TWO OPERATING MODES ELECTRO-HYDRAULIC SERVO VALVE

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Abstract: *This material refers to a new type of hydraulic equipment for proportional distribution of the working fluid, electro-hydraulic servo valve type, which can work also in high adjustable frequency, through remote electronic control. The equipment, which can be used in precision hydraulic systems, particularly those with automatic operating mode, is patent pending. It offers several advantages over conventional solutions and can operate in two operating modes: as an electro-hydraulic device for proportional distribution of the working fluid, and as an electro-hydraulic distribution device of high adjustable frequency.*

Keywords*: electro-hydraulic servo valve, proportional distribution, high adjustable frequency*

1. Introduction

There are known electro-hydraulic servo valves, consisting of a body in which there slides a distribution slide valve, driven by the pressure created on its ends by a "nozzles - clack valve" unit, receiving the oscillation motion from a " torque motor ", consisting of two electric coils and a metal fitting, but these devices have the following disadvantages: the need for special filtration of the working fluid, permanent loss of pressure through nozzle chokes, generating excessive oil heating, even in the non-actuated position, and a complex electronic actuation device called servo controller, which further increases the already high cost price of servo valves.
There are also known electro-hydraulic proportional directional control valves, consisting of a body in which there slides a distribution slide valve, to which there are attached two proportional control solenoids, but they have the disadvantage that they cannot operate at high frequencies of oscillation, having high attenuation.
The technical problem solved by this new type of servo valve [1] consists in eliminating the nozzles - clack valve unit, which used to lead to a fine filtration of the working fluid and large pressure losses, this unit being replaced by a drive system made up of a proportional reduction piston, a reversal slide valve and a cam rotary oscillator, leading to very inexpensive electronic control device and servo valve construction, that can operate also at very high frequencies without recording a measurable attenuation.

2. Force feedback electro-hydraulic servo valve

Figure 1 shows the construction and operation of the most representative type of hydraulic servo valve: force feedback two-stage electro-hydraulic servo valve. The device comprises three systems, namely:
The control system, electromechanical converter type, positioned on the upper level, which is made up of a torque motor with two electrical coils, a mobile fitting and a fixed fitting. If at this system an electrical input is applied, namely supply current for a coil, this results in a mechanical output, namely mobile fitting movement proportional to the intensity of the supply current of the coil. The mobile fitting, which has a widened area in the form of a blade, moves to the left or right, depending on which coil is supplied with current.
The nozzle-blade preamplifier, mechanical-hydraulic converter type, positioned on the middle level, which is a double hydraulic potentiometer, consisting of a body, where two calibrated nozzles are placed, a blade integral with the mobile fitting of the torque motor and two adjustable hydraulic resistances (throttles). If at this system a mechanical input is applied, namely blade movement towards one or the other of the two nozzles (depending on the amount of the current and which

electric coil of the torque motor is supplied), this results in a hydraulic output type differential pressure between the supply circuits of these nozzles. This differential pressure is caused by the blade getting close to one nozzle (pressure increases) simultaneously with distancing from the other nozzle (pressure decreases), when it is driven to move from its null position.

The distribution system, hydro mechanical converter type, consisting of a body, in which there can move linearly a four arms sliding cylindrical valve, and by this movement there is achieved the communication area controlled, between the pressure circuits (P), provided with two filters, and the return circuit (T) with consumer circuits (A and B). The movement of the distribution sliding valve in magnitude and direction is proportional to the pressure difference applied on its ends.

The force feedback of servo valve is provided by a flat spring, integral with the mobile fitting of the torque motor and the blade of the nozzle-blade preamplifier. The spring has at its end a metal ball by which it is fixed in a housing made in the central area of the distribution spool valve. The servo valve ensures proportionality between the supply current of the torque motor windings and the flow on consumers A or B.

The disadvantages of this type of servo valve that the new type intends to remove are:

- **excessive filtration of oil**, due to the possibility of partial or total plugging of the calibrated nozzles;
- **Permanent loss of pressure** through the nozzle-blade preamplifier, as a result of continuous oil flow through the two calibrated nozzles, which leads to additional heating of the hydraulic oil;
- **the high cost of the electronic control device** type servo controller.

