


MORAY TV-1A HYDRAULIC MERCURY  
TRANSFER AND JETTISON SYSTEM 1-A


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## INTRODUCTION

Two of the basic requirements for MORAY TV-1A are a longitudinal trim capability and a means of providing emergency buoyancy. The translation of a high density mass, fore and aft, is the selected method for accomplishing vehicle trim. Mercury is the material which serves this function. A mercury jettison capability provides the means of gaining emergency buoyancy. Stability is improved by installing this system in the lowest possible position to increase the vehicle's meta-centric height.

## BACKGROUND

Since MORAY TV-1A is essentially the first of its kind, some of the static and dynamic performance characteristics are difficult to compute or predict. Therefore, a vehicle trim capability, at least for preliminary test phases, has been considered a primary requirement since the inception of the project. It was also highly desirable that the same system be capable of providing a large net buoyancy gain in an emergency condition.

The trim-ballast requirements imposed upon the system are as follows:

1. Provide static ballast which maintains the proper buoyancy level when used in conjunction with buoyant material.
2. Provide dynamic ballast which, when jettisoned, will create substantial positive buoyancy for the vehicle.
3. Provide static pitch trim capability by transferring mercury fore and aft.
4. Provide dynamic pitch trim, during underwater operations, by transferring mercury fore and aft.
5. Provide rapid forward pitch unbalance and rapid recovery, to aid in breaking surface during dives, by transferring mercury fore and aft.

An engineering study revealed that the most practical approach to the problem was to provide the operators with the ability to transfer a large mass of mercury either fore, aft or overboard.

A development program was conducted which resulted in the installation of a system into MORAY TV-1A which fulfills all of the trim-ballast requirements.

HYDRAULIC MERCURY TRANSFER AND JETTISON SYSTEM

1. The system is comprised of a jettisonable cylindrical mercury container forward, a spherical mercury container aft, mercury and oil, a hydraulic power package, a pressure equalizing device, a jettison valve network and the various interconnecting lines and valves, enclosure (1) and (2).

The basic features and principals of operation are as follows:

Each mercury container utilizes a rubber diaphragm to establish upper and lower variable volume portions, the diaphragms acting as transfer barriers.

The upper portions of the containers are interconnected and contain hydraulic oil. The lower portions are also interconnected and contain mercury, enclosure (3) and (4).

2. The actual transfer of mercury is accomplished by pumping hydraulic oil into the upper portion of one of the containers. The pressure of the oil transmits force to the upper surface of the mercury, thereby "pushing" the mercury out of the bottom port, through a line and line valve, enclosure (7) and (8), to the opposite container. The oil displaced in this opposite container is forced out of the top of the container, through a line, to the reservoir which feeds the pump. Thus, one direction of the closed loop cycle is completed.

3. The pumping action is provided by the "hydraulic power package." It consists of a housing reservoir, enclosure (9), a "wet" D. C. motor, a position displacement pump, a pressure relief valve with an indicating switch, and a four-way flow directing valve, enclosure (10).

4. The mercury jettison valve network includes two automatic (depth sensitive) valves and two operator controlled, electric motor driven ball valves. One of each are forward and the other aft. The redundancy in this area is considered desirable, enclosure (11), (12), (13) and (14).

5. The forward mercury container has a jettisonable capability. This is accomplished by an operator actuated pump and a release cylinder on the forward container, enclosure (16) and (17). The container's two arms, resting on a one inch diameter rod in the rear, provide the pivoting action at jettison, enclosure (5) and (6). The forward container, with its 560 pound capacity of mercury, also has the capability of carrying 4 ninty-five pound lead plates in the bottom cavity, enclosure (5).

Two quick disconnects allow the container to freely release from the hydraulic and mercury lines during jettison, enclosure (5).

The nose section of the vehicle was modified by fabrication of a swinging jettisonable door to allow the release of the forward container.

6. With the exception of the two electric jettison valves, the entire system is depth insensitive. This is accomplished by the inclusion of a spring loaded bellofram-piston unit referred to as the "fluid makeup device," enclosures (9) and (15). The electric jettison valves, which are individual pressure vessels, have been proof tested to 3000 psi external pressure. They could be oil filled and pressure equalized to remove all depth limitations from the system.

Enclosure (18) is a summary of information concerning the individual components in this system.

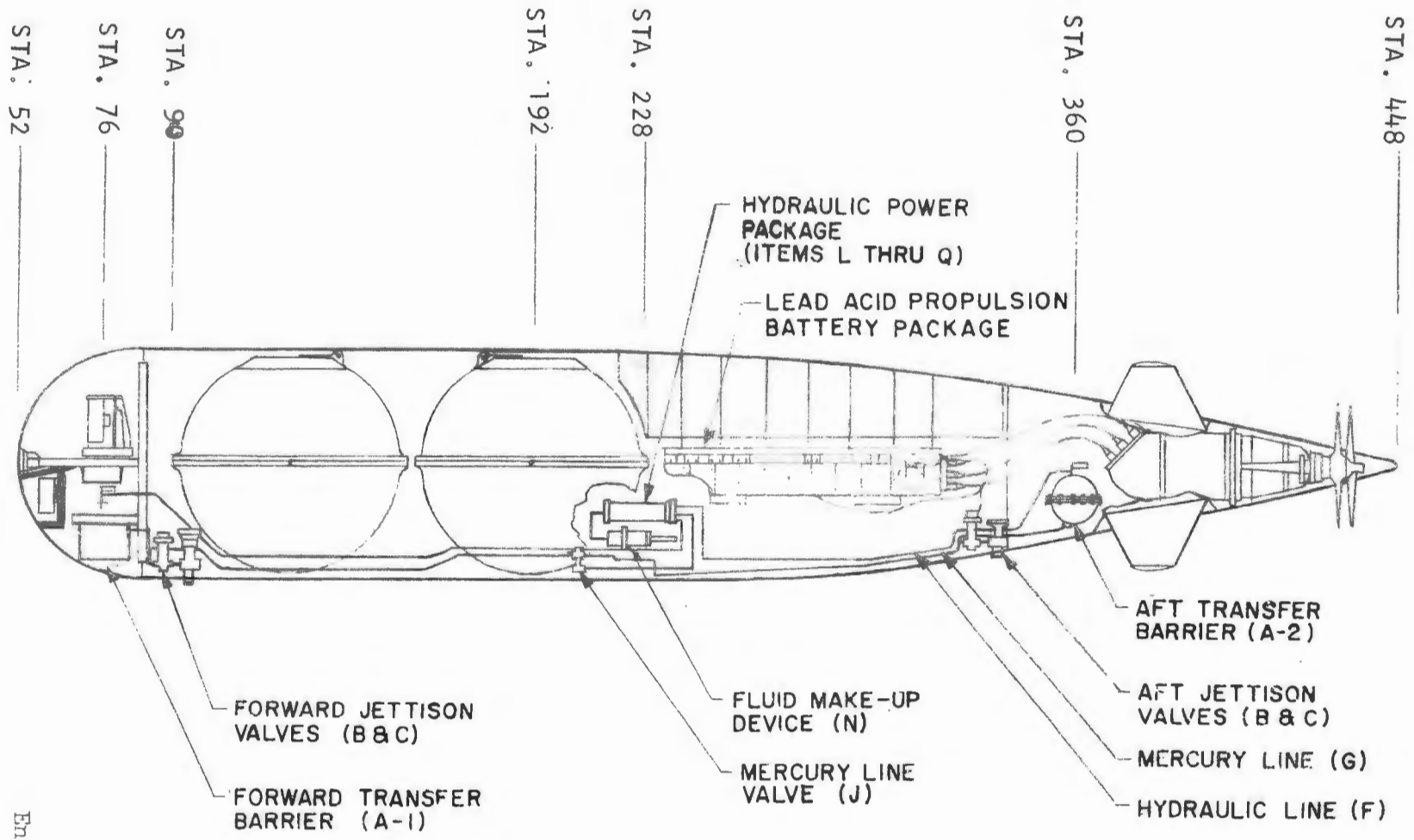
Measurements and tests conducted on this system have produced the following data:

