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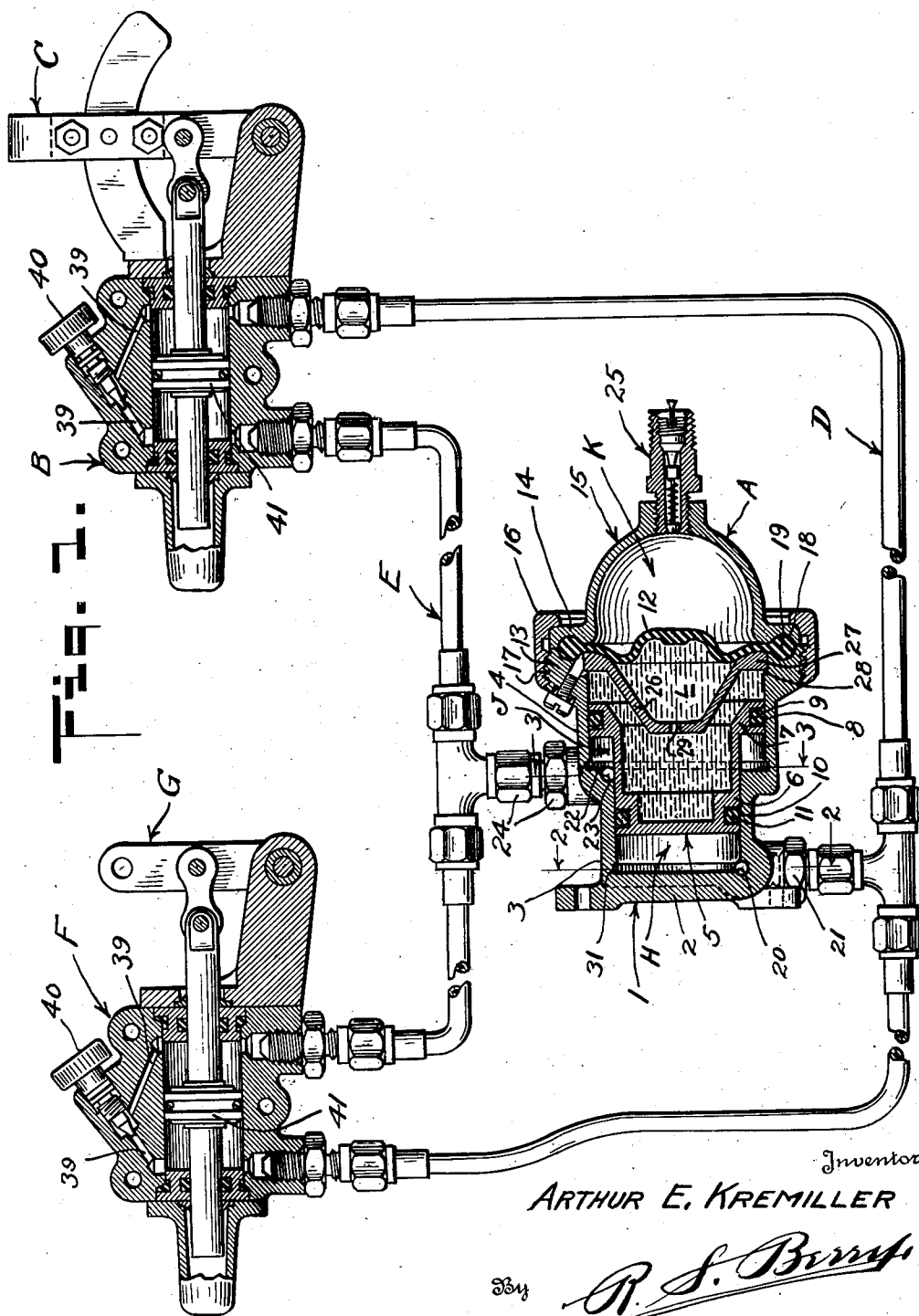
A. E. KREMILLER

