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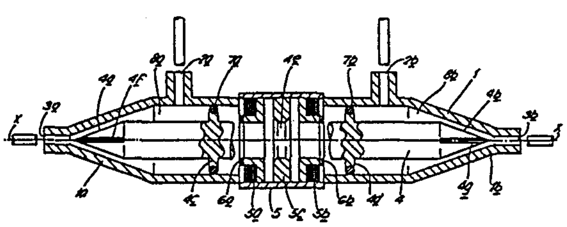
(54) **Proportioners.**

(57) Proportioners may be used in hydraulic circuits to provide the symmetrical deployment of components controlled by these circuits. In the airbrake-deploying circuit of an aircraft, for example, certain fail-safe conditions must be satisfied i.e. the symmetrical deployment of the airbraking surfaces, and therefore the inclusion of a proportioner is desirable if not essential. The invention described herein relates to a proportioner having twin fluid flow path which incorporates a stepper motor, the stepper motor being operable to adjust the flow in each flow path via throttling means so that the airbrakes, for example, are deployed synchronously. The proportioner is also inherently fail-safe, as the pressure differential in the two fluid flow path acts to cancel any imbalance which may be present in the hydraulic circuit should the stepper motor fail.



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PROPORTIONERS

This invention relates to proportioners suitable for use in hydraulic circuits.

Proportioners may be used in hydraulic circuits to provide the symmetrical deployment of components controlled by such circuits. For example, in the airbrake-deploying circuit of an aircraft, certain fail-safe conditions must be satisfied ie the symmetrical deployment of the airbraking surfaces, and thus the inclusion of a proportioner may be desirable if not essential. Hitherto, where proportioners have relied only on differential hydraulic pressures or flows, they have proved somewhat imprecise.

It is therefore an object of the present invention to provide a proportioner that has improved precision of operation.

It is a further object to provide a proportioner which is simple and therefore cheap to produce.

Yet a further object is to provide a proportioner which is inherently fail-safe.

According to the present invention, there is provided proportioning means for connection to a source of fluid pressure and to separate actuators which require to be synchronously moved, including in combination, casing means having twin fluid flow path means each having an inlet for connection to said source and an outlet for connection one of said actuators, fluid flow throttling means, and pressure-sensitive piston-cylinder means, the proportioning means further including stepper motor means having stator means and shaft means, the stator means being carried by said casing means and the shaft means lying within said casing means to actuate said fluid flow throttling means, whereby stepping of the stepper motor in response to variations in flow to the actuators effects a decrease or increase of flow in order to effect synchronisation of the actuators, and on failure of the stepper motor, any pressure differential within said pressure-sensitive piston-cylinder means causes said shaft means to actuate said flow throttling means to effect synchronisation of the actuators.

Preferably, the stepper motor is reciprocatory and the fluid flow throttling means comprise valve surfaces formed upon spaced ends of the casing means and between which is carried said stator means of the stepper motor, the fluid flow throttling means further comprising opposed valve members carried at the remote ends of the shaft means of the stepper motor, each valve member being operable to mate with its associated valve surface to open and close the valve thereformed, so that when one valve is substantially fully opened, the opposed valve is substantially closed.

The valve members and valve surfaces may be of conical shape, the valve members having bleed flutes formed on the conical surface.

Each pressure-sensitive piston-cylinder means may be formed by an end portion of the casing means and each piston may be formed by an end portion of the shaft means, the two being sealed by sealing means provided.

Advantageously, the casing means, the stepper motor means, the pressure-sensitive piston-cylinder means and the fluid flow throttling means are arranged to be coaxially aligned.

For a better understanding of the invention, reference will now be made, by way of example, to the accompanying drawings in which:-

Figure 1 shows a sectional side elevation of a proportioner;

Figure 2 shows a schematic block diagram of an airbraking system as fitted to an aircraft incorporating the proportioner.

