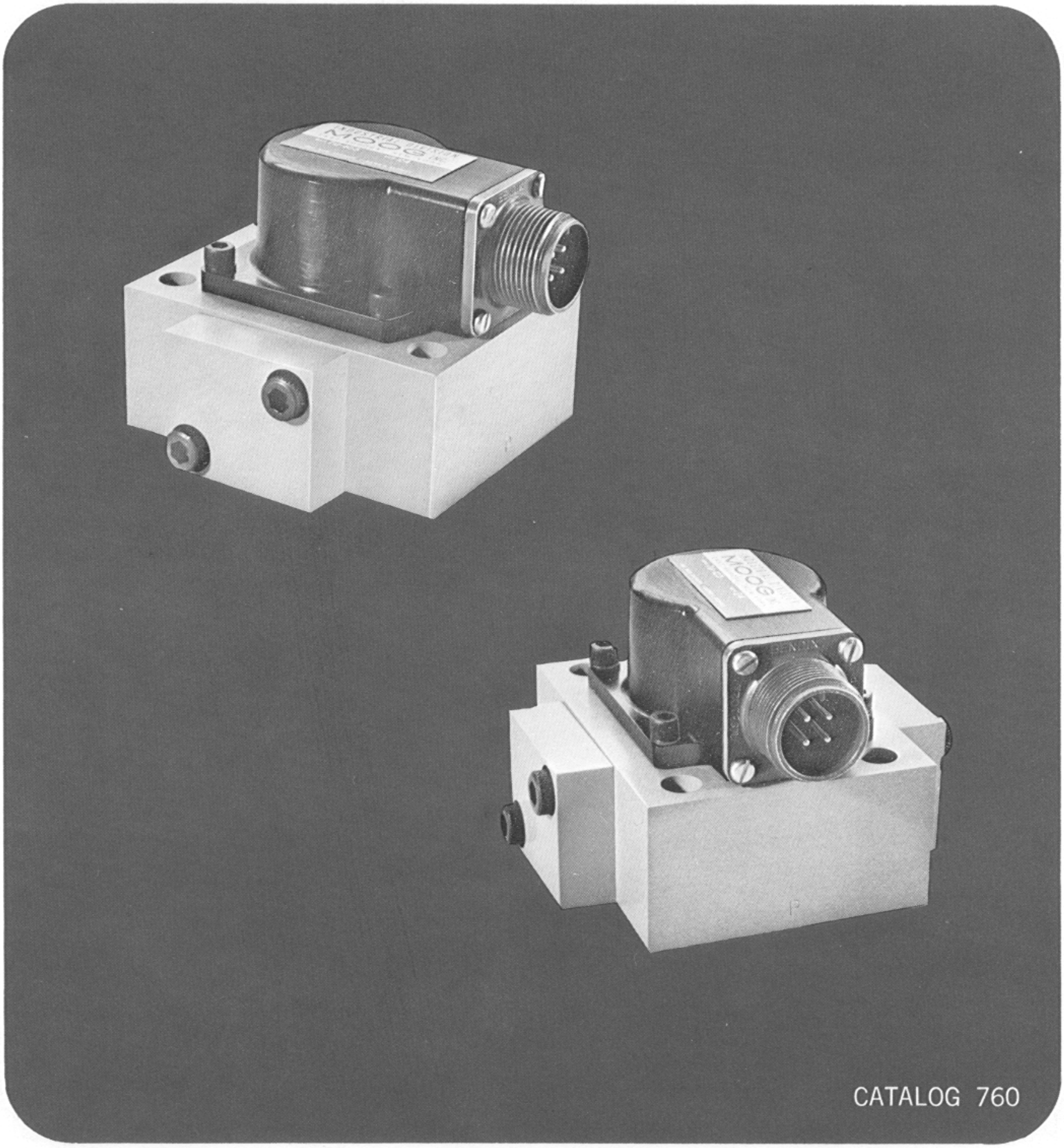
MOOG
INDUSTRIAL DIVISION

Series 76 Flow Control Servovalves



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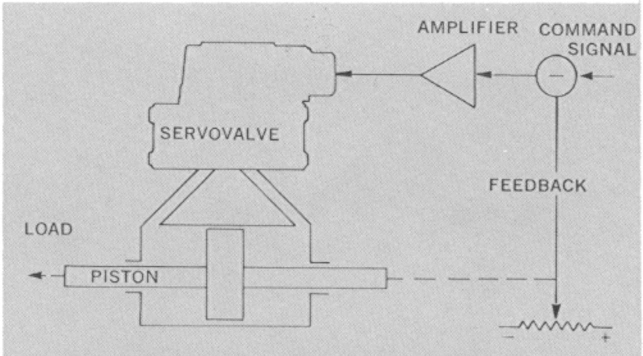
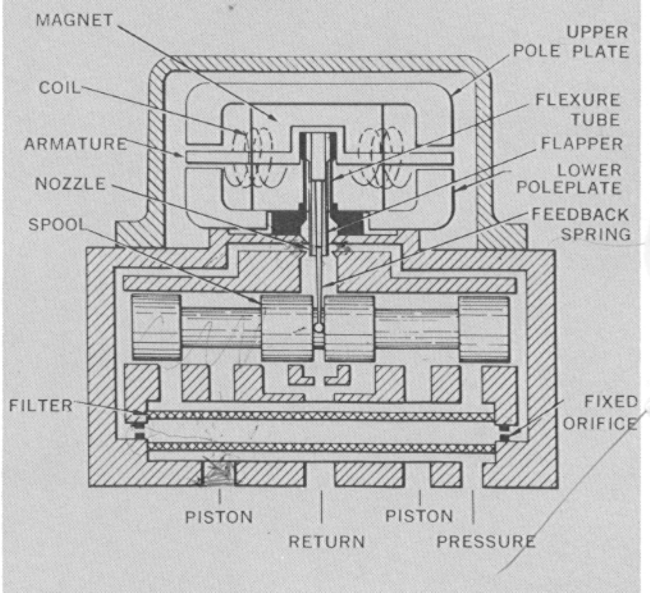


In a conventional closed-loop position control system, valve flow is applied to a hydraulic piston which drives the load. Load position is measured electrically and fed back for comparison with a signal representing the desired position. The resulting error signal is amplified, providing current input to the valve to control flow.

Industrial Series 76 Flow Control Servovalves

The MOOG Series 76 Servovalves are low cost, field serviceable, flow control industrial valves with a wide range of application in automatic control of industrial equipment.

The MOOG Series 76 Industrial Servovalves are pilot operated, closed center, four-way sliding spool valves in which the output flow to a constant load is proportional to electrical input current. The servovalves are normally used in closed loop position, velocity and force systems to provide precise, fast response control at high power levels. Designed specifically for industrial use, Series 76 servovalves embody in excess of 15 years of MOOG experience as the leading supplier of two-stage servovalves.



Design Features:

