EMG Servo Technique

Plunger Coil Regulators TR-h 7/S and TR-h 7/SE TR-h 7/F and TR-h 7/FE

TÜV CERT
ZERTIFIKAT
Qualitätssicherungssystem
DIN ISO 9001 / EN 29001
Registrier-Nr. 70 100 M 504

Contents

General

The plunger coil regulator finds application in electrohydraulic control and closed loop control systems. As the final control element between the electrical signal transmitter or detecting element and the hydrostatic servo-motor the plunger coil regulator controls an oil flow proportional in magnitude and direction to the measured value. Electro-hydraulic control circuits of this kind combine electrical measuring elements and transistor amplifiers both having practically no time constant and hydrostatic servomotors with low inertia. This combination is therefore particulary suitable for regulating and control requirements, where high speed of response is necessary .
EMG undertake the design of complete regulation equipment and automatic control systems incorporating the moving coil regulator.
As a result of partical experience two types have been produced.

The block type	TR-h 7 / S
	TR-h 7 / F
The direct fitting type	TR-h 7 / SE
	TR-h 7 / FE

Constructions

The plunger coil regulator consists of an electrical part and a hydraulic part arranged coaxially.

Electrical part
The plunger coil, an aluminium body carrying two control coils, moves axially in the circular air gap of the permanent magnet. This magnet is fixed to the top part of the housing, in which the adjusting device for the plunger coil is. This adjusting device and two opposed springs (mid-position springs) hold the moving coil in the middle position. The electrical connection between the plunger coil and the connector is made via a terminal board by four flexible leads with AMP. All plunger coil regulators have the same design of the electrical part.

Hydraulic part of the TR-h 7 / S and TR-h 7 / F
With the plunger coil regulator type TR-h 7 / S the control piston is axially movable installed in the control hull, which is fixed to the housing block.
With the type TR-h 7 / F the pilot piston ist laterally movable in the slave piston which is movable arranged in the housing block. The holes for the inlet pressure oil (P), return oil (T), leak oil (L) and for the motor leads (A) + (B) are all on one side. Thus the plunger coil regulator can be connected with O-Ring sealing by means of four fixing screws to a mounting plate to which the pipe connections are made.

Hydraulic part of the TR-h 7 / SE and TR-h 7 / FE
With theese types the control hull is screwed into the flange of the electrical part. The applied five (four) circular grooves provide the connections to the pipes via the reception hull in the electro-hydraulic control unit, type EH-ST.

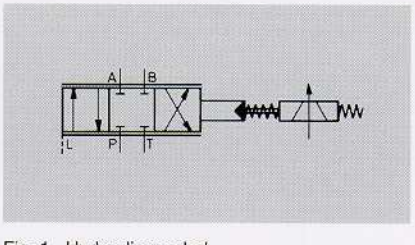
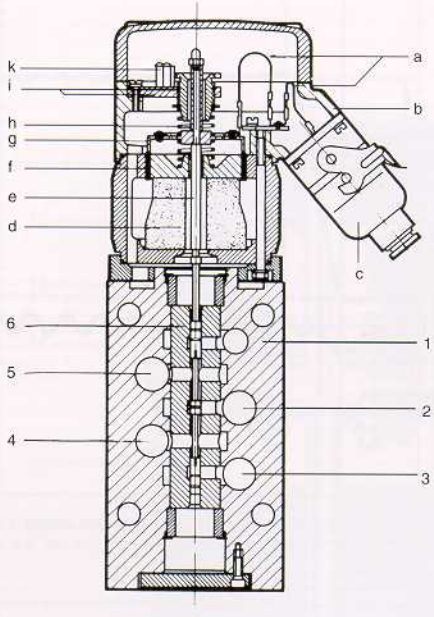


Fig. 1 Hydraulic symbol

Cut View

Fig. 2 Cut view of the plunger coil regulator type TR-h 7 / S. Magnethead shown 90° turned.

Fig. 3 Cut view of the plunger coil regulator type TR-h 7 / SE



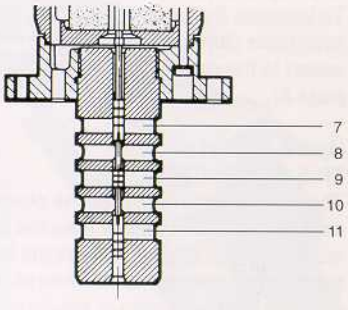
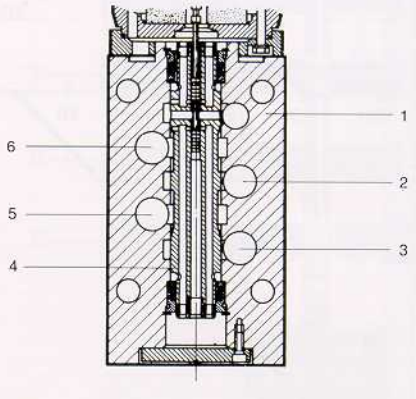


Fig. 2
a Flexible leads with AMP connectors
b Housing
c Connector
d Permanent magnet
e Control piston
f Control windings
g Plunger coil
h Centering springs
i Adjusting device
k Locking device
1 Housing block
2 Connection P
3 Connection T
4 Connection A
5 Connection B
6 Control hull

Fig. 3
7 Connection T
8 Connection B
9 Connection P
10 Connection A
11 Connection T

Fig. 4 Cut view of the plunger coil regulator TR-h 7 / F

Fig. 5 Cut view of the plunger coil regulator TR-h 7 / FE



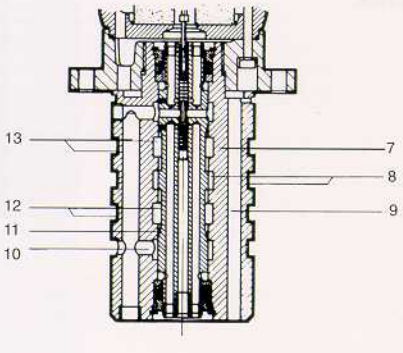


Fig. 4
1 Housing block
2 Connection P
3 Connection T
4 Slave piston
5 Connection A
6 Connection B

Fig. 5
7 Control hull
8 Connection P
9 Leakage
10 Connection T
11 Slave piston
12 Connection A
13 Connection B

Mode of Operation

The plunger coil is held in its middle position by mechanical spring forces. By the magnetic field of the energized plunger coil and the magnetic field of the permanent magnet a force is produced, which is proportional to the control current and causes a displacement proportional to the restoring force of the spring. The full displacement of 4 mm in either direction corresponds to a control current of ± 300 mA in the control oil. The transient response characteristics of the moving coil regulator for any displacement is shown in fig. 6.
To increase the sensivity of the system an adjustable dither signal of max. 25 mA is added to the control current (see fig. 12, page 8).