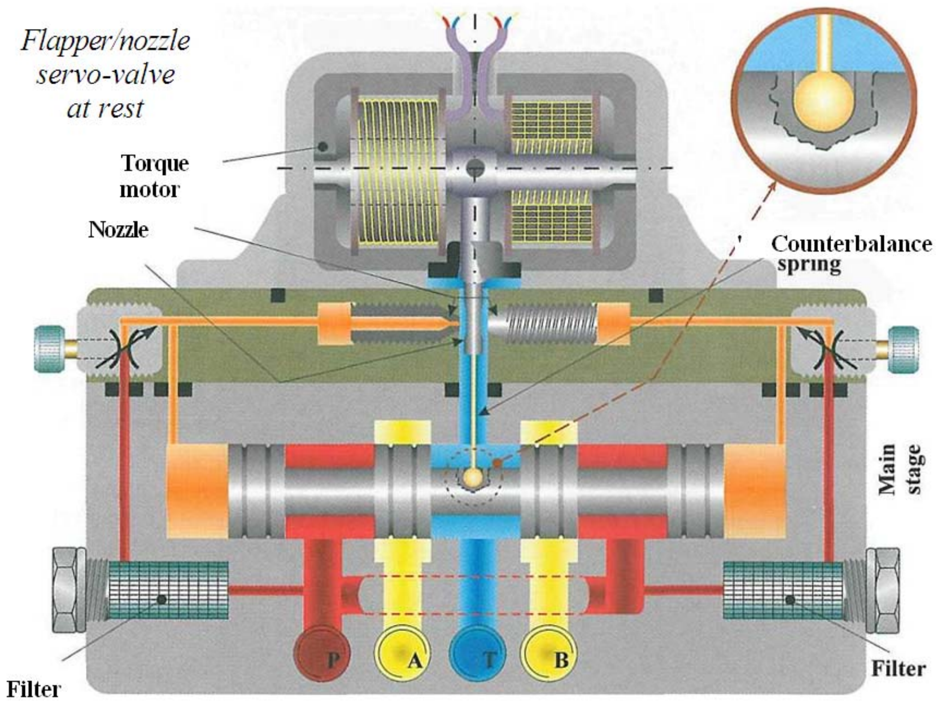


Fig.1 Force feedback electro-hydraulic servo valve

3. Internal position feedback 4/3 proportional directional control valve

4/3 proportional directional control valves can be directly controlled or pilot-operated, with one or two proportional solenoids, with or without electronic control unit. Figure 2 shows a modern 4/3 proportional directional control valve, directly controlled, with two proportional solenoids, internal position feedback provided by means of an electronic control unit and a linear displacement LVDT type transducer.

