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ARROW 2

ARMAMENT HYDRAULIC SYSTEM

REPORT NO. 72/SYSTEMS 19/40

JUNE 1957

This brochure is intended to provide an accurate description of the system(s) or service(s) for purposes of the Arrow 2 Mock-up Conference, and is not to be considered binding with respect to changes which may occur subsequent to the date of publication.

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MALTON — ONTARIO

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1. General Description of the Sparrow 2D Armament Hydraulic System

1.1 The armament installation consists of four Sparrow 2D missiles stowed in pairs abreast. One outboard missile and one inboard missile, on opposite sides of the aircraft centre line, form a pair. The two pairs of missiles are staggered, one pair being referred to as the forward missiles, the other the aft missiles.

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1.2 Each pair of missiles, and its associated equipment, is hydraulically linked and operated independently of the other pair.

1.3 The armament hydraulic system is a sub-system of the utility hydraulic system and, as such, has a nominal operating pressure of 4000 p.s.i. and a zero flow return pressure of 90 p.s.i. As a sub-system, it is completely contained within the armament pack. It is connected to the utility hydraulic system by two self-sealing, quick disconnect couplings mounted on the right hand side of the forward face of the bulkhead at aircraft station 485.

1.4 Each missile installation has the following hydraulically actuated equipment:

(a) Missile wing doors

(b) Missile fin doors

(c) Missile up-lock

(d) Missile extension and retraction mechanism (comprising a front jack and a rear jack)

(e) Drag link doors (aft missiles only).

1.5 The missiles may be extended in any one of the following modes:

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Mode 1 - The two aft missiles only

Mode 2 - The two forward missiles only

Mode 3 - All four missiles.

NOTE: Mode 3 is actually modes 1 and 2 operated simultaneously.

2. System Requirements

2.1 To provide a limited number of modes for extending the missiles as described in Section 1.5.

2.2 To provide sequences of operation for operational and training missions as well as for ground servicing.

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2.2.1 Operational mission sequence requirements for any extension mode are as follows:

(a) Lower missiles

(b) Fire missiles

(c) Retract empty launchers to their secondary up position (i.e. launcher in contact with bottom skin seals)

NOTE: The forward missiles must be fired before the aft missiles in mode 3. If any missile of mode 1 or mode 2 is hung up, it will automatically be jettisoned. If a forward missile of mode 3 is hung up, the aft missile will be jettisoned and their launchers retracted to allow for the jettisoning of the forward hung up missile.

2.2.2 Training mission sequence requirements for any extension mission are as follows:

(a) Lower missiles

(b) Fire missiles

NOTE: The jettisoning of hung up missiles is not automatic, but must be done by action of the pilot.

(c) Retract empty launchers to their secondary up position, or retract unfired missiles to full up position.

NOTE: Retraction of launchers in associated pairs is automatic, whether the missiles are fired or jettisoned. However, retraction of an unfired missile and the other empty launcher of the pair must be by deliberate action of the pilot. In mode 3 if one of the forward missiles is hung up, the aft missile will not fire. However, all four launchers may be retracted to full up position and the aft missiles re-lowered, with a mode 1 selection, and fired. Jettisoning of the forward hung up missile will jettison the aft missiles first. (See note in Section 2.2.1).

2.2.3 Ground operation sequence requirements are the same as for training mission, except that the firing signal and jettison signal can not be supplied to the armament pack.

2.3 To lower all four missiles at once, in minimum time, without cavitation.

2.4 To limit maximum terminal velocities.

2.5 To limit the initial and final loading on the missile to 10 "g", both on extension and retraction.

3. Sequence of Operation

3.1 Operational mission (see Fig. 6.6.1, 6.2 and 6.3)

Origin of Signal	Hydraulic Operations for Selected Mode 1, 2, or 3
Fire control	Operates door selector valves for selected mode. Wing and fin doors open. For Mode 1 and 3 drag line doors also open.
Doors "full open" limit switches.	Actuates compensating valves, placing the forward and aft missile jacks in series.
Limit switches on compensating valve spools.	Missile up-lock jacks unlock.
Limit switches on up-locks (both up-locks must be open)	Actuates missile selectors. Missiles are extended.
As each missile approaches the extended position, limit switches are actuated by the front jack shroud.	The compensating valve associated with each missile is operated, putting the jacks in parallel.

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Origin of Signal	Hydraulic Operations for Selected Mode 1, 2, or 3
Limit switches are actuated by compensating valve spools	Door selector valves are actuated, closing wing and fin doors (drag link doors for aft missiles, remain open). Missile up-locks are closed.
Missiles are fired and hung-up missiles are jettisoned.	Note: for order of firing or jettisoning see note in Section 2.2.1.
As each missile leaves its launcher it actuates a "Missile Released" limit switch. It also mechanically operates the secondary up stops.	As the second missile leaves its launcher both compensating valves go into series position.
When both compensating valve spools of a missile pair are in series: Note: for mode 3, this signal, from forward missile compensators, fires the aft missile.	Missile door selector valve operates the door jacks, opening wing and fin doors, and up-locks are re-opened.

Origin of Signal	Hydraulic Operations for Selected Mode 1, 2, or 3
Doors "full open" limit switch.	Missile selector operates, retracting launchers to secondary up position.
Launcher in secondary up position.	Wing, fin and drag link doors close (modes 1 and 3) Wing and fin doors (mode 2).

Note: A hung-up forward missile in a mode 3 selection is jettisoned by the closing of the aft missile drag link doors, thus beginning the forward launcher retracting cycle.

3.2 Training Mission

The sequence of operation for a training mission is the same as that for an operational mission, except that there is no automatic jettison of hung up missiles. Therefore, the pilot must decide whether to retract or jettison the hung-up missiles. This is done by deliberate switch selection.

3.2.1 Retraction of Missiles

The actuation of the cockpit switch opens the doors of the

selected mode. When the doors are fully open, the limit switches activate the compensating valves into series and retraction begins. Since the secondary up stop of a hung up missile is not rotated, the missile and launcher will be retracted to the full up position, while the empty launcher will retract to the secondary up stop. If a forward missile is hung up in a Mode 3 selection, the aft missiles will not fire (see Note in Section 2.2.2).

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3.3 Ground Operation

The lowering sequence of operation is the same as that of a training mission, except that the fire control system signal to open the wing fin and drag link doors is replaced by a signal from the "lower" contacts of the ground service switch for the applicable pair of missiles or empty launchers. The missiles or empty launchers will remain down until a "raise" selection is made on the ground service switch. Then the normal training mission retraction sequence will follow, the missile being retracted to the full up position and empty launchers to their secondary up stops.