A proportioner, as shown in figure 1, comprises a casing 1 in which are formed a pair of inlet ports 2a, 2b and a pair of outlet ports 3a, 3b. A linear stepper motor 5 of annular form is mounted rigidly in the casing 1. A shaft 4 having an axis X-X passes through the annulus of the motor 5 and is carried on a pair of phosphor-bronze bush bearings 6a, 6b for reciprocatory movement along its axis. The stepper motor 5 consists of two toroidal phase windings 5a, 5b and a samarium cobalt permanent magnet 5c. The shaft 4 has a portion 4e in its centre which is adapted so that the shaft can be "stepped" to the right or left along its axis X-X by the motor 5. The outlet ports 3a, 3b are located at the ends of the casing coaxially with X-X. Adjacent the ports 3a, 3b, on the interior of the casing 1, are provided conical valve surfaces 1a, 1b respectively. At each end of the shaft 4, is a conical valve member 4a, 4b having a fluid bleed flute 4f, 4g, which can mate with the surfaces 1a, 1b. The relative positions of surfaces 1a, 1b and members 4a, 4b respectively control the flow of fluid through the outlet ports 3a, 3b. Flanges 4c, 4d are formed on the shaft 4 to form two separate hydraulic fluid cylinders 8a, 8b. '0' ring seals 7a, 7b prevent the flow of fluid between the flanges 4c, 4d and the casing 1, but they allow the shaft 4 to move relative to the casing 1 when the stepper motor 5 is operated.

Under normal operating conditions, the proportioner forms part of a system, as shown in figure 2. A pump 9 pumps hydraulic fluid into the proportioner 10 from a fluid reservoir (not shown). The inlet pressures at the inlet ports 2a, 2b are equal. The fluid flows through the proportioner 10 and is fed to meters 11 and 12 via the outlet ports 3a, 3b. The meters 11, 12 measure the flowrate from each half of the proportioner 10 as the fluid passes through them to airbrake jacks (not shown). Signals representing the measured flowrates are sampled at intervals by a comparator/controller 13 and the signals are compared. If one signal is greater than the other, the comparator/controller 13 then signals the proportioner 10, indicating to the motor 5 which way it should "step" to correct the imbalance present in the system. For example, if the signal sampled from meter 12 was greater than the one sampled from meter 11, ie the flow out of the outlet port 3b was greater than the flow out of port 3a, the comparator/controller 13 would signal the proportioner 10, indicating to it that the motor 5 should "step" the shaft 4 to the right ie bringing the valve surface 1b and valve member 4b closer together and the moving valve surface 1a and valve member 4a further apart to respectively decrease and increase the flow.

Similarly, if the signal sampled from meter 11 was greater than that from meter 12, the shaft 4 would be "stepped" to the left. The next time the signals from the meters 11, 12 are sampled, the procedure is repeated. This may be carried out several times until the two flowrates are balanced. Sampling may be carried out every 40 ms - the motor 5 can "step" the shaft 4 in increments of 0.635 mm

(0.025 in) giving a range of possible outlet flowrates determined by the physical size of the proportioner.

If, however, the linear stepper motor 5 fails, the proportioner would then act to balance the pressures in the two hydraulic cylinders 8a, 8b. For example, if the motor 5 failed as the airbrakes were being applied and, say, the left airbrake jack was the more deployed ie there was a greater flowrate through cylinder 8a than through cylinder 8b, then the pressure in the left hydraulic cylinder 8a of the proportioner would be less than the pressure in the right hydraulic cylinder 8b. The greater pressure in cylinder 8b would then cause the shaft 4 to move towards the left, tending to close the off port 3a and open port 3b until the pressures in both cylinder 8a, 8b were balanced, thus producing equal deployment of the airbrakes. If, on the other hand, the motor 5 fails as the airbrakes are being retracted with, say, the left airbrake retracted to a greater extent than the right airbrake, then the greater pressure in the right airbrake jack due to the action of the surrounding air on the airbrake surface would cause the shaft 4 to move to the left tending to close off port 3a and open port 3b, thus produicng a greater flowrate through the right hydraulic cylinder 8b, until the pressures are balanced.

CLAIMS

1. Proportioning means for connection to a source of fluid pressure and to separate actuators which require to be synchronously moved, including in combination, casing means having twin fluid flow path means each having an inlet for connection to said source and an outlet for connection to one of said actuators, fluid flow throttling means, and pressure-sensitive piston-cylinder means, the proportioning means further including stepper motor means having stator means and shaft means, the stator means being carried by said casing means and the shaft means lying within said casing means to actuate said fluid flow throttling means, whereby stepping of the stepper motor in response to variations in flow to the actuators effects a decrease or increase of flow in order to effect synchronisation of the actuators, and on failure of the stepper motor, any pressure differential within said pressure-sensitive piston-cylinder means causes said shaft means to actuate said flow throttling means to effect synchronisation of the actuators.