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COMPENSATOR-ACCUMULATOR UNIT FOR HYDRAULIC SYSTEMS

Filed Aug. 20, 1943

3 Sheets-Sheet 1



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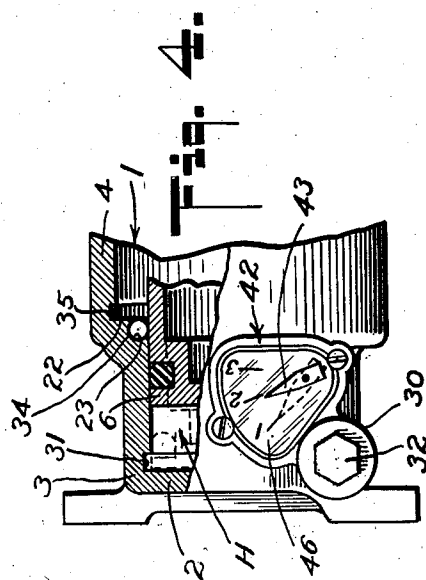
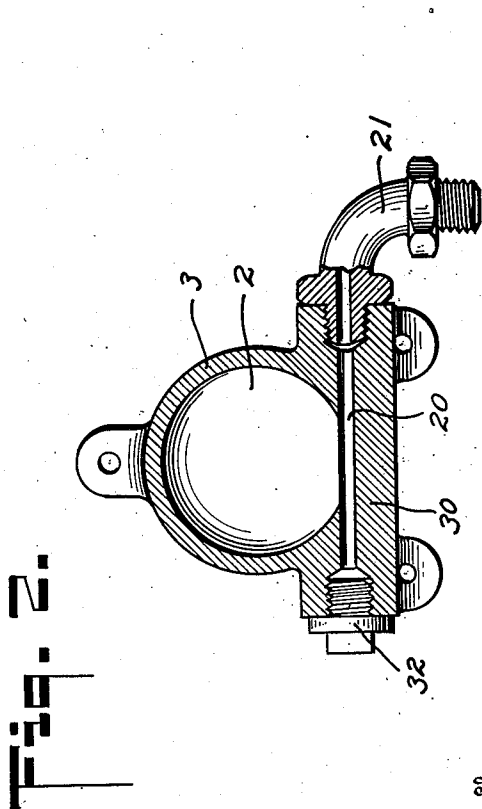
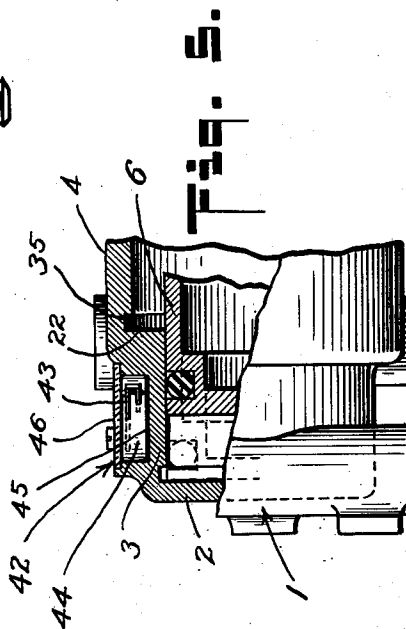
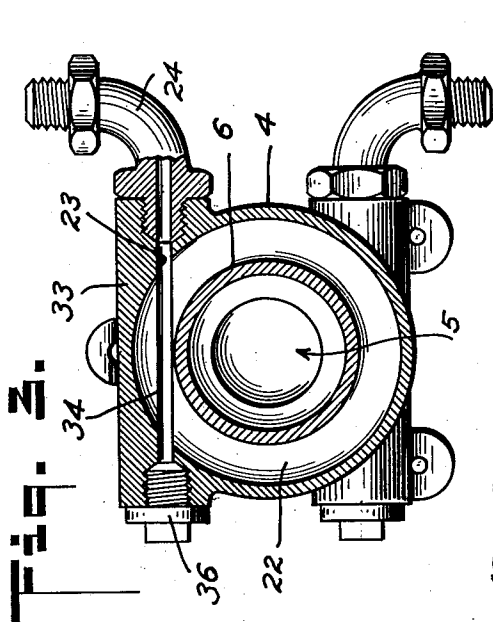
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COMPENSATOR-ACCUMULATOR UNIT FOR HYDRAULIC SYSTEMS

