accumulator pump relief valve, located near the hydraulic tank on the left side of the unit, is set at 1800 psi and prevents an excess pressure buildup in the accumulator pump.

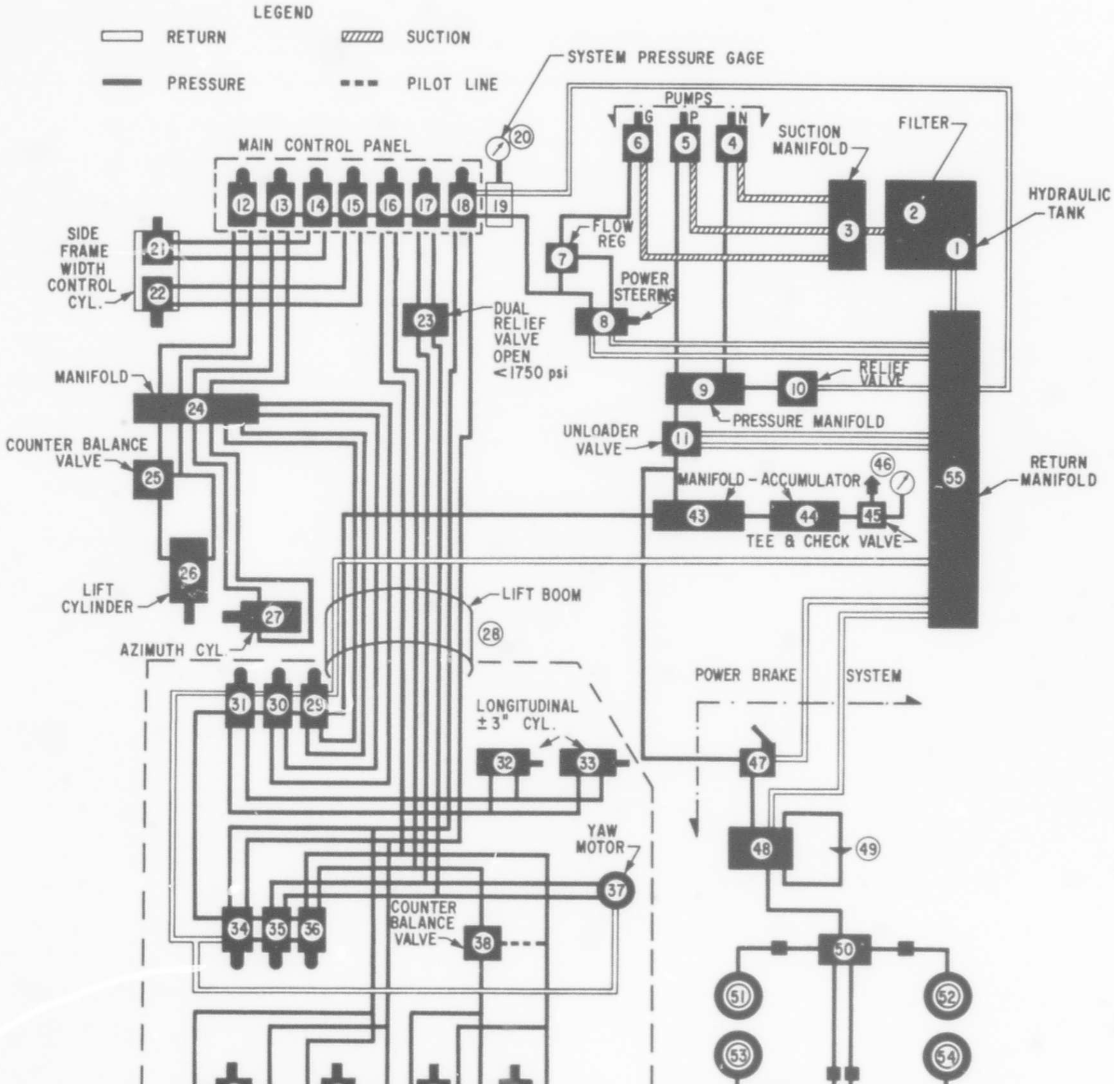

Figure 2. Hydraulic Diagram

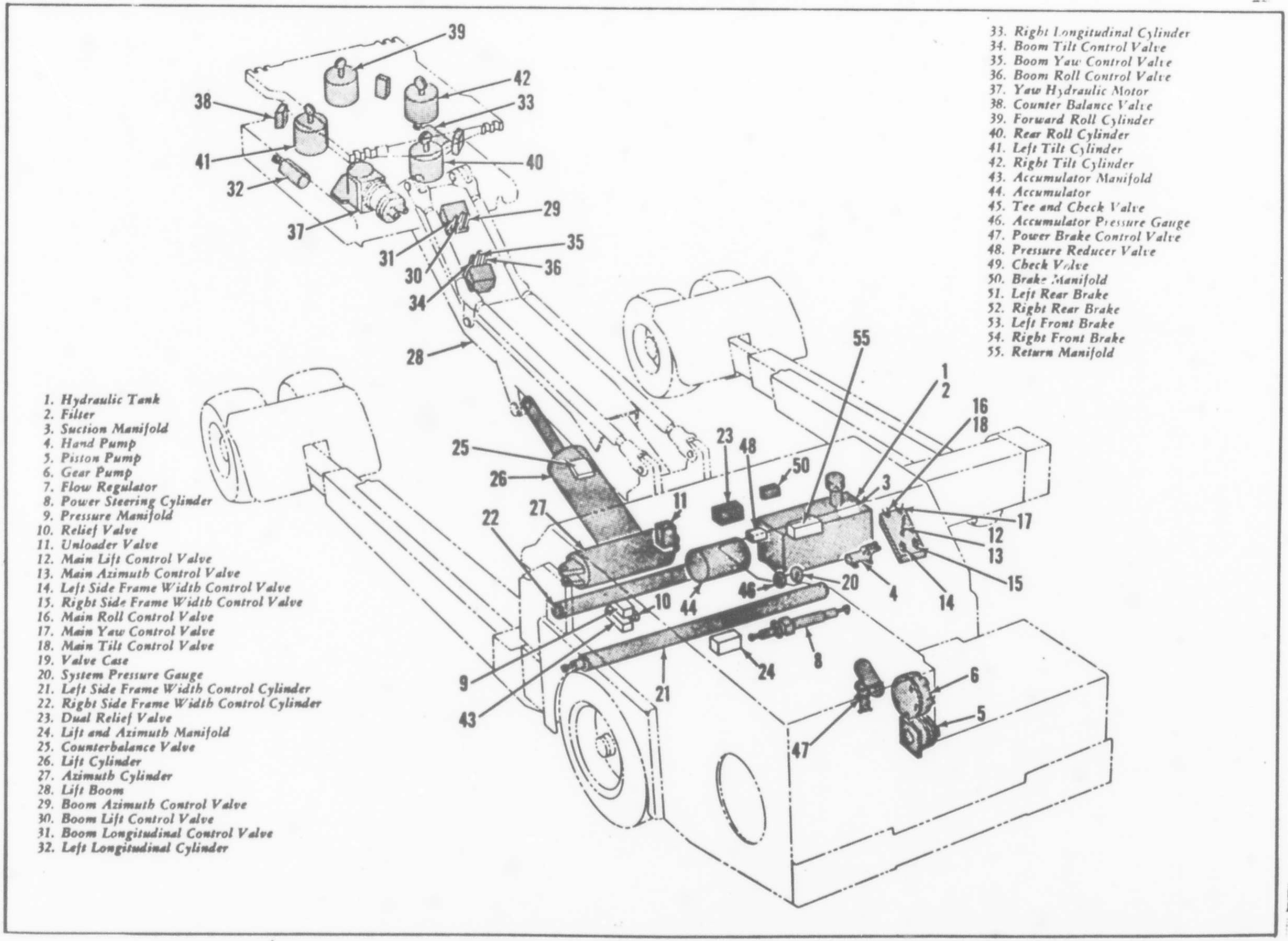

Figure 3. Hydraulic Components

d. Since the lift truck possesses only one lift cylinder and since failure of this cylinder would result in dropping the boom, the design of this lift cylinder is of great importance. This lift cylinder has a designed safety factor of 4 based on an operating pressure of 1500 psi. This means that the lift cylinder will withstand a pressure of almost 6000 psi before failure would occur. Because the operating pressure in the lift cylinder is 1300 psi with a 6000-pound load on the forks, a considerable margin of safety exists (TWX -- AFATL Eglin AFB, 5 Mar 68).

e. To ensure that the lift cylinder is operating correctly, a requirement will be included in the MHU-83/E T.O. which will require the MHU-83/E boom to be proof-loaded to 7000 pounds after any maintenance is done on the hydraulic system. (Telecon between Lt Griebe (WLDM) and Mr. Ambruster (AFATL), 23 Jan 68.)

f. A counterbalance valve in the cantilever lift cylinder circuit prevents collapse of the cantilever lift boom in the event of hydraulic failure or line breakage. This counterbalance valve is located on the top of the lift