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H. G. CONWAY ET AL

2,659,204

HYDRAULIC POWER SYSTEM

Filed Nov. 18, 1950

2 Sheets-Sheet 1

Fig. 1.

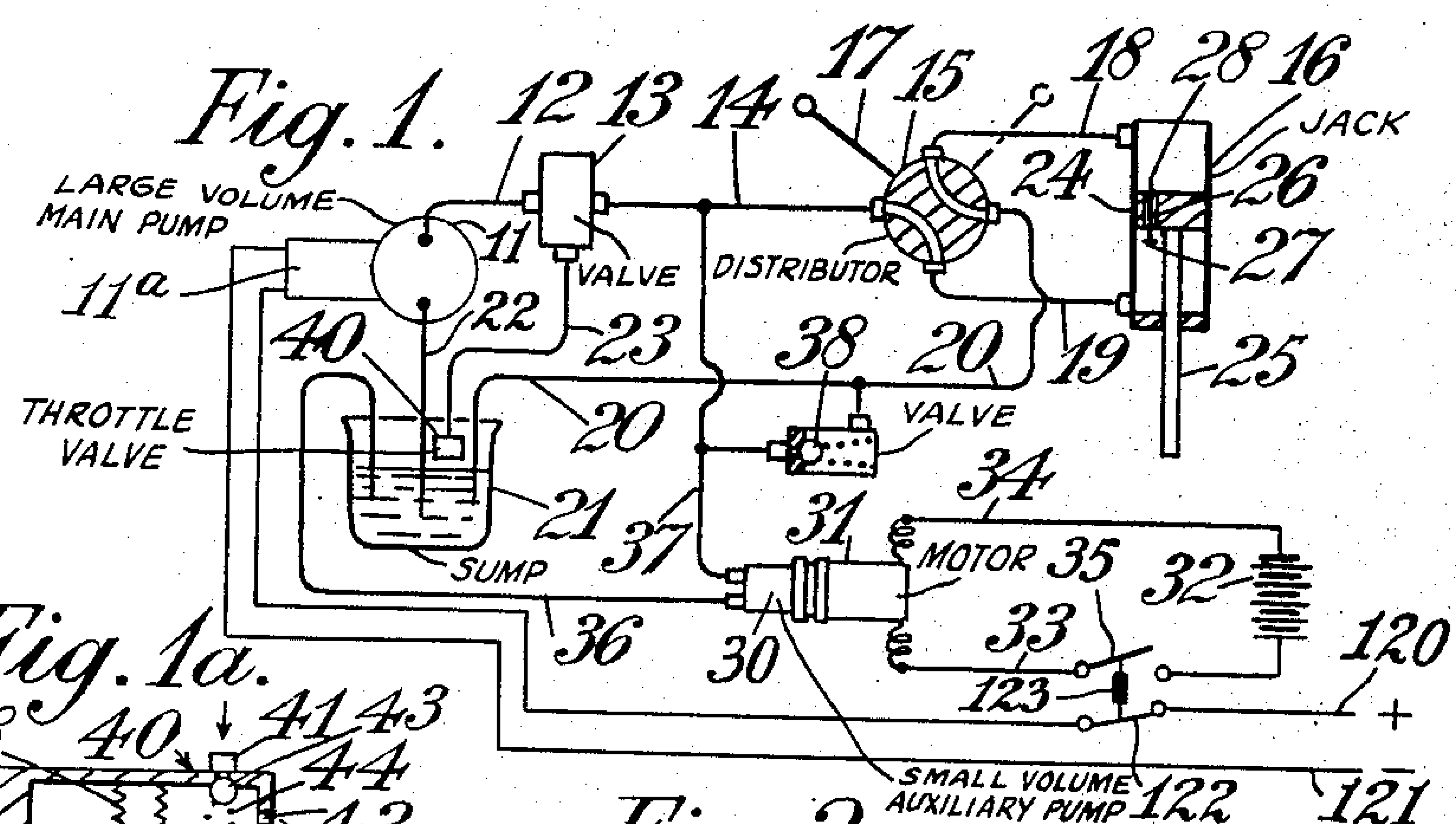

Fig. 1a.