- a. Weight of tank and jettisonable fittings . . . 79.5 Kg (175 lbs)
- b. Maximum weight of mercury in system . . . . . 254 Kg (560 lbs)
- c. Weight of transferable mercury . . . . . 227 Kg max (500 lbs)
- d. Maximum weight of lead plates . . . . . 172 Kg (380 lbs)
- e. Maximum buoyant force gain due to mercury container jettison (wgt-wgt of displaced water) . . . . . 462 Kg (1039 lbs)
- f. Flow rate . . . . .  $1.52 \times 10^{-2}$  meter<sup>3</sup>/min (4GPM)
- g. Weight change per unit time . . . . . 204 Kg/min (450 lbs/min)
- h. Vehicle attitude variations, surfaced . . .  $\pm .175$  rad ( $\pm 10^\circ$ )
- i. Operating pressure, max. internal differential . . . . .  $2068 \times 10^3$  newton/meter<sup>2</sup> (300 psi)
- j. Proof internal pressure . . . . .  $3447 \times 10^3$  newton/meter<sup>2</sup> (500 psi)
- k. External pressure limit . . . . .  $2068 \times 10^4$  newton/meter<sup>2</sup> (3000 psi) \*

\*Reference: Depth limitation, paragraph 6.

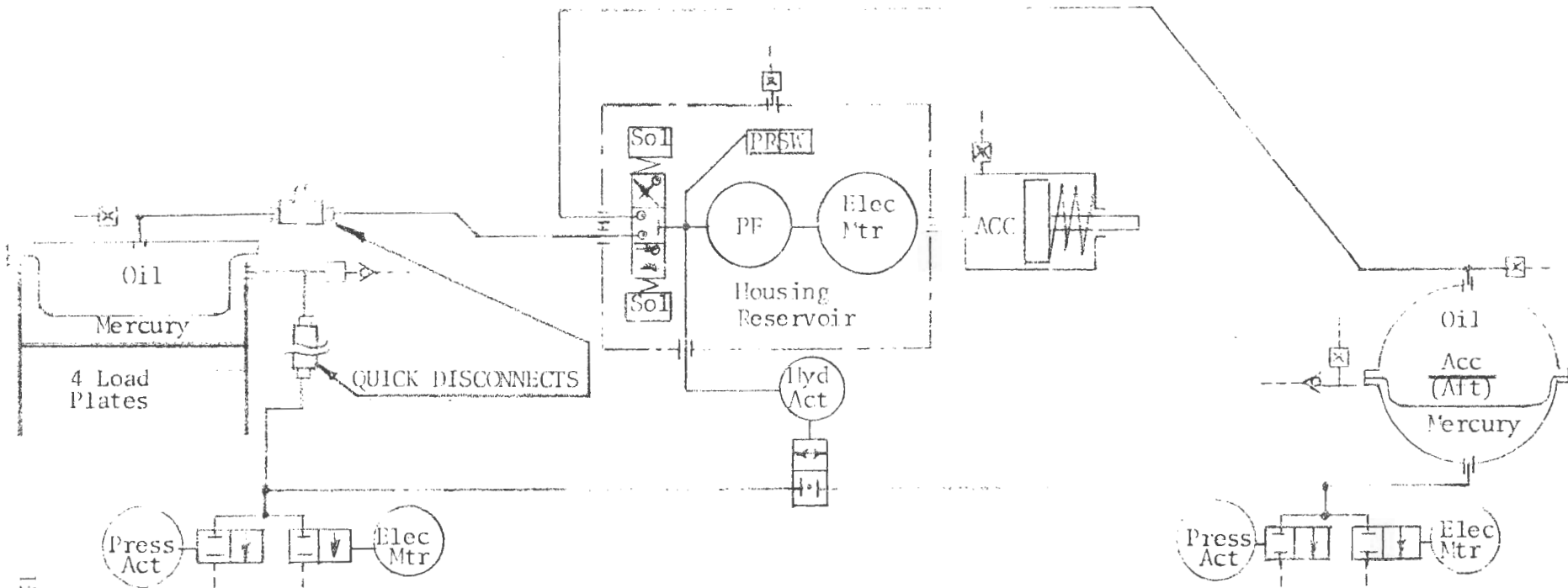
The transfer portion of the system has undergone dynamic testing in ocean waters with good results. The following tests conducted during the week of 1 February 1966 off San Clemente Island proved the operability of the improved mercury jettison container system.

- a. Submerged, trimmed condition. Release mercury tank.
- b. 50% of the nose section submerged, 30° nose up attitude, 30° right roll. Release mercury tank.
- c. 50% of the nose section submerged, 30° nose up attitude, 30° left roll. Release mercury tank.
- d. Nose on bottom, 30° nose down attitude, 30° right roll. Release mercury tank.
- e. Nose on bottom, 30° nose down attitude, 30° left roll. Release mercury tank.
- f. Nose on ocean bottom, 30° nose down attitude, 0° roll. Release mercury tank.
- g. End of test.



**MORAY TV-1A**  
 RELATIVE POSITIONS OF MAJOR COMPONENTS  
 FOR  
 HYDRAULIC MERCURY TRANSFER SYSTEM 1-A

Enclosure (1)

