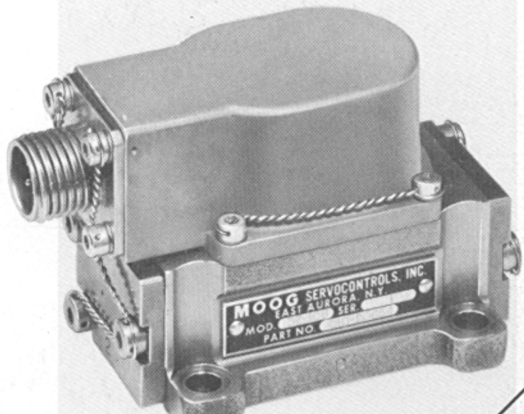
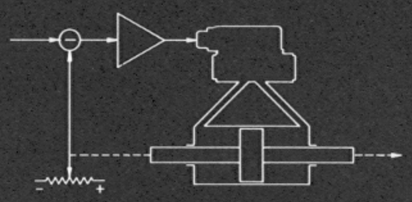
CATALOG 310-A



MOOG

SERIES 31 AND 32 FLOW CONTROL SERVOVALVES . . .

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

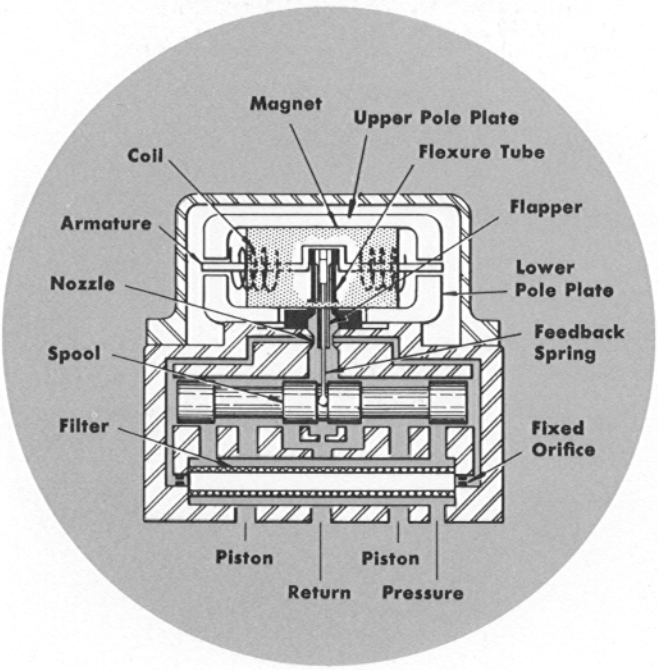


INTRODUCTION The NEW Series 31 and 32 servovalves are miniaturized two-stage flow-control valves which utilize internal mechanical feedback. Features of the new design include high performance, simplification and compactness, together with a wide temperature capability.

Series 31 and 32 valves are well suited to applications requiring precise control at high power levels. These applications include flight control systems for military aircraft and missiles, nuclear reactor control devices, and a wide range of industrial installations where small size together with high performance are essential.

The Series 31 and 32 valves differ only in the diameter of the hydraulic port circle and the size of the second-stage sliding spool. A larger spool and port circle diameter are used in the 32 Series valves, giving a greater maximum flow capacity. The smaller spool of the Series 31 valves contributes to a higher dynamic response.

MOOG FLOW CONTROL SERVOVALVES



OPERATION

Moog Series 31 and 32 servovalves consist of a polarized electrical force motor and two stages of hydraulic power amplification. The polarizing magnetic flux circuit is formed by upper and lower pole plates supported by two Alnico magnets. The motor armature extends between 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. Two torque motor coils are located about the armature, one on either side of the flexure tube.