3.4 Manual Jettison

A means is also provided to dump the missiles if necessary when the aircraft is in the air. This may occur on either operational or training missions, therefore any number of the four missiles may remain on the launchers. With a "Jettison"

selection of hung up or unfired missile(s), the doors open and the launchers are lowered. If both forward and aft missiles are hung up, all four launchers will lower. When the launchers reach their fully extended position the hung up missile(s) will be jettisoned (aft first in the case of all four being lowered). A normal "missile released" retraction will then occur.

4. Components - Their Description and Purpose in the Circuit

NOTE: It has been decided that there should be two restrictor valves incorporated in the drag link door jacks system. This change will not be shown on the schematics, and is, therefore, not mentioned in the brochure. At present, the brochure indicates that there is only one restrictor.

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4.1 Restrictors

A restrictor is an orifice having a given pressure drop for a given flow and temperature. There are two types of restrictors installed, one having the same flow-pressure characteristic in each direction (two way restrictor); the other, a given flow characteristic in one direction and a free flow in the opposite direction.

4.1.1 Wing, Fin, and Drag Link Door Restrictors

These are two way restrictors each having the same purpose in the circuit, that is, they limit the operating speed of the doors. The drag link doors restrictor, however, has a different flow characteristic than the wing and fin door restrictors. When the doors are opening, the restrictors decrease the pressure acting on the head end of the jack, thereby decreasing the opening speed. When the doors close, the flow is restricted on leaving the head end of the jack, thus giving a lower pressure differential, resulting in slower door closing speeds.

4.1.2 Missile Jack Restrictors

There are three separate restrictors installed for each jack, and a fourth is incorporated in the flow regulator. One restrictor is installed at the "down" port of the rear jack and is used during extension and retraction, having the same flow characteristics in each direction. When a missile is lowered, the restrictor decreases the pressure on the extension area of the rear jack, and reduces the pressure build-up through the flow regulator on the retraction area of the front jack. In the retraction case, it restricts the flow from the jack, causing pressure build-up on the rear jack "down" port, while the flow regulator restrictor decreases the pressure on the "up" port of the front jack, resulting in lower piston velocities. The other two restrictors are installed at the "up" and "down" ports of the compensating valve. Each has a given flow characteristic one way, to build up back pressure on the jacks, and free flow the other way, so that when one restrictor is building up pressure the other is allowing free flow. The restrictor placed at the valve "up" port maintains a given rear jack piston velocity during the parallel operating portion of the extension stroke, when no damping exists on the jack. The restrictor at the valve "down" port serves the same purpose for the front jack during retraction.

4.2 Door Jacks and Up-lock Release Jacks

The wing, fin and drag link door operating jacks are all identical, standard piston type, and have no dampers or internal locks. The up-lock release jacks are similar to the door jacks, except for size and shape. The rod ends of the jacks are under pump pressure at all times, and piston movement is a result of the equal fluid pressures acting on the differential area, between the head and rod ends.

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4.3 Missile Front Jack (Fig. 1)

The front jacks of forward and aft missiles are similar in construction and differ only in size. Each consists of three concentric tubes, two fixed and one movable. It has a damper and damping holes which serve to reduce the movable tube velocity of both front and rear jacks (hydraulically interconnected - see Section 4.5), during the last portion of the extension stroke. The area contained between the inner and outer fixed tubes is the extension area, and that between the inner fixed tube and movable tube is the retraction area. The swept volume of the extension area is equal to the swept volume of the rear jack retraction area (see Section 4.4).

During extension, the flow of fluid is from the rear jack, through the down port, and into the space between the inner and outer fixed tubes. The return flow is from the space between inner

fixed tube and movable tube, through the damper holes, then through the centre of the fixed tube to the up port. This jack, together with the rear jack, forms the missile extension mechanism.

4.4 Missile Rear Jack (Fig. 2)

The rear jacks of both forward and aft missiles differ only in size. This type of jack consists of five concentric tubes, three fixed and two movable. It has a damper and damping holes which serve to reduce the velocity of both front and rear jacks during the last portion of the retraction stroke. The area contained between the outer and second fixed tubes is the retraction area, and that contained between the movable tubes is the extension area. During extension the flow is from the missile selector, through the down port, through the inner fixed tube, down the inner movable tube and past the check valve into the space between the movable tubes. The return fluid flows from the retraction space, through the space between the second and inner tubes to the up port and then to the front jack down port. For retraction it is the opposite, except that the fluid by-passes the check valve and flows through the damping holes to return through the inner movable and fixed tubes.

4.5 Compensating Valve (Fig. 4)

There is one compensating valve installed for each missile

operating circuit. The valves for the forward and aft missiles are of the same type and differ only in size.

These valves are essentially four way, two position valves, actuated by pilot pressure supplied from a source external to the valve. Each is composed of a spool with slots to direct the flow, detents at each end to hold the spool in position in case of pilot pressure failure, and a pilot pressure valve at each end to position the spool. The pilot pressure valves are operated by solenoids. Also incorporated in this valve are two limit switches used to operate other equipment in the armament system (see Section 3.1).

The prime function of this valve, is to change the flow pattern to the forward and aft missile jacks from a normal series connection to a parallel connection, near the end of their extension or retraction strokes. This parallel connection is required to correct any mis-alignment that may occur during the series connected portion of the stroke. It also allows the application of full pump pressure to both jacks at the up or full down positions and holds the launchers (missiles on or off) against maximum loads.

4.6 Selector Valves (Fig. 5)

All selector valves used are of the four way, two position type, differing in size and slightly different in the flow pattern. Each

valve is pilot pressure operated through pilot valves and solenoids, the pilot pressure being applied to one of two pistons. These pistons in turn position the valve slide, to produce the flow pattern required. In the case of door selector valves, wing and fin doors and drag link doors (shown in Fig. 5), the valve slide configuration is such that pressure is applied at the rod end port at all times, changing the flow to the head end port only.

The missile selector valves are similar in construction, but are different in size. The valve slide directs pump pressure to the down port and return pressure at the up port for extension, then reverses the flow pattern for retraction. The door selector and the missile selector valves have incorporated in them a check valve, a thermal relief valve and two detents. The check valve prevents fluid from flowing back through the pressure port, thereby holding the missiles and doors in the up position. The detents hold the slide in the selected position in case of hydraulic or electrical failure. Excessive pressure due to temperature changes is prevented by the thermal relief valve. The missile up-lock release selector valve is based on the same principle as above, but has only one pilot pressure valve and one solenoid. The pistons, therefore, are of different sizes. The flow pattern is similar to that

of the door selector valve.