cylinder. The valve requires 250 psi to lower the load. If adequate pressure is not available, the load cannot be lowered, thus preventing collapse of the load because of any malfunction (see Figures 2 and 4). The counterbalance valve has a maximum design pressure of 3000 psi. Although there are no reliability data available for the counterbalance valve, it is believed that because of its simple design the reliability will be very high.

g. Except for 19 stainless steel braided teflon hoses used on the bomb cradle and brake line retractors, hydraulic hoses are single-wire braid assemblies designed in accordance with MIL-H-8794. All hydraulic hoses are designed to withstand an operating pressure of 3000 psi, or greater. The maximum operating pressure used in the system is 1500 psi, which is used in the Manipulator Head Motion System.

h. To prevent abrasion of the flexible hydraulic lines near the interface between the chassis and boom (Figure 5), rubber grommets are being added to the chassis metal edge and the sheet metal on the boom will be rounded to eliminate the sharp edges. (Information provided by AFATL (ATZC) to WLDM per telecon 15 Nov 67).

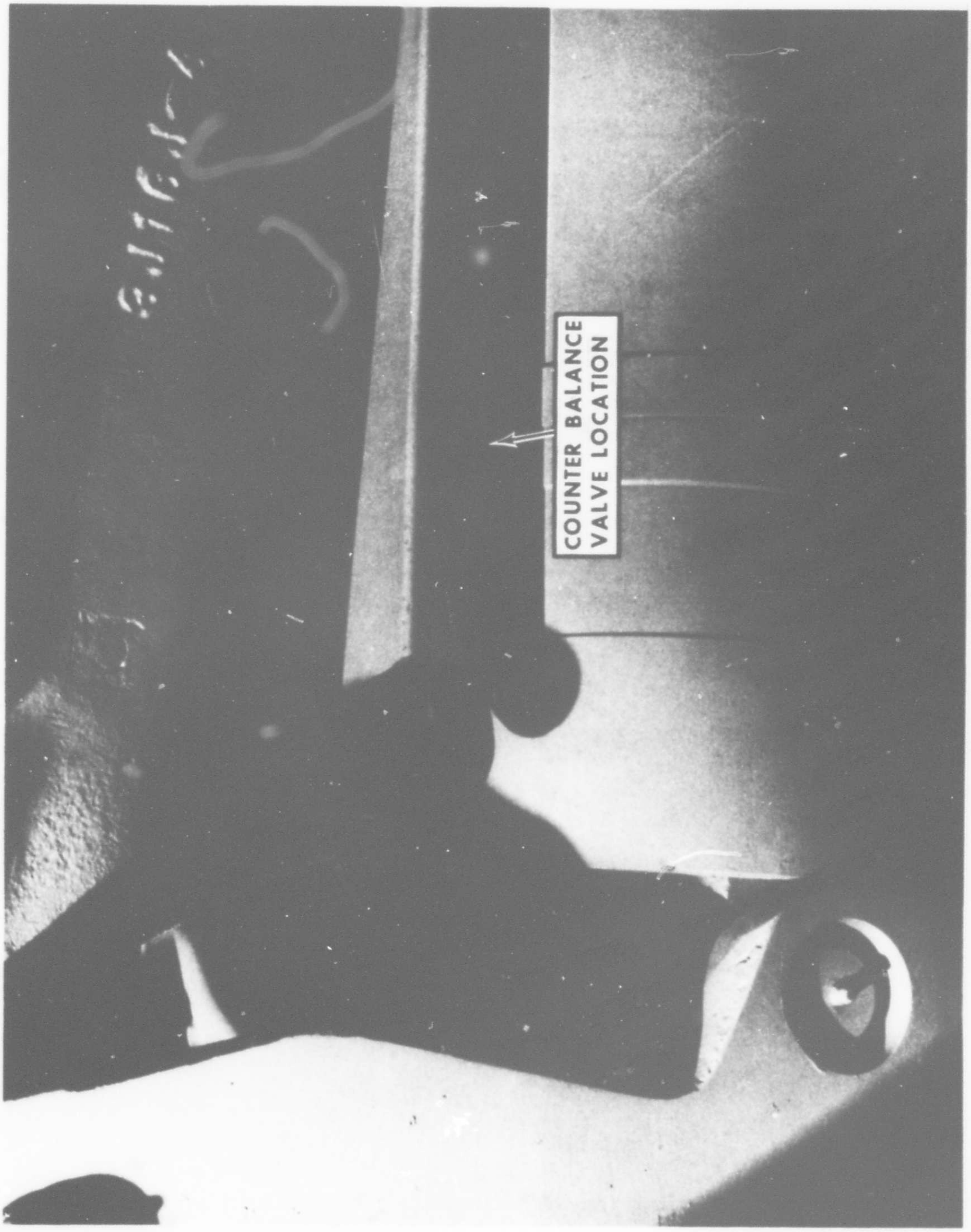

Figure 4. Counterbalance Valve Location on Lift Cylinder

Figure 5. Boom Chassis Interface

3. CONCLUSION

The hydraulic system of the MHU-83/E Bomb Lift Truck is satisfactory from the standpoint of nuclear safety.