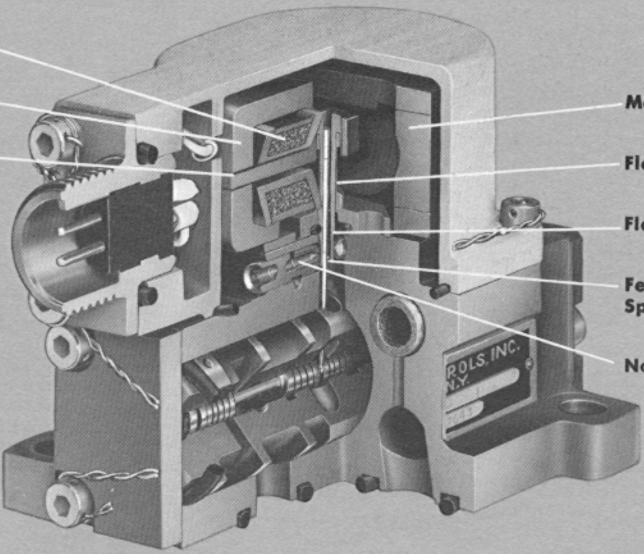
Rigidly attached to the armature at the flexure tube support point is the flapper of a hydraulic amplifier. The flapper extends through the tubular flexure member and passes between two nozzles, creating two variable orifices between the nozzle tips and the flapper. Pressure oil is supplied to these orifices through two fixed upstream orifices. The intermediate pressures developed are applied to either end of the output stage sliding spool.

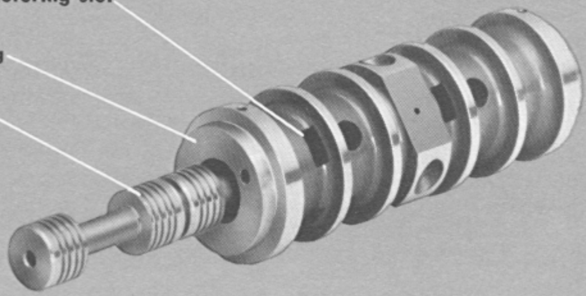
The spool is of a conventional four-way design so output flow from the valve, at a fixed valve pressure drop, is proportional to spool displacement. A cantilever-spring feedback element relates spool displacement to torque at the motor armature. This feedback spring is fixed to the armature-flapper assembly at the flexure tube support point. The free end of the spring extends through the flapper to engage a slot at the center of the spool.

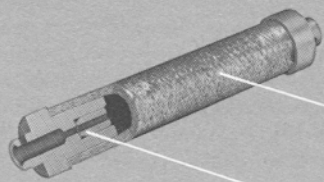
As signal is applied to the motor coils, a torque is developed upon the armature, causing it to pivot about the flexure tube support. The resulting motion at the flapper causes one nozzle orifice to open as the other closes. In consequence, flow is directed towards one end of the sliding spool causing spool displacement. As the spool moves from the centered position, a torque proportional to spool displacement is applied to the armature by the feedback spring. This torque opposes that developed by the motor and a condition of torque equilibrium will exist when the feedback spring torque equals the electrical motor torque.

By a method of rate cancellation, the centering spring rate of the flexure tube is essentially offset by the decentering action of the permanent magnet motor. With the resulting condition of zero effective spring rate, the flapper is free to move so as to create a balance between the input and feedback torques. Balance of these torques produces spool displacements proportional to electrical input signals.

SERIES 31 AND 32







- Internal mechanical feedback arrangement yields a simplicity of parts.
- "Rate-Cancelled", frictionless, nozzle-flapper hydraulic amplifier.
- Torque motor sealed in air.
- Magnetic fields isolated from fluid-filled areas.
- Torque motor essentially insensitive to the presence of external magnetic objects.
- Flow to first-stage hydraulic amplifier filtered by a single large-capacity 20 micron filter element.
- Mass-balanced armature-flapper assembly.
- Motor coils protected during thermal and vibration extremes by resilient potting.
- Spool-bushing diametral clearance maintained within ± 10 millionths of design clearance for reduced dirt susceptibility. Mating surfaces finished to 2 - 5 microinch smoothness.
- Compact and rugged to withstand acceleration extremes.
- Complete design symmetry for minimum thermal null shift.
- No valve centering adjustment required.
- Stainless steel in all fluid areas, optional.
- Metallic seals for operation to 600° F oil and ambient, optional.

characteristics of SERIES 31 and 32 servovalves

The information presented below is intended as a guide for the specification of particular valve characteristics. Improvement of certain characteristics can usually be achieved, although generally at the expense of others. Individual model data sheets will serve to illustrate typical design compromises.