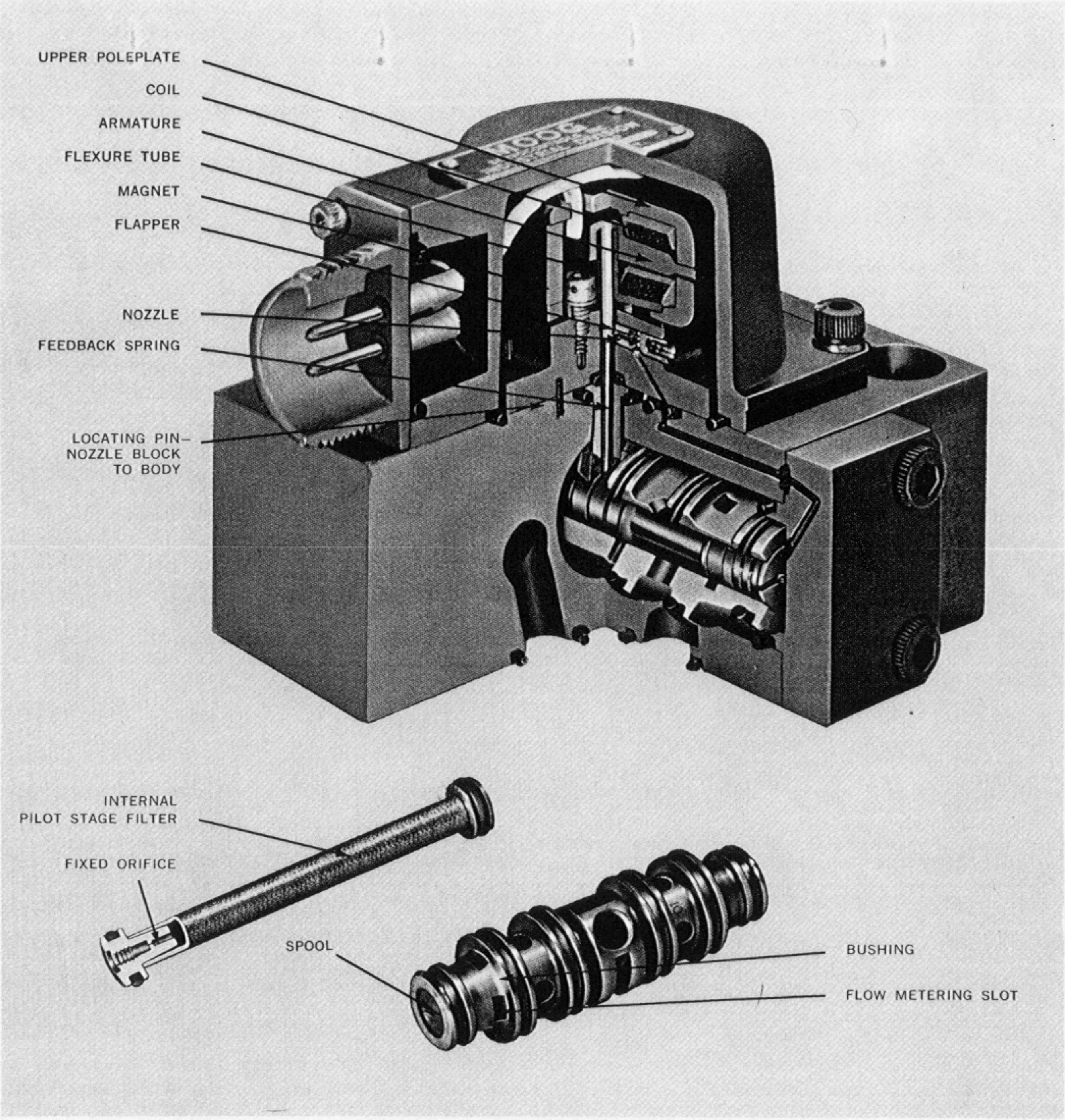
Outstanding design features of the Series 76 Servovalve include:

- Internal mechanical feedback with simplicity of parts.
- "Rate-cancelled" frictionless, nozzle-flapper pilot stage.
- Torque motor sealed in air to isolate magnetic fields from fluid.
- Flow to pilot stage filtered by internal 35 micron filter. External surface of filter is flushed by 2nd stage flow.
- Motor coils protected during thermal and vibration extremes by resilient potting.
- Spool-bushing diametral tolerances held within 10 microinches . . . for reduced dirt susceptibility. Mating surfaces finished to 2-5 microinch smoothness.
- Rugged construction to withstand industrial usage.
- Complete design symmetry for minimum thermal null shift. Bushing retained by center pin.
- External null adjustment provided.

Operation:

Moog Series 76 industrial servovalves consist of a polarized electrical torque motor and two stages of hydraulic power amplification. The motor armature extends into the air gaps of the magnetic flux circuit and is supported in this position by a flexure tube member. The flexure tube acts also as a seal between the electromagnetic and hydraulic sections of the valve. The two motor coils surround the armature, one on each side of the flexure tube.

The flapper of the first stage hydraulic amplifier is rigidly attached to the midpoint of the armature. The flapper extends through the flexure tube and passes between



two nozzles, creating two variable orifices between the nozzle tips and the flapper. The pressure controlled by the flapper and nozzle variable orifice is fed to the end areas of the second stage spool.

The second stage spool is a conventional four-way sliding spool design in which output flow from the valve, at a fixed valve pressure drop, is proportional to spool displacement from the null position. A cantilever feedback spring is fixed to the flapper and engages a slot at the center of the spool. Displacement of the spool deflects the feedback spring which creates a torque on the armature/flapper assembly.

Input signal induces a magnetic charge in the armature and causes a deflection of the armature and the flapper. This assembly pivots about the flexure tube and increases the size of one nozzle orifice and decreases the size of the other. This action creates a differential pressure from one end of the spool to the other and results in spool displacement. The spool displacement causes a torque in the feedback wire which opposes the original input signal torque. Spool movement continues until the feedback wire torque equals the input signal torque.