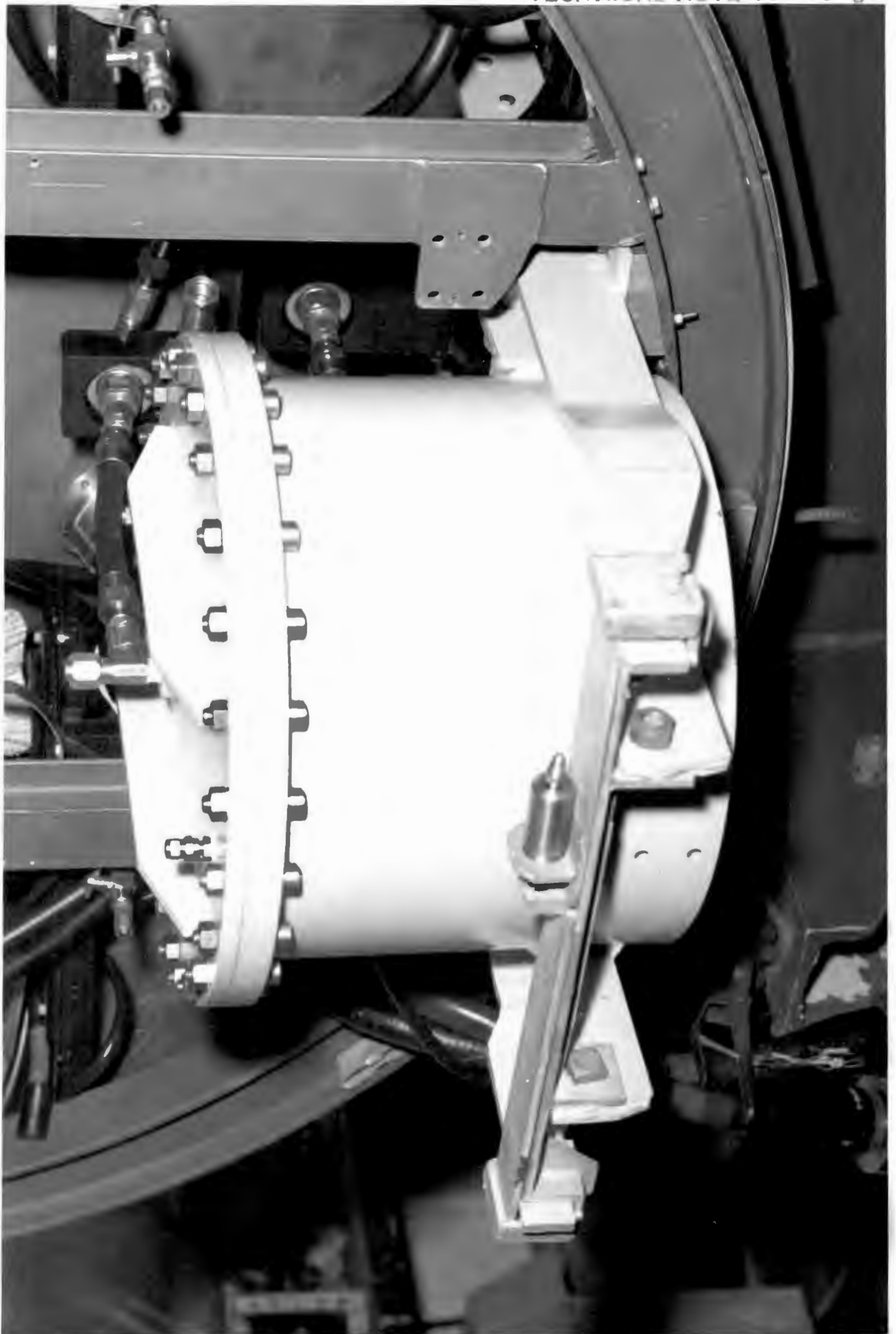


MORAY TV-1A HYDRAULIC MERCURY  
TRANSFER AND JETTISON SYSTEM 1-A  
SCHEMATIC WITH J.I.C. STANDARD SYMBOLS

Incluse ure (2)

TECHNICAL NOTE 404-55-66





FORWARD CYLINDRICAL MERCURY TANK

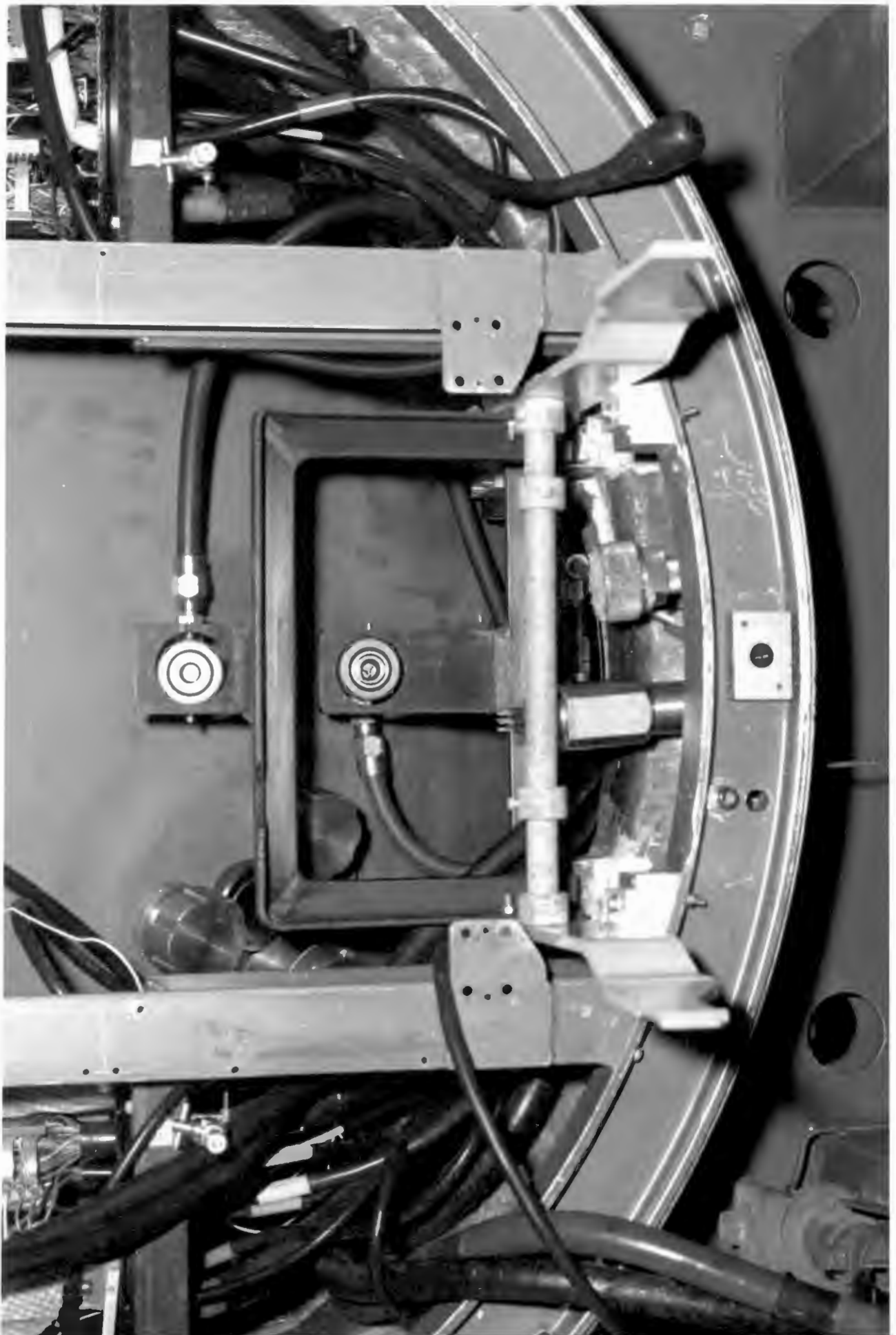


AFT SPHERICAL MERCURY TANK



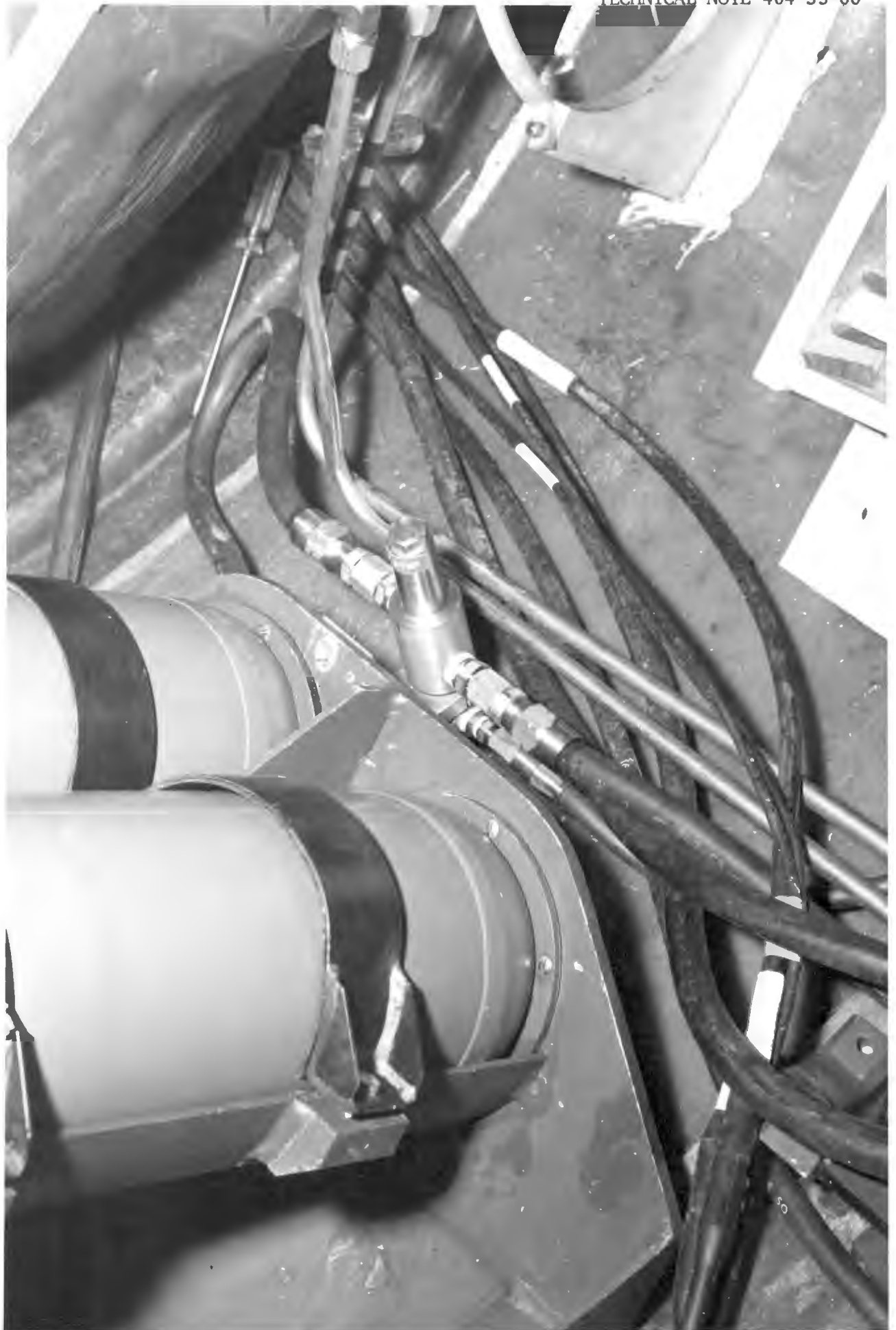
FORWARD CYLINDRICAL MERCURY TANK, BOTTOM VIEW