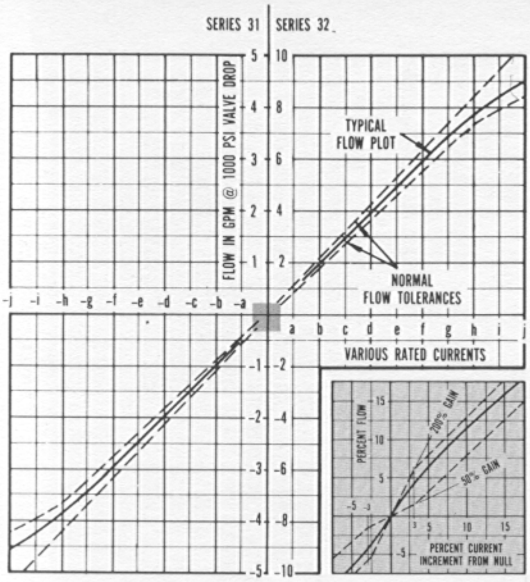


FIGURE 1

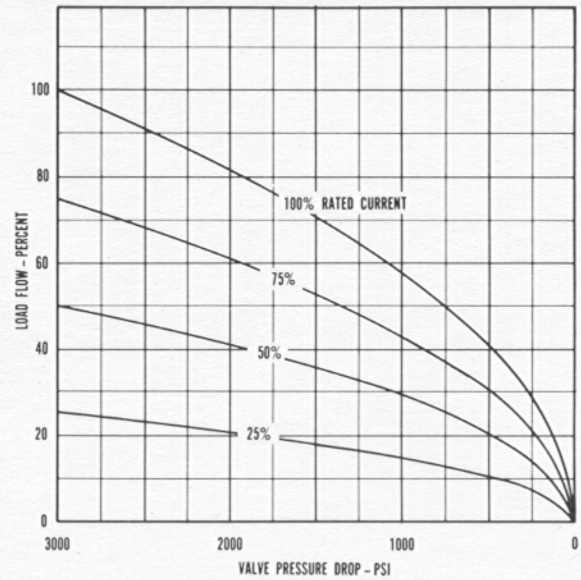


FIGURE 2

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 valves with various maximum flow capacities. The points a, b, - - - j correspond to rated currents for valves of increasing flow capacity. The rated current value in milliamperes may be selected throughout the range indicated in Figure 4. Valves may be supplied with maximum flow capacities somewhat above the nominal maximums of 4 gpm and 8 gpm (at 1000 psi valve drop) for the Series 31 and 32 valves, respectively. With higher flows some saturation occurs, as indicated by the tolerance envelope of Figure 1. 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 ± 3% rated current input 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. Over the temperature range from —20°F to 350°F a flow gain change of 10% may result. Supply pressure variations from 1000 to 3000 psi will cause less than 5% change from the normal parabolic flow-pressure relationship.

LOAD FLOW-PRESSURE CHARACTERISTICS are essentially parabolic throughout the entire operating range, as illustrated in Figure 2. With the mechanical feedback design, these characteristics closely approximate the theoretical square-root orifice relationship of the second-stage flow metering slots.

NULL PRESSURE GAIN normally exceeds 30% of supply pressure for 1% of rated current and can be as high as 80%.

NULL LEAKAGE is composed of first stage flow and second stage null leakage flow. Normal first stage flows are less than 0.3 cis. Increased first stage flows permit higher frequency response. Second stage null leakage flow is related to the maximum valve flow at rated system pressure and is normally maintained less than 5% of this flow.

NULL SHIFT may be specified for particular environmental variables as listed below.

	Range	Max. null bias
Temperature	—65°F to 350°F	4%
Acceleration	to 50 g	5%
Supply pressure	80% to 110%	2%
Quiescent current	50% to 200% rated current	2%
Back pressure	0% to 20% of supply	2%

SERVOVALVE

RATED FLOW 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).

NOMINAL FLOW GAIN Slope of a line connecting the origin to the rated flow — rated current point on a plot of load flow vs. input current at constant valve pressure drop. Expressed as cis/ma or gpm/ma.

FLOW NONLINEARITY Deviation of load flow curve, at any current, from a straight line drawn through the null point with a slope equal to the nominal flow gain. Expressed in percent of rated flow.