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3 Sheets-Sheet 2



Inventor
ARTHUR E. KREMILLER

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R. S. Barrett
Attorney

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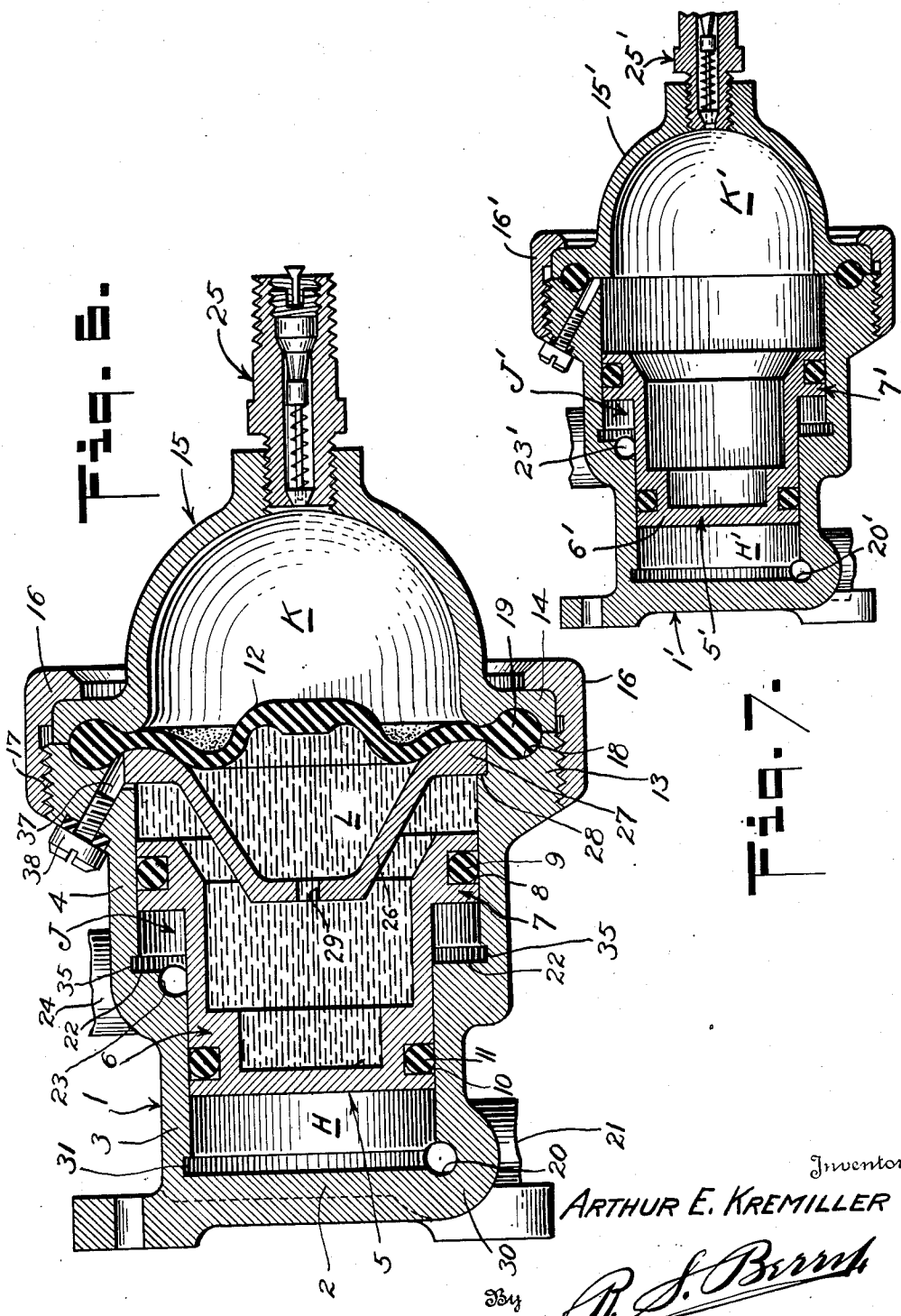
A. E. KREMILLER

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COMPENSATOR-ACCUMULATOR UNIT FOR HYDRAULIC SYSTEMS

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3 Sheets-Sheet 3



Inventor
ARTHUR E. KREMILLER

R. S. Bernick
Attorney

UNITED STATES PATENT OFFICE

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COMPENSATOR-ACCUMULATOR UNIT FOR
HYDRAULIC SYSTEMSArthur E. Kremiller, Glendale, Calif., assignor to
Adel Precision Products Corp., a corporation
of California

Application August 20, 1943, Serial No. 459,429

11 Claims. (Cl. 138—31)

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This invention relates to hydraulic systems of the closed, manually operated and remote control type as employed for operating the engine throttles and other mechanisms in aircraft, and more particularly pertains to and has for an object the provision of a novel and highly efficient thermal change compensator-accumulator unit which in addition to maintaining the proper volume of hydraulic fluid throughout such a system regardless of thermal expansion and contraction of the fluid and fluid lines, operates to supply an initial pressure to the system and maintain it under a predetermined pressure in such manner as to improve the operation thereof as to quickness and accuracy of response under all working conditions and temperatures.

Another object of my invention is to provide a compensator-accumulator unit of the character described in which a novel dual and coaxial piston unit and an especially constructed cylinder-diaphragm assembly are so arranged and related as to provide compensating chambers of equal volume and an accumulator-compensator unit of simple, compact and light weight construction.