ENCLOSURE (5)

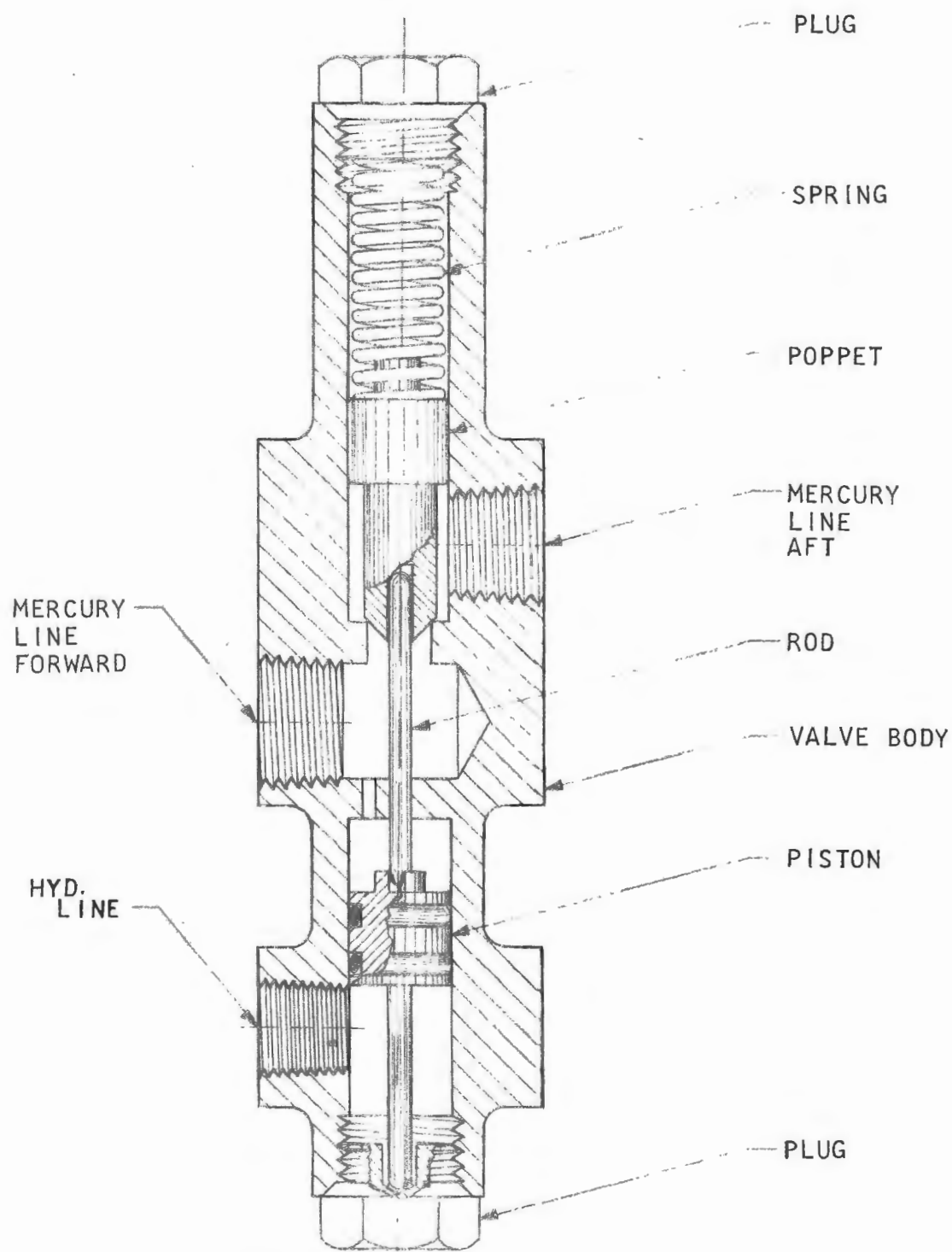


JETTISONABLE TANK PIVOT & QUICK DISCONNECTS





MERCURY LINE VALVE INSTALLATION



TWO WAY MERCURY LINE VALVE  
HYDRAULICALLY ACTUATING

SCALE 1/1  
Enclosure (8)



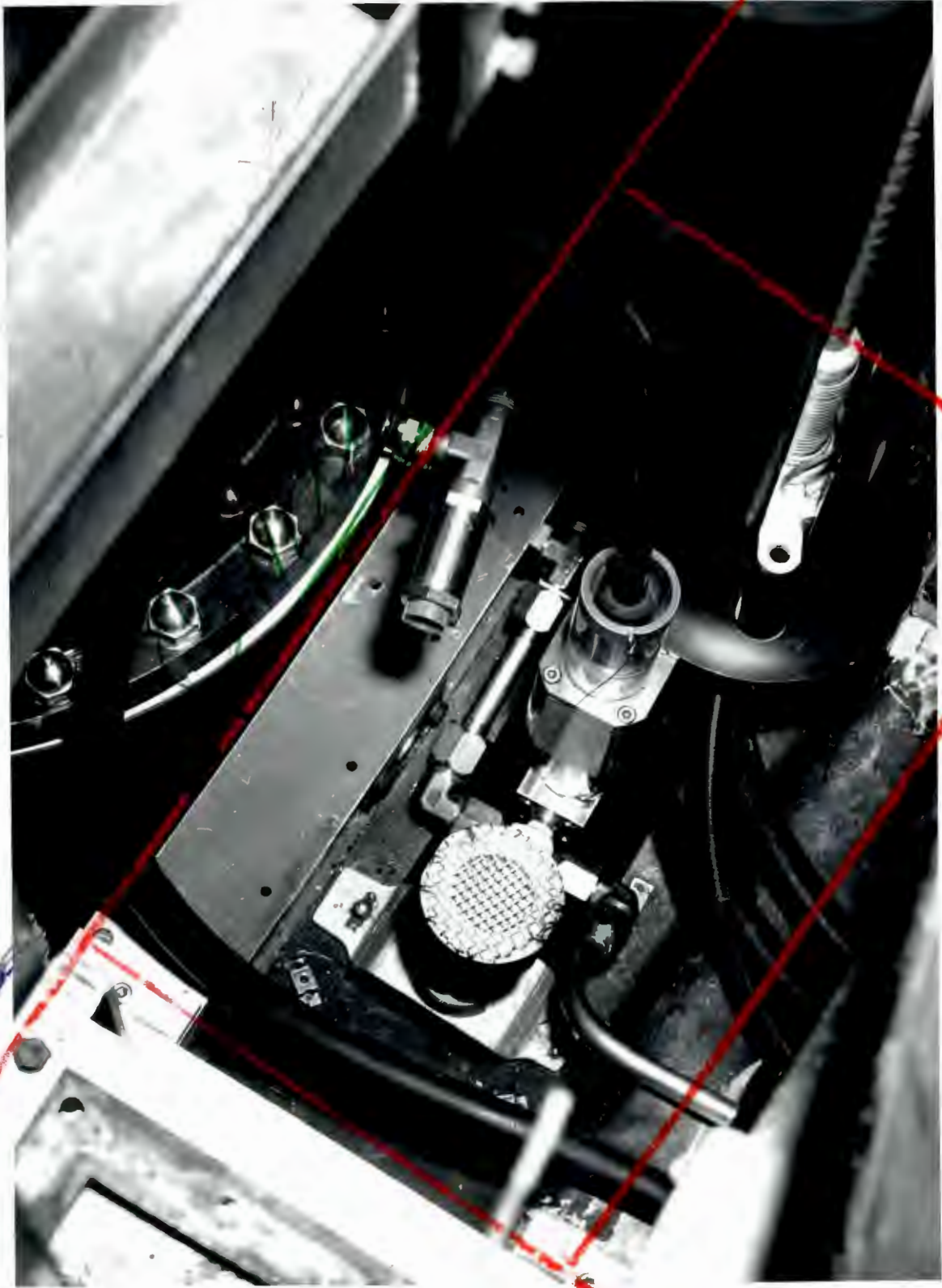
POWER PACKAGE (UPPER) FLUID MAKE-UP DEVICE (LOWER)