SECTION III

CANTILEVER

1. GENERAL

a. The lift boom raises and lowers the weapon to the desired height. Lifting action is accomplished by hydraulic pressure within the piston-type lift cylinder which forces the lift boom upward. The cradle can be lowered to a point where the bottom of the bomb is at a minimum of 12 inches above the ground or raised to maximum height, at which the bottom of the bomb is 96 1/2 inches above the ground. The lifting boom may also be used to lift the front wheels off the ground for side width adjustment of the outriggers.

b. The lift boom is manually controlled at either of two positions. A three-position, spring-centered, spool-type control valve located on the control panel in front of the operator is used for the major operations of the lifting cycle. A similar control valve (Figure 2, item 30), located on the forward end of the boom, more precisely controls the lifting action so that an observer may make an exact positioning adjustment to align the weapon with the rack.

c. The tubular cast steel lift boom supports the bomb cradle. The lift boom is connected at the rear of the boom support. Two parallel rods are connected to the boom support at the rear and the bomb cradle is connected at the front (Figures 6 and 7). These rods maintain the bomb in the level plane at all times during the lift cycle. The lift boom is designed with a safety factor to minimize deflection of the lifting system.

d. The lift boom is supported by high-strength bronze bearings throughout. The frame of the lift boom and lift linkage absorbs the majority of the lifting stresses within its own structure. Pressure-type lubrication fittings are located on the lift boom and linkage at each of the bearing areas.

2. SAFETY ANALYSIS

a. Static overload tests conducted on the MHU-83/E Lift Truck were 200 percent of the maximum rated load. The tested overload was based on a rated load of 7000 pounds for the cradle and a rated load of 6000 pounds for the fork

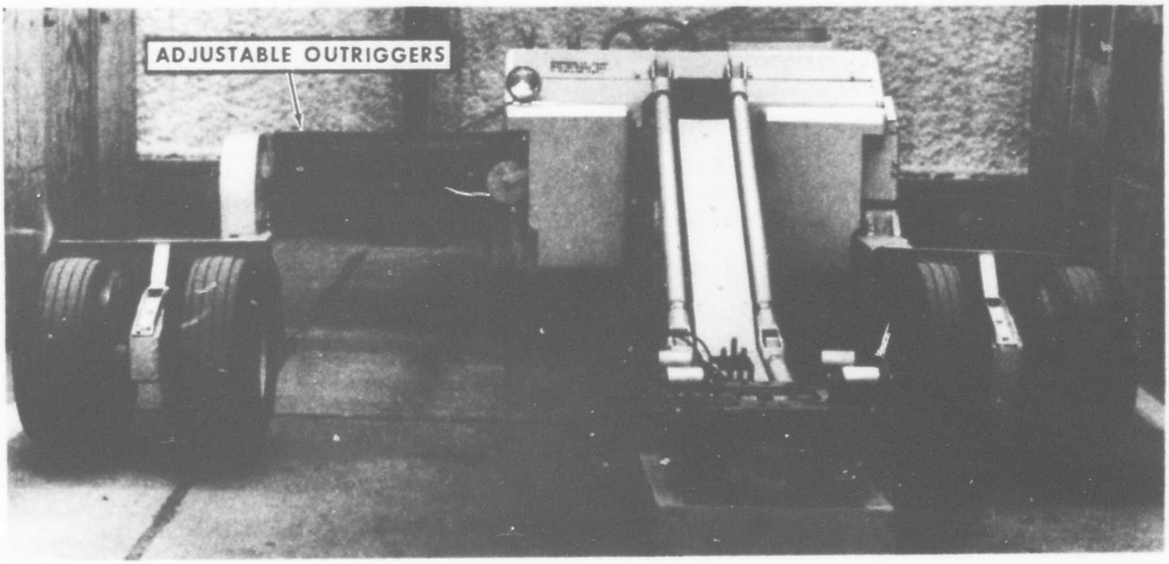

Figure 6. MHU-83/E Lift Truck Showing Outriggers

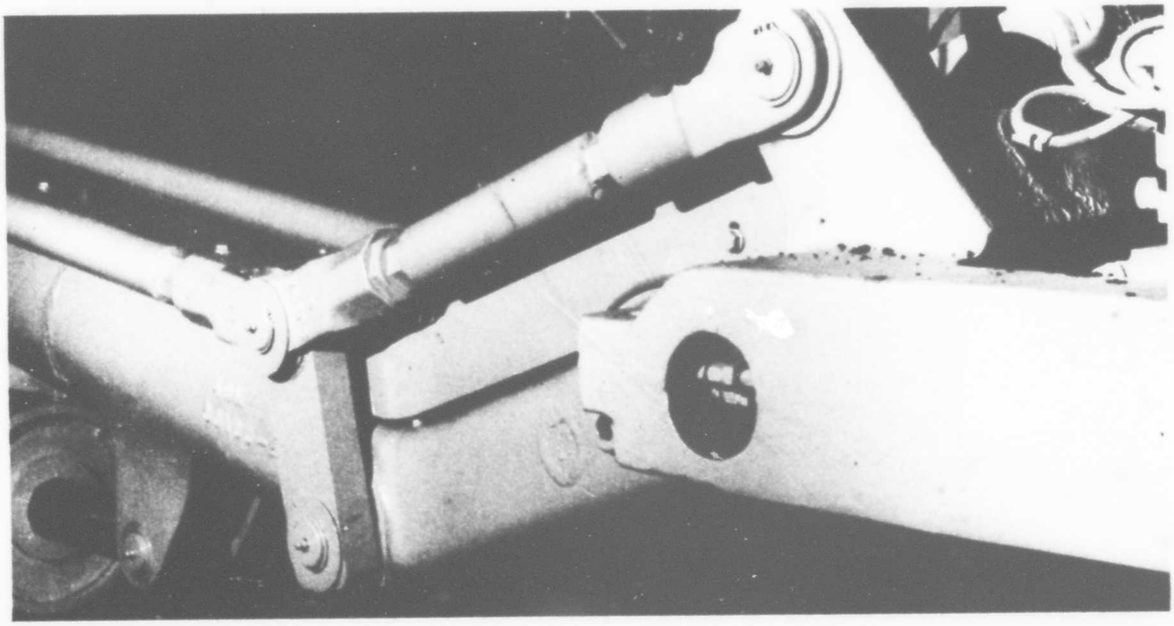

Figure 7. Boom Assembly

lift adaptor. After testing it was concluded that the MHU-83/E Lift Truck can be expected to statically withstand two times the full rated load without degradation or structural failure (Technical Report No. AFSWC-TR-67-13).

b. The duplicate control valve located at the forward end of the boom offers more precise control during weapon loading.

3. CONCLUSION

The cantilever lift boom of the MHU-83/E Bomb Lift Truck is satisfactory from the standpoint of nuclear safety.