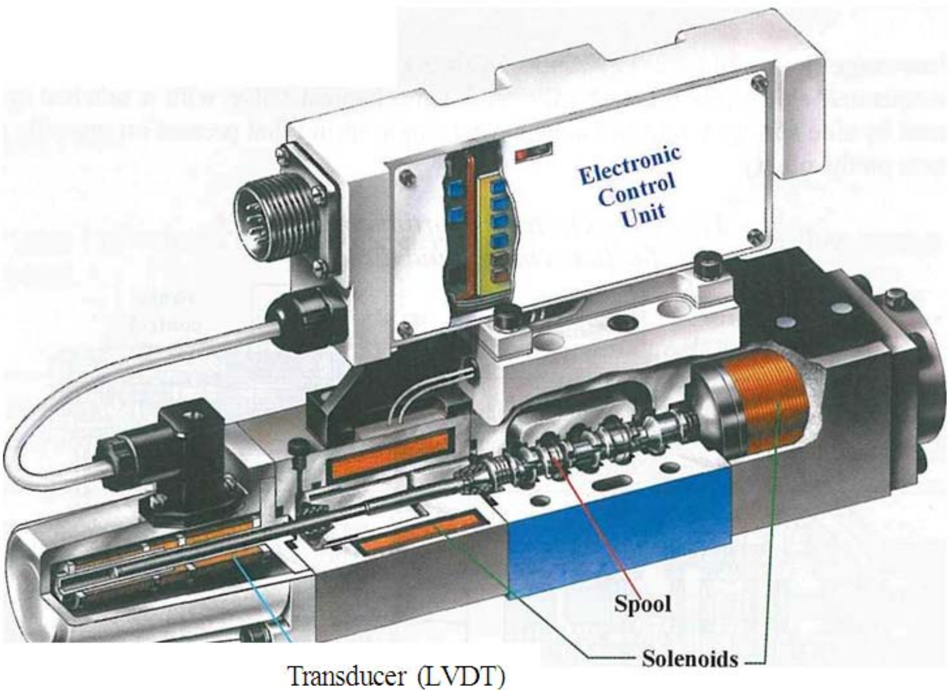


Fig.2 Internal position feedback 4/3 proportional directional control valve

The disadvantages of this type of electro-hydraulic proportional **directional control valves**, which the proposed solution removes, relate to **the relatively high price** and the fact that **they can not operate at high oscillation frequencies**, having high attenuation.

4. Structure of the two operating modes electro-hydraulic servo valve

The two operating modes electro-hydraulic servo valve, Figure 3, Figure 4, Figure 5, is composed of a body closed by two caps, between which there can slide a spool and a distribution bushing. The spool and the bushing are kept in the middle position by two springs per each. The spool can be brought into an initial position, the null, by a screw present in one of the two caps, or by actuating with a control pressure, created by a proportional reduction piston and distributed by a reversing slide valve, both present in the second cap. The bushing can also be actuated by a cam rotary oscillator, mounted on top of the servo valve body.
This hydraulic servo valve has the following advantages:
- it does not have pressure losses, at rest in the middle position, which leads to the elimination of permanent cooling of the working fluid;
- filtration of working fluid (hydraulic oil in this case) can be normal, with a fineness of 25 microns;
- the use of a single proportional solenoid, associated with a reduction slide valve, of a reversing solenoid, and also of a cam rotary oscillator, driven by a variable speed small motor, leads to a cheap constructive solution both for the servo valve and the electronic control device required;
- to the upper speed limit of the cam oscillator, attenuation of fluid distribution in frequency is almost zero, there being possible to achieve very high working frequency (about 200 Hz).
The body **1** of the servo valve, parallelepiped shape, is closed on the left side with a cap **2** and on the right side with another cap **3**, in which there is a bushing **4**, sliding between two springs **5.1** and **5.2**. In the bushing there is a distribution spool **6**, which is positioned between two more springs **7.1** and **7.2** which rest on a washer **8** and a plate **9**, being in constant contact with an adjustment screw **10**. The screw **10,** located in the cap **2**, is held in place by a nut **11** and protected by a small cap **12**.
The body **1** can be adjusted by means of screws on a block of hydraulic circuits, not shown, as it has five ports for connections, noted and arranged according to the international rules: **P-** pressure circuit, **A** and **B** – consumer circuits, **T** (two ports) - return circuits. In the body **1** these ports communicate with ducts made in the bushing **4**, like this: **P** with **d**, **A** with **e**, **B** with **f** and **T** with **g**.

Also in the body **1** there is made a hole, which communicates with the port **P** and makes the connection with a duct **a**, located in the cap **3**, interconnecting in its turn to a reduction piston **14** seating, which is in contact with the rod of a proportional solenoid **13**.