4.7 Flow Regulator (Fig. 3)

The flow regulators are essentially variable orifice restrictors which limit the maximum flow of fluid in one direction, normally allowing free flow in the opposite direction. One is installed for each missile to limit the maximum piston velocity attainable by both front and rear jacks during extension. The flow regulators, used in the armament pack, incorporate fixed orifice restrictors in the normal free flow direction, which are used in conjunction with restrictors at the outlet ports of the rear jacks. (see Section 4.1.2).

4.8 Thermal Relief Valve

A thermal relief valve has been incorporated in the system to prevent an excessive build up of pressure after the armament pack is removed from the aircraft.

APPENDIX I

Avro Part No.	Description	No. Per A/C	Spec. No.	Manufacture
7-1956-23	Filter 40 G. P. M.	1	E 353	Parmatic
7-1994-27	Jack, Door, Wing Fins and Drag Links	10	E 516	Electrol
7-1994-28	Jack - Launcher Up-Lock Release	4	F 529	
7-1994-29	Front Jack, Forward Missile	2	E 528	
7-1994-31	Rear Jack, Forward Missile	2	E 527	
7-1994-32	Front Jack, Aft Missile	2	E 528	
7-1994-33	Rear Jack, Aft Missile	2	E 527	
7-1994-34	Valve - Missile Selector (Forward)	1	E 524	
7-1994-35	Valve-Door Selector	3	E 522	
7-1994-36	Valve Up-lock Selector	2		
7-1994-37	Valve Compensating	4	E 509	
7-1994-39	Flow Regulator 4 G. P. M. (Forward Missile)	2	E 519	
7-1994-41	Valve Restrictor (Wing and Fin Doors)	2	E 518	
7-1994-42	Valve Restrictor (drag link doors)	1	E 518	
7-1994-43	Flow Regulator 16 G. P. M. (aft missile)	2	E 517	

Avro Part No.	Description	No. Per A/C	Spec. No.	Manufacture
7-1994-47	Valve Missile Selector (Aft)	1	E 524	
7-1994-52	Valve Manifold Assy.	1	E 522	
7-1994-44	Manifold	1		
7-1994-26	Manifold (drag link doors)	1		
7-1994-53	Valve Manifold Assy.	1	E 522	
7-1994-55	Valve Restrictor	1	E 533	
7-1994-61	Valve Restrictor	1	E 533	
7-1994-71	Valve Restrictor	2	E 499	
7-1994-72	Valve Restrictor	2	E 499	
7-1994-73	Valve Restrictor	2	E 499	
7-1994-74	Valve Restrictor	2	E 499	
7-1994-76	Valve-Thermal Relief	1	E 578	
CS-C-200-12	Coupling Halves (Pressure)	1		
CS-C-201-16	Coupling Halves (Return)	1		