SECTION IV

THE BOMB CRADLE

1. GENERAL

a. The bomb cradle assembly is located at the front of the lifting boom. It holds the boom in a level position during the lifting action and is equipped with positioning adjustments. The cradle assembly consists of rollers, a table, a cylinder mount frame holding the tilt and roll cylinders, a center shaft, a yaw bearing, a roller mount frame, and a base frame. (Figures 8, 9, 10, 11.)

b. The base frame of the cradle is mounted to the boom by a large pin. Tension rods attached to the top and back of the base frame maintain a level attitude at all operating heights.

c. The roller mount frame has four large cam roller bearings attached which roll in a longitudinal plane within the base frame track. Hydraulic cylinders provide 12 inches of longitudinal movement and stops are provided to prevent the roller mount frame from rolling off the base frame track.

d. The center shaft is mounted to the roller mount frame through four large ball bearings. Yaw motion of 90 degrees is provided from a hydraulic motor through a large gear plus worm reduction.

e. The tilt and roll cylinders are mounted to the cylinder mount frame directly beneath the table. The cylinder mount frame is attached rigidly to the center shaft.

f. The table is mounted on the top of the cradle assembly by a universal coupling. The table is rectangular, 19 inches wide by 18 inches long, with various holes provided for bomb support rollers. Attached to the table by spherical, self-aligning bearings are four small cylinders with vertical piston rods. These cylinders provide 7 degrees roll and 5 degrees tilt (Figure 8).

g. The cradle assembly includes four rollers which can be used to support the weapon on the cradle.