ENCLOSURE (9)





5X7 or 6X8



FORWARD JETTISON VALVE INSTALLATION

Enclosure (11)

12  
15



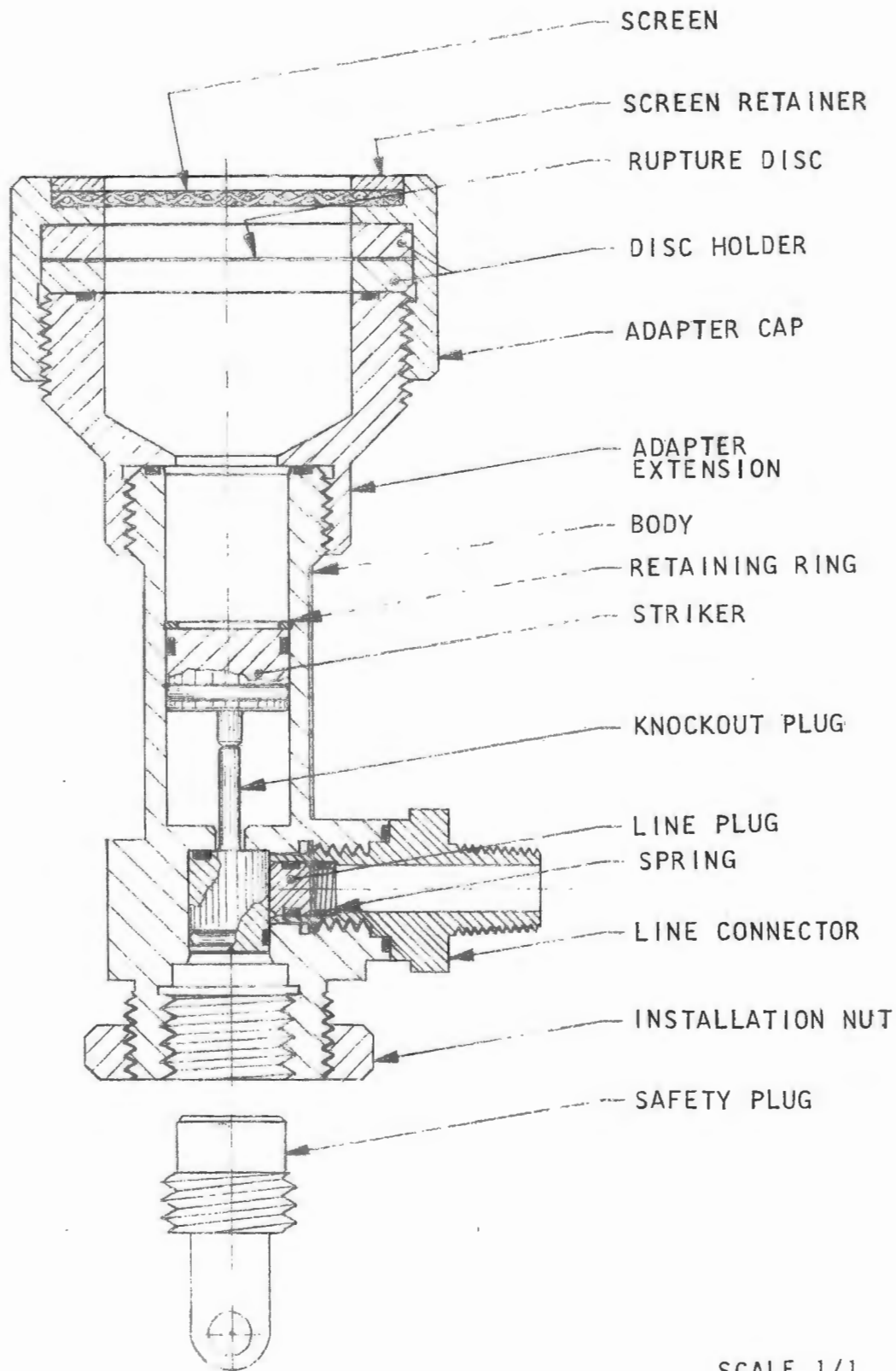
FORWARD JETTISON VALVE INSTALLATION

Enclosure *57*

12 *#*



AFT JETTISON VALVE INSTALLATION

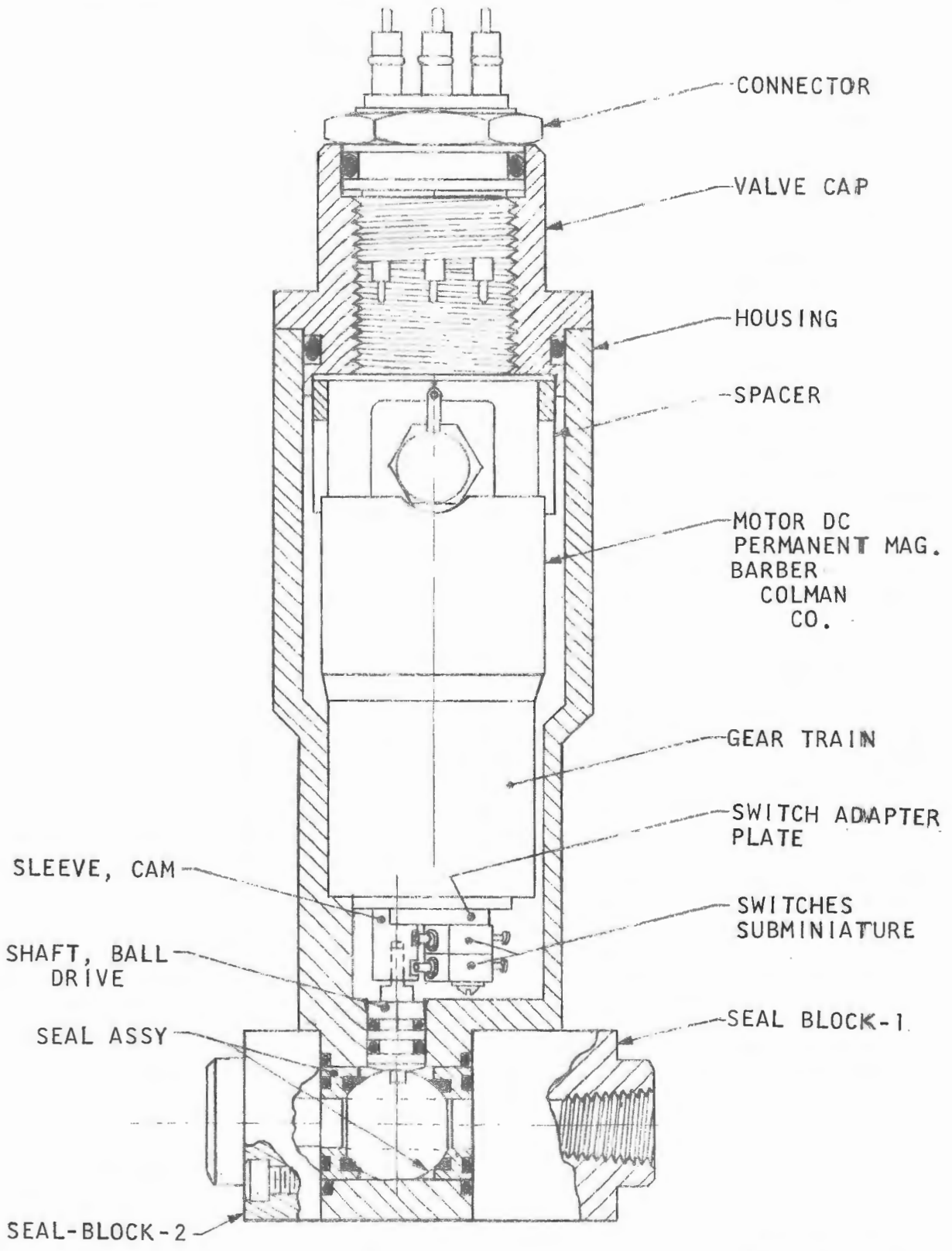


- SCREEN
- SCREEN RETAINER
- RUPTURE DISC
- DISC HOLDER