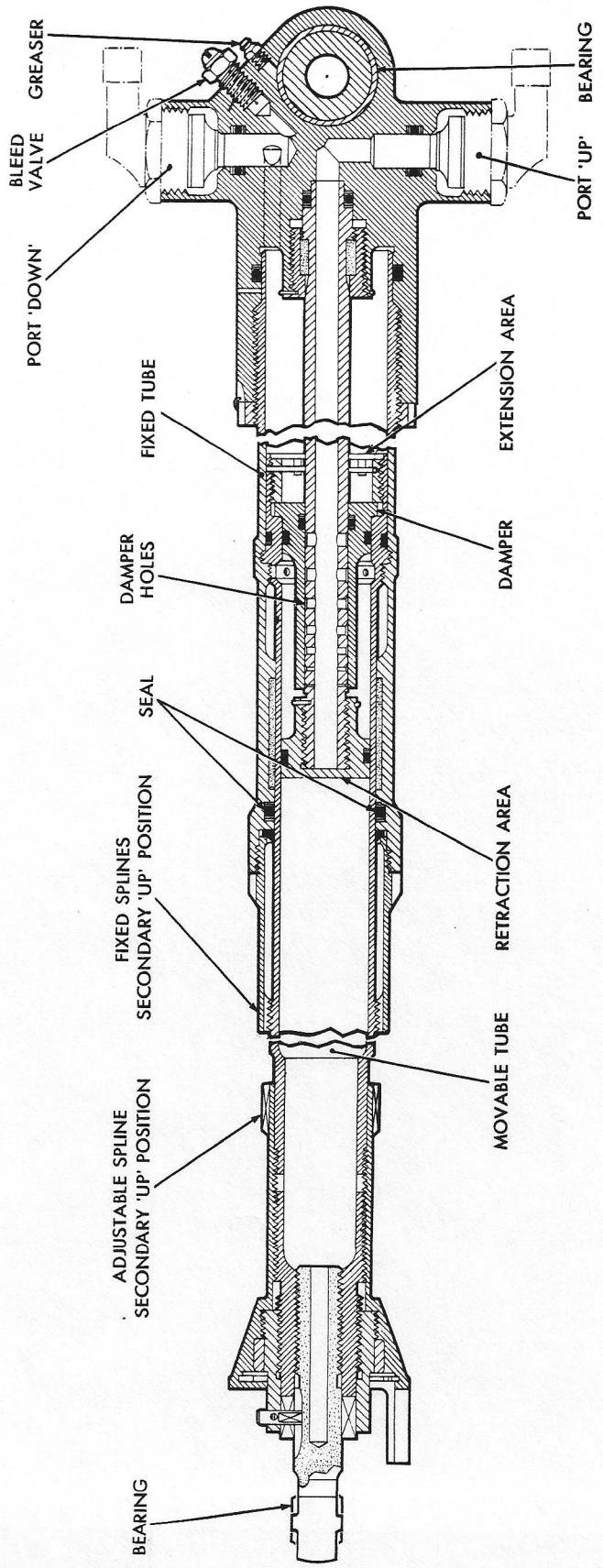

FIG. 1 TYPICAL FORWARD JACK - ARMAMENT PACK

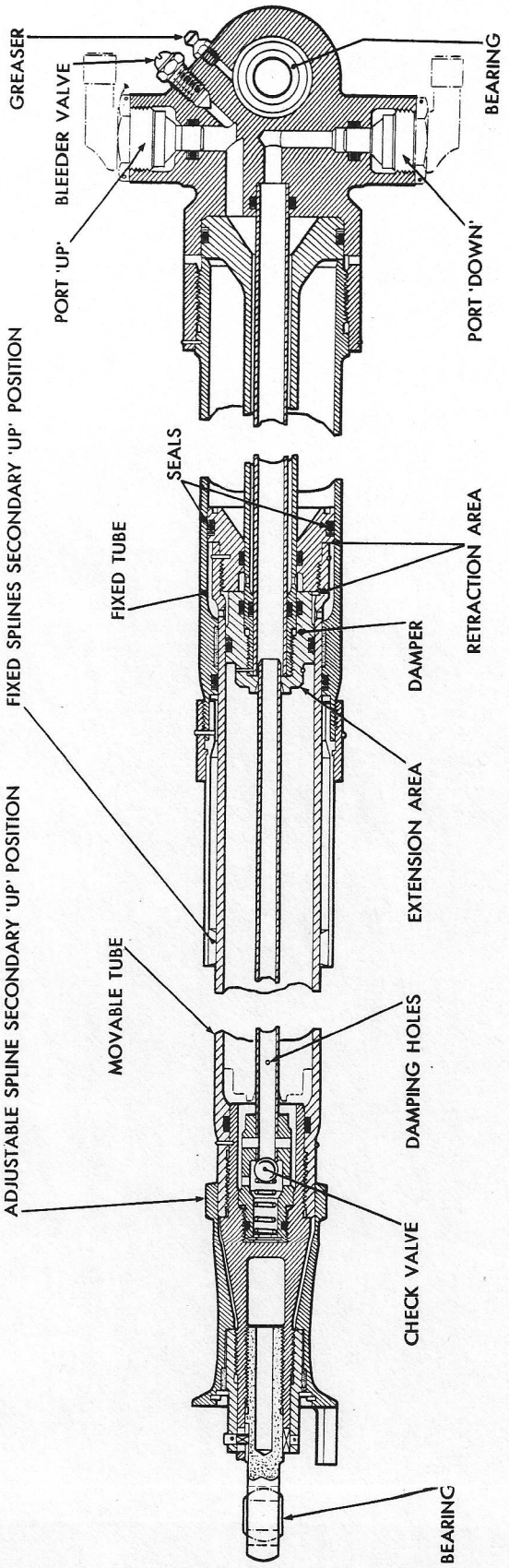

FIG. 2 TYPICAL REAR JACK - ARMAMENT PACK

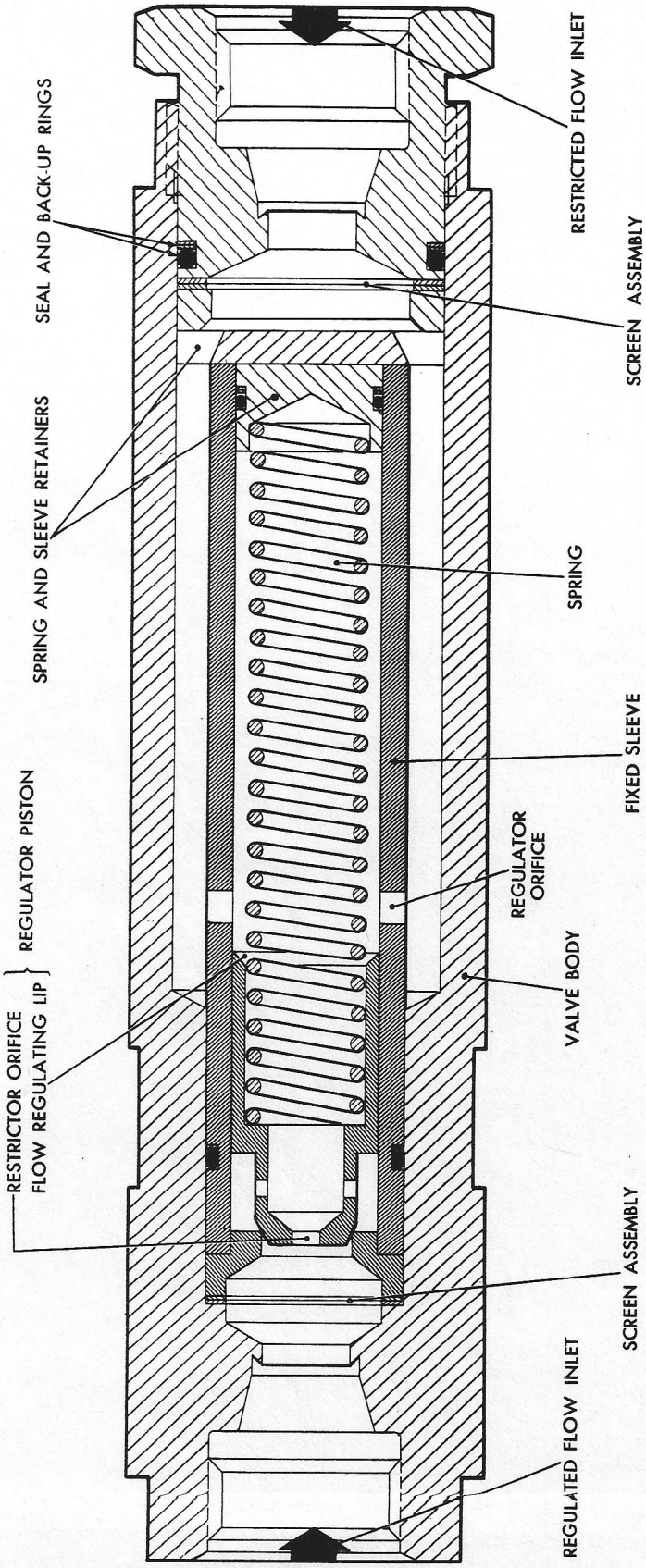