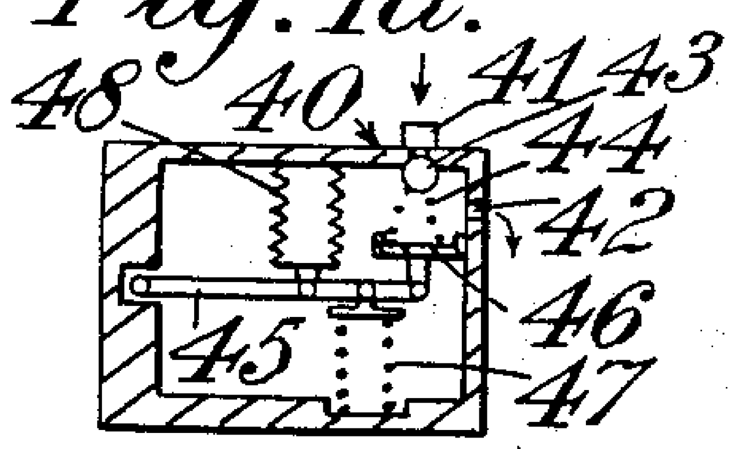

Fig. 2.

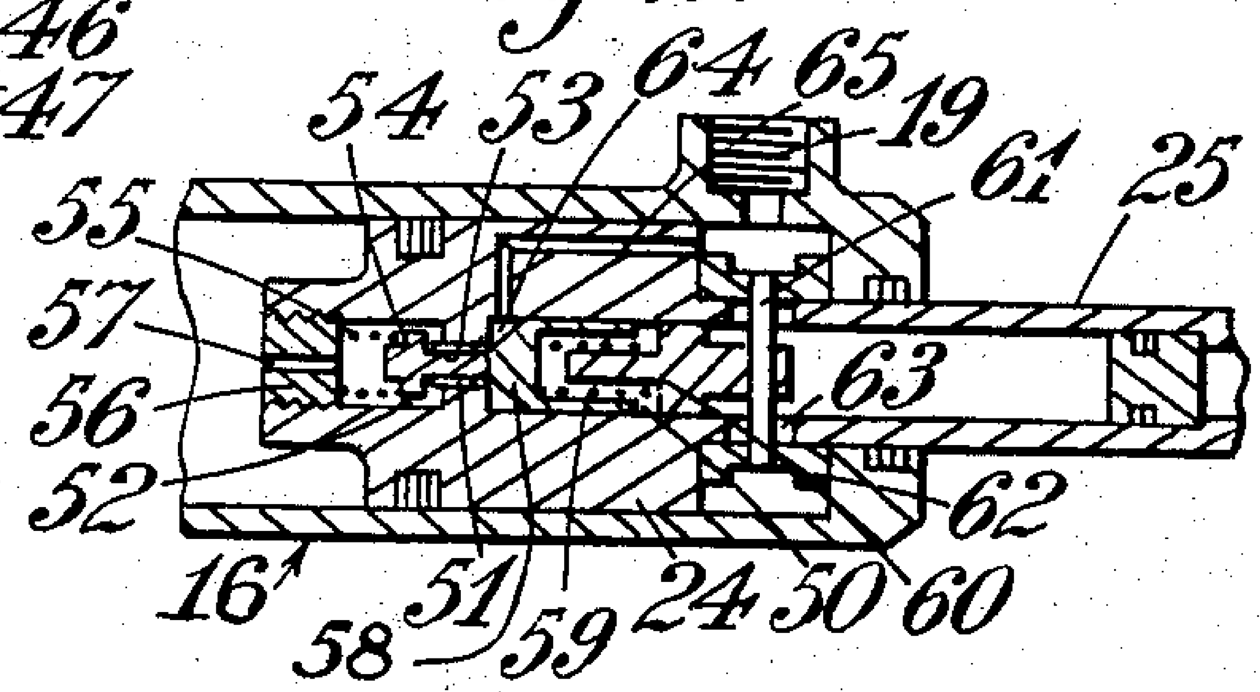

Fig. 3.