Hydraulic part of TR-h 7 / S and TR-h 7 / SE

The control piston linked to the plunger coil controls the return oil flow from the servomotor in either direction by means of control throttles (change of direction of oil-flow in A and B). The design of the control throttles is evaluated to obtain a specific oil flow rate at a pressure drop of 10 bars with full deflection of the control piston. The specific oil flow rate corresponds to the designation of the regulator type (see table 2, page 8).

Example: With plunger coil and control piston going up oil-flow from P to A and thus to the servomotor is obtained. The return oil flow from the servomotor gets via B through the control throttle to T and into the tank. With moving coil going down the reverse movement of the servomotor takes place.

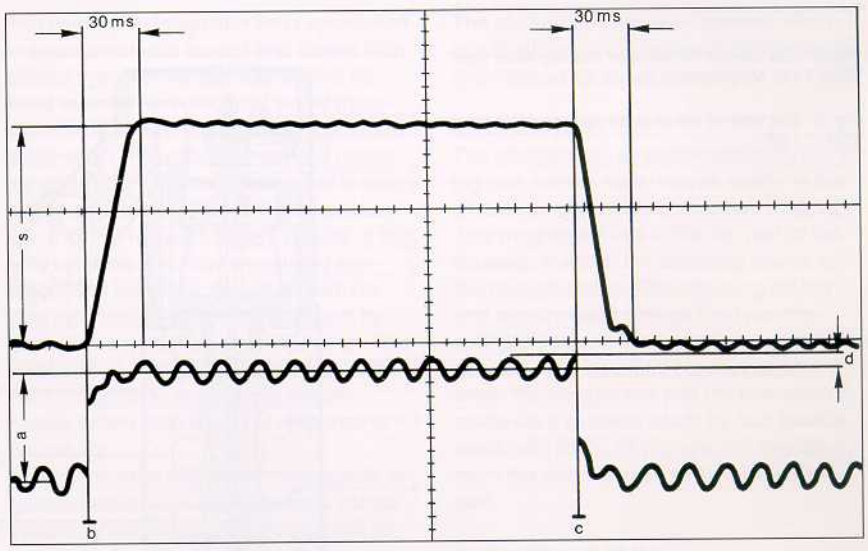


Fig. 6 Transient response characteristic stroke s = vs time t of TR-h 7 / S and TR-h 7 / SE at 20 bars; a = control current, b = on, c = off, d = dither 25 mA

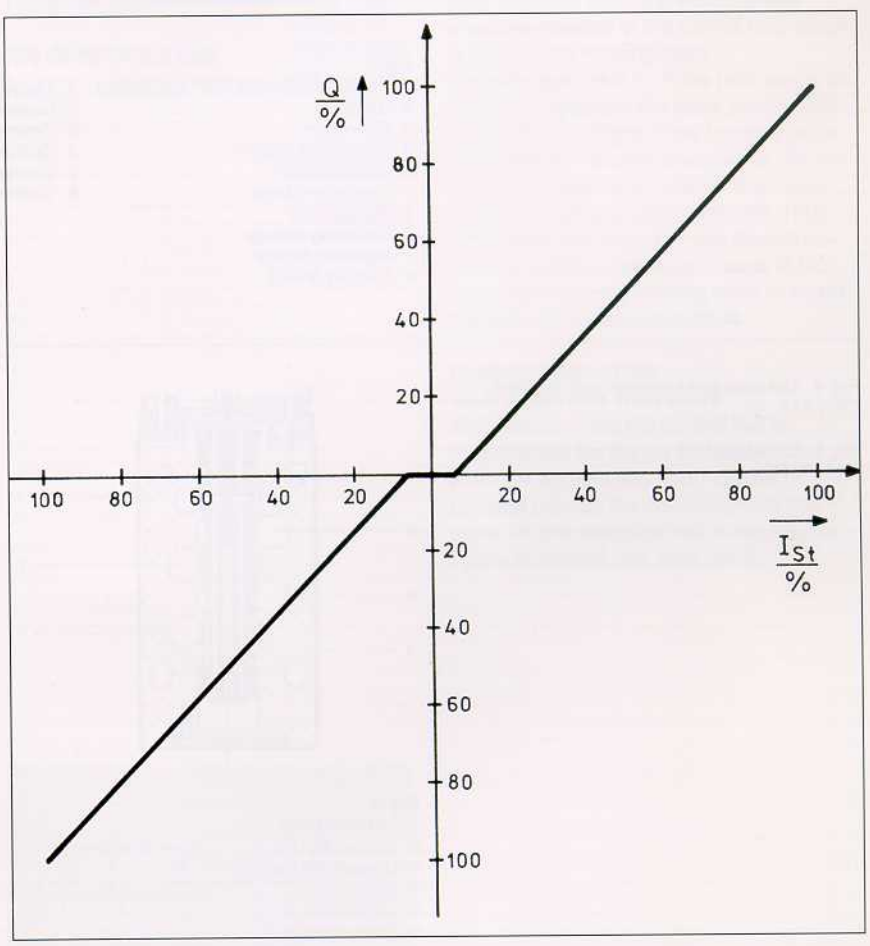
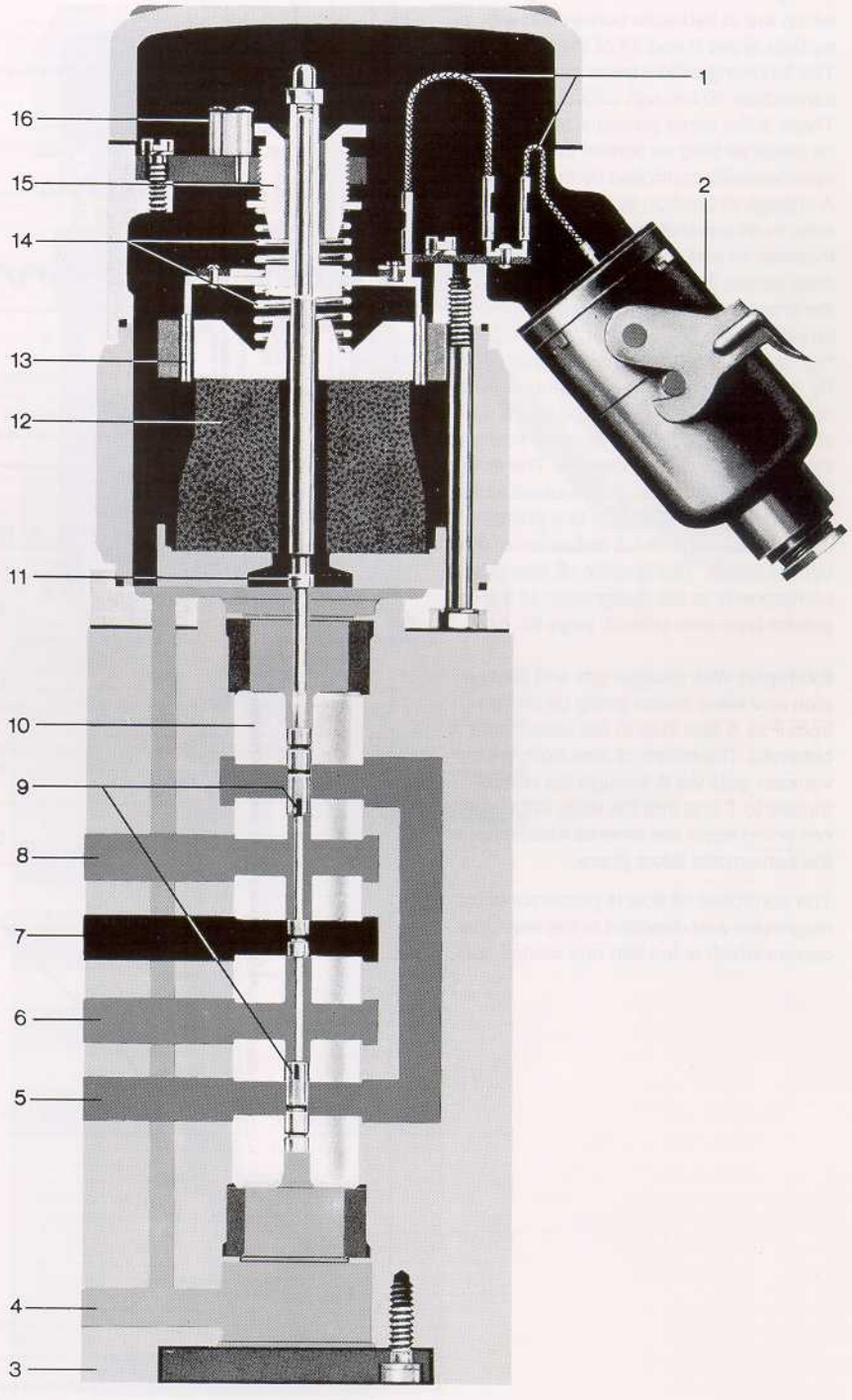