Another object of my invention is to provide a compensator-accumulator unit of the character described in which leakage and pinching and consequent damage of the diaphragm are prevented by the provision of a low temperature oil or grease chamber between the diaphragm and the piston in an arrangement causing the diaphragm to be balanced between air pressure on one side and a viscous fluid on the other side.

A further object of my invention is to provide a compensator of the character described in which an efficient indicator is embodied in such manner as to show at all times the position of the dual-piston to give the proper reading for the required temperature.

With the foregoing objects in view, together with such other objects and advantages as may subsequently appear, the invention resides in the parts and in the combination, construction and arrangement of parts hereinafter described and claimed, and illustrated by way of example in the accompanying drawing, in which:

Fig. 1 is a semi-schematic view of a hydraulic system equipped with a compensator embodying my invention, showing the transmitter or pump cylinder, the accumulator and the motor or driven cylinder in longitudinal section;

Fig. 2 is a cross sectional view taken on the line 2—2 of Fig. 1;

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Fig. 3 is a cross sectional view taken on the line 3—3 of Fig. 1;

Fig. 4 is a fragmentary side-elevation of one end of the accumulator showing the indicator in elevation and parts of the housing and piston in section;

Fig. 5 is a part sectional, part elevational view similar to Fig. 4 with the indicator shown in section as well as portions of the housing and piston;

Fig. 6 is an enlarged longitudinal sectional view of the compensator accumulator unit;

Fig. 7 is a longitudinal sectional view of a modified form of the invention.

As shown in Fig. 1 of the accompanying drawing, a compensator unit A embodying my invention is employed in connection with a dual line, closed and manually operable hydraulic remote control system in which a transmitter or pump unit B of the double-acting cylinder type operated by a friction-locked handle C is connected by fluid lines D and E with a receiver or motor unit F of the double-acting cylinder type identical with unit B except that it operates a crank arm G adapted to be connected with the aircraft-carried mechanism (not shown), which is to be controlled or actuated by such a system.

The compensator unit A includes a generally cylindrical housing 1 closed at one end by a wall 2, open at its other end. Within the housing are coaxial cylinders 3 and 4 of which the cylinder 3 is of smaller diameter than cylinder 4.

As here provided a dual piston unit 5 consisting of a piston portion 6 operable in the cylinder 3 and a piston portion 7 operable in the cylinder 4 is contained in the housing 1. The piston portion 7 is formed as a radially extending annular enlargement of the skirt of the piston portion 4 and has a peripheral groove 8 therein containing a sealing ring 9 of circular cross section. A similar sealing 10 is mounted in a groove 11 therefor in the head of the piston portion 6.

A bladder type diaphragm 12 of flexible elastic material is mounted on and closes the open end of the housing 1 being held between a flange 13 on the housing and a flange 14 on a cup-like extension 15 of the housing. A flanged nut 16 threadedly engaged with screw threads 17 on the housing flange 13 holds the cup-like extension 15 and the diaphragm in place, there being complementary grooves 18 in the flanges 13 and 14 receiving a marginal bead 19 of the diaphragm which bead forms an effective fluid tight seal.

It is now seen that there is provided in the

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cylinder 3 between the piston portion 6 and the wall 2, an accumulator-compensator chamber H which is adapted to be connected with the line D by means of a port 20 and suitable fittings 21 as shown in Fig. 1.

In the cylinder 4 between the piston portion 7 and an annular shoulder or wall 22 at the juncture of cylinders 3 and 4, is formed another compensator-accumulator chamber J of a volume equal to chamber H and adapted to be connected with the system line E by means of a port 23 and fittings 24 as shown in Fig. 1.

An air chamber K is provided between the cup-like extension 15 and the diaphragm 12 and is adapted to be supplied with air under pressure through a suitable valved intake 25, and to maintain the air therein under predetermined pressure.

I may as here shown also use a chamber L which is defined between the dual piston unit 5 and the diaphragm 12, as a fluid chamber for liquid or gaseous fluid. As here shown the chamber L is filled with a viscous fluid such as oil or grease. Preferably the piston unit 5 is hollow thereby affording (as shown in Fig. 1) considerable depth and area for chamber L, and providing for requisite movement of the diaphragm as well as for a large volume of oil or grease between the diaphragm and the piston whereby the diaphragm is balanced between air under pressure on one side and a viscous fluid on the other side so that the latter operates the dual piston to create pressure in the chambers H and J thereby regulating pressure within the hydraulic system.