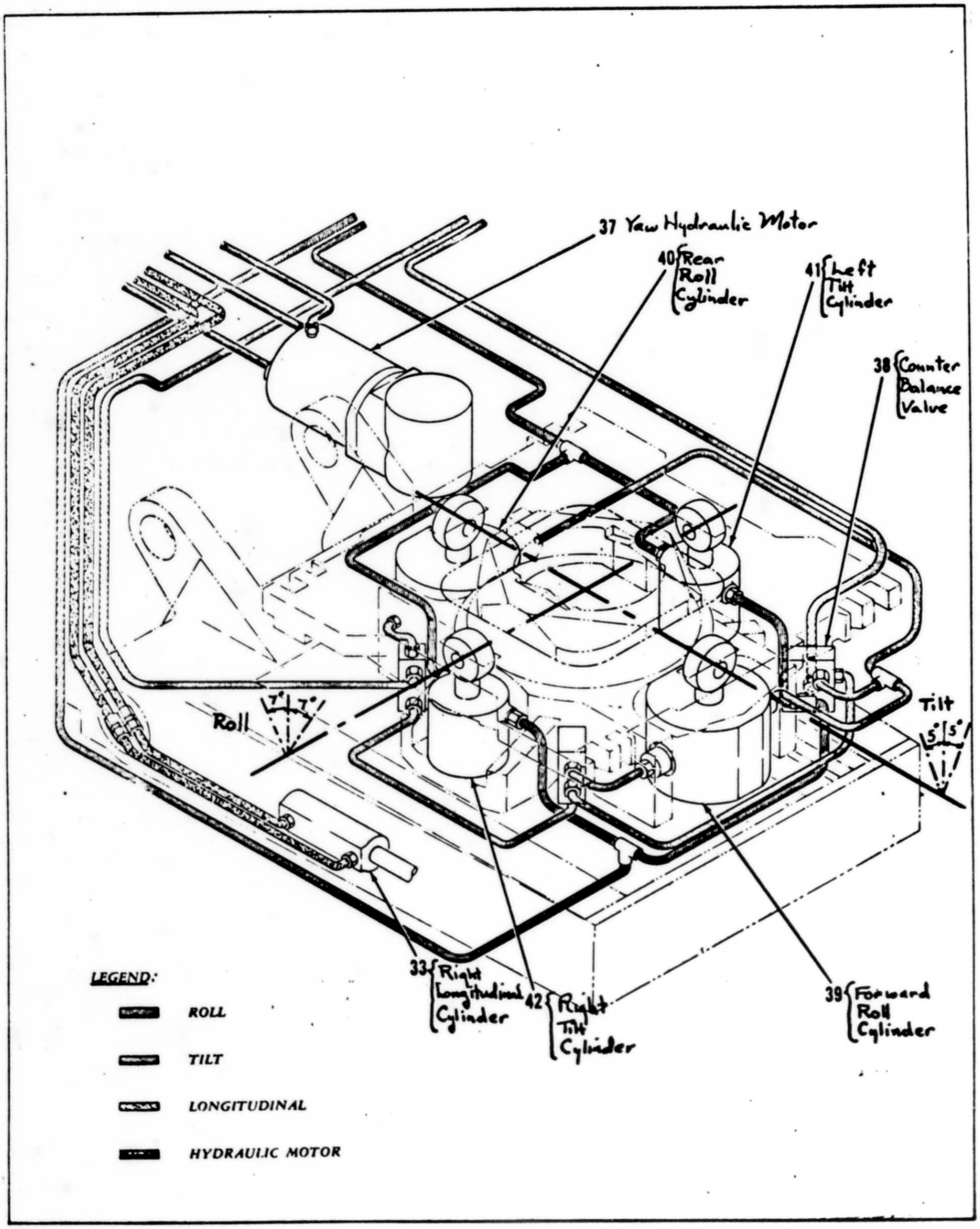

Figure 8. Cradle Hydraulic Components

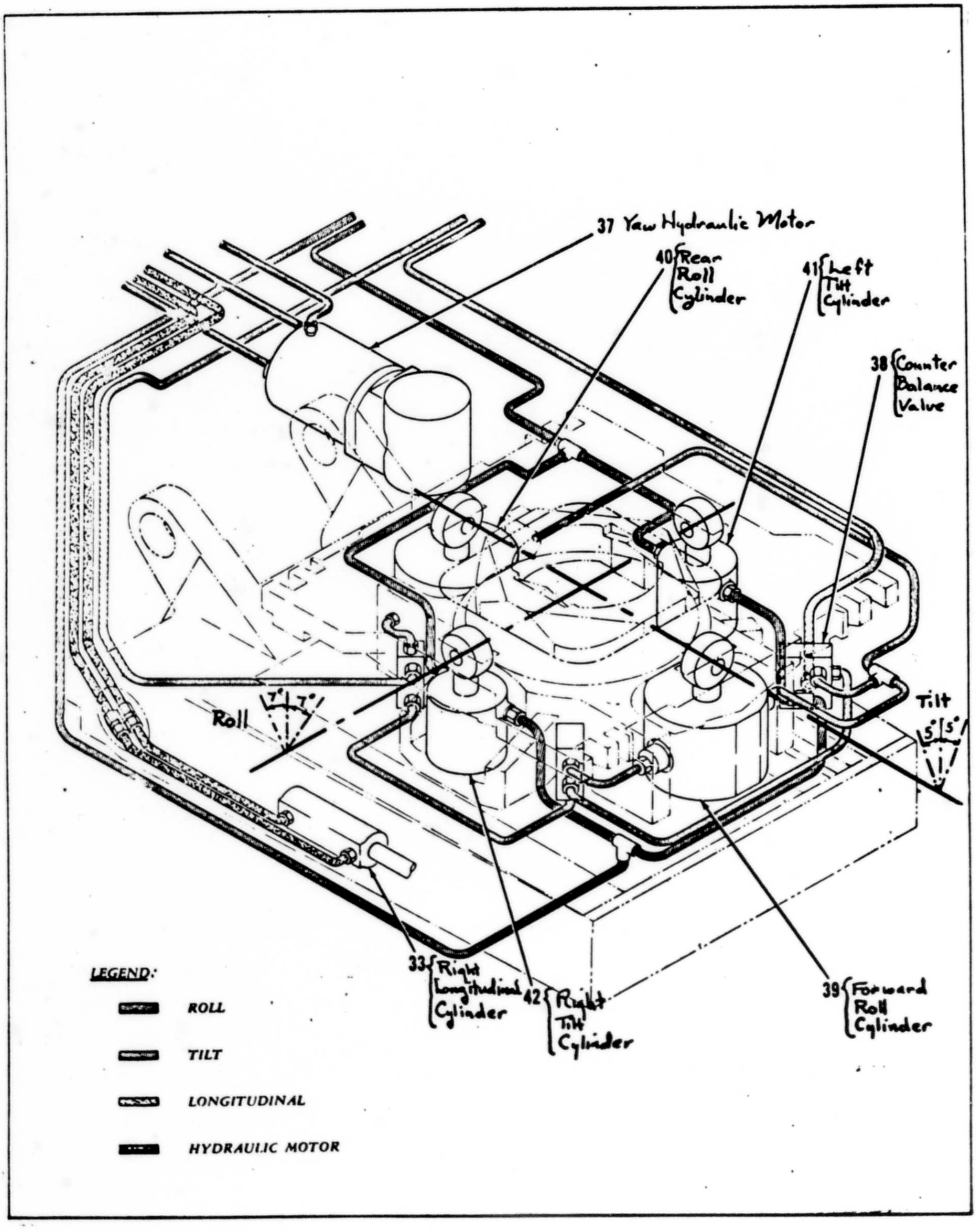

Figure 8. Cradle Hydraulic Components

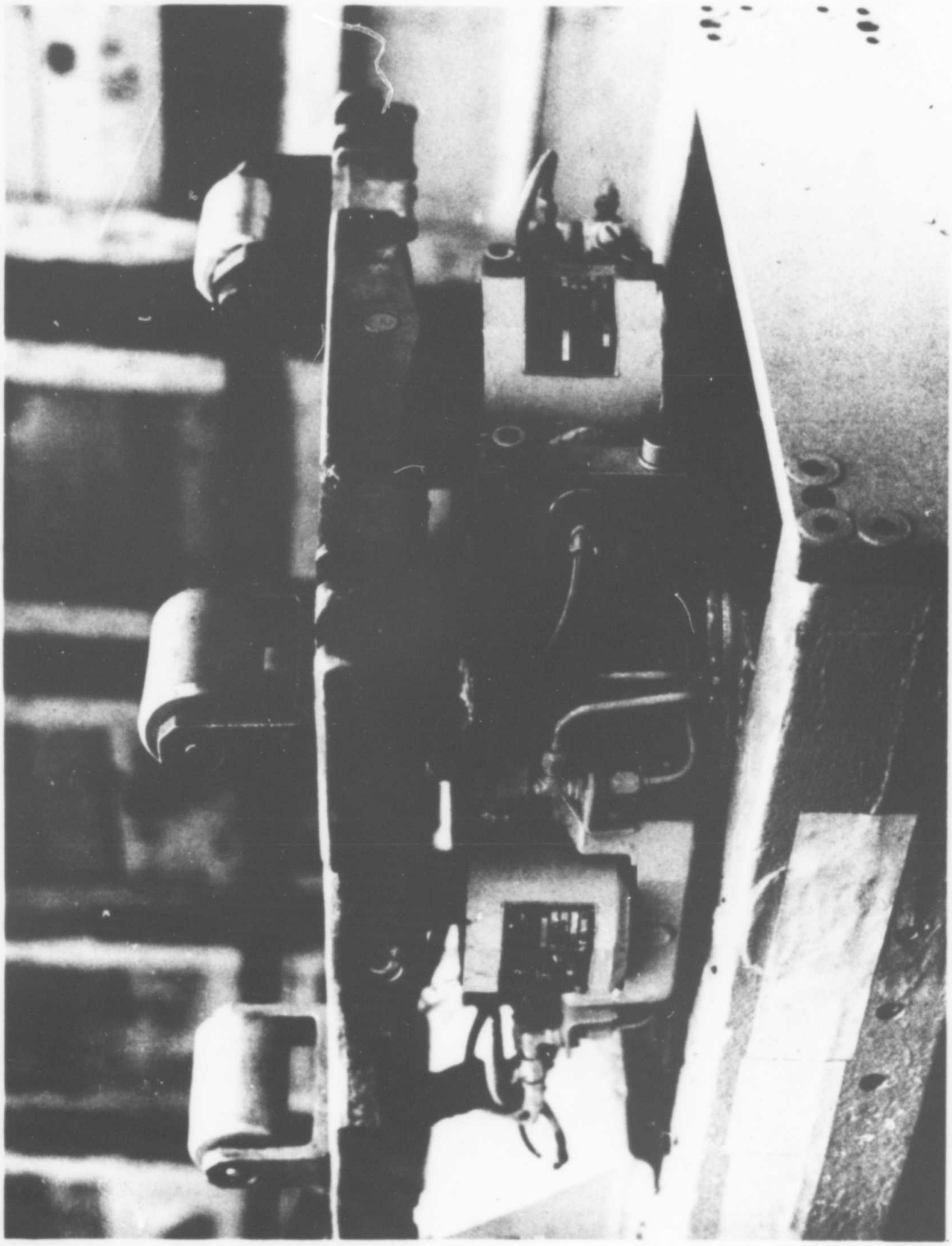

Figure 10. Bomb Cradle Arrangement

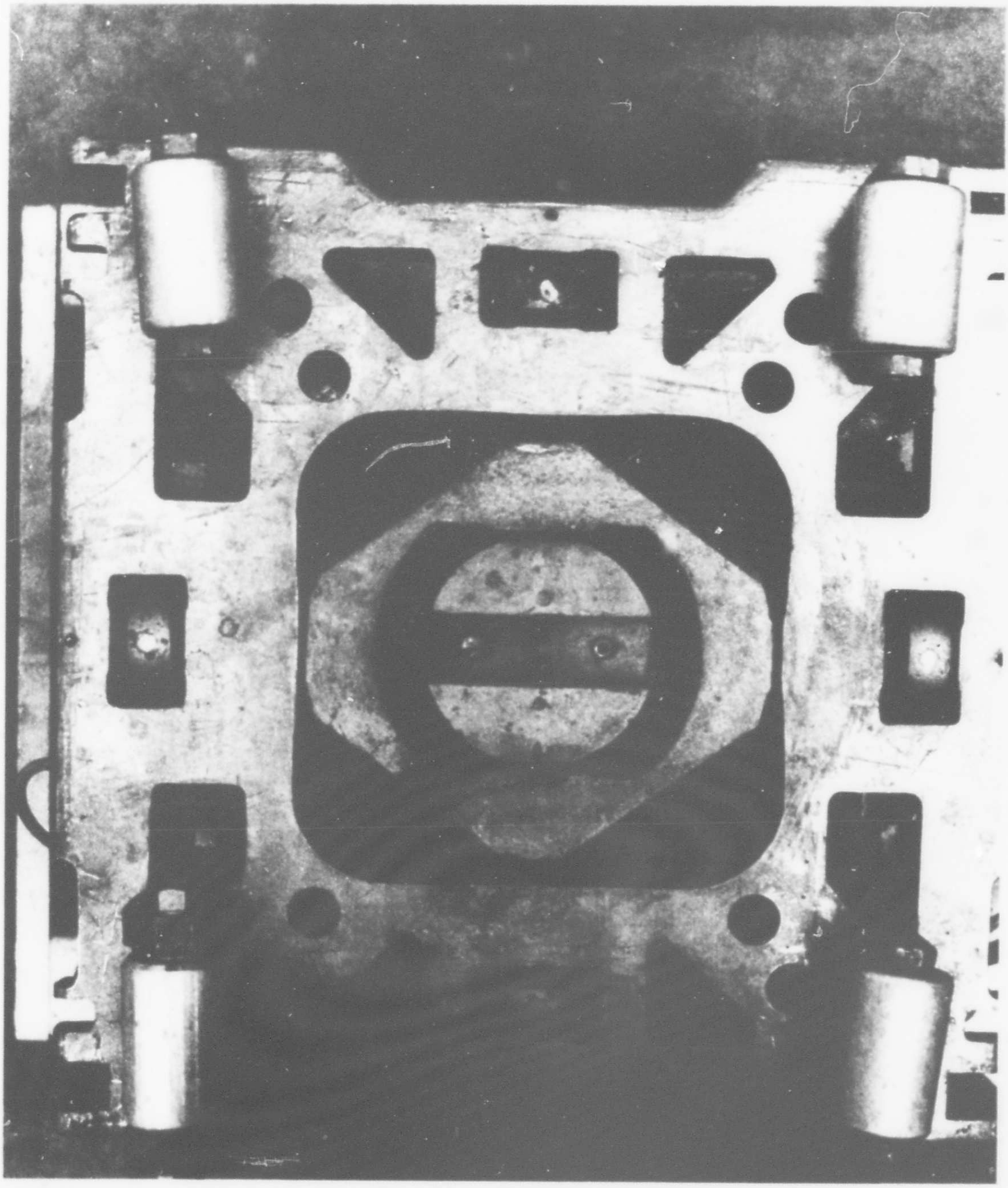

Figure 11. Bomb Cradle Arrangement

2. SAFETY ANALYSIS

a. There are provisions on the table for the attachment of a tie-down strap to secure the weapon on the lift truck.

b. Both the roll and tilt motions of the table are limited by the physical design of the cradle assembly so that failure of the roll or tilt cylinders would not drop the weapon.

c. The table yaw hydraulic system has a relief valve so that the table and hydraulic system will be protected from damage if the table is inadvertently moved past its farthest position in the yaw plane and the control valve is not shut off.

3. CONCLUSION

The bomb cradle of the MHU-83/E Bomb Lift Truck is satisfactory from the standpoint of nuclear safety.

SECTION V

MECHANICAL TRACTION COMPONENTS

1. GENERAL

a. The lift truck is equipped with an automotive-type clutch, transmission, and differential. Power to drive the wheels is delivered to the clutch from the engine crankshaft through a gear train enclosed in the main gear box. The clutch and transmission then transmit this power to the differential through a gear reducer, angle drive, and drive shaft. Both drive and steering are accomplished at the rear wheels.

b. Traction power from the angle gear box is transferred through the drive shaft to a modified automotive limited-slip differential and rear axle assembly.

c. The brakes are hydraulic, aircraft, expander-tube-type, and are operated by the foot brake valve. The lift truck is also equipped with a parking brake.

d. The lift truck is equipped with hydraulically actuated individual front wheel outriggers (Figure 6). Individually controlled outriggers permit the front wheel track to be altered on either or both sides while the vehicle is stopped or in motion, permitting instantaneous adjustment for wide track stability or narrow track for easy air transport. The outriggers may also be extended to increase the wheel base of the vehicle when carrying extremely heavy loads.

e. The vehicle is equipped with high flotation tires for soft soil conditions.

2. SAFETY ANALYSIS

a. The power steering valve and cylinder assembly is located below the steering column (Figures 2 and 3). It is a standard automotive-type power steering cylinder, is rated at 1500 psi, and has an internal relief valve. In the event of hydraulic failure, it is possible to mechanically steer the lift truck.