- ADAPTER CAP
- ADAPTER EXTENSION
- BODY
- RETAINING RING
- STRIKER
- KNOCKOUT PLUG
- LINE PLUG SPRING
- LINE CONNECTOR
- INSTALLATION NUT
- SAFETY PLUG

JETTISON VALVE,  
PRESSURE OPERATED

SCALE 1/1  
Enclosure (13)

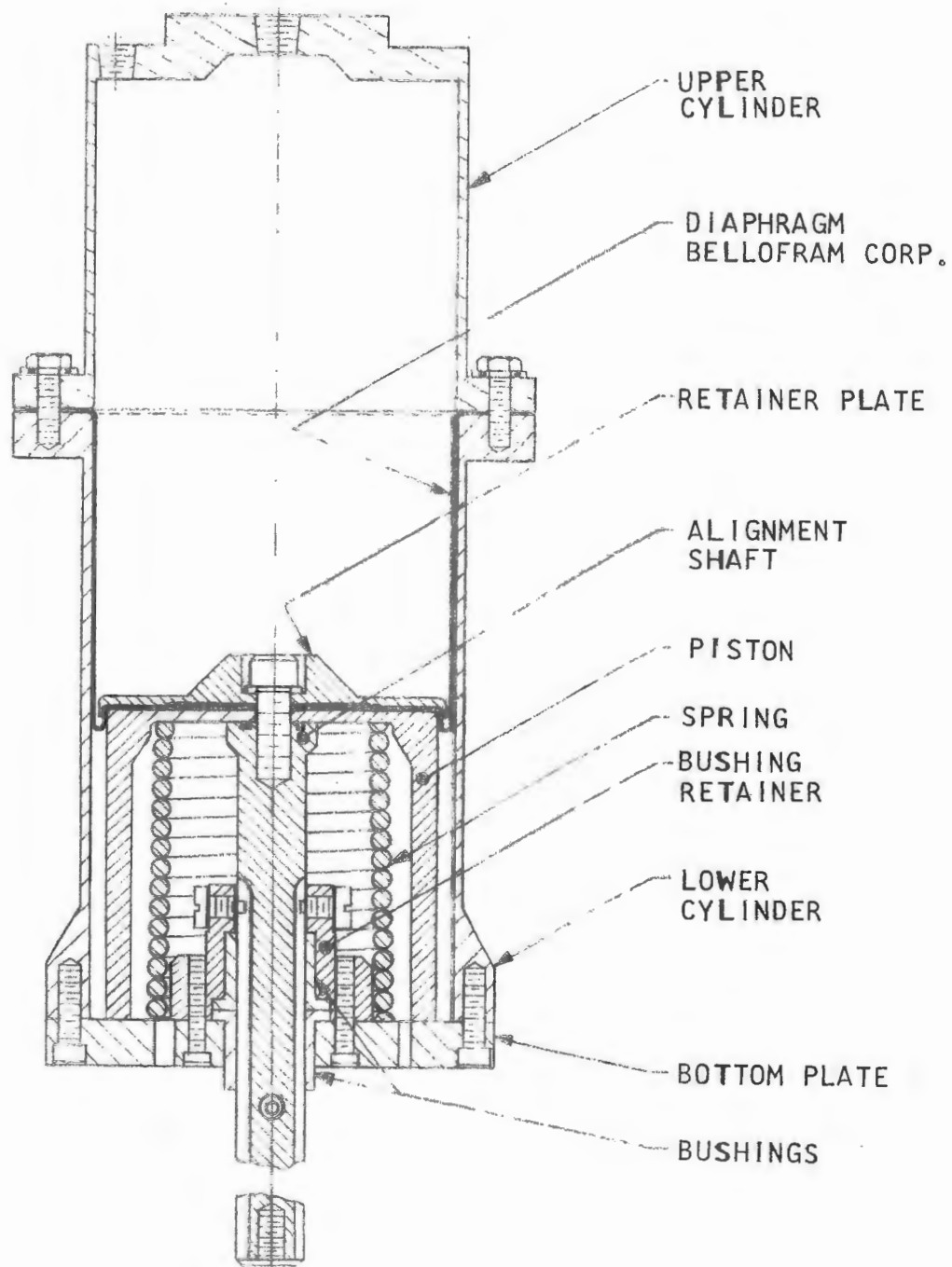




BALL VALVE,  
ELECTRIC MOTOR OPERATED

SCALE 1/1

Enclosure (14)