NULL Position of the second-stage spool which produces zero differential load pressure and zero load flow.

NULL PRESSURE GAIN Slope at null of a plot of load differential pressure vs. input current with zero load flow. Expressed as psi/ma.

NULL BIAS CURRENT Input current required to bring the valve to null. Null bias current is a function of valve hysteresis, temperature, applied acceleration, and supply and return pressures. Expressed in ma or percent of rated current.

NULL SHIFT Change in null bias current required as a result of a change in environmental parameters. Null shift can be specified for changes in temperature, pressure, acceleration, quiescent current, etc. Expressed as percent of rated current.

GENERAL CHARACTERISTICS

		valve pressure drop 1000 psi	valve pressure drop 3000 psi
Maximum rated flow	Series 31	4 gpm	7 gpm
	Series 32	8 gpm	14 gpm
Operating supply pressure		50 psi to 4000 psi	
Proof pressure		6000 psi pressure port	
		4500 psi return port	
Burst pressure (return open)		10,000 psi	

Temperature range (fluid and ambient)	—65°F to 350°F standard, to 450°F or to 600°F on special order
Electrical signal power (approximate)	40 milliwatts maximum
External leakage	None
Fluid	Hydraulic or pneumatic to specification
Recommended system filtration	10 microns
Weight (approximate)	0.75 pounds

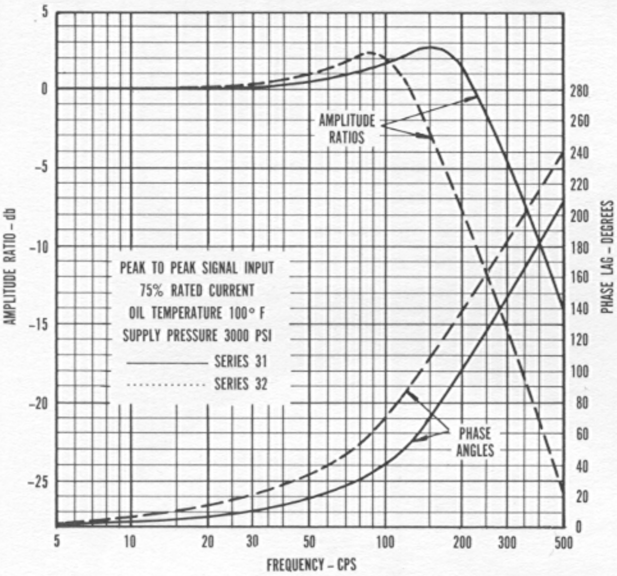


FIGURE 3

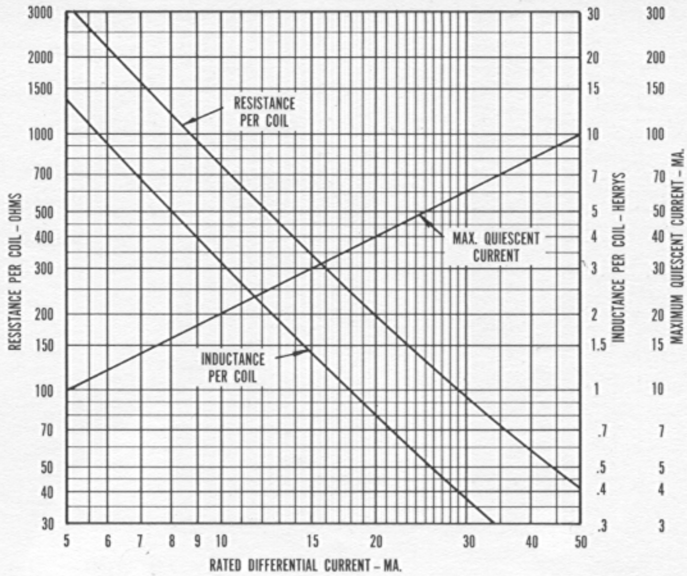


FIGURE 4

FREQUENCY RESPONSE is most practically defined by limit curves, and will approximate the responses indicated in Figure 3. For system design, Series 31 and 32 valve response can be approximated by a second-order transfer function. The apparent natural frequency will be about 180 cps and 120 cps for the Series 31 and 32 valves, respectively. A damping ratio of about 0.5 would apply to each response. Frequency response is somewhat dependent on signal amplitude, temperature and supply pressure.