Fig 7. Flow curve of TR-h 7 / .S related on pressure drop of 10 bars. Q = flow rate (standard rates see page 8, table 2. I_{St} = control currtent (100 % ≙ 300 mA across one coil).

Type TR-h 7/S

Fig. 8 Operational scheme of plunger coil regulator type TR-h 7 / S

1 Connection leads with AMP plugs
2 Connector
3 Housing block
4 Leakage connection L
5 Drain connection T
6 Servomotor connection A
7 Pressure connection P
8 Servomotor connection B
9 Control throttles
10 Control hull
11 Control piston
12 Permanent magnet
13 Plunger coil assembly
14 Mid-position spring
15 Adjusting assembly
16 Locking device



Mode of Operation

Hydraulic part of
TR-h 7 / F and TR-h 7 / FE

The pilot piston linked to the plunger coil controls an oil flow (see table 4, page 8) through control throttles 13 in Fig. 11 which are in hydraulic connection with the surface areas 6 and 14 of the salve piston. The incoming oilflow takes place from P-connection 10 through constant throttles 4. There is the same pressure at both surface areas as long as control throttles 13 are symmetrically controlled by the pilot piston. A change of position of the pilot piston results in an unbalance in oil flow through throttles 13 and changes the pressure drop across the constant throttles. Thus the pressures at the surface areas are different and the slave piston is moved with high speed until the system is readjusted. By these means the slave piston simultaneously follows the deflection of the moving coil controlling the return oil flow from the servomotor at throttles 12. The design of the control throttles is evaluated to obtain a specific oil flow rate at a pressure drop of 10 bars with full deflection of the control piston. The specific oil flow rate corresponds to the designation of the regulator type (see table 3, page 8).

Example: With plunger coil and pilot piston and slave piston going up oil-flow from P to A and thus to the servomotor is obtained. The return oil flow from the servomotor gets via B through the control throttle to T and into the tank. With plunger coil going down the reverse movement of the servomotor takes place.

The controlled oil flow is proportional in magnitude and direction to the electrical current which is fed into one control coil.

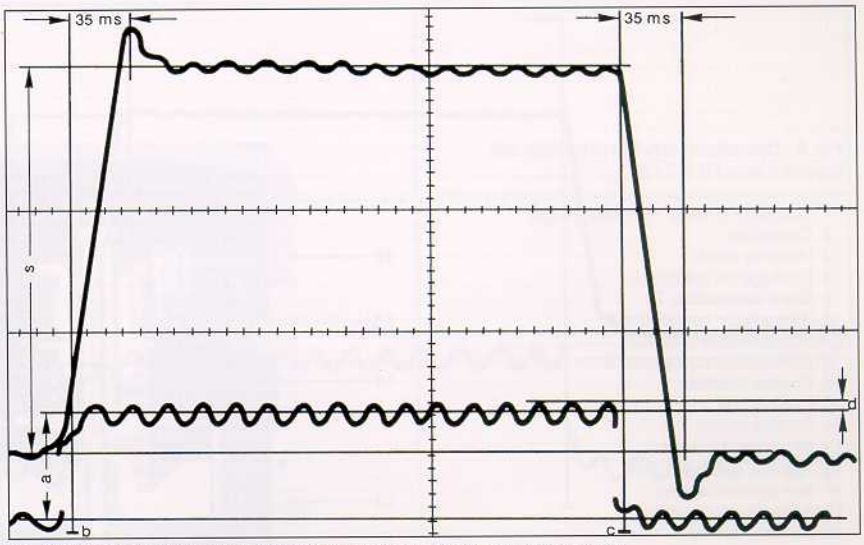


Fig. 9 Transient response characteristic stroke s = vs time t of TR-h 7 / F at 35 bars; a = control current, b = on, c = off, d = dither 25 mA