A guard or stop member 26 of concavo-convex form is mounted as a partition between the diaphragm 12 and the piston, within the cylinder 4, being seated at its margin portion 27 in a recess 28 in said cylinder, with its generally convex side directed away from the diaphragm. An opening 29 in the member 26 allows for passage of fluid into the space between the member and the diaphragm. The movement of the piston unit toward the diaphragm is limited by the piston portion 7 engaging the marginal portion of the member 26. The diaphragm is limited by the member 26 as to its movement toward the piston and thereby prevented from being pinched or damaged, there being also the body of the viscous fluid between the member 26 and the diaphragm. The marginal portion 27 of member 26 contacts the diaphragm adjacent the bead 19 and acts as a support for the diaphragm which latter, however, is free to move from one side to the other of a somewhat spherical space afforded between the members 15 and 26, being limited by the concave surfaces of said members.

As shown in Figs. 2 and 4 the port 20 which affords connection of chamber H with the line D is extended transversely of cylinder 3 through a portion 30 of the wall of the cylinder 3 so as to intersect a counterbored groove 31 formed at the outer end of the cylinder next adjacent the end wall 2. This arrangement provides for communication of the chamber H with the port 20 when the piston 6 reaches the ends of its stroke against the wall 2 as shown in dotted lines in Fig. 4. One end of the port 20 is closed by means of a plug 32 while the other end has one of the fittings 21 mounted therein as shown in Fig. 2.

As shown in Figs. 3 and 5 the port 23 which provides for connection of the chamber J with the fluid line E, is extended transversely of the cylinder 4 through a portion 33 of the wall of the cylinder and so as to form a groove 34 across

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the face of the shoulder 23, and to intersect a counterbored groove 35 in said cylinder adjacent the shoulder 22. This arrangement affords the communication of the chamber J with the port 23 when the piston 7 reaches the end of its stroke against the shoulder 22. A plug 36 closes one end of the port 23 while one of the fittings 24 is mounted in the other end of the port.

The housing 1 is equipped with two or more bleeder openings such as the one 37 shown in Fig. 6 and closed by a screw plug 38, said opening providing for the introduction of the viscous fluid into the chamber L and also making it possible to bleed air therefrom.

Synchronization of the compensator and in fact the entire system is made possible by by-pass passages 39 in the cylinders of the units B and F, there being valves 40 controlling said passages so that an equal volume of fluid may be provided on opposite sides of the pistons 41 in said cylinders, the lines E and D and the chambers H and J connected to said lines.

The systems and the chambers H and J are charged with the hydraulic fluid through ports 20 and 23 upon removal of the associated plugs 32 and 36, the valves 48 being removed to bleed air from the system.

The chamber L is filled with a viscous fluid such as grease or oil, through one of the openings 37, following which the air chamber K is charged with air through the valved intake 25 until an air pressure greater than or equal to the load on the motor unit F is attained whereupon the entire system is initially placed under the desired fluid pressure and so maintained to an extent (say approximately 1000 pounds per square inch) such that sluggishness of action is eliminated, erratic operation due to compression of the fluid is appreciably reduced, the intaking of air into the system is prevented and a quick power transmission and response of the motor unit is assured when the manually operated transmitter or pump unit B is actuated.

When thermal expansion takes place in the lines and associated elements of the system, the piston unit 5 will be moved toward the diaphragm 12, which through the body of liquid in chamber L will be bulged to the right into the chamber K thereby permitting of said movement of piston unit 5 so that the capacity of the chambers H and J in cylinders 3 and 4 respectively will be increased to accommodate the aforesaid expansion of the fluid.

When contraction of the fluid takes place the air pressure in chamber K bulges the diaphragm 12 to the left into the concave side of the member 26 and the fluid between the diaphragm and the piston unit 12 operates to move the piston to the left thereby forcing fluid from chambers H and J through the ports 20 and 23 into the lines D and E. Any leakage of fluid will be compensated for by the same action as when contraction takes place. It is now apparent that the accumulator-compensator unit will operate to compensate for thermal contraction and expansion and for fluid leakage to the end that the requisite volume of fluid is contained in the system at all times and under such pressure as will improve the operation of the system in the manner as hereinbefore set forth.

The efficacy of the accumulator-compensator unit is increased by reason of the dual, coaxial piston unit and the separate compensating chambers defined in the cylinders 3 and 4 of the single housing. Moreover, the particular air chamber-

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diaphragm arrangement with the viscous fluid chamber L between the piston and the diaphragm as here provided make for accuracy and reliability of performance, reduces leakage and improves the unit generally for the reasons hereinbefore noted.

The construction and arrangement of the parts and elements of the compensator-accumulator renders the device well suited to use in aircraft hydraulic systems due to the simplicity and compactness of construction and the small size and low weight of the unit as a whole.

