COMPONENTS FOR ELECTRO-PNEUMATIC SYSTEM

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Summary

The following components are presented:
(a) Pneumatic actuator with built-in electrically controlled valves;
(b) Electrically controlled pneumatic valve;
(c) Electrically controlled locking device.
These components are used in an elbow system (the SVEN-elbow). They have been long-life and temperature tested and partly manufactured in a small pilot series.

Introduction

The components to be presented are intended to be used in a system operating in a pulsed mode. Both four-way and three-way regulation is possible but four-way regulation has been preferred for our purpose partly because it makes it possible to obtain variable average pressure level. More details about the system can be found in Johansson, *et al.*/1/.

Pneumatic Actuator with Built-in Electrically Controlled Valves

An actuator of a new type has been developed. The conventional crank arm has been replaced by a horn-shaped link -- an evolute curve. The link is driven by a pair of rollers on the piston shaft. This makes it possible to fasten the motor rigidly to the forearm or upper arm. The conventional type of pivoted mounting is thus unnecessary. Figure 1 shows a sketch of the design and Figure 2 is a photograph of it.

Four valve units, individually controlled from electrical signals, are included in the design. Preliminary specifications are:

Piston area	5 cm^2 and 3.25 cm^2
Stroke	2.5 cm
Total volume	12.5 cm^2
Length of lever arm	1.2 cm

The work has been performed at the Research Institute of the Swedish National Defence, coordinated by the Swedish Institute for the Handicapped and sponsored by the Swedish Board for Technical Development.

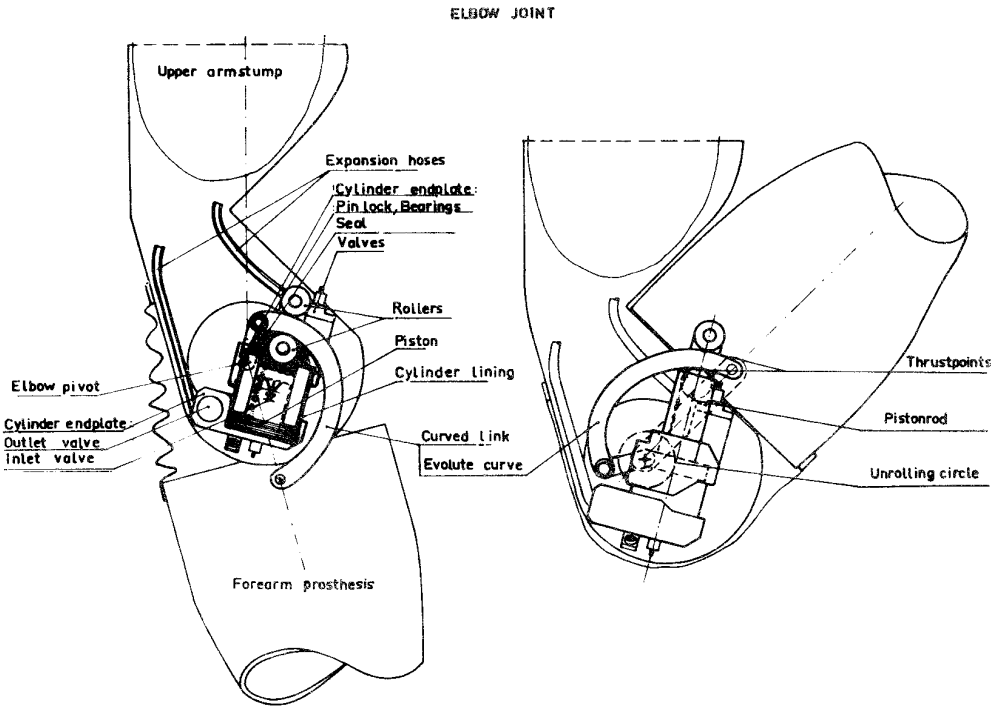

ELBOW JOINT
Upper armstump
Expansion hoses
Cylinder endplate
Pin lock, Bearings
Seal
Valves
Rollers
Piston
Cylinder lining
Elbow pivot
Cylinder endplate
Outlet valve
Inlet valve
Curved link
Evolute curve
Forearm prosthesis
Thrustpoints
Pistonrod
Unrolling circle

Fig. 1.