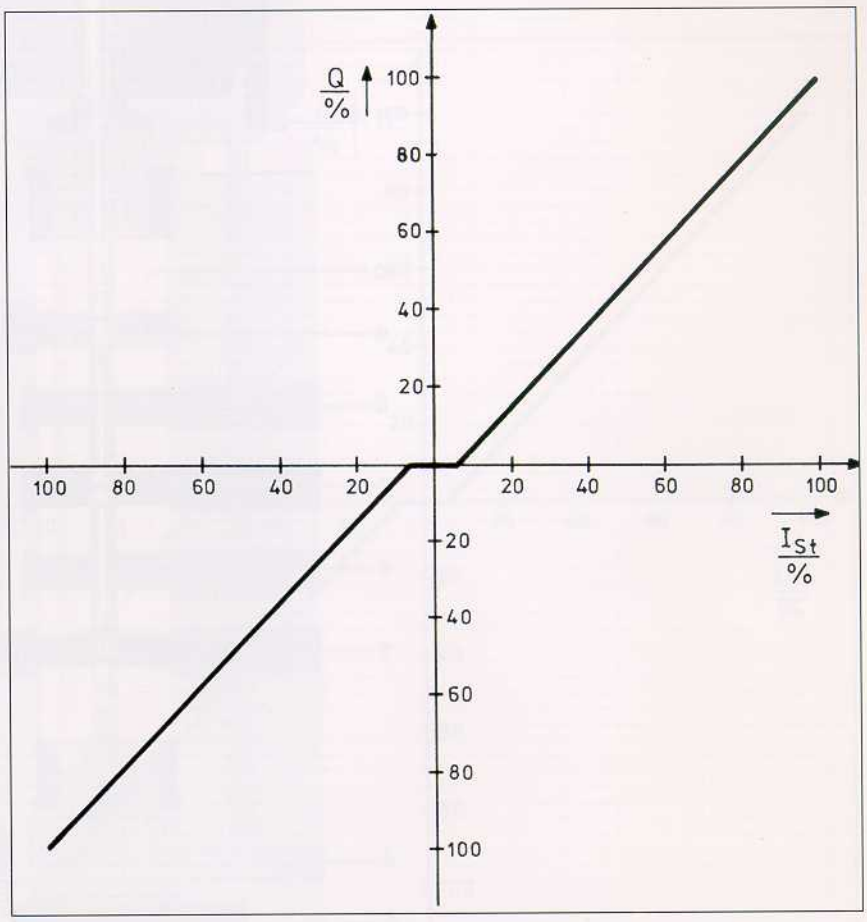
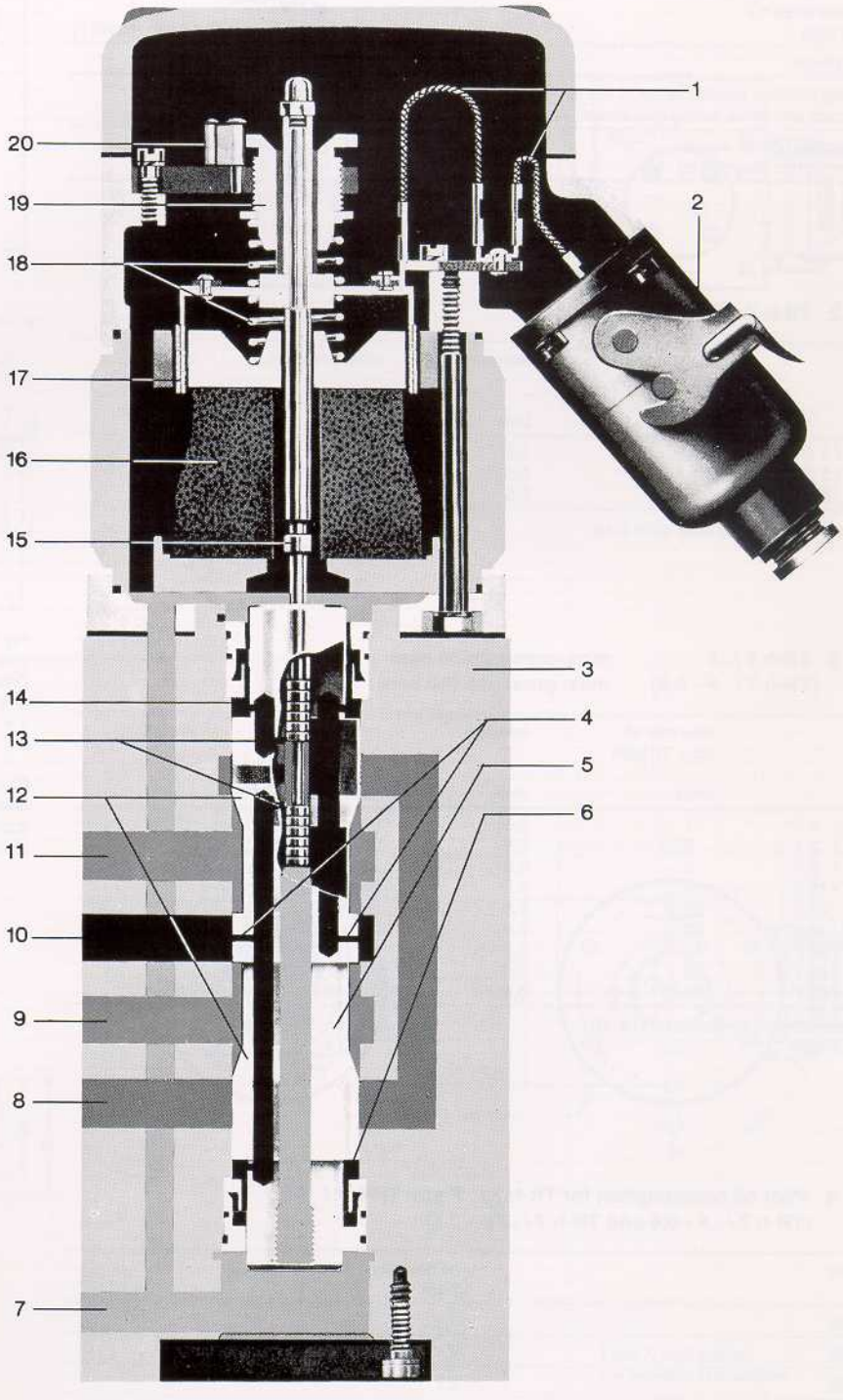


Fig 10. Flow curve of TR-h 7 / ..F related on pressure drop of 10 bars. Flow rate for pressure drop P_x is to be calculated by $Q_x = Q\sqrt{\frac{\Delta P_x}{10}}$
Q = flow rate, I_{St} = control current 100 % ≙ 300 mA in one coil.
Standard flow rates see page 8, table 3.

Type TR-h 7/F

Fig. 11 Operation scheme of plunger coil regulator type TR-h 7 / F

1 Connection leads with AMP plugs
2 Connector
3 Housing block
4 Constant throttles
5 Slave piston
6 Pressure chamber (below)
7 Leak oil connection L
8 Drain connection T
9 Servomotor connection A
10 Pressure connection P
11 Servomotor connection B
12 Control throttles (main)
13 Control throttles (pilot)
14 Pressure chamber (above)
15 Pilot piston
16 Permanent magnet
17 Plunger coil assembly
18 Mid-position springs
19 Adjusting assembly
20 Locking device



Technical data

Table 1 The plunger coil has two control coils. For each coil the following technical data are valid:

maximum admissible current full deflection (4 mm stroke)	450 mA approx. 300 mA
resistance at 20 °C winding data	40 Ohms 300 windings, 0,18 mm (SWG 7)
control power	3,6 W
inductivity (without consideration of the counter electromagnetic force during movement)	3 mH
superimposed dither signal (see connection diagram fig. 12)	25 mA adjustable 50 Hz