As shown in Figs. 4 and 5 I provide a novel and efficient indicator generally designated 42 and mounted on the housing 1 to show the position of the dual piston unit 5 whereby the operator may ascertain at all times the extent of the compensating action being effected by the unit.

In this connection it should be noted that the housing 1 is made of a non-magnetic metal such as aluminum or an aluminum alloy while the piston unit 5 is made of magnetic metal such as iron, whereby a magnetized indicator needle or pointer 43 rotatably supported in chamber 44 in the housing as shown in Fig. 5 will move responsive to movement of the piston unit. A suitably marked dial 45 is mounted in the bottom of the chamber 44 while a transparent cover 46 closes the outer side of the chamber. As shown in Fig. 4 the needle and dial are visible at all times and indicate the position of the piston unit 5. If desired the piston and needle may both be magnetized so that appropriate movement of the needle will be caused by the compensating movements of the piston.

As shown in Fig. 7 a modified form of my invention is constructed in the same manner as the unit shown in Fig. 6 except that the diaphragm 12 and diaphragm stop 26 are omitted. In this form the compressed air chamber occupies the entire housing space between the piston and cup-like extension of the housing. This air chamber is designated K' and the other parts of the device corresponding to similar parts in the first described form are designated by the same reference characters with addition of the prime character. Thus the housing of the modified form is designated 1', the piston unit 5', the compensating chambers H' and J' and so on throughout Fig. 7.

This modified form is applied on the same manner as the accumulator shown in Fig. 1 and has the same general mode of operation except that the diaphragm and fluid between the diaphragm and the piston are omitted. The piston 5' is balanced between air pressure on one side and the pressure of fluid in the hydraulic system in chamber H' and J' on the other side so that the fluid compensating action under thermal contraction and expansion takes place in the same manner as described in connection with the compensator unit shown in Figs. 1 and 6.

The embodiment of the invention shown in Fig. 7 will often be found to operate satisfactorily in situations where the chamber K' is constantly located in the upper part of the structure, but when the device must undergo great change in position, as in aircraft, it is best to use diaphragm, sealed in place as shown in Fig. 6, effectually to prevent liquid from seeping into the air chamber. Furthermore, it is much easier to make a liquid-tight fit around a diaphragm than between a piston and its containing cylinder, and therefore an advantage is obtained by filling the hollow pis-

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ton 5 with liquid, in the manner hereinbefore described.

While I have shown and described specific embodiments of my invention I do not limit myself to the exact details of construction set forth, and the invention embraces such changes, modifications and equivalents of the parts and their formation and arrangement as come within the purview of the appended claims.

I claim:

1. In a temperature change compensator-accumulator unit for hydraulic systems, a substantially cylindrical housing, a flexible elastic diaphragm mounted as a partition in said housing and defining between one end of the housing and one face of the diaphragm a chamber for retaining air under pressure, a valved intake for said air chamber, a pair of coaxial cylinders in said housing between the other face of said diaphragm and the other end of said housing, one of the cylinders being of greater diameter than the other, a dual piston unit having one piston portion reciprocally mounted in one of said cylinders and its other piston portion reciprocally mounted in the other of said cylinders whereby fluid-containing compensating chambers are provided in said cylinders between portions of the cylinder and the heads of the piston portions, a port through which fluid may flow to and from each of said compensating chambers, members providing for the connection of said ports with the fluid lines of a hydraulic system, and means providing for movement of the dual piston unit responsive to movement of said diaphragm.

2. In a temperature change compensator-accumulator unit for hydraulic systems, a substantially cylindrical housing, a flexible elastic diaphragm mounted as a partition in said housing and defining between one end of the housing and one face of the diaphragm a chamber for retaining air under pressure, a valved intake for said air chamber, a pair of coaxial cylinders in said housing between the other face of said diaphragm and the other end of said housing, one of the cylinders being of greater diameter than the other, a dual piston unit having one piston portion reciprocally mounted in one of said cylinders and its other piston portion reciprocally mounted in the other of said cylinders whereby fluid-containing compensating chambers are provided in said cylinders between portions of the cylinder and the heads of the piston portions, a port through which fluid may flow to and from each of said compensating chambers, members providing for the connection of said ports with the fluid lines of a hydraulic system, and means providing for movement of the dual piston unit responsive to movement of said diaphragm, including a fluid filled chamber between said dual piston unit and said diaphragm.