SPOOL DRIVING FORCE GRADIENT will generally exceed 1½ pounds/percent input current on both the Series 31 and 32 valves. Maximum spool driving force will depend upon the supply pressure. With a 3000 psi supply, the maximum spool driving forces will be 55 pounds and 110 pounds for the Series 31 and 32 valves, respectively.

RESOLUTION is normally less than 0.5% of rated current without input dither. If dither is used, peak-to-peak amplitudes less than 20% of rated current are recommended. With the higher temperature valves, resolution will be somewhat greater at elevated temperatures.

INPUT CURRENT is normally considered to be the differential current between the two motor coils. Quiescent current levels from zero to approximately 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 as indicated in Figure 4.

COIL IMPEDANCE expressed as the resistance and inductance for each coil is indicated in Figure 4 for various rated currents. Both coils are identical, with production tolerances on coil resistance normally ±10% Inductance is determined under pressurized operating conditions and is greatly influenced by reflected hydromechanical impedance. At signal frequencies below 100 cps, inductance is essentially linear.

HYSTERESIS is normally less than 3% of rated current. With valves supplied for the higher temperature ranges, hysteresis will be somewhat greater.

TERMINOLOGY

FREQUENCY RESPONSE Relationship of output flow (at zero load pressure) to input current when the current is made to vary sinusoidally at constant amplitude over a range of frequencies. Relationship is given in terms of amplitude ratio and phase angle. Amplitude ratio, expressed in db, is the ratio of flow amplitude at any frequency to that at a specified reference frequency (usually 5 cps). Response may vary with signal amplitude, so peak-to-peak current should be specified.

SPOOL DRIVING FORCE GRADIENT Change in spool positioning force per unit current input. Measured with the spool blocked and expressed in pounds/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.

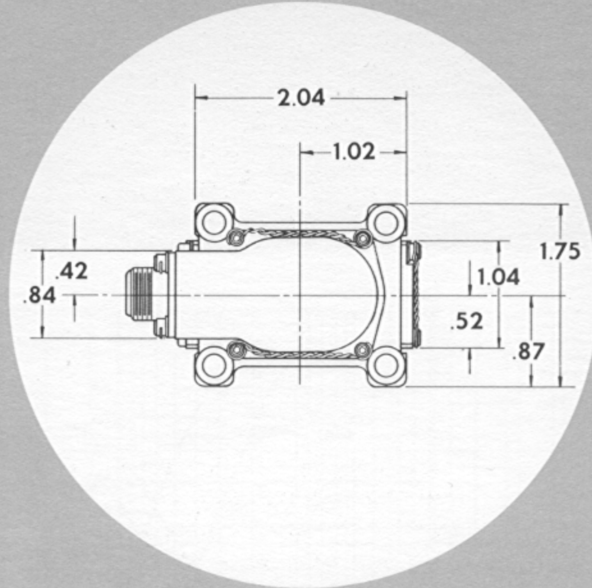
HYSTERESIS Total difference in differential currents required to produce zero flow as the valve is cycled between rated positive and negative current. Measured with zero load pressure and expressed as percent of rated current.

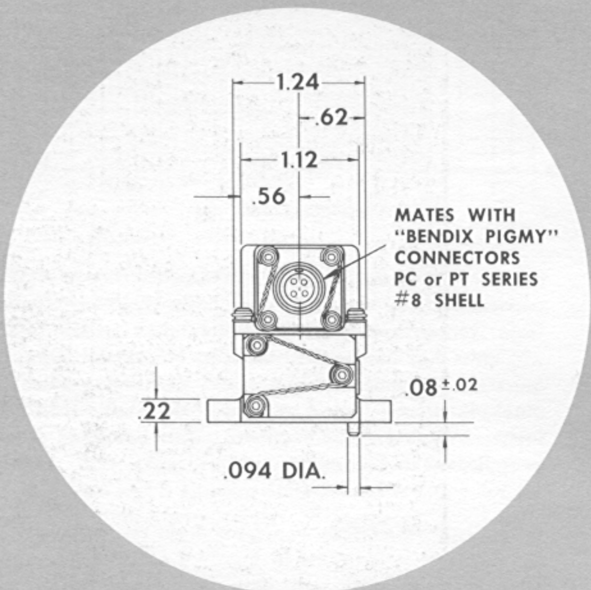
DITHER A small amplitude ac input current sometimes utilized to improve system resolution.