FIG. 3 FLOW REGULATOR

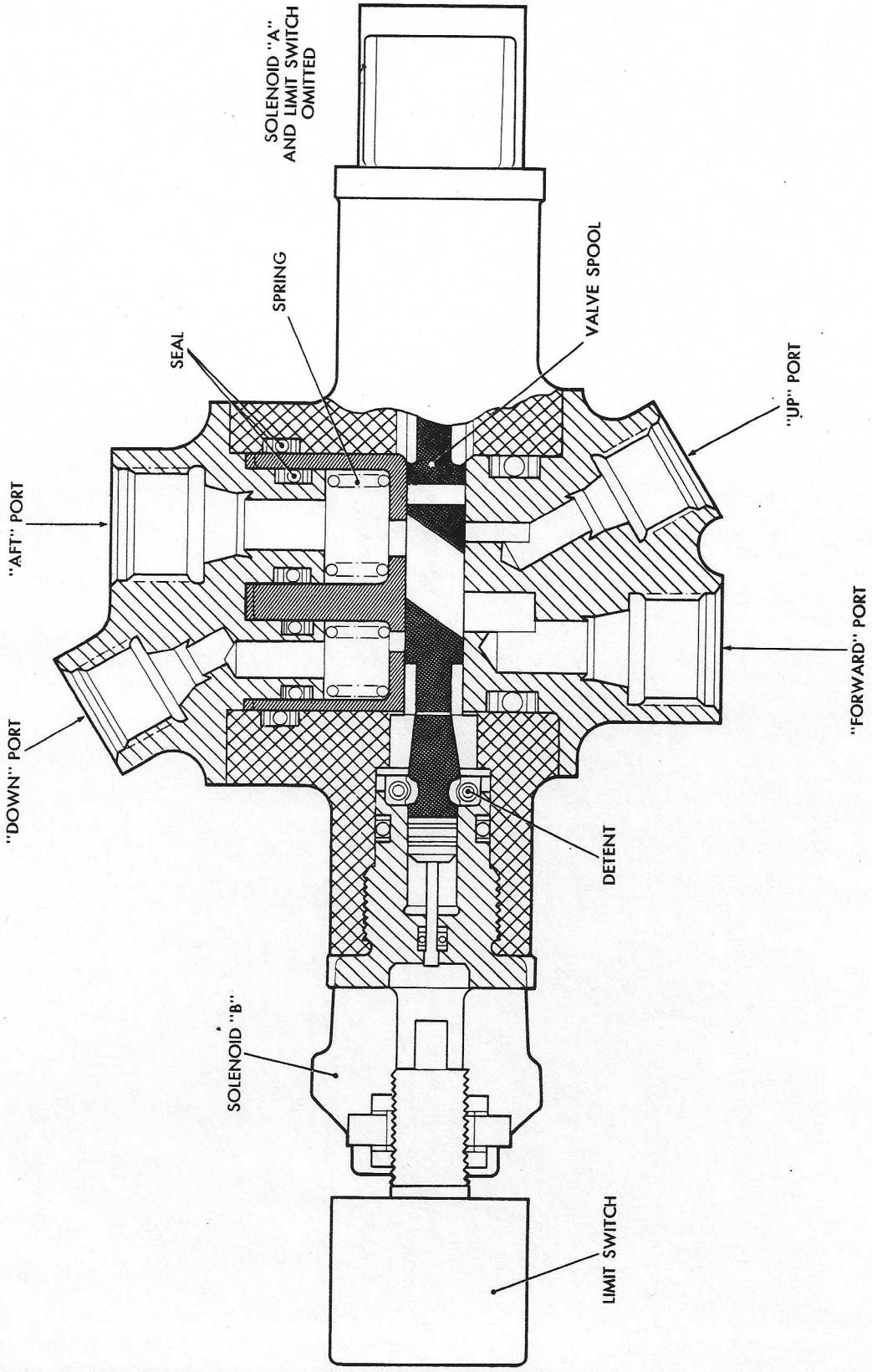

FIG. 4 COMPENSATING VALVE

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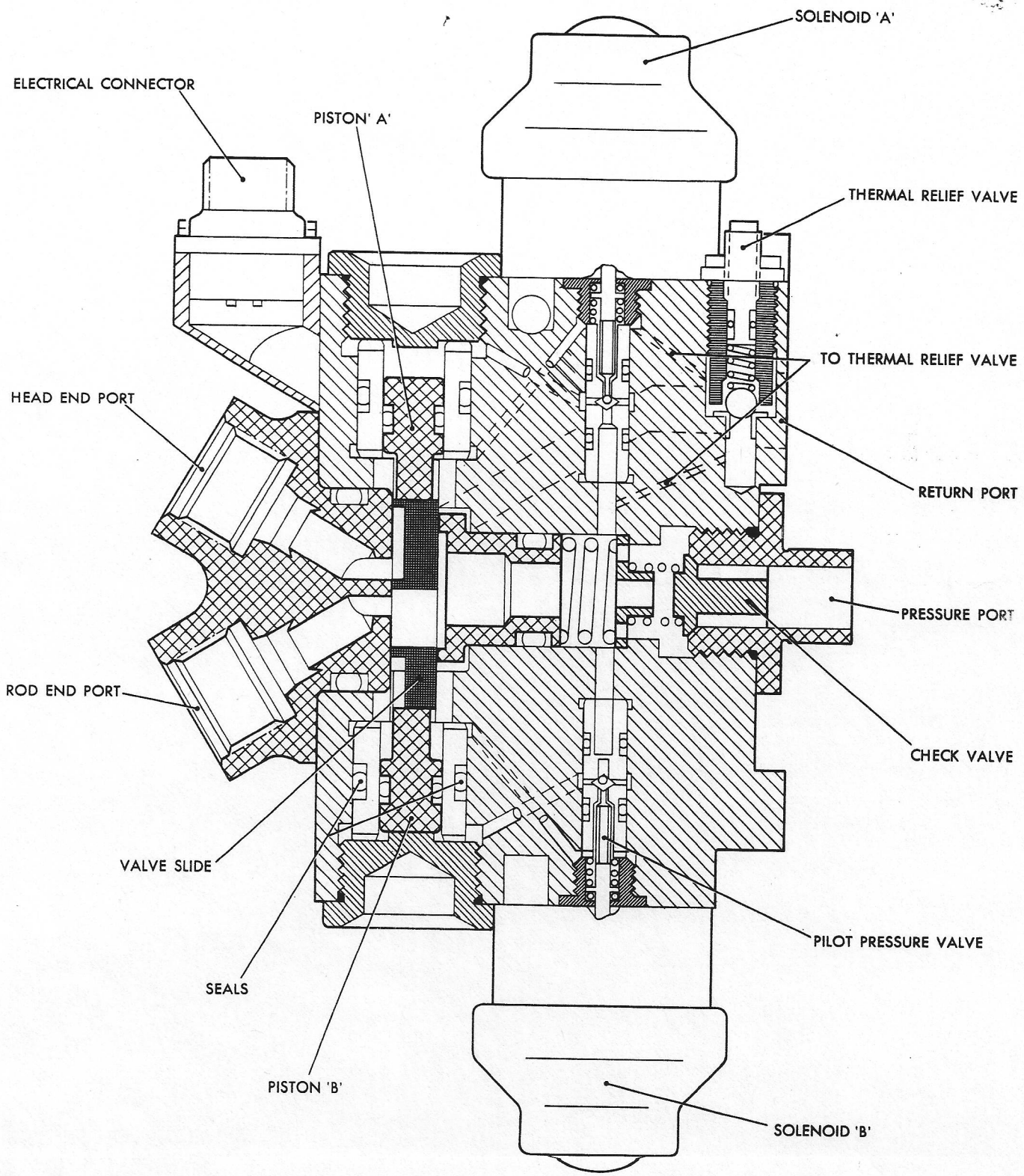