3. In a temperature change compensator-accumulator unit for hydraulic systems, a substantially cylindrical housing, a flexible elastic diaphragm mounted as a partition in said housing and defining between one end of the housing and one face of the diaphragm a chamber for retaining air under pressure, a valved intake for said air chamber, a pair of coaxial cylinders in said housing between the other face of said diaphragm and the other end of said housing, one of the cylinders being of greater diameter than the other, a dual piston unit having one piston portion reciprocally mounted in one of said cylinders and its other piston portion reciprocally mounted in the other of said cylinders whereby

fluid-containing compensating chambers are provided in said cylinders between portions of the cylinder and the heads of the piston portions, a port through which fluid may flow to and from each of said compensating chambers, members providing for the connection of said ports with the fluid lines of a hydraulic system, and means providing for movement of the dual piston unit responsive to movement of said diaphragm, including a fluid filled chamber between said dual piston unit and said diaphragm, said piston unit being hollow with the hollow space thereof forming a part of the fluid filled chamber between the piston unit and the diaphragm.

4. In a temperature change compensator-accumulator unit for hydraulic systems, a substantially cylindrical housing, a flexible elastic diaphragm mounted as a partition in said housing and refining a chamber for retaining air under pressure, a valved intake for said air chamber, a pair of coaxial cylinders in said housing between the other face of said diaphragm and the other end of said housing, one of the cylinders being of greater diameter than the other, a dual piston unit having one piston portion reciprocally mounted in one of said cylinders and its other piston portion reciprocally mounted in the other of said cylinders whereby fluid-containing compensating chambers are provided in said cylinders between portions of the cylinder and the heads of the piston portions, a port through which fluid may flow to and from each of said compensating chambers, members providing for the connection of said ports with the fluid lines of a hydraulic system, and means for moving said dual piston unit responsive to an air pressure effected movement of said diaphragm, including a fluid filled chamber defined between the piston unit and the diaphragm, said piston unit being hollow with the hollow space thereof forming a part of said fluid filled chamber, and a perforated concavo-convex member interposed between the piston unit and said diaphragm to limit the movement of the diaphragm toward the piston unit, and having its concave side opposed to the diaphragm.

5. In a temperature change compensator-accumulator unit for hydraulic systems, a substantially cylindrical housing, a flexible elastic diaphragm mounted as a partition in said housing and defining between one end of the housing and one face of the diaphragm a chamber for retaining air under pressure, a valved intake for said air chamber, a pair of coaxial cylinders in said housing between the other face of said diaphragm and the other end of said housing, one of the cylinders being of greater diameter than the other, a dual piston unit having one piston portion reciprocally mounted in one of said cylinders and its other piston portion reciprocally mounted in the other of said cylinders whereby fluid-containing compensating chambers are provided in said cylinders between portions of the cylinder and the heads of the piston portions, a port through which fluid may flow to and from each of said compensating chambers, members providing for the connection of said ports with the fluid lines of a hydraulic system, and means providing for movement of the dual piston unit responsive to movement of said diaphragm, said cylinders having counterbored grooves therein which are intersected by said ports.

6. In a compensator-accumulator unit, a housing closed at one end and open at its other end, a cup-like housing extension at the open end of

said housing, cooperating abutting flanges on the housing and said extension, a flanged nut screwed on said one of the flanges and encompassing the other flange for holding the extension on the housing, a flexible elastic diaphragm having a marginal portion clamped between said flanges, said diaphragm and extension providing a chamber for air under pressure, a valved air intake for said air chamber, a pair of coaxial cylinders formed between the diaphragm and said closed end of the housing, the cylinder next adjacent the diaphragm being of greater diameter than the other cylinder and defining an annular wall at the juncture thereof with said other cylinder, a dual piston unit having one piston portion reciprocable in said other cylinder and its other piston portion of greater diameter than the first mentioned piston portion and reciprocally mounted in the larger cylinder, there being a fluid-containing compensating chamber in the larger cylinder between the second named piston portion and said annular wall, a port leading through the housing into said compensating chamber, means providing for connection of said port with a fluid line of a hydraulic system, a second fluid containing compensating chamber formed in the smaller cylinder between the head of the piston unit and the closed end of the housing, a port leading through the housing into the second compensating chamber, means providing for connecting the last named port with another fluid line of said hydraulic system, and a fluid filled sealed chamber between the piston and said diaphragm.