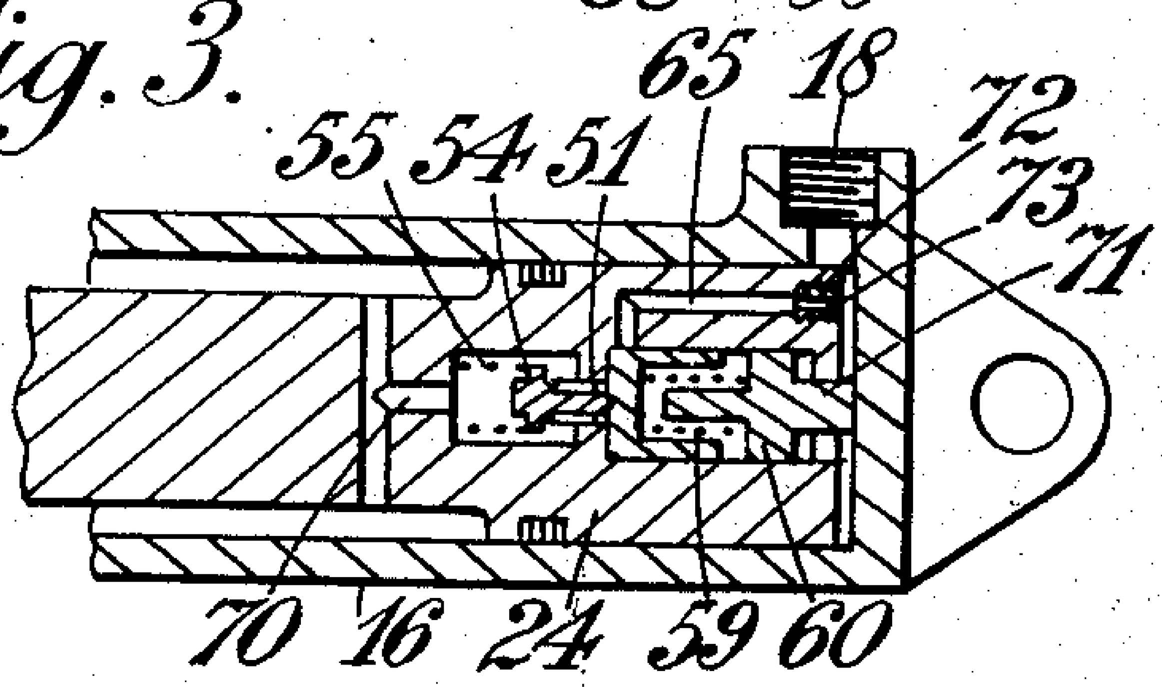

Fig. 4.