General Characteristics

The information presented is intended as a guide for the specification of valve characteristics. Stock models are available in each series built to specifications representative of usual system requirements. Improvement of certain characteristics can be achieved on special order, although generally at the expense of others.

Operating supply pressure	50-3000 psi
Proof pressures at pressure port	150% supply
at return port	100% supply
Burst pressure (return open)	250% supply
Temperature range	—65° F to 275° F
External Leakage	none
Fluid	Petroleum base hydraulic fluid. Others on special order.
System Filtration	10 microns recommended
Weight	1.7 pounds

Flow Gain and Nonlinearity tolerances are most practically specified by an envelope on a plot of load flow versus current input. Figure 1 shows normal flow tolerances for production valves. Some saturation occurs as the high flow limit of the series is reached. Flow gain at null is determined by the relationship of the spool and bushing metering edges, and may vary somewhat from valve to valve. With standard production tolerances, flow gain in the region of ±5% rated current from null may range from 50 to 200% of the nominal flow gain. Valve flow gain will vary with such operating variables as temperature and supply pressure.

Load Flow—Pressure Characteristics are essentially parabolic, see Fig. 2. With the mechanical feedback design, these characteristics closely approximate the theoretical square-root orifice relationship of the second-stage flow metering slots.

Null Leakage is composed of first-stage flow and second-stage null leakage flow. This leakage is generally less than 3% of rated flow.

Pressure Gain at null normally exceeds 30% of supply pressure for 1% of rated current and can be as high as 80%

Null Shift may be specified for particular environmental variables as listed below.

		Max. Null Bias
Temperature	100° change	2%
Supply Pressure	80% to 110%	2%
Back Pressure	0% to 20% of supply	2%

Frequency Response for typical valves is shown in Figure 3. For system design, valve response can be approximated by a second-order transfer function. The apparent natural frequency will be about 140 cps and a damping ratio of about 0.9 would apply. Frequency response is somewhat dependent on signal amplitude, temperature and supply pressure.

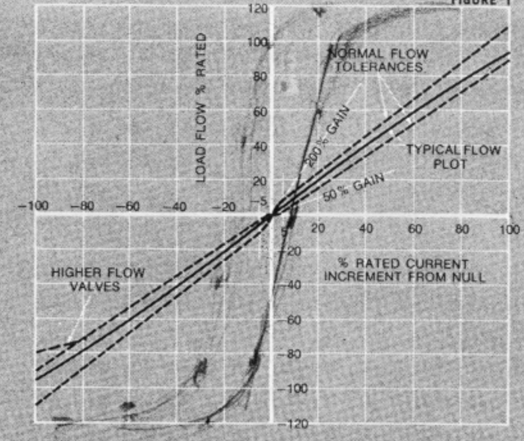
Resolution is less than 0.5% of rated signal without dither. If dither is used, peak-to-peak amplitudes less than 20% of rated current are recommended.

Input Current is normally considered to be differential current between the two motor coils. Quiescent current levels from zero to twice rated current may be used. The coils may be operated in series or parallel aiding with zero quiescent current. With a series coil connection, full valve output will be achieved with one-half rated differential current input. Valves may be supplied with a range of rated currents from 8 ma to 200 ma. Stock valves are supplied with rated currents of 15 ma and 40 ma.

Coil Resistance and Inductance values vary with rated current specified. Stock valves are supplied with coil resistance of 80 and 200 ohms and approximate inductance of 0.8 and 1 henry, respectively. Production tolerance on coil resistance is normally ±12%. Inductance is determined under pressurized operating conditions and is greatly influenced by back emf's

Total per valve (wires)