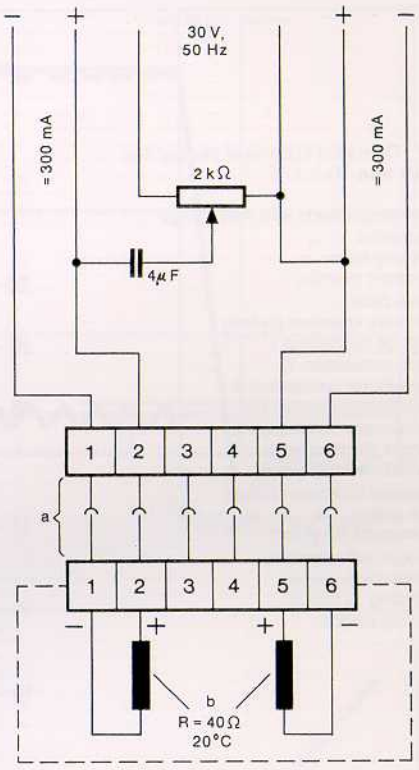


Fig 12
connection diagram of TR-h 7
Dither circuit only necessary if no EMG amplifiers used.
a = plug unit Han 6 B
b = control coils

Plunger coil regulators for higher pressure and flow rates on request. Types for explosion proof applications and for fire resistant liquids are available.

Table 2 TR-h 7 / .S

Type	flow rate at Δp = 10 bars	leakage	max. pressure	weight
	l/min	l/min	bars	kg
TR-h 7 / 1 S	1	0,5	25	17
TR-h 7 / 2 S	2	0,5	25	17
TR-h 7 / 2 S	5	0,5	25	17

recommended oil: hydraulic oil H-L 46

Table 3 TR-h 7 / ..F max. pressure 60 bars
(TR-h 7 / ..F - 0,6) max. pressure 100 bars

Type	flow rate at Δp = 10 bars	leakage	pressure range min.	max.	weight
	l/min	l/min	bars	bars	kg
TR-h 7 / 1 F	1	0,5	20	60 (100)	17
TR-h 7 / 2 F	2	0,5	20	60 (100)	17
TR-h 7 / 5 F	5	0,5	20	60 (100)	17
TR-h 7 / 10 F	10	0,5	20	60 (100)	17
TR-h 7 / 20 F	20	0,5	20	60 (100)	17
TR-h 7 / 30 F	30	0,5	20	60 (100)	17
TR-h 7 / 40 F	40	0,5	20	60 (100)	17
TR-h 7 / 60 F	60	0,5	20	60 (100)	17
TR-h 7 / 80 F	80	0,5	20	60 (100)	17

recommended oil: hydraulic oil H-L 46

Table 4 Pilot oil consumption for TR-h 7 / ..F and TR-h 7 / ..FE (TR-h 7 / ..F - 0,6 and TR-h 7 / ..FE - 0,6)

pressure bars	oil quantity l/min
20 (60)	2,6
30 (70)	3,4
40 (80)	3,7
50 (90)	4,1
60 (100)	4,5

Dimensions

Fig. 13 Dimensions of TR-h 7 / S

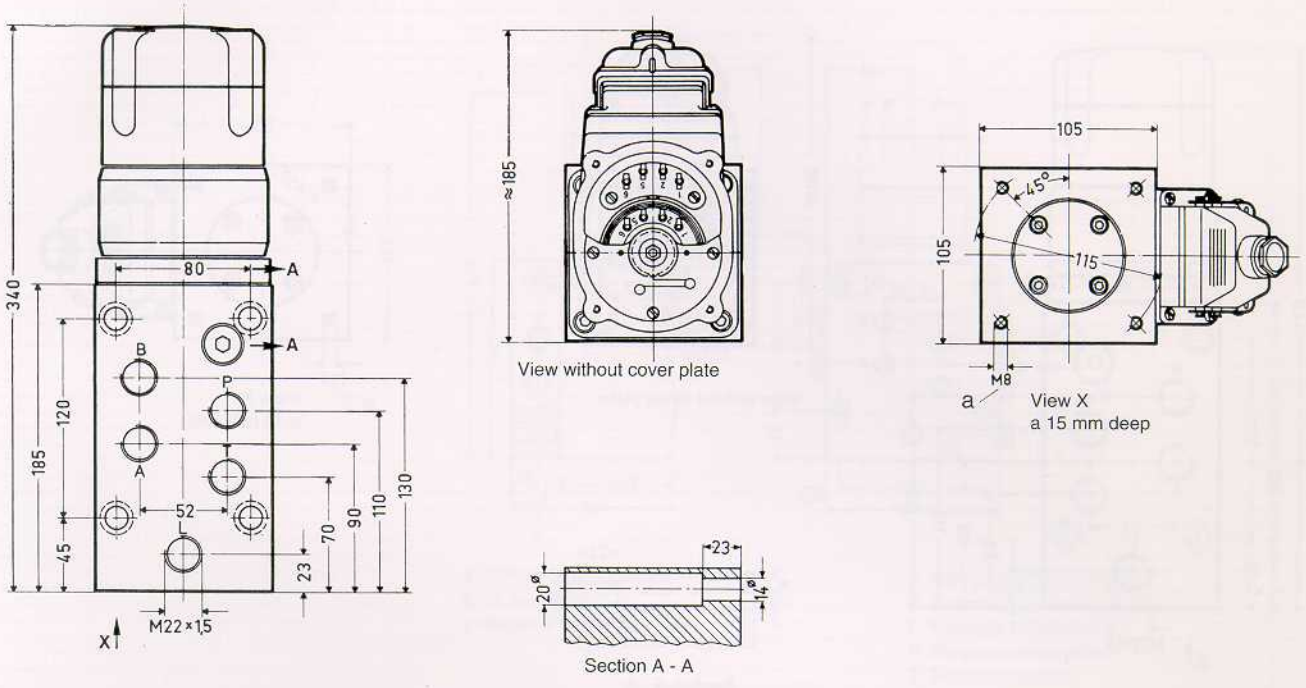
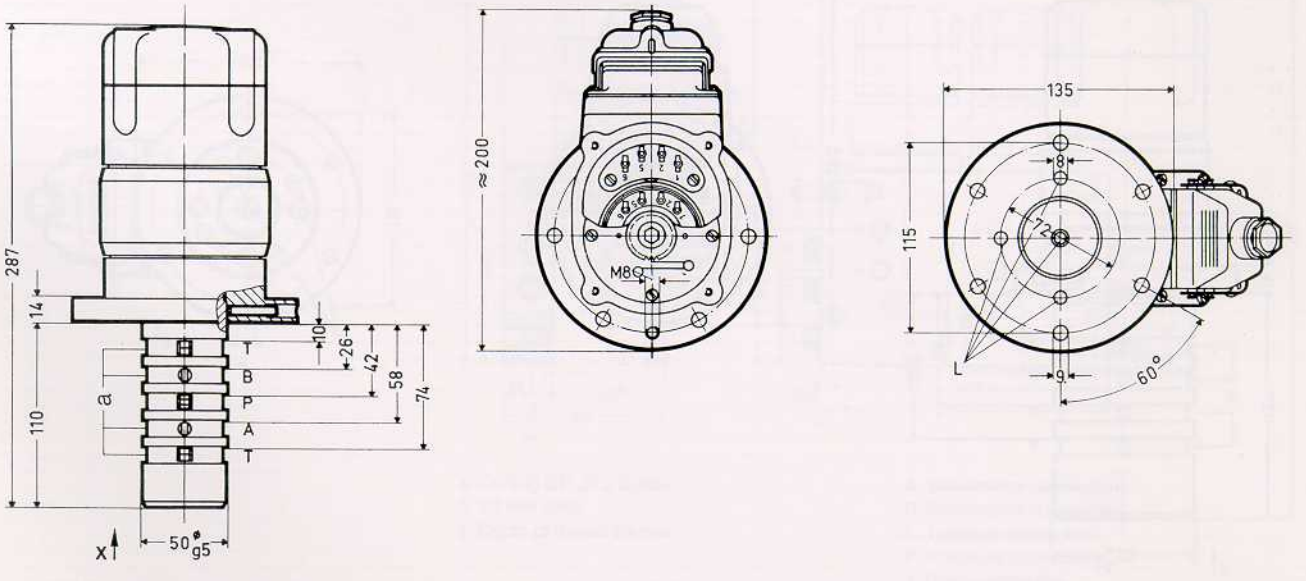