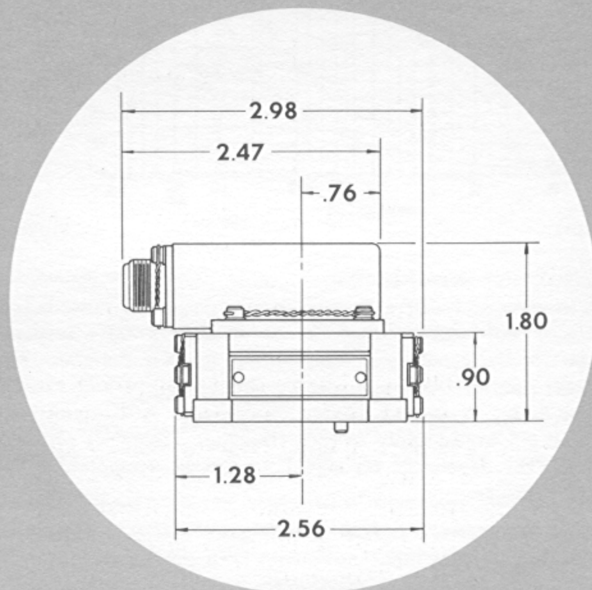
COIL IMPEDANCE The vector ratio of the ac voltage across a valve coil to the ac current through the coil. Coil impedance will vary with frequency, but can be approximated by the dc coil resistance and the apparent coil inductance measured at a signal frequency (usually below 100 cps). If the valve coils are connected in a push-pull circuit, mutual inductance will cause the plate-to-plate inductance to be approximately three times the inductance per coil.

INSTALLATION

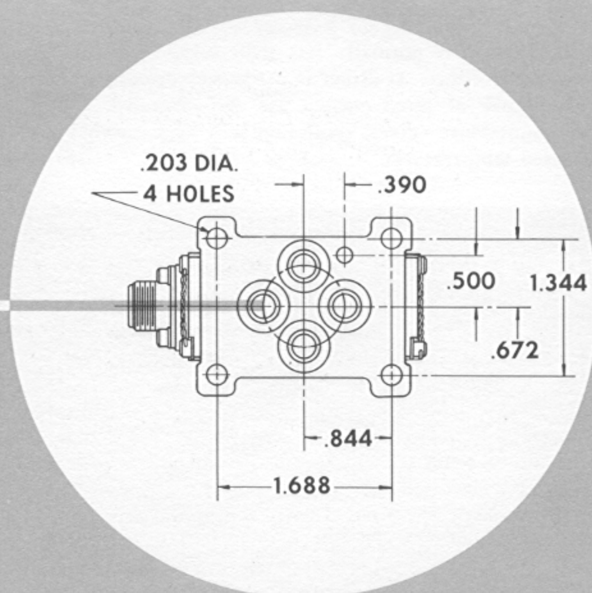
Valve motor cap may be reversed end for end. Alternate cap designs for side mounting electrical connectors are available. Valves may also be supplied with MS flange type connectors or pigtail leads.







	SERIES 31	SERIES 32
PORT CIRCLE DIAMETER	0.625 IN.	0.780 IN.
PORT DIAMETER	0.187 IN.	0.250 IN.



DESIGN

As missile programs passed from early development to production, servovalves of increased sophistication became necessary. Keeping pace with this development, Moog has been responsible for all major servovalve improvements.

FIRST

- Nozzle-flapper servovalves*
- Segmented Bushing*
- Double-nozzle servovalves*
- Dry motor servovalves†
- Volume producer of double-nozzle mechanical feedback servovalves†

PRODUCTION

Holding tolerances to millionths of an inch is a production skill which enables Moog to be the leading supplier of electrohydraulic servovalves. This precision production know-how has developed at Moog concurrently with the creation of basic electrohydraulic control components. Production to date of over 100,000 servovalves is vivid proof of a production capability which can support your quantity servovalve requirements.