FIGURE 1



NORMAL FLOW GAIN TOLERANCE

FIGURE 2

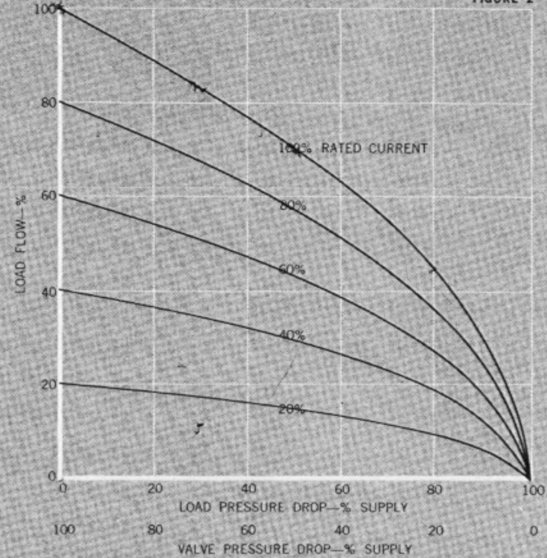
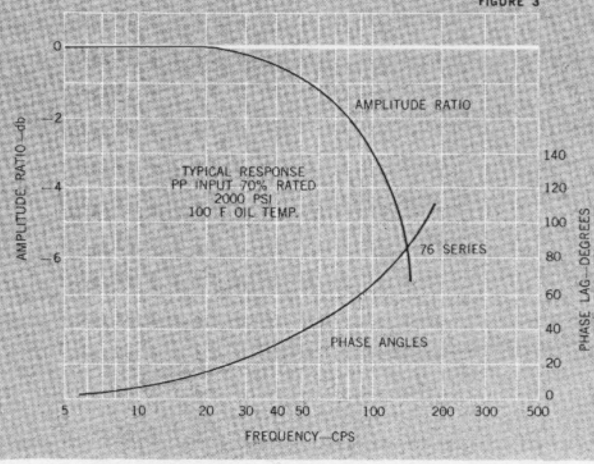


FIGURE 3



of the torque motor. These effects vary with most operating conditions and vary greatly with signal frequencies above 100 cps. Normally, the apparent inductance is determined at 50 cps.

Hysteresis is less than 3% of rated current.

Spool Driving Forces are dependent upon the supply pressure, and the hydraulic amplifier pressure gradient. Normal pilot stage configurations will produce spool driving force gradients which exceed 1.2 lbs/% input current, with a 2000 psi supply. Under these conditions, maximum spool force is 110 lbs.

Servovalve Terminology

Rated Flow The load flow specified for conditions of rated valve pressure drop and rated current input. Expressed as cu.in/sec [cis] or gal/min [gpm].

Rated Current The specified differential input current increment from null to produce rated flow. Expressed in milliamperes [ma].

No-load Flow Gain The slope of the no-load flow versus current input relationship in the region of essentially linear control [excluding null effects and flow saturation]. Expressed in cis/ma.

Symmetry The degree of equality between the normal flow gain of one polarity and that of the reversed polarity. Symmetry is measured as the difference in normal flow gain of each polarity, expressed as percent of the greater.

Linearity The degree to which the normal flow curve conforms to a straight line with other operational variables held constant. Linearity is measured as the maximum deviation of the normal flow curve from the normal flow gain line, expressed as percent of rated current.

Pressure Gain The change in load pressure drop with input current for a condition of zero load flow. Expressed as psi/ma.

Null The condition where the valve supplies zero load flow at zero load pressure drop.

Null Bias The input current required to bring the valve to null, excluding the effects of valve hysteresis. Expressed as percent of rated current.

Null Shift The change in null bias resulting from changes in operating conditions or environment. Expressed as percent of rated current.

Resolution Maximum increment of input current required to produce a change in the valve output flow. Expressed in percent of rated current.