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FIG. 5 SELECTOR VALVE

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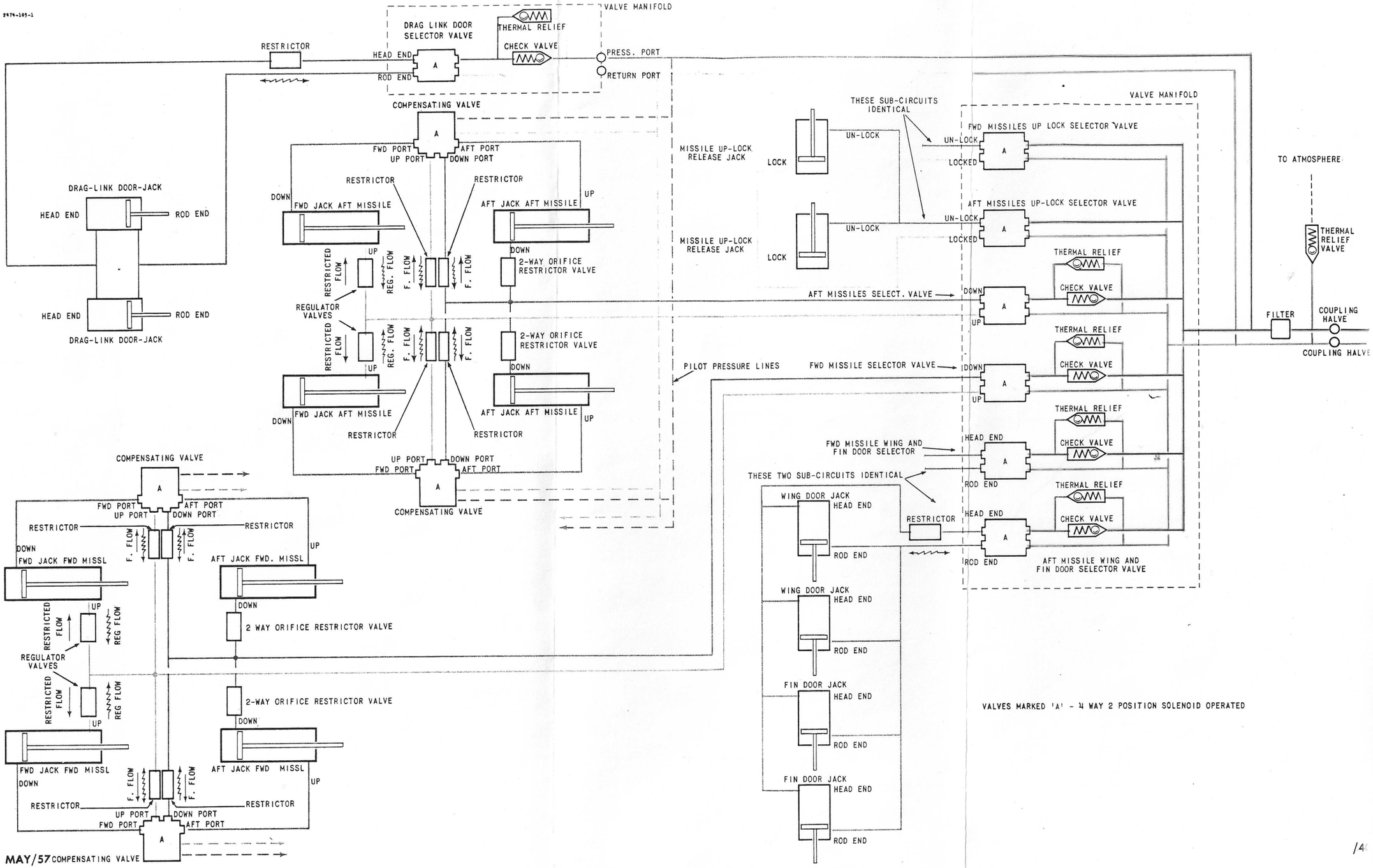