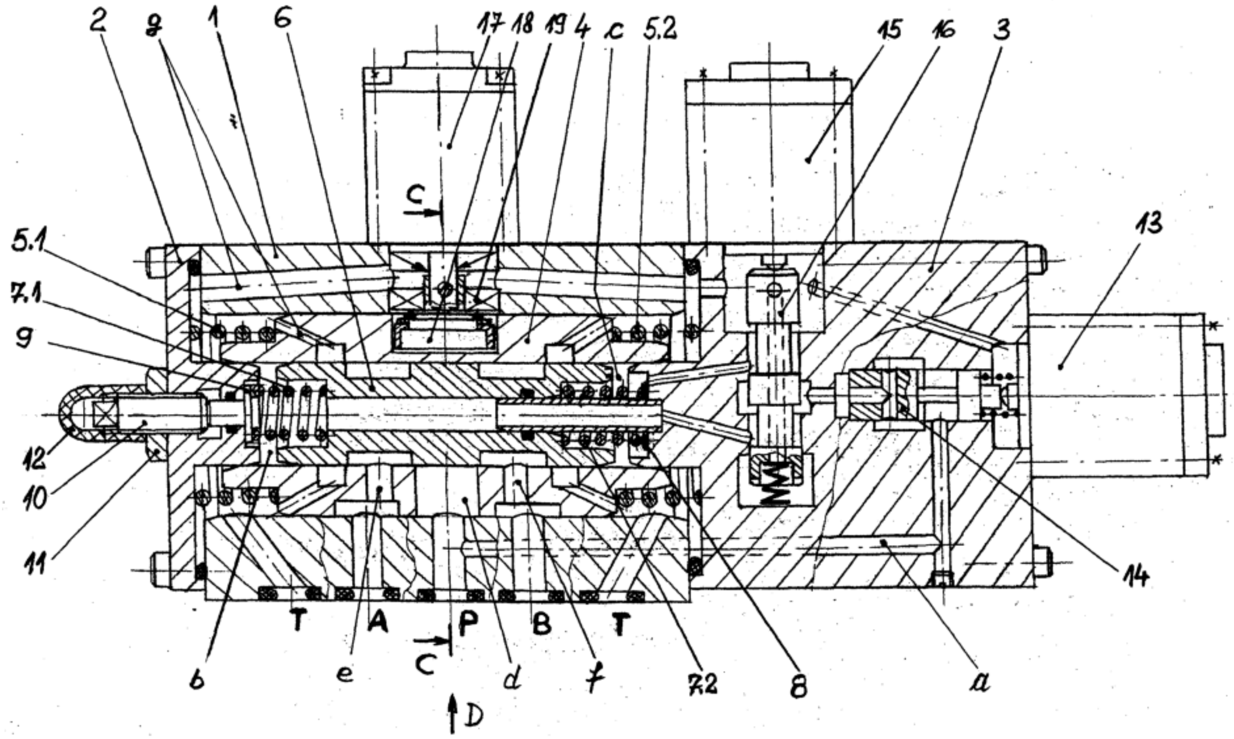
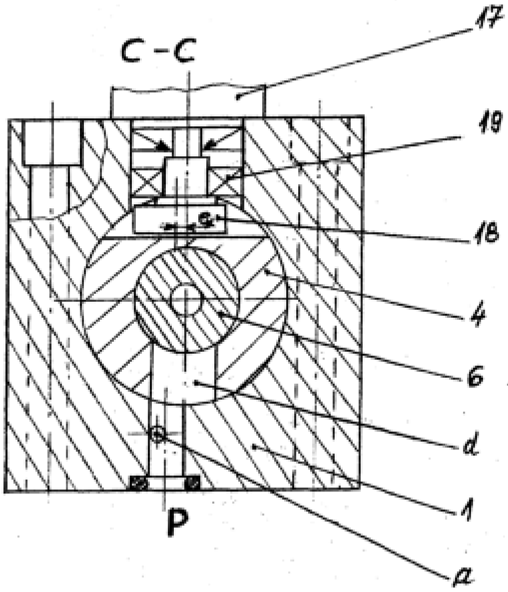


Fig.3 Longitudinal section through the two operating modes electro-hydraulic servo valve