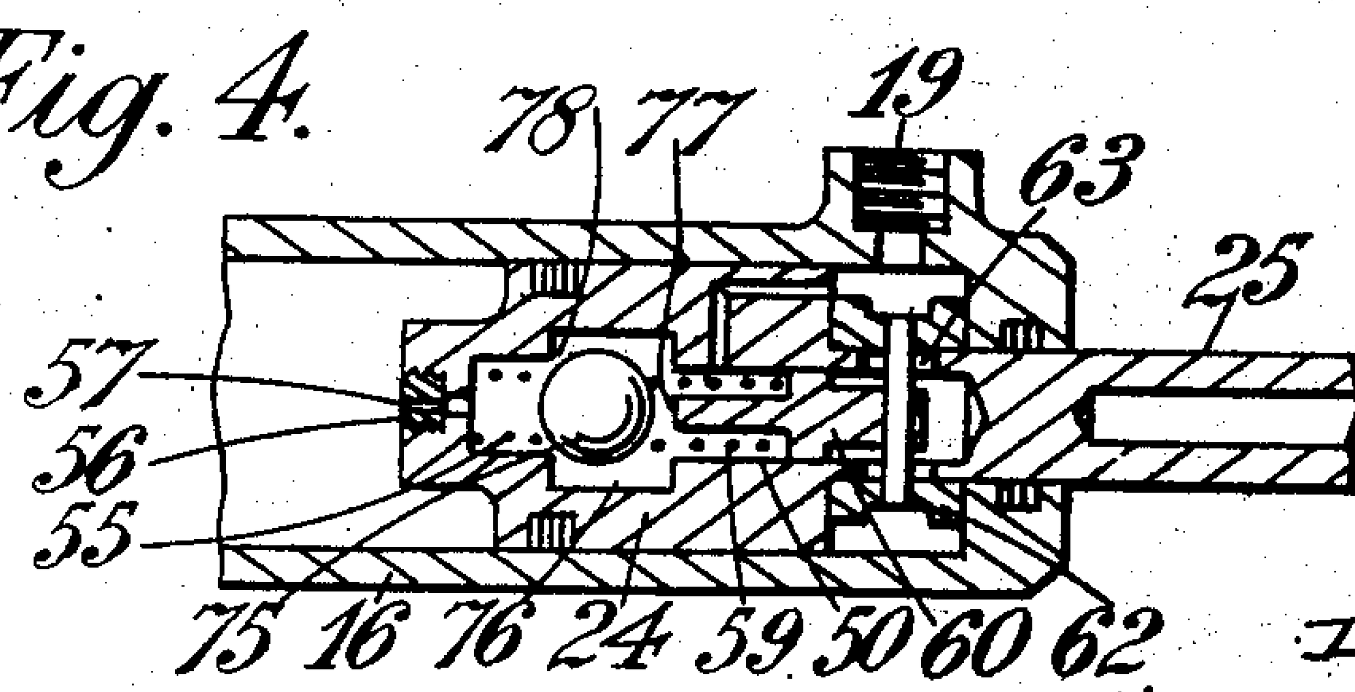

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Fig. 5.

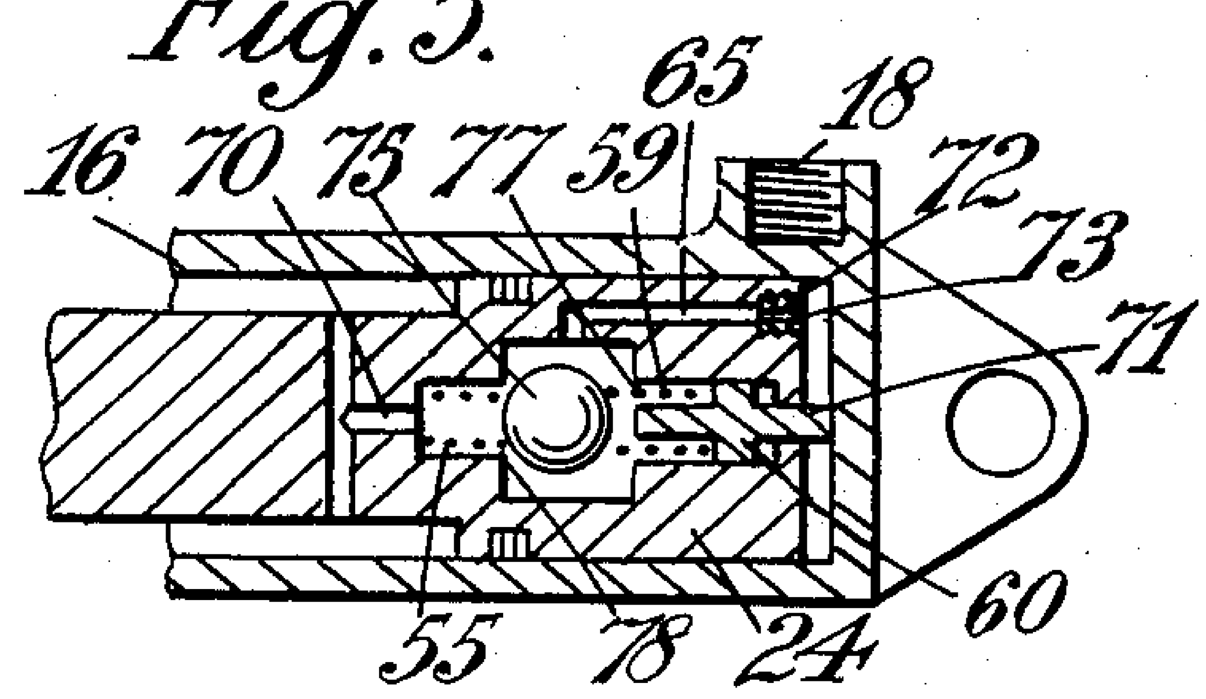


Fig. 6.