FIG. 6 SCHEMATIC, MISSILES EXTENDING IN SERIES - DOORS OPENED

VALVES MARKED 'A' - 4 WAY 2 POSITION SOLENOID OPERATED

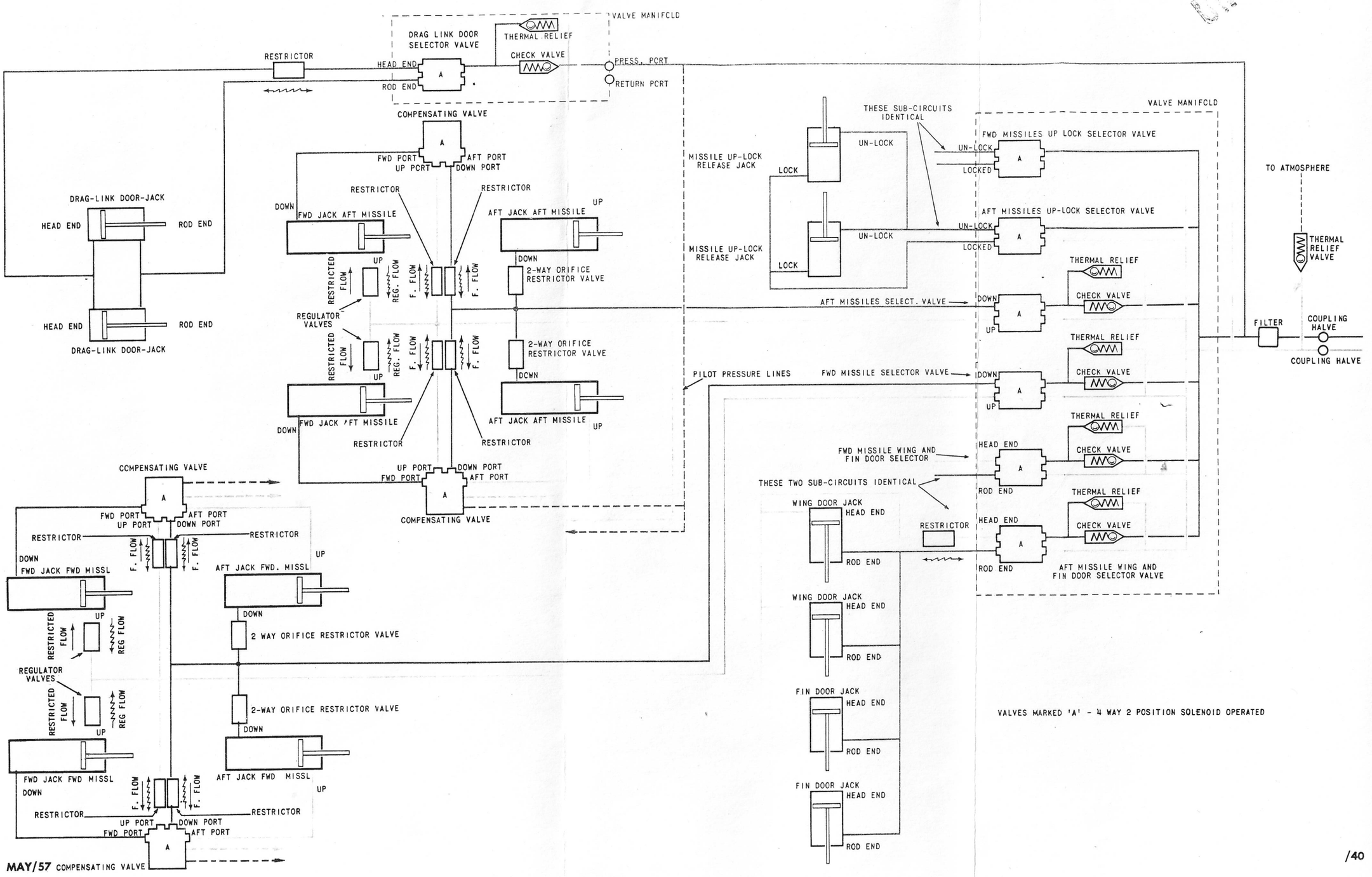

FIG. 7 SCHEMATIC, MISSILES EXTENDING IN PARALLEL - DOORS CLOSING

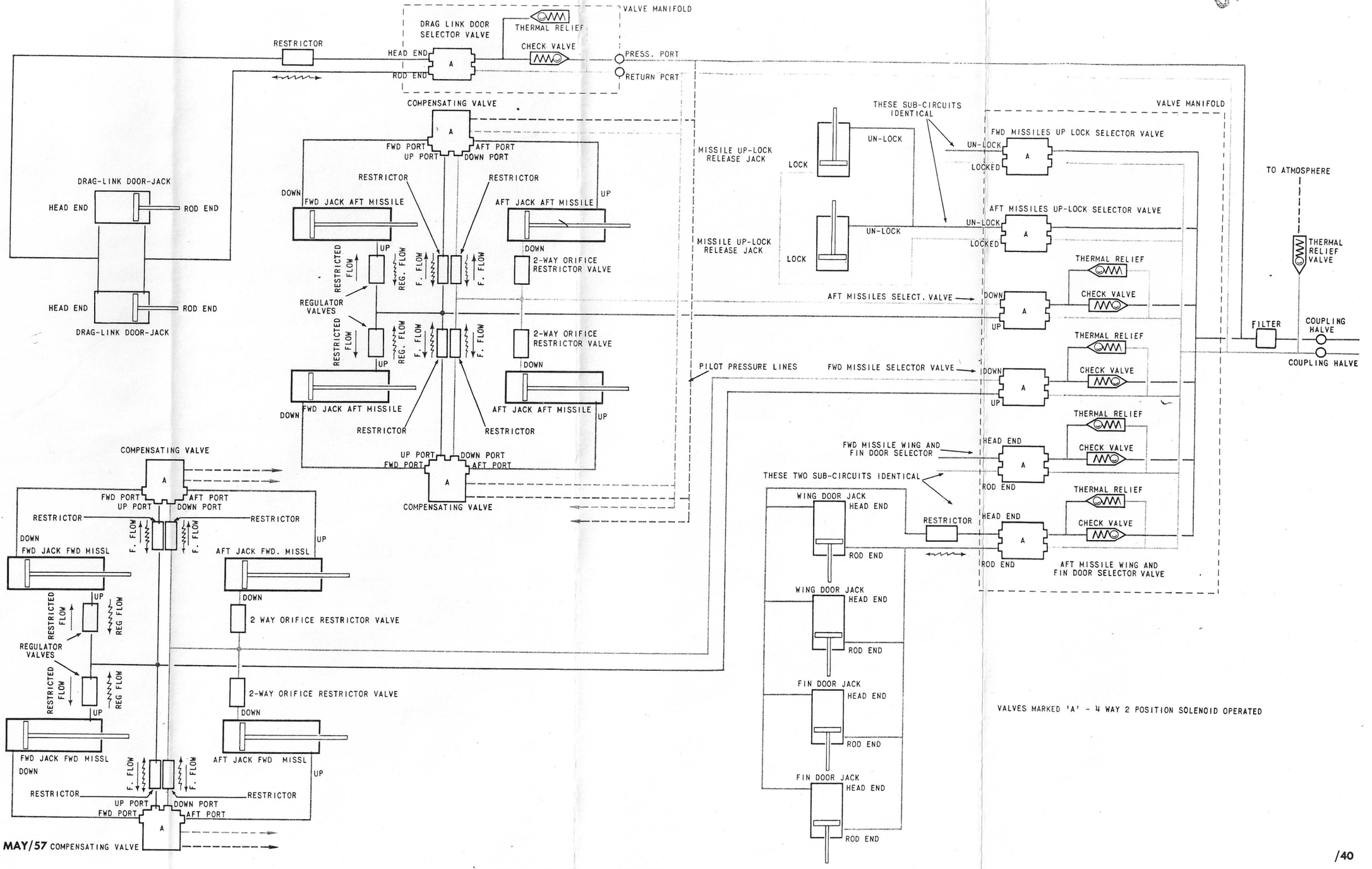

FIG. 8 SCHEMATIC, MISSILES RETRACTING IN SERIES - DOORS OPENED