Fig. 14 Dimensions of TR-h 7 / SE



a = Groves 10 mm wide

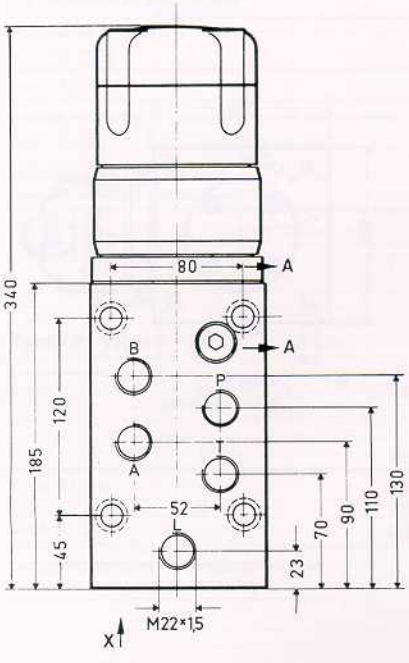
All sizes in mm
modification reserved

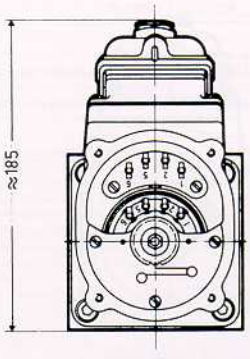
View without cover plate

View X with gasket
L = leakage connection

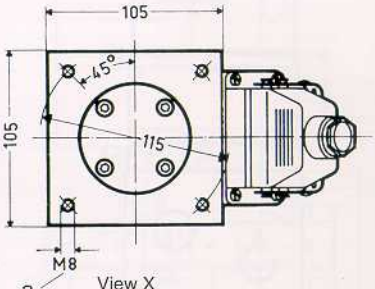
Dimensions

Fig. 15 Dimensions of TR-h 7 / F

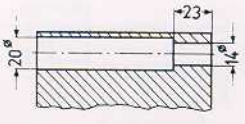




View without cover plate

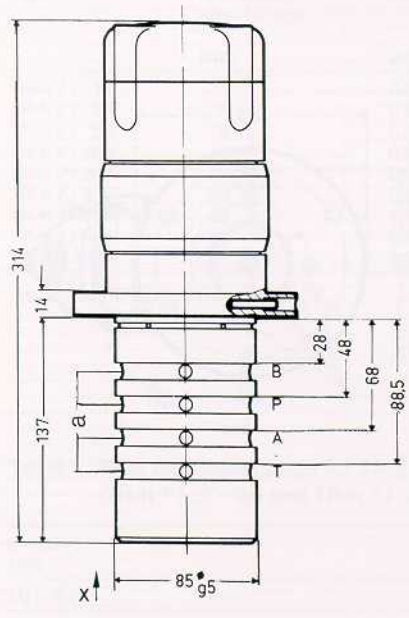


View X
a 15 mm deep



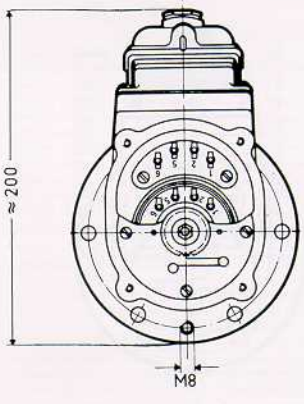
Section A - A

Fig. 16 Dimensions of TR-h 7 / FE

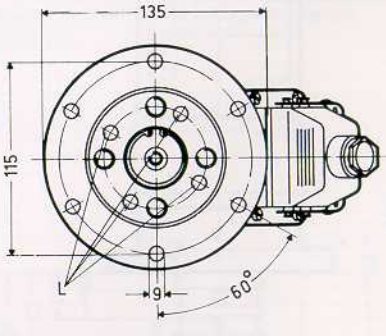


a = Groves 10 mm wide

All sizes in mm
modification reserved



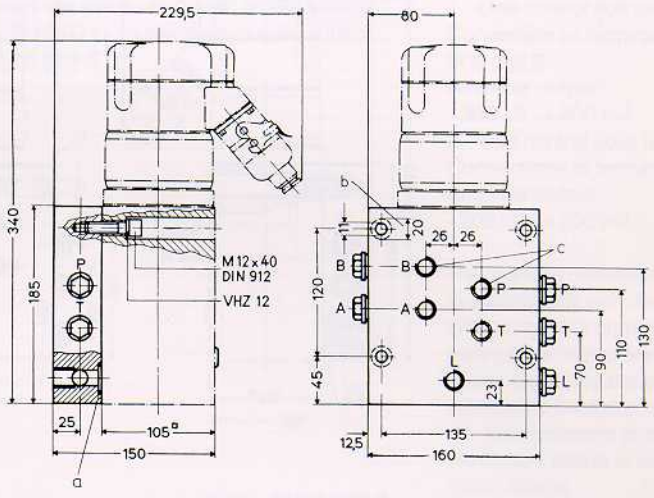
View without cover plate



View X with gasket
L = leakage connection

Dimensions

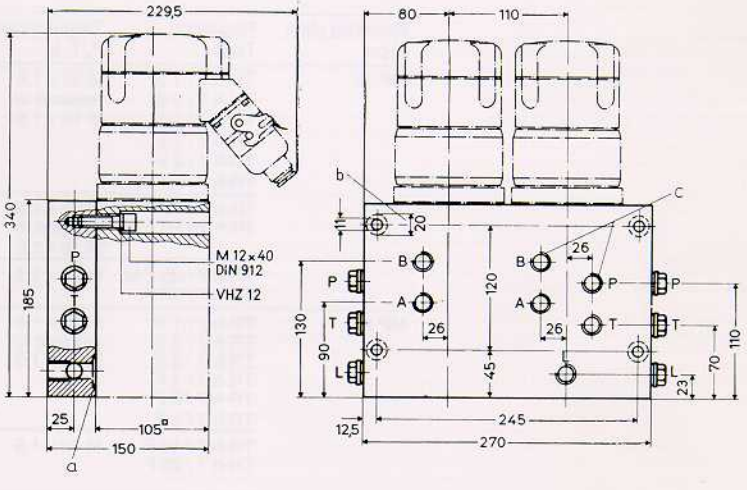
Fig. 17 Dimensions of the mounting plate type MP 12



a O-Ring OR 24 x 3 mm
b 12 mm deep
c Depth of thread 20 mm

A Servomotor connection
B Servomotor connection
L Leakage connection
P Pressure connection
T Drain connection