7. In a compensator-accumulator unit, a housing closed at one end and open at its other end, a cup-like housing extension at the open end of said housing, cooperating abutting flanges on the housing and said extension, a flanged nut screwed on said one of the flanges and encompassing the other flange for holding the extension on the housing, a flexible elastic diaphragm having a marginal portion clamped between said flanges, said diaphragm and extension providing a chamber for air under pressure, a valved air intake for said air chamber, a pair of coaxial cylinders formed between the diaphragm and said closed end of the housing, the cylinder next adjacent the diaphragm being of greater diameter than the other cylinder and defining an annular wall at the juncture thereof with said other cylinder, a dual piston unit having one piston portion reciprocable in said other cylinder and its other piston portion of greater diameter than the first mentioned piston portion and reciprocally mounted in the larger cylinder, there being a fluid-containing compensating chamber in the larger cylinder between the second named piston portion and said annular wall, a port leading through the housing into said compensating chamber, means providing for connection of said port with a fluid line of a hydraulic system, a second fluid containing compensating chamber formed in the smaller cylinder between the head of the piston unit and the closed end of the housing, a port leading through the housing into the second compensating chamber, means providing for connecting the last named port with another fluid line of said hydraulic system, a fluid filled sealed chamber between the piston and said diaphragm, and a stop member interposed between the piston and said diaphragm in the last named fluid filled chamber to limit the movement of the diaphragm in one direction.

8. In a compensator-accumulator unit, a hous-

ing closed at one end and open at its other end, a cup-like housing extension at the open end of said housing, cooperating abutting flanges on the housing and said extension, a flanged nut screwed on said one of the flanges and encompassing the other flange for holding the extension on the housing, a flexible elastic diaphragm having a marginal portion clamped between said flanges, said diaphragm and extension providing a chamber for air under pressure, a valved air intake for said air chamber, a pair of coaxial cylinders formed between the diaphragm and said closed end of the housing, the cylinder next adjacent the diaphragm being of greater diameter than the other cylinder and defining an annular wall at the juncture thereof with said other cylinder, a dual piston unit having one piston portion reciprocable in said other cylinder and its other piston portion of greater diameter than the first mentioned piston portion and reciprocally mounted in the larger cylinder, there being a fluid-containing compensating chamber in the larger cylinder between the second named piston portion and said annular wall, a port leading through the housing into said compensating chamber, means providing for connection of said port with a fluid line of a hydraulic system, a second fluid containing compensating chamber formed in the smaller cylinder between the head of the piston unit and the closed end of the housing, a port leading through the housing into the second compensating chamber, means providing for connecting the last named port with another fluid line of said hydraulic system, a fluid filled sealed chamber between the piston and said diaphragm, and a stop member interposed between the piston and said diaphragm in the last named fluid filled chamber to limit the movement of the diaphragm in one direction, said piston unit being hollow to define the major part of the sealed fluid filled chamber, said stop member being concavo-convex with its concave side opposed to the diaphragm and its convex side adapted to extend into the hollow piston unit.

9. In a temperature change compensator accumulator unit for a hydraulic system, a housing having coaxial cylinders therein with one cylinder of greater diameter than the other and each cylinder provided with a port for intaking and discharging hydraulic fluid, means affording the connection of said ports with the fluid lines of a hydraulic system, a dual piston unit having one piston portion operable in one of said cylinders and its other piston portion operable in the other of said cylinders, and a gaseous fluid chamber provided in said housing and containing gaseous fluid under pressure so that the piston unit is subject to movement in one direction responsive to

pressure of said gaseous fluid and is subject to movement in the opposite direction responsive to pressure of the hydraulic fluid in said cylinders.

10. In a hydraulic compensator, an elongated housing closed at opposite ends and a pair of connected pistons arranged to reciprocate correspondingly and simultaneously in said housing, the said housing and pistons being constructed and arranged so that there is defined in the housing between one closed end thereof and the pistons a pair of separate compensating chambers in each of which one of the pistons is reciprocable, said chambers being of equal volumetric capacity and adapted to contain hydraulic fluid, there being between the other end of said housing and said pistons a gaseous fluid chamber for containing a gaseous fluid under pressure for moving said pistons in one direction, each of said compensating chambers having a port therein affording the ingress and egress of hydraulic fluid from a fluid line of a dual line hydraulic system.

11. In a hydraulic compensator, an elongated housing closed at opposite ends and a pair of connected pistons arranged to reciprocate correspondingly and simultaneously in said housing, the said housing and pistons being constructed and arranged so that there is defined in the housing between one closed end thereof and the pistons a pair of separate compensating chambers in each of which one of the pistons is reciprocable, said chambers being of equal volumetric capacity and adapted to contain hydraulic fluid, there being between the other end of said housing and said pistons a gaseous fluid chamber for containing a gaseous fluid under pressure for moving said pistons in one direction, each of said compensating chambers having a port therein affording the ingress and egress of hydraulic fluid from a fluid line of a dual line hydraulic system, the said compensating chambers and pistons being coaxial and of differential diameters with the piston of larger diameter disposed so as to be exposed to the gaseous fluid under pressure in said gaseous fluid chamber.

ARTHUR E. KREMILLER.

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