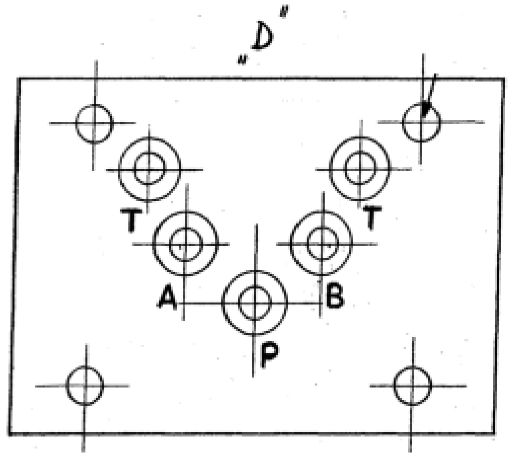


Fig.5 Clamping of the servo valve international mirror

Fig.4 Cross section in the oscillator

In the cap **3** there is also a reversal spool **16**, held by a spring in contact with the rod of another solenoid **15**, for switching, which can link the output of the reduction piston **14** to a control chamber **b**, or another control chamber **c**, located at the ends of the spool **6**.
The bushing **4** has a milled slot, in the middle, on outer surface and opposite to the duct **d**, where there is a rotary cam **18**, fixed to the shaft of a small motor **17**, reinforced with a bearing **19**, mounted in a seating at the upper side of the body **1**.

5. Functioning of the two operating modes electro-hydraulic servo valve

Functioning of the servo valve is as follows:
At rest, or null position, the servo valve in terms of construction and functioning can have two types of hydraulic coverage: positive coverage, when all holes (P, A, B and T) are closed, or negative coverage, when all holes are in throttled communication, equal crossing sections. To achieve this state, remove the protection small cap **12**, loosen the nut **11** and operate the screw **10**, so that the spool **6** is in the middle position, then tighten the nut **11** for locking.
At functioning as proportional distribution hydraulic equipment, the servo valve must be capable of distributing from port **P** to port **A** or to port **B** a fluid flow proportional to an electric control current.
Proportional distribution is done as follows: the solenoid **13** is power supplied; it drives the piston **14**, which generates at its output a pressure + the inlet pressure of the duct **a**, but proportional to the control current. This reduced pressure is applied to the end of the spool **6**, in the control chamber **b** and produces a force which moves the spool to the right, opposite to the spring **7.2**, making communications **P** to **A** and **B** to **T**, opening section and flow being proportional to the control current.
When supplying the solenoid **15**, it drives the spool **16,** which moves downwards, against the supporting spring, and allows the installation of low pressure in the control chamber **c,** which produces a force that causes the spool **6** to move to the left, against the spring **7.1**, this time making communications **P** to **B** and **A** to **T**, opening section and flow also being proportional to the control current (applied to the same solenoid **13**).
At functioning in frequency, which in the existing servo valves is synonymous with response to a sinusoidal electrical signal, for example, the servo valve must supply from the port **P** the ports **A** and **B**, successively, with prescribed and adjustable frequency. This happens as follows: this time there is supplied the small motor **17**, which rotates the cam **18** and causes the bushing 4 to move left and right, and the spool **6** being fixed, by movement of the bushing there is achieved distribution **P** to **A** and **B** to **T**, respectively **P** to **B** and **A** to **T**, successively, with a frequency equal to the speed of the small motor **17**, which can be adjusted via the control electric current. By canceling the control current applied to the small motor **17**, it stops, and the bushing **4** returns to its initial position, being brought by the springs **5.1** and **5.2**, which does not allow the cam **18** to remain in any position.

6. Conclusions

- With this material the authors test the market of those interested in producing a new type of electro-hydraulic servo valve, cheaper and higher energy efficiency, cumulating two functions, proportional distribution and high frequency adjustable distribution of flow to hydraulic displacement rotary or linear motors. For this type of servo valve a patent application has been filed.
- For operation under proportional flow distribution, there is electrically powered a proportional solenoid, in order to adjust the displacement of the spool, and a solenoid type "all-or-nothing", in order to change the direction of movement.
- For operation under high frequency adjustable distribution, there is electrically powered only the small motor which drives a cam plate.
- This servo valve has some advantages relating to: simplified construction, no pressure losses in the "null position", average fineness of the hydraulic oil filtration, capability for operation as a generator of high-frequency hydraulic impulses.

REFERENCES

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