Fig. 18 Dimensions of the mounting plate MP 21



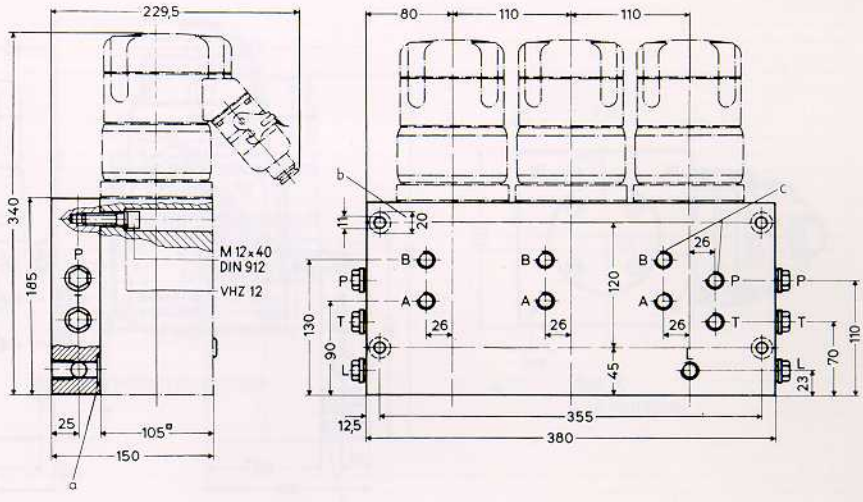
a O-Ring OR 24 x 3 mm
b 12 mm deep
c Depth of thread 20 mm

A Servomotor connection
B Servomotor connection
L Leakage connection
P Pressure connection
T Drain connection

All sizes in mm
modification reserved

Dimensions

Fig. 19 Dimensions of the mounting plate MP 31



a O-Ring OR 24 x 3 mm
b 12 mm deep
c Depth of thread 20 mm

A Servomotor connection
B Servomotor connection
L Leakage connection
P Pressure connection
T Drain connection

All sizes in mm
modification reserved

Table 5 Mounting plates

Mounting plate Type	Regulator Type	Tube connection P, T, L	Tube connection A, B	Tube diameter mm P, T, L	Tube diameter mm A, B
MP 12	TR-h 7 / 1 S TR-h 7 / 2 S TR-h 7 / 5 S TR-h 7 / 1 F TR-h 7 / 2 F TR-h 7 / 5 F	M 22 x 1,5 reduced to M 18 x 1,5	M 22 x 1,5 reduced to M 16 x 1,5	15 x 1,5	12 x 1,5
	TR-h 7 / 10 F TR-h 7 / 20 F	M 22 x 1,5 reduced to M 18 x 1,5	M 22 x 1,5 reduced to M 18 x 1,5	15 x 1,5	15 x 1,5
	TR-h 7 / 30 F to TR-h 7 / 80 F	M 22 x 1,5	M 22 x 1,5	18 x 1,5	18 x 1,5
MP 21	TR-h 7 / 1 S TR-h 7 / 2 S TR-h 7 / 5 S TR-h 7 / 1 F TR-h 7 / 2 F TR-h 7 / 5 F	M 22 x 1,5 reduced to M 18 x 1,5	M 22 x 1,5 reduced to M 16 x 1,5	15 x 1,5	12 x 1,5
	TR-h 7 / 10 F TR-h 7 / 20 F	M 22 x 1,5	M 22 x 1,5 reduced to M 18 x 1,5	18 x 1,5	15 x 1,5
	TR-h 7 / 30 F to TR-h 7 / 60 F	M 22 x 1,5	M 22 x 1,5	18 x 1,5	18 x 1,5
MP 31	TR-h 7 / 1 S TR-h 7 / 2 S TR-h 7 / 1 F TR-h 7 / 2 F	M 22 x 1,5 reduced to M 18 x 1,5	M 22 x 1,5 reducted to M 16 x 1,5	15 x 1,5	12 x 1,5
	TR-h 7 / 5 F TR-h 7 / 10 F	M 22 x 1,5	M 22 x 1,5 reduced to M 18 x 1,5	18 x 1,5	15 x 1,5
	TR-h 7 / 20 F	M 22 x 1,5	M 22 x 1,5	18 x 1,5	18 x 1,5

Reducing fittings included

Fitting Instructions

Plunger coil regulator type TR-h 7 / S and TR-h 7 / F

Using the plunger coil regulator in a plant the following conditions are to be fulfilled for proper operation. The mounting plate is to be connected to the electro-hydraulic power station type EH-NG by means of cleaned pipes. The plunger coil regulator has to be sealed against the mounting plate by means of five O-rings, type OR 24x3. For connection to an existing hydraulic plant a magnet screen fine filter with a mash width of 0,06 mm or a pressure filter with 25 µm filter rate has to be installed between pump and plunger coil (pressure pipe).

The operational pressure should be adjustable and indicated at a manometer. For the selection of the servomotor (hydraulic cylinder) it has to be considered that the working pressure at the cylinder is lower for the pressure drop across the regulator corresponding to the actual flow rate (see page 4 and 6).

For design of the pump the leakage oil (see tables 2 and 3) and in case of TR-h 7 / F and TR-h 7 / FE the control oil consumption (see table 4) have to be considered.

The tube connections between moving coil regulator and cylinder are to be kept as short as possible by reason of technological experiences. The leak oil pipe is to be placed continuously downwards to enable the oil to flow pressure less to drain. For horizontal installation of the regulator tube connections are to be placed downwards. At the highest locations of the connecting tubes to the cylinder provisions for ventilation are to be made. In case that tube connections are placed lower the cylinder itself should have facilities for ventilation at the highest location. The plunger coil regulator may be preferrably installed higher than the servomotor (cylinder, oil motor etc.)

Plunger coil regulator type TR-h 7 / SE and TR-h 7 / FE

For these types the same instructions are valid part of which is fullfilled by the constructive combination of the regulator and the electro-hydraulic power station (EH-NG) to an electro-hydraulic control unit (EH-ST).