2. Proportioning means according to claim 1, wherein the stepper motor shaft is reciprocatory, and wherein the fluid flow throttling means comprise valve surfaces formed upon spaced ends of the casing means and between which is carried said stator means of the stepper motor, the fluid flow throttling means further comprising opposed valve members carried at the remote ends of the shaft means of the stepper motor, each valve member being operable to mate with its associated valve surface to open and close the valve thereformed, so that when one valve is substantially fully opened, the opposed valve is substantially closed.

3. Proportioning means according to claim 2, wherein the valve members and valve surfaces are of conical shape, the valve members having bleed flutes formed on the conical surface.

4. Proportioning means according to any one of claims 1 to 3, wherein each pressure-sensitive piston-cylinder means is formed by an end portion of the casing means, and each piston is formed by an end portion of the shaft means, and sealing means are provided for effecting sealing between said portions of the casing means and the shaft means.

5. Proportioning means according to claim 4, wherein the casing means, the stepper motor means, the pressure-sensitive piston-cylinder means and the fluid flow throttling means are arranged to be coaxially aligned.

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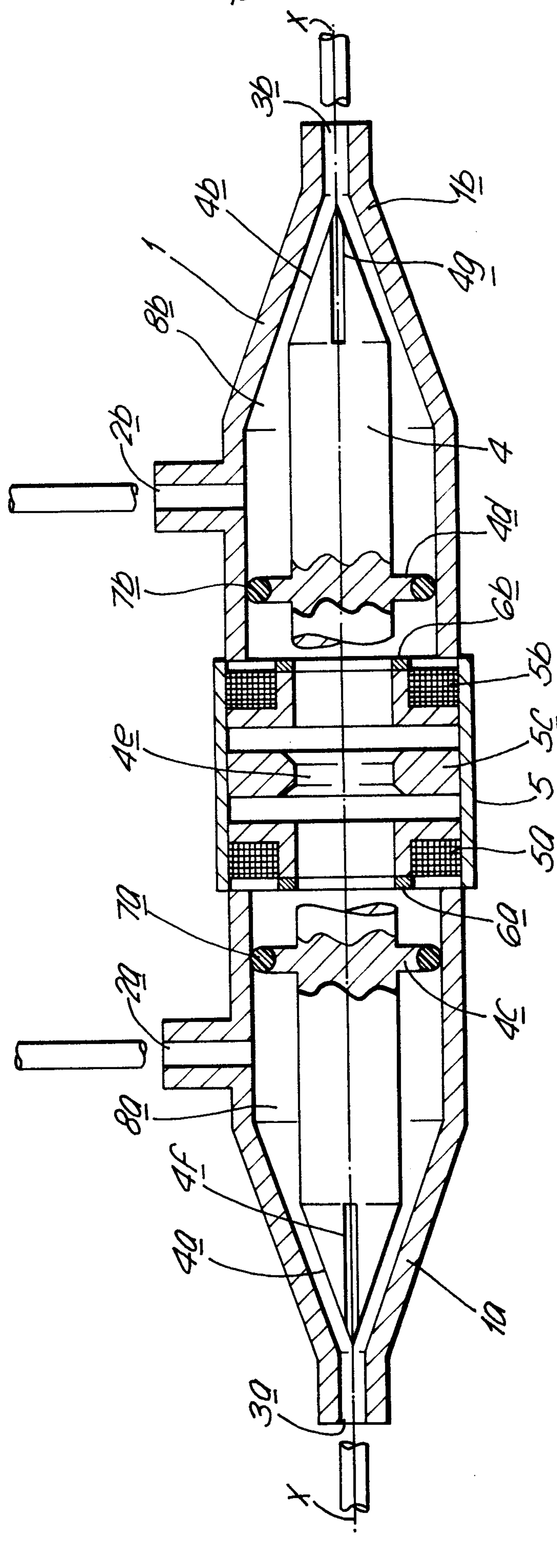
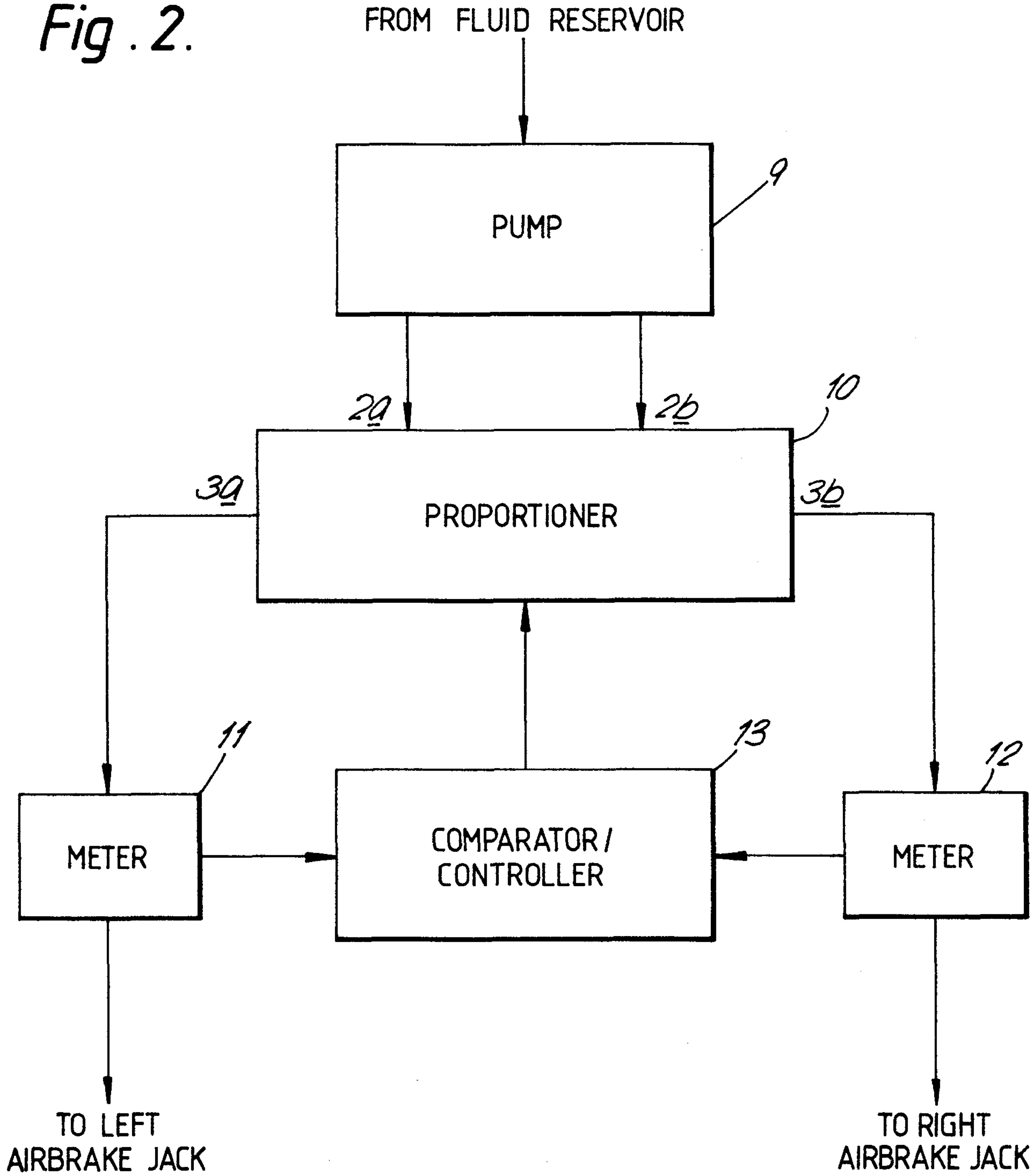


Fig. 1.

Fig. 2.


FROM FLUID RESERVOIR
PUMP
9
2a
2b
10
PROPORTIONER
3a
3b
METER
11
COMPARATOR / CONTROLLER
13
METER
12
TO LEFT AIRBRAKE JACK
TO RIGHT AIRBRAKE JACK