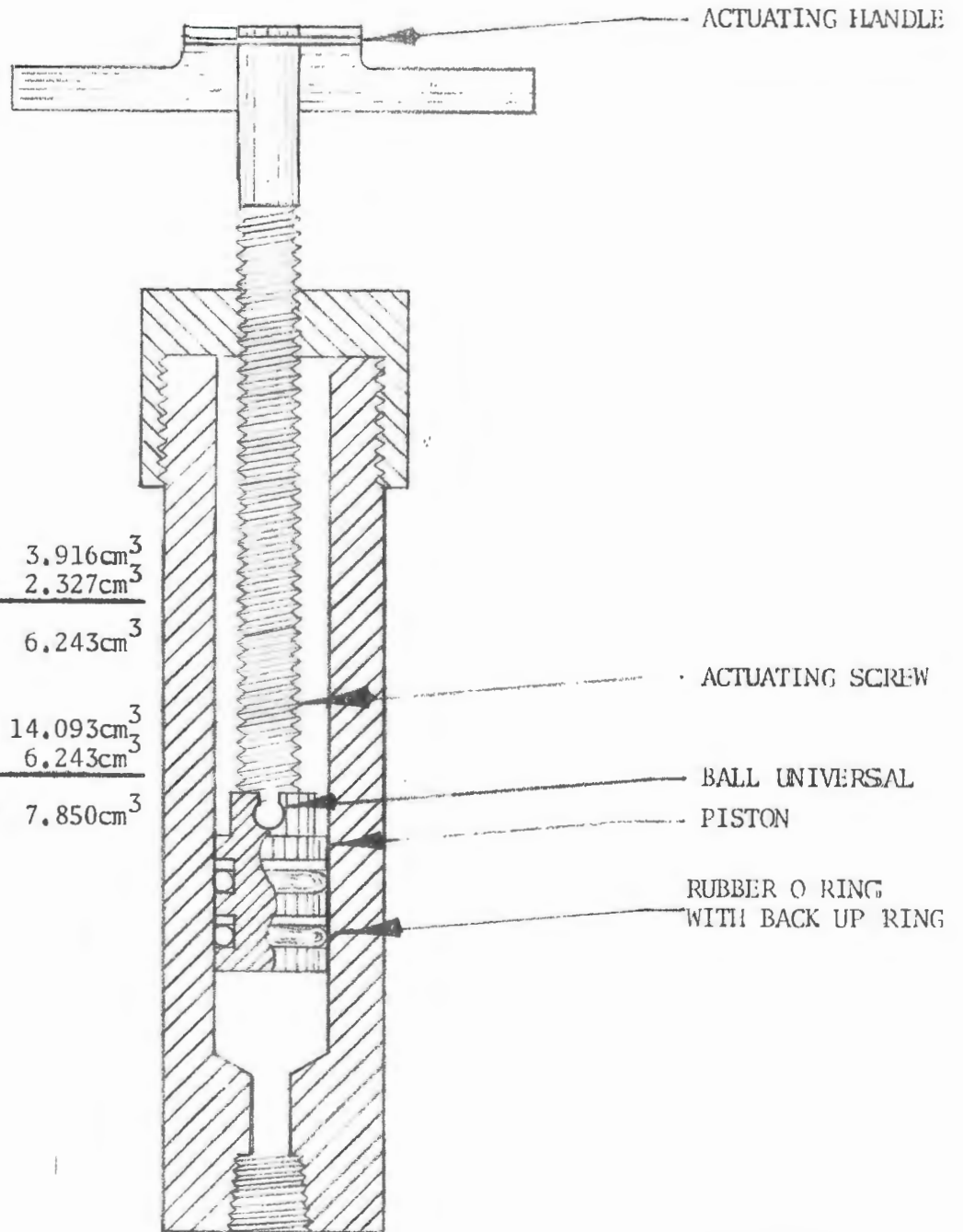


FLUID MAKEUP DEVICE,  
HYDRAULIC MERCURY  
TRANSFER SYSTEM

SCALE 1/2

Enclosure (15)

MERCURY CONTAINER & FLOAT RELEASE PUMP  
HYDRAULICALLY ACTUATING

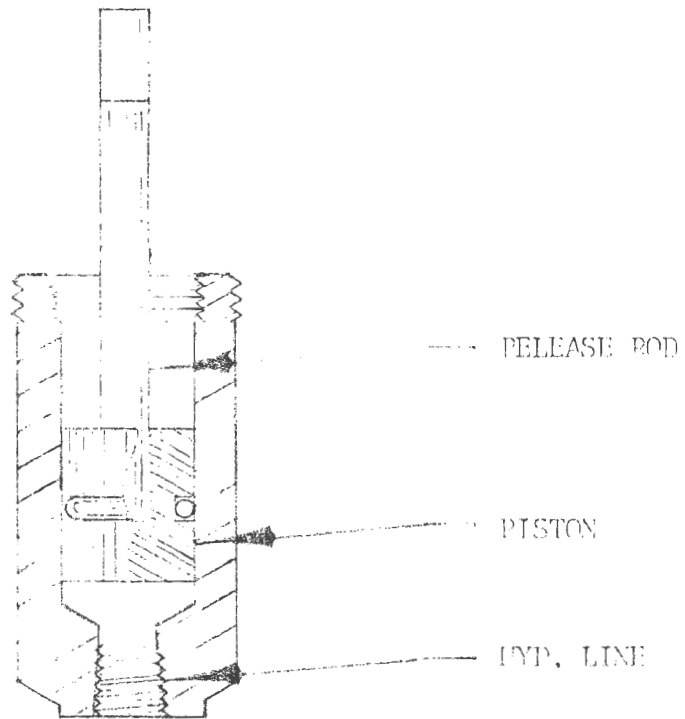


Volume of Hg Release CyL	=	3.916cm <sup>3</sup>
Volume of Float Release CyL	=	2.327cm <sup>3</sup>
<hr/>		
Total Volume Required	=	6.243cm <sup>3</sup>
Actuating CyL Piston Disp.	=	14.093cm <sup>3</sup>
Total Volume Required	=	6.243cm <sup>3</sup>
<hr/>		
Safety Reserve Volume	=	7.850cm <sup>3</sup>

SCALE 1/1

MERCURY CONTAINER RELEASE CYLINDER

HYDRAULICALLY ACTUATING



SCALE 1/1

Enclosure (17)



MORAY TV-1A HYDRAULIC MERCURY  
TRANSFER AND JETTISON SYSTEM 1-A  
COMPONENT SUMMARY

ITEM	COMPONENT	FUNCTION	SOURCE
A-1	Forward Transfer Barrier (1180 cu.in. accumulator)	To contain, separate & transmit pressure between oil & mercury.	Designed by Code 4046 NOTS China Lake
A-2	Aft Transfer Barrier (1000 cu.in. accumulator)	To contain, separate & transmit pressure between oil & mercury.	TAVCO, Inc., Santa Monica, Calif., Dwg. No. 217112
B	Jettison Valves (Electric motor driven ball type) (2 required)	To give operator, mercury jettison control.	Designed by Code 4046 NOTS China Lake Dwg No. SK 597756
C	Jettison Valves (Automatic pressure actuated type) (2 required)	To automatically jettison mercury (1000 lbs) if maximum operational depth is exceeded.	Designed by Code 4046 NOTS China Lake Dwg. SK 597757
D	Check Valves (Sea water inlet type) (2 required)	Aids flow rate during jettison; permits sea water to displace mercury.	Republic Valve Co., L. A., Calif., No. 496-6SST-2
E	Air Bleed Valves (4 required)	To remove air during filling operation.	NUPRO Valve Co., L. A., Calif. No. 4P-4M-SST
F	Hydraulic Line & Fittings	Provide path for hydraulic fluid (pump - transfer barriers).	Haskel Inc., L.A., Calif. 401 Series flexible hose and fittings
G	Mercury Line & Fittings	Provide path for mercury forward transfer barrier to aft transfer barrier.	Haskel Inc., L.A., Calif. 401 Series flexible hose and fittings
H	Mercury & Hydraulic Line Quick Disconnects	Provide a means of disconnecting lines at jettison.	Oman Masoh Corp. Van Nuys, Calif., H Series SXHC8-8-56 SXIN8-8-56

Enclosure (18)

ITEM	COMPONENT	FUNCTION	SOURCE
I	Hydraulic Oil	Liquid pumped to top of mercury to force transfer.	MIL H5606 Type as available
J	Mercury (568 lbs)	Mass transferred for trim or jettisoned for emergency ballast.	Goldsmith Brothers, Div. National Lead Co., Chicago, Ill.
K	Mercury Line Valve, Hydraulic Operated	To restrict flow of mercury except during pumping operation.	Designed by Code 4046 NOTS China Lake.
L	Fluid Make-up Device Bellofram-piston, spring loaded	System pressure equalizer with ambient & overpressure for pump inlet.	Designed by Code 4046 NOTS China Lake SK 598204
M	Pump, Positive Displacement	To force oil to transfer barriers thereby forcing mercury transfer.	Vickers, Inc., Torrance, Calif. No. PF 3809-20
N	Motor, .75 HP, 24 VDC, 3800 RPM	Prime mover for hydraulic pump; run in oil as "wet D.C. motor."	Electric Speciality Co., Stamford, Conn. No. 32-159D
O	Control Valve Four-way flow direction	To direct flow of hydraulic oil between pump, transfer barrier and reservoir.	Adel Valve Co., Burbank Calif. Dwg. No. 71239
P	Housing Hydraulic Power Package	Contains "Hydraulic Power Pkg" items & performs as pump reservoir.	Designed by Code 4046 NOTS China Lake
Q	Pressure Relief Valve (300 psi)	To relieve pump when either container is full (transfer completed).	Circle Seal Valve Co., Pasadena, California P.N. 51595-3PP-200
R	Pressure Switch Relief Indicator	To indicate completed mercury transfer to operator.	Designed by Code 4046 NOTS China Lake

\*Items M through R make-up the "Hydraulic Power Package."  
System Wiring Diagram - Bulweps Dwg. No. SK 573626, located - Code 4046, U. S. NOTS, China Lake, California

Enclosure (18)