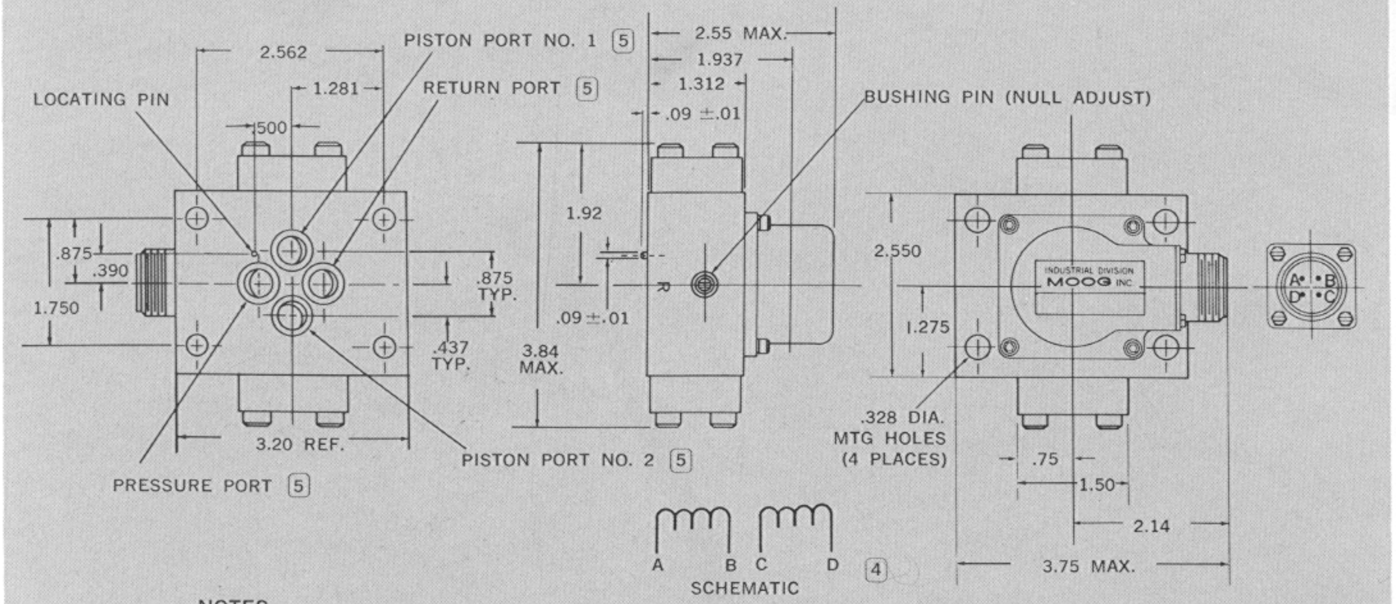
Hysteresis The difference in current required to produce the same output as the valve is cycled between rated positive and negative current. Expressed as percent of rated current.

Dither A small amplitude ac input sometimes utilized to improve system resolution.

Spool Driving Force Gradient The change in spool positioning force per unit current input. Measured with the spool blocked and expressed in pounds/percent of rated current.

Coil Impedance The complex ratio of coil voltage to coil current. Coil impedance will vary with frequency, signal amplitude, and other operating conditions, but can be approximated by the dc coil resistance and the apparent coil inductance measured at a signal frequency. If the valve coils are connected in series, mutual inductance will cause the total inductance to be approximately three times the inductance per coil.

Frequency Response The relationship of load flow with zero load pressure drop to input current when the current is made to vary sinusoidally at constant amplitude over a range of frequencies. Frequency response is given in terms of amplitude ratio, expressed in db, and phase angle, in degrees.



NOTES:

1. Suggested mounting screws 5/16—18 X 2" long socket head cap screw.
2. Fluid: Industrial type petroleum base hydraulic fluid, 10 micron (25 absolute) filtration recommended.
3. Operating temperature range: 65° F to +275° F.
4. Valve phasing: Flow out of port No. 2 will result when: Series operation: B and C connected together, A plus, D minus, push-pull operation: B and C plus, A and D minus, current C-D > B-A.
5. Ports: 312 dia. C bored nominally. 380 ID X .562 OD X .055 deep.
6. Replace 4 shipping O-rings with MS 28775-013 (.070 sect X .426 ID.) when installing valve.
7. Surface to which valve is mounted requires 32 RMS finish, flat within .001.
8. Electrical connector mates with MS 3106-14S— 2S or equivalent.
9. Null adjust: Flow out of port No. 2 is obtained with clockwise rotation of null adjust pin.

Series 76 Stock Servovalves

MOOG maintains a stock of Series 76 servovalves in five different models. These models cover the range of flow output from 1 to 15 gpm (at 1000 psi). Characteristics of each model are controlled for optimum system performance in usual application. These stock valves are made in production quantities, so each user gains the cost and technical advantages of an established production design.

For those systems that do not require some unusual performance feature, stock valve offers these advantages:

- Immediate delivery
- Decreased cost
- Established and production proven performance

Available From Stock in Five Sizes

Model No.	Rated Flow (1000 psi drop) (gpm)	Rated Input Signal (differential current) (ma)	Coil Resistance (ohms ±12%)
76-100	1	15	200
76-101	2.5	15	200
76-102	5	15	200
76-103	10	15	200
76-104	15	40	80