Setting in Operation

The plunger coil regulator is to be connected to the electrical supply unit or transistor amplifier by means of the connector plug. There are different connections possible depending upon the amplifier in use:

1. One control coil used:
Connection at terminals 1 and 2
or 5 and 6
Amplifier output:
- 300...0...+ 300 mA

2. Two control coils used in parallel:
Connections at terminals 1-5 and 2-6
Amplifier output:
- 300...0...+ 300 mA

The working conditions have to be fullfilled in accordance with the fitting instructions. With no control current through the control coils (dither signal always present) the oil flow is locked by the control piston. This represents neutral position of the servomotor. Readjustment of the mid-position of the control piston is necessary if the servomotor moves.

The function of the hydraulic circuit is checked by deflecting the control piston by hand upwards and downwards after the cover plate of the plunger coil regulator has been removed. With sufficient dither signal a slight vibration can be noticed at the top of the control piston.

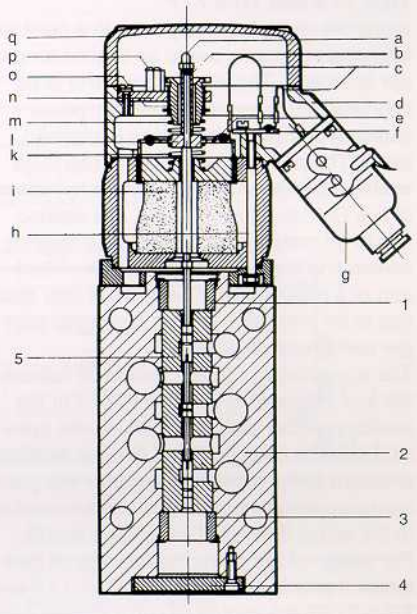
Dismantling

If the instructions of the electro-hydraulic power unit for changing the oil and if the filter conditions are observed the plunger coil regulator needs no maintenance. If anything goes wrong determine whether the fault is in the electrical or in the hydraulic part of the plunger coil regulator (hand operation of the control piston see "setting in operation"; testing the coil values at the plug).

Electrical part (Fig. 20)
Remove housing cover q. Remove screws (o) and lift complete adjusting assembly (n). Pull out connection leads (c) to the plunger coil (l) off the terminal board (f). While doing this hold down the terminal-ring (e) of the plunger coil to prevent it from being damaged. Lift out the mid-position spring (m). Draw out the plunger coil together with control piston. Immediately cover the circular air gap of the permenent magnet (8) to keep it clean. Disconnect the moving coil (l) from piston (h) by removing the cap nut (a) and distance hull (b). Lift out the lower mid-position spring (k).
Replacement of a defective connector plug (g):
Draw out connection leads. Loosen plug (g) from housing (d).
Should it be necessary to replace the permanent magnet (i) or the housing (d) separate the electrical part from the hydraulic part:
With type TR-h 7 / S by loosing of the four fixing bolts of the flange, with type TR-h 7 / SE by loosing of the grub screw (6) at the side of the flange and screwing out the control hull (7).

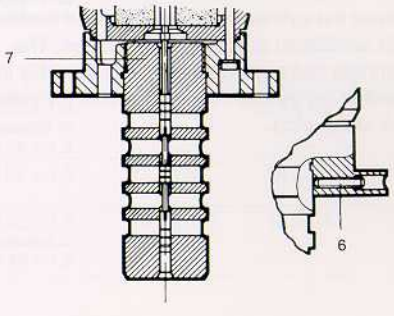
Hydraulic part of TR-h 7 / S (Fig. 20)
The control piston is drawn out of the hydraulic part together with the electrical part. Remove the bottom cover plate (4). Remove the safety rings (1 and 3) and push out the control hull (5).

Fig. 20 Cut view of TR-h 7 / S.
Magnet head shown 90° turned
1 Safety ring
2 Housing block
3 Safety ring
4 Cover plate
5 Control hull



Hydraulic part of TR-h 7 / SE (Fig 21)
The control hull (7) is easily to be screwed out after the grub screw (6) has been loosened.

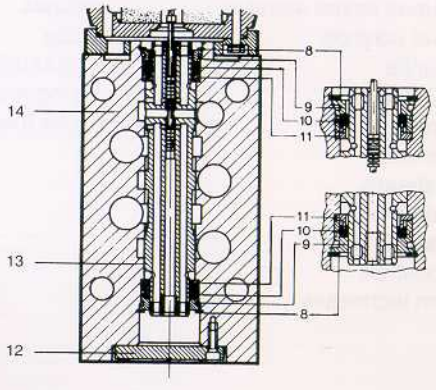
Fig. 21 Cut view of TR-h 7 / SE
6 Grub screw
7 Control hull



Hydraulic part of TR-h 7 / F

The pilot piston is drawn out of the hydraulic part together with the electrical part. Remove bottom cover plate (12). Remove safety rings (8), pressure rings (9), groove rings (10) and retaining rings (11). The slave piston can be drawn out by means of a bolt (metric thread M 8) screwed into the slave piston from below.

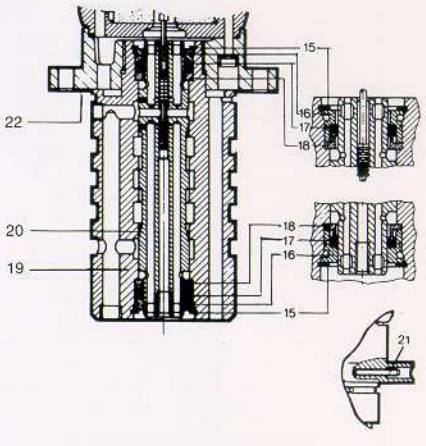
Fig. 22 Cut view of TR-h 7 / F
8 Safety ring
9 Pressure ring
10 Groove rings
11 Retaining rings
12 Cover plate
13 Slave piston
14 Housing block



Hydraulic part of TR-h 7 / FE

Loosen grub screw (21) and screw out the control hull (19) together with slave piston (20). Dismantling of the slave piston (20): Remove safety rings (15), pressure rings (16), groove rings (17) and retaining rings (18). Slave piston to be pulled out by means of a bolt (metrical thread M 8).

Fig. 23 Cut view of TR-h 7 / FE
15 Safety rings
16 Pressure rings
17 Groove rings
18 Retaining rings
19 Control hull
20 Slave piston
21 Grub screw
22 Gasket



Assembly is carried out in the reverse order. All throttles and channels should first be thoroughly cleaned. The sliding surfaces of the pilot piston and the control piston must be glossy and free from grooves. For assembly cleaness is extremly important.

Electrohydraulic Control Systems supplied by EMG

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Your local representaive:

Elektro-Mechanik GmbH
Industriestraße 1
D-57482 Wenden
Phone: (02762) 612-0
Telefax: (02762) 612-394
Internet: http://www.emg-wenden.de
eMail:V3@EMG-wenden.de

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