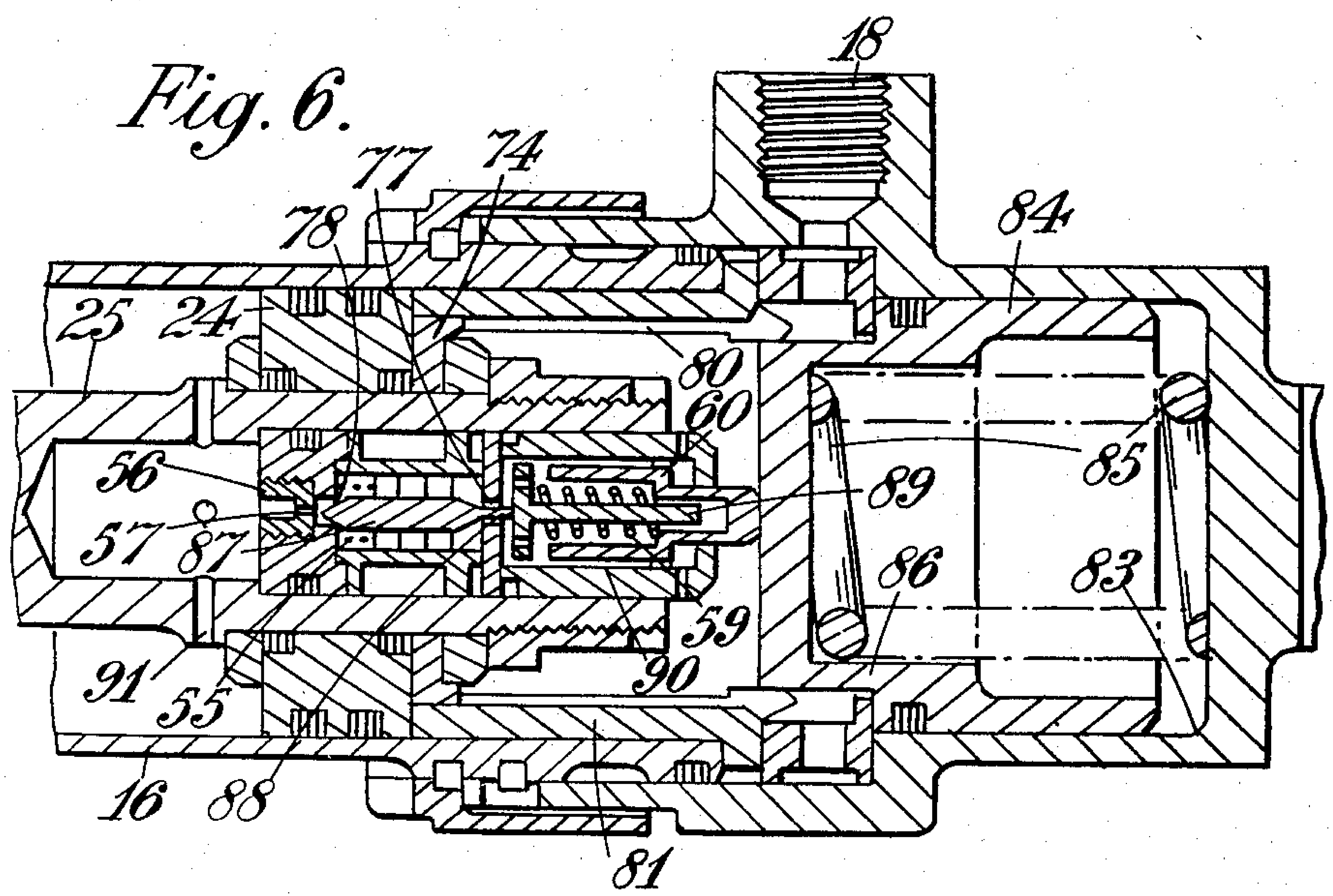