b. The power brake valve is located on the floorboard of the unit between the clutch and accelerator pedals at the operator's position (Figures 2 and 3). This valve is a three-way, two-position, normally closed, spring-return, pressure-compensated valve. The valve is designed to provide the same pedal feel as a standard hydraulic automotive brake pedal. The pressure to this valve is supplied directly from the accumulator so that in the event of hydraulic pump pressure failure, adequate pressure is available to the brakes for a minimum of ten stops.

3. CONCLUSION

The mechanical traction components of the MHU-83/E Bomb Lift Truck are satisfactory from the standpoint of nuclear safety.

SECTION VI

ADDITIONAL ITEMS

1. GENERAL

a. Lifting forks may be installed at the front of the bomb table. Each fork is attached to the fork adapter by a quick release pin by which the forks may be removed easily for width and positioning adjustment (Figures 12 and 13). The three positions of the forks are (1) fork tines forward below the fork adapter, (2) fork tines forward above the fork adapter, (3) fork tines rear above the fork adapter. The fork adapter with short bar provides fork centerline spacing of 24 and 28 inches. The fork adapter with long bar provides centerline spacing of up to 78 inches, in 2-inch increments. The fork tines are 2 1/4 inches thick and 4 inches wide at the heel of the fork. Eleven holes are located in each fork for location of the weapon support rollers in different positions for handling weapons of various diameter (Figures 12 and 13).

b. The bomb stand (not supplied with the unit) may be used to support the bomb prior to lifting (Figure 14).

2. SAFETY ANALYSIS

a. Static overload tests were conducted on the lift truck with the fork lift adapter installed. The adapter withstood twice the full rated load without degradation or structural failure. (Technical Report No. AFSWC-TR-67-13.)

b. The bomb stand presently being used is not of adequate size. As shown in Figures 14, 15, and 16 there is very little room for the manipulator head to move under the weapon and through the stand. This is far from an ideal condition and the stand should be modified. With the stand as currently designed it would not be hard to strike the weapon with the bomb cradle, or the stand itself, and knock the weapon off.

3. CONCLUSIONS

a. The lifting forks are adequate from the standpoint of nuclear safety.

b. The present bomb stand (Federal Stock No. 1730-624-1132) is not of sufficient height and width to be safely used in weapon loading with the MHU-83/E Bomb Lift Truck. A new stand should be designed for this purpose.