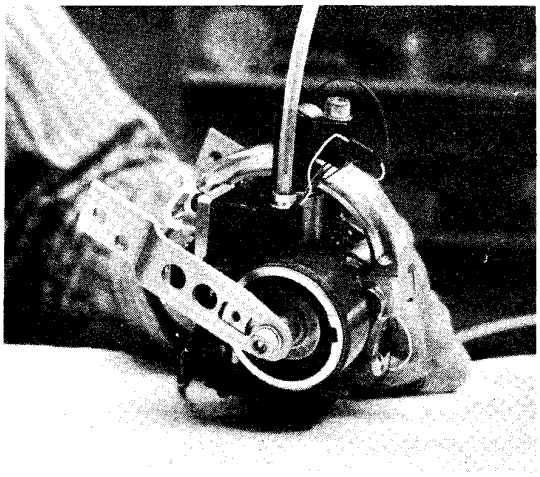


Fig. 2.

Supply pressure	40 bars
Maximum motor torque (at 40 bars)	2.4 kpm and 1.5 kpm
Angle of rotation	5 - 125 degrees
Velocity (without load)	~ 125°/sec
Weight	250 g

Electrically Controlled Pneumatic Valve

The valve body contains two single valve-units (orifices), one up-stream and one down-stream, each controlled by a solenoid. To the up-stream-part the pneumatic supply is connected (three-way coupling) and through the down-stream-part is the gas outlet. Between the orifices is the connection for the motor cylinder.

Each orifice is controlled individually by electrical pulses, which open the valve. Without pulses the valve is closed. The gas flow is determined by the pulse frequency and pulse-width, giving two different principles of modulation (pulse-frequency or pulse-width-modulation). Pulse-width-modulation requires less power, and gives less wear and less noise than pulse-frequency-modulation. In order to get reliable operation a current-amplitude of about 350 mA and a pulse-width of about 1 ms is required (the pneumatic pulse-width is larger).

By means of two valve bodies a four-way-valve-function is obtained. Figure 3 shows the mechanical construction.

Electrically Controlled Locking Device

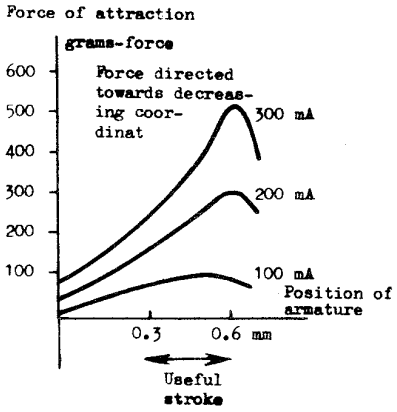
Figure 4 shows the construction. The lock consists of three main assemblies -- the stator, the armature and the swage block. The latter assembly consists of a disk with 26 holes and a hollow axle in one piece, mounted with needle rollers on a pivot. The movement of the forearm (and disk) is locked by means of 4 pairs of pins of which one pair is in hole position when locked. The armature (and pins) are radially fixed to the stable part of the actuator by a torque beam, but axially movable. The torque beam measures the torque imbalance (the difference between the torque on the motor side and arm side of the lock) by means of a strain gauge. This torque imbalance signal can be fed back to get torque balance automatically before unlocking.

Table 1.

Preliminary data for Electromagnet and Pneumatic Valve

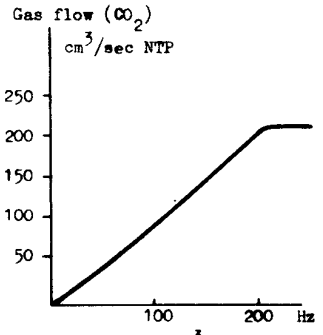
Electromagnet

Diameter	10 mm
Length	15 mm
Volume	1 cm^3
Weight	6.5 g
Coil turns	670
Wire diameter	0.12 mm
Coil resistance	20 Ω
Max. force at 300 mA	500 gf
Max. power consumption in coil	2 W
Air gap width	35 µm
Bearing, radial play	5 - 10 µm