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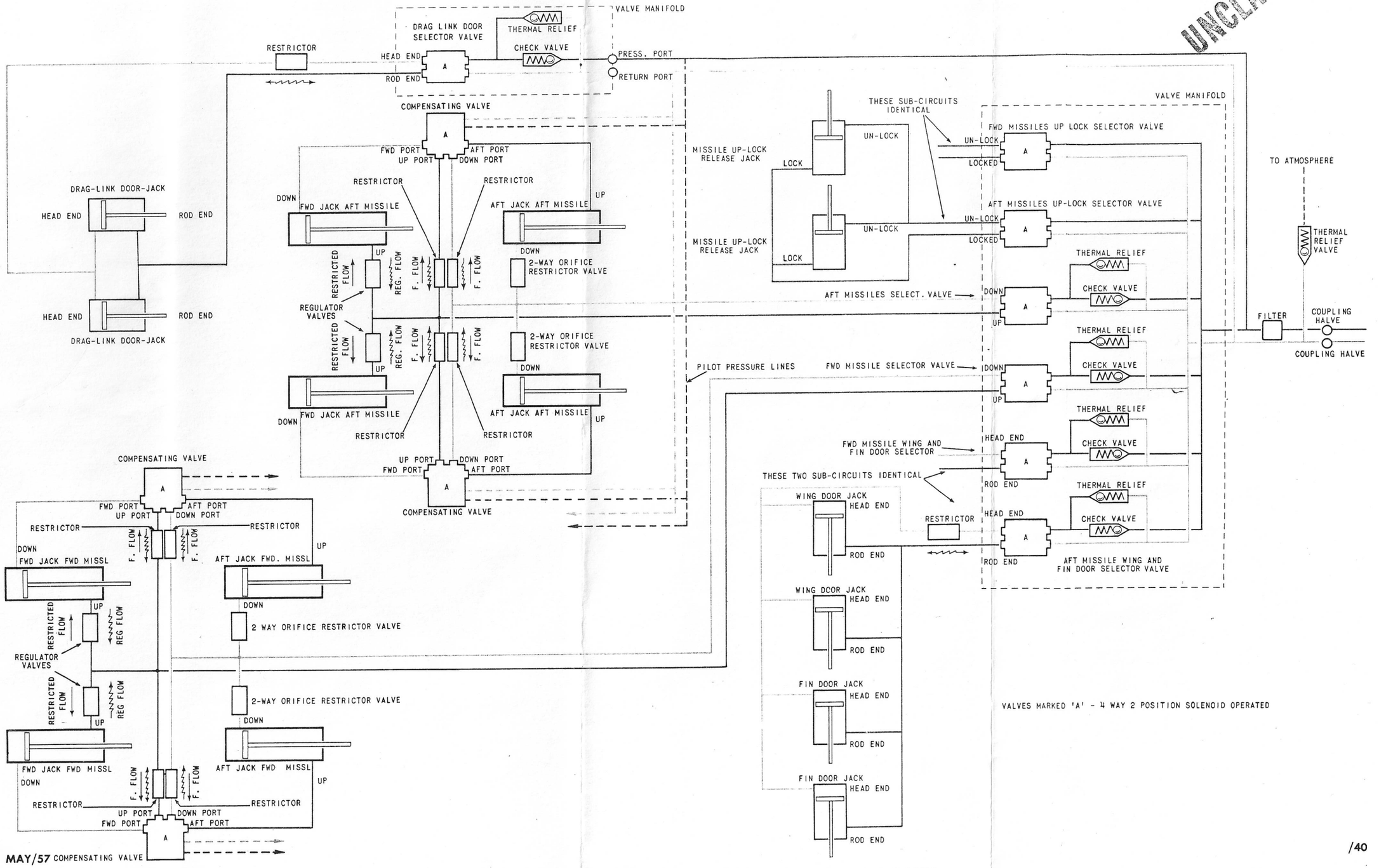

FIG. 9 SCHEMATIC, MISSILES OR LAUNCHERS RETRACTING IN PARALLEL - DOORS CLOSING

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2489-105-1

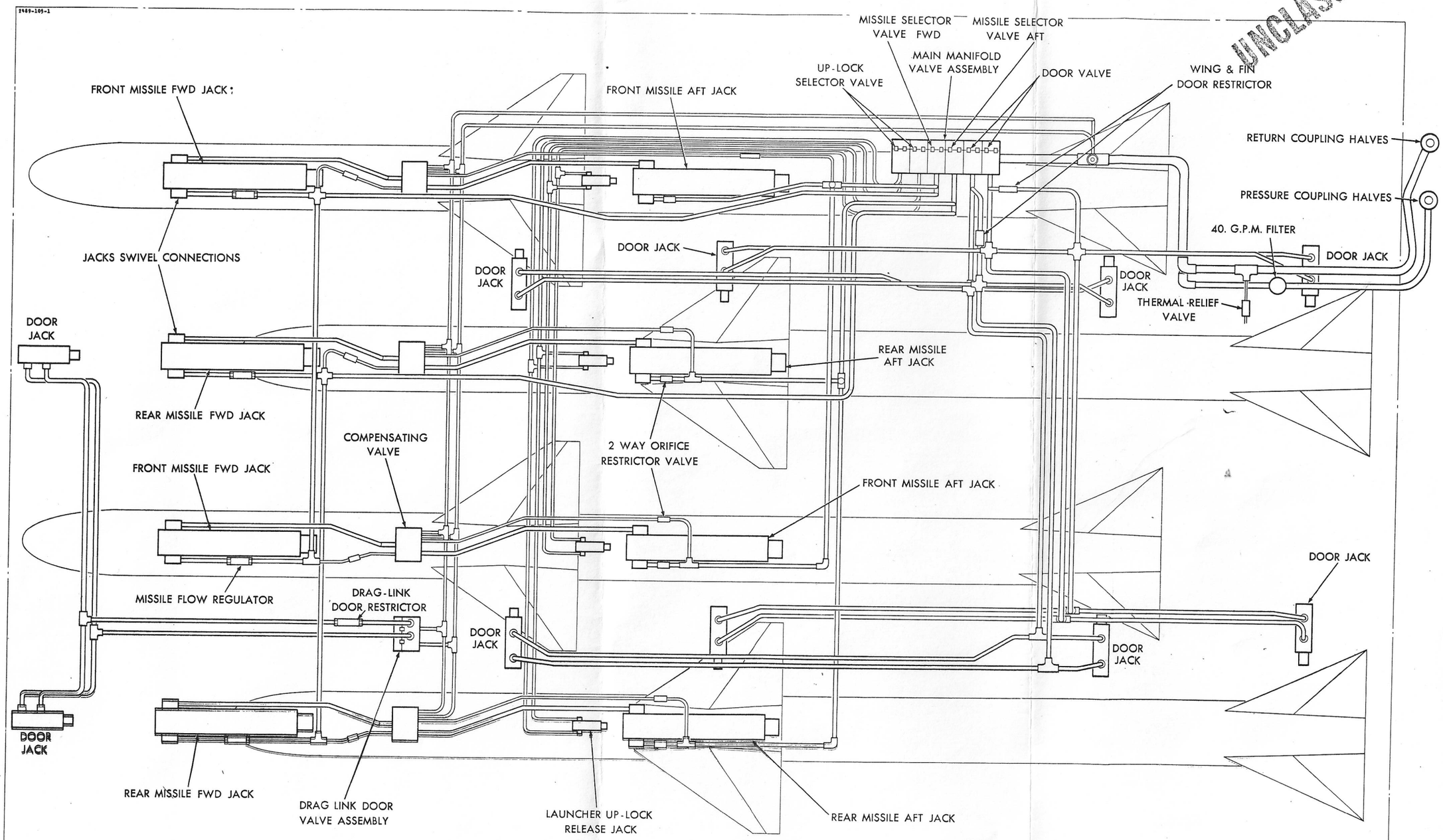

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FIG. 10 DIAGRAMMATIC OF ARMAMENT HYDRAULICS