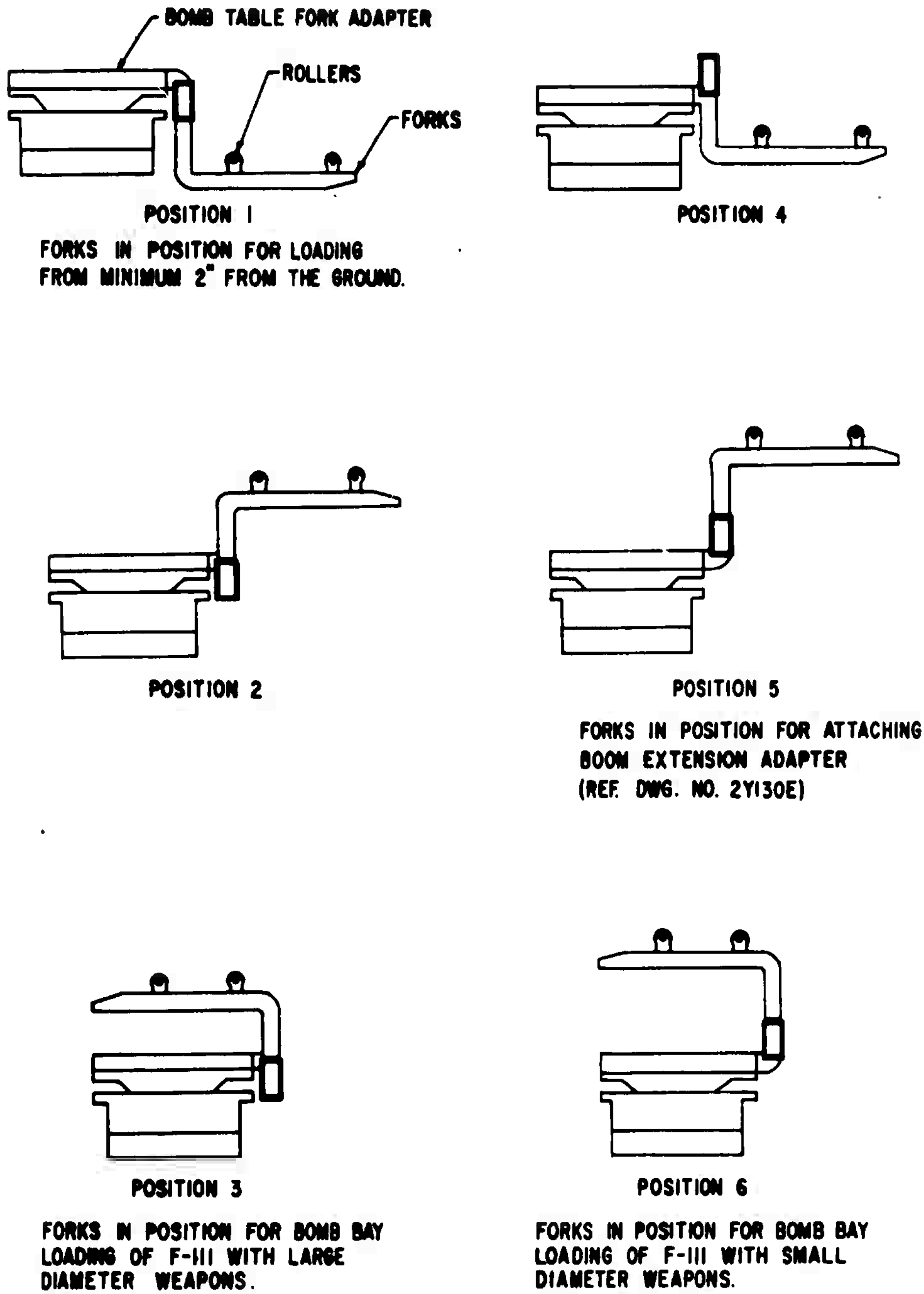

Figure 12. Adjustable Forks for MHU-83/E

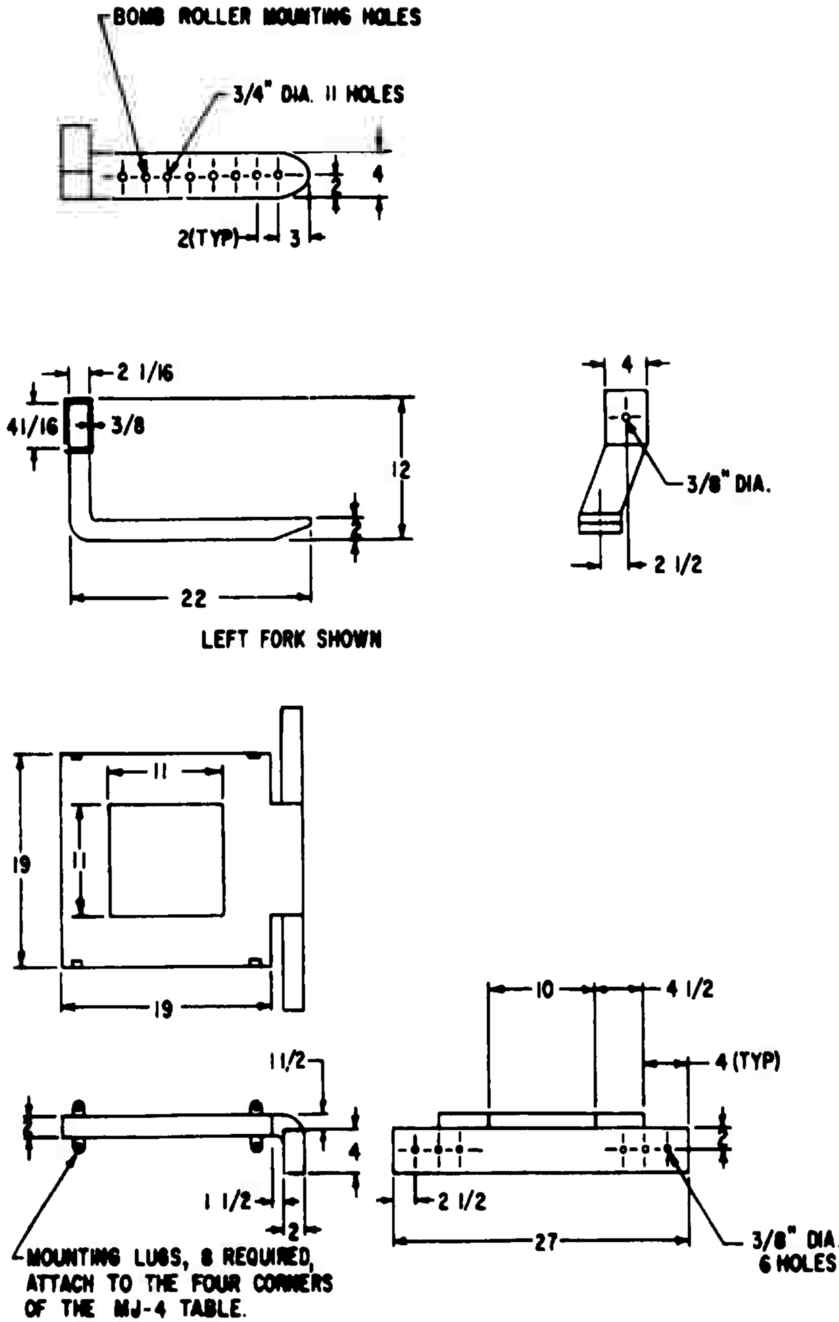

Figure 13. Bomb Table Fork Adapter

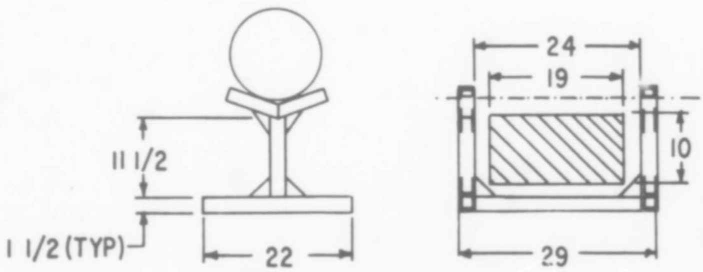

Figure 14. Bomb Stand

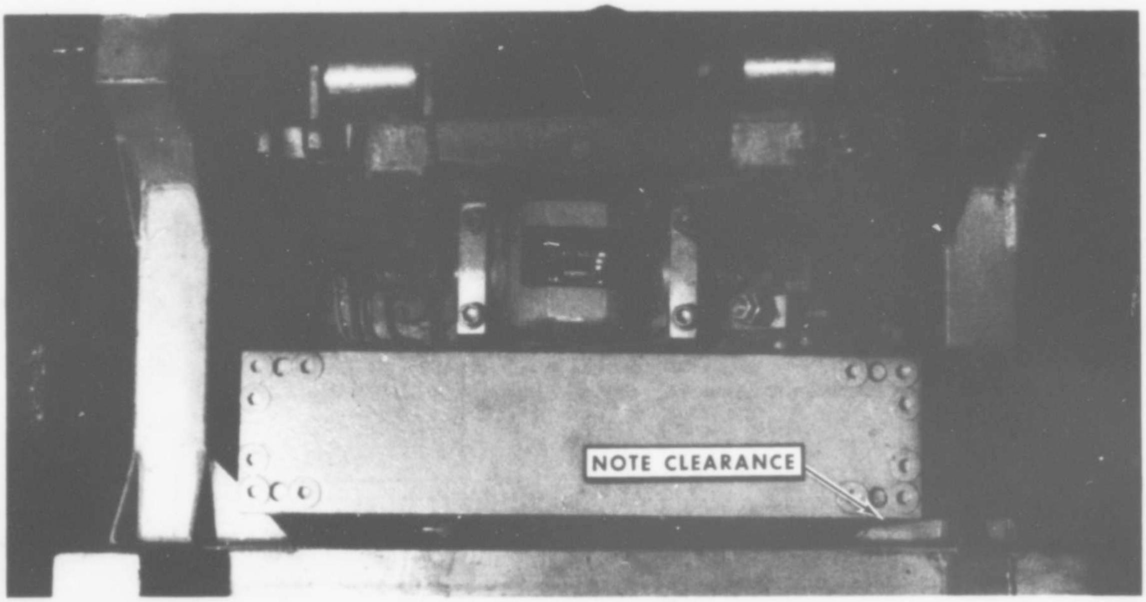

Figure 15. Bomb Stand and Bomb Cradle

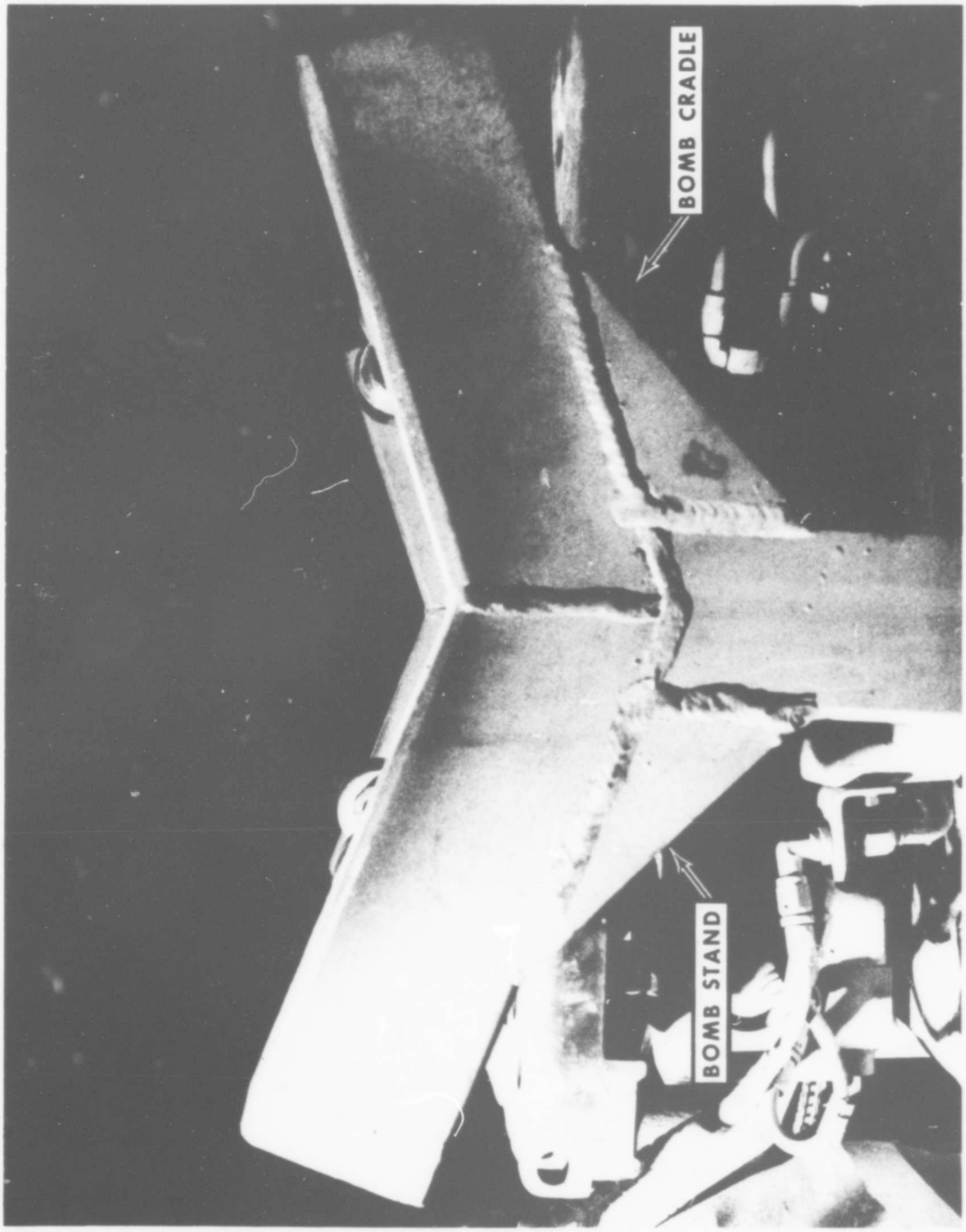

Figure 16. Bomb Stand and Bomb Cradle (Side View)

SECTION VII

CONCLUSIONS AND RECOMMENDATION

1. The MHU-83/E Munitions Handling/Loading Lift Truck is well designed with respect to safety features and will adequately withstand intended loads.

2. The Bomb Stand (Federal Stock No. 1730-624-1132), although not supplied with the unit, is presently used for weapon loading. The clearance between the bomb cradle and the stand is considered to be marginal and the stand should not be used with the MHU-83/E.

3. A system for numbering the roller holes on the bomb cradle and forks should be added to facilitate loading and ensure proper roller placement.

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11. SUPPLEMENTARY NOTES

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13. ABSTRACT
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The MHU-83/E Munitions Handling/Loading Lift Truck was evaluated against nuclear safety criteria. Results show that the MHU-83/E is well designed with respect to safety features and will adequately withstand intended loads.

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