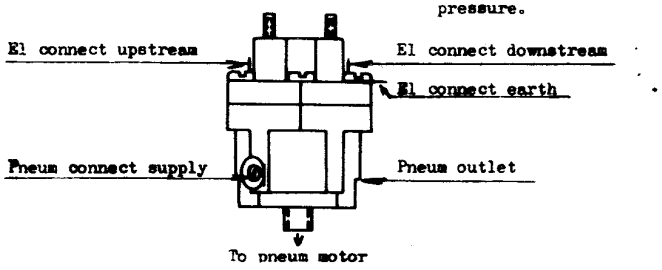


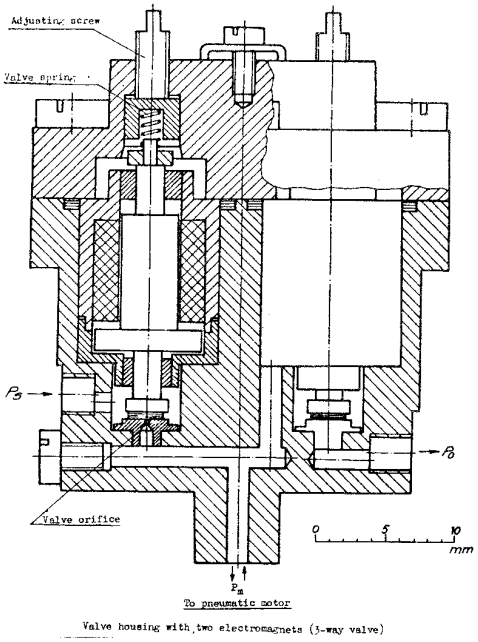
Valve assembly with two valves

Width	16 mm
Length	30 mm
Height	40 mm
Volume	12 cm^3
Weight	40 g
Orifice diameter	0.3 mm
Stroke	0.3 - 0.5 mm
Max. pulse frequency (at 1 ms current pulse)	200 Hz
Coil power consumption at 200 Hz pulse frequency	0.6 W
Max. pressure	60 bar



Gasflow in cm^3/sec of NTP through valve element at 1 ms currentpulse through coil with 20 bar supply pressure.





Valve housing with two electromagnets (3-way valve)

Fig. 3. Mechanical construction

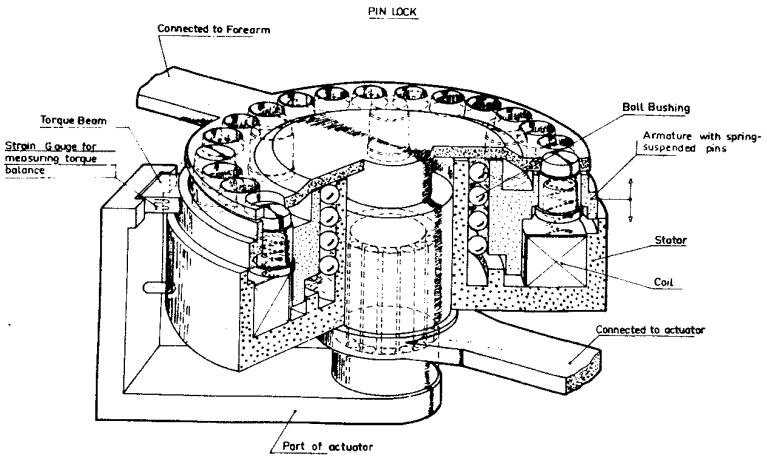


Fig. 4. Details of the locking device

Specifications:

Weight	75 gr
Max torque	~ 2.5 kpm
Angle between adjacent locking positions	3.5^0
Coil resistance	25 Ω
Unlocking current	400 mA
Holding current	100 mA
Max torque for unlocking	(3-4)% of max torque

References

/1/ Johansson, C., Persson, T.R., and Ulén, E.; "Report on Development of Pneumatically Operated Elbow Joint and Electrically Controlled Pneumatic Valve," FOA 2 report No. C 2407-54, July 1970.