TECHNICAL NOTE 404-35-66

ADDENDUMS TO TECHNICAL NOTE 404-35-66

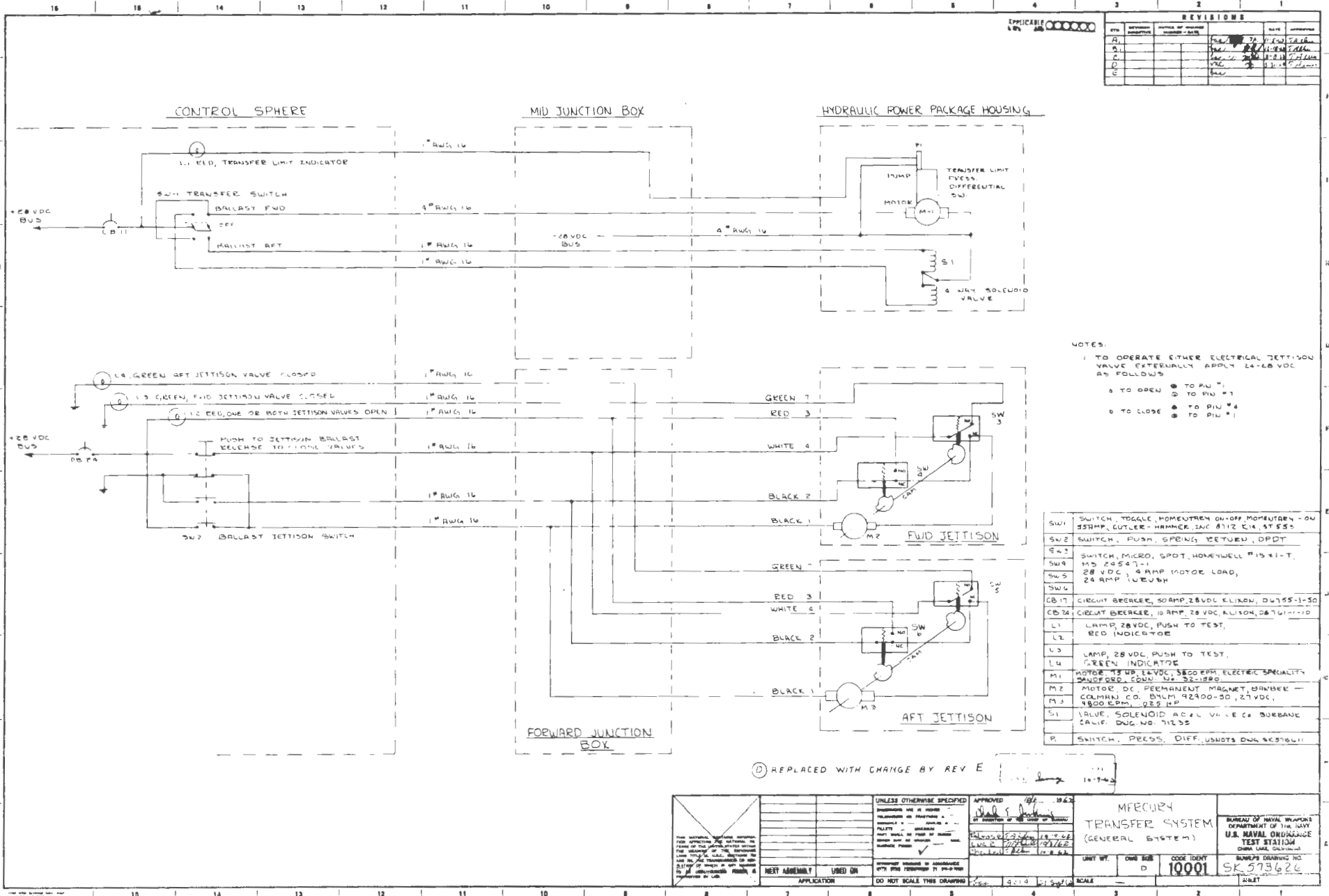
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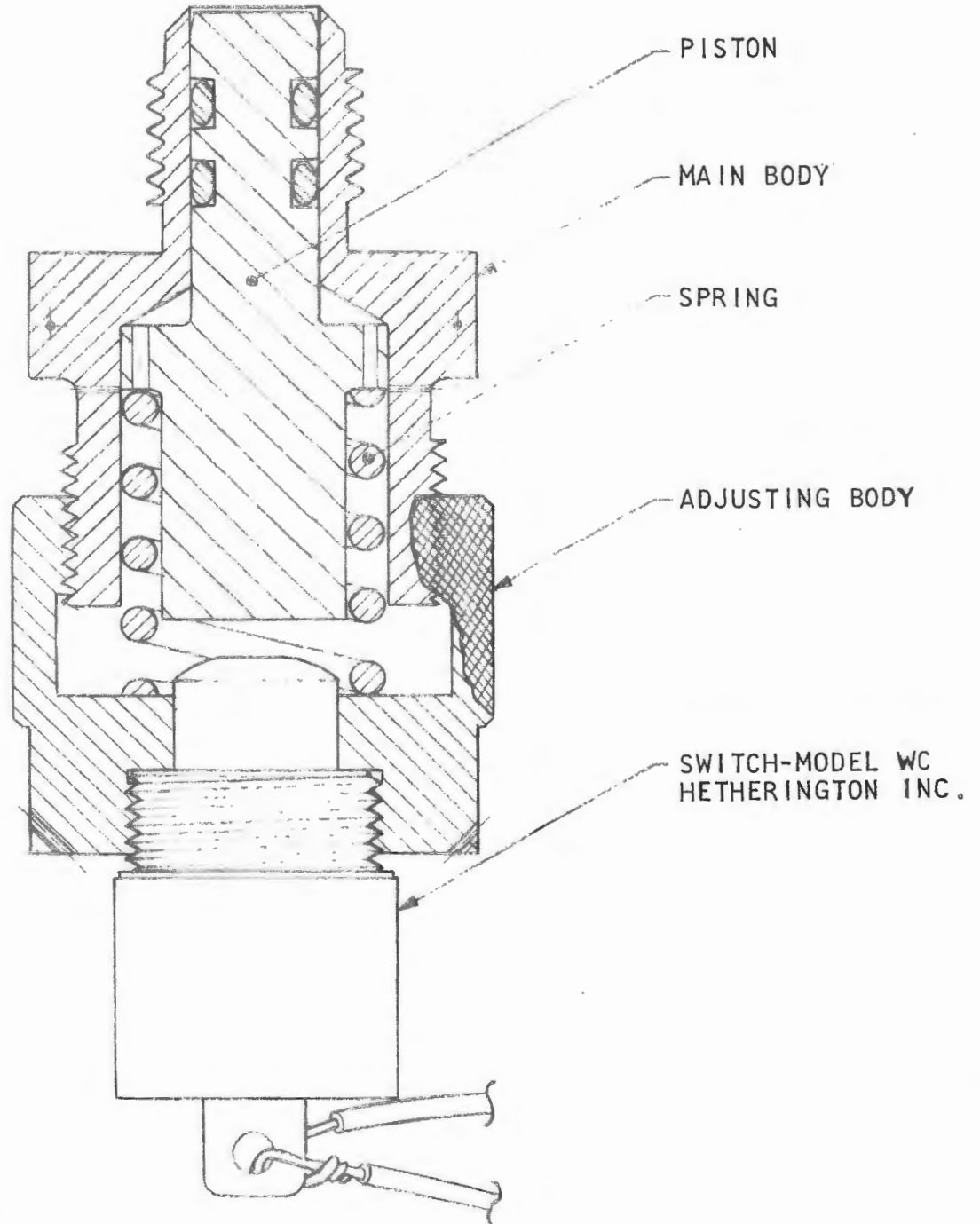
DATE: 2 May 1966

M. W. Smith

- 1 - Electric Schematic of MTS 1-A and 1-B.
- 2A - Illustration of "Adjustable Pressure Differential Switch" installed in Hydraulic Power Package 1-B.
- 2B - Photograph of above switch.
- 3 - Photograph of "Adel" 4-way valve installed in Hydraulic Power Package 1-B.

Addendum (1)





ADJUSTABLE PRESSURE DIFFERENTIAL SWITCH:  
OIL (RESERVOIR) IMMERSSED TYPE

SCALE 3/1

Addendum (2A)