RELIABILITY

Today, reliability is the key requirements for missiles. At Moog, product reliability is a major design consideration. Consequently, environmental testing is an integral part of product development.

Use of advanced inspection techniques and custom designed testing installations permit continuous monitoring of Moog's manufacturing processes. Moog's Quality Control has the tools to assure reliability through maintenance of high standards.

* patented

† patent pending

MOOG OFFERS...

A wide range of design variations in the 31 and 32 Series.

Many different models can be produced for specific applications.

Data sheets giving specifications of particular models are available.

Moog Servocontrols, Inc. and its field representative organizations will be pleased to work with engineering and purchasing personnel in developing valves for virtually any known or potential application.

Through its centralized design and production facilities, the company can readily supply valves to specification.

Contact . . .

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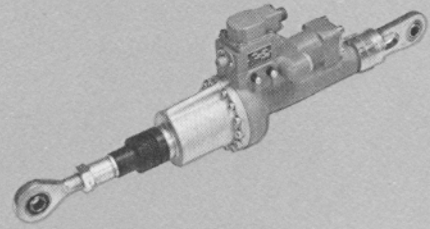
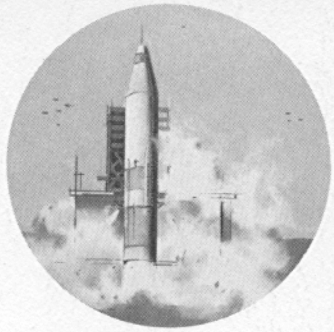
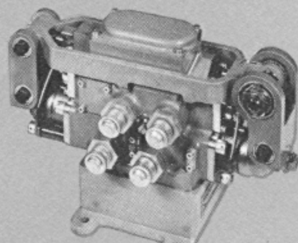
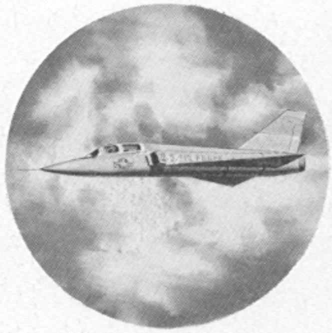


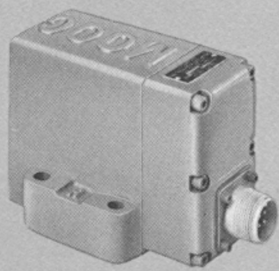


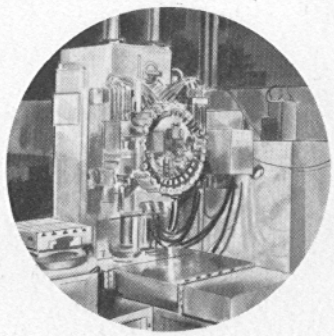
Moog designs and produces an entire series of servovalves, actuators, integrated servo systems and related test equipment for a variety of applications. Design configurations of standard units can be modified to specification. Custom designs for special applications are practicable.

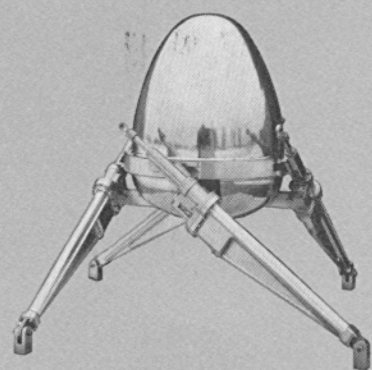


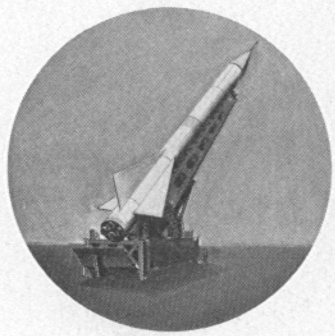


Standard servovalves available from Moog include flow control, pressure control, dynamic-pressure-feedback flow control, acceleration switching and dual input designs. Additional information on servovalves, actuators and systems can be obtained from the company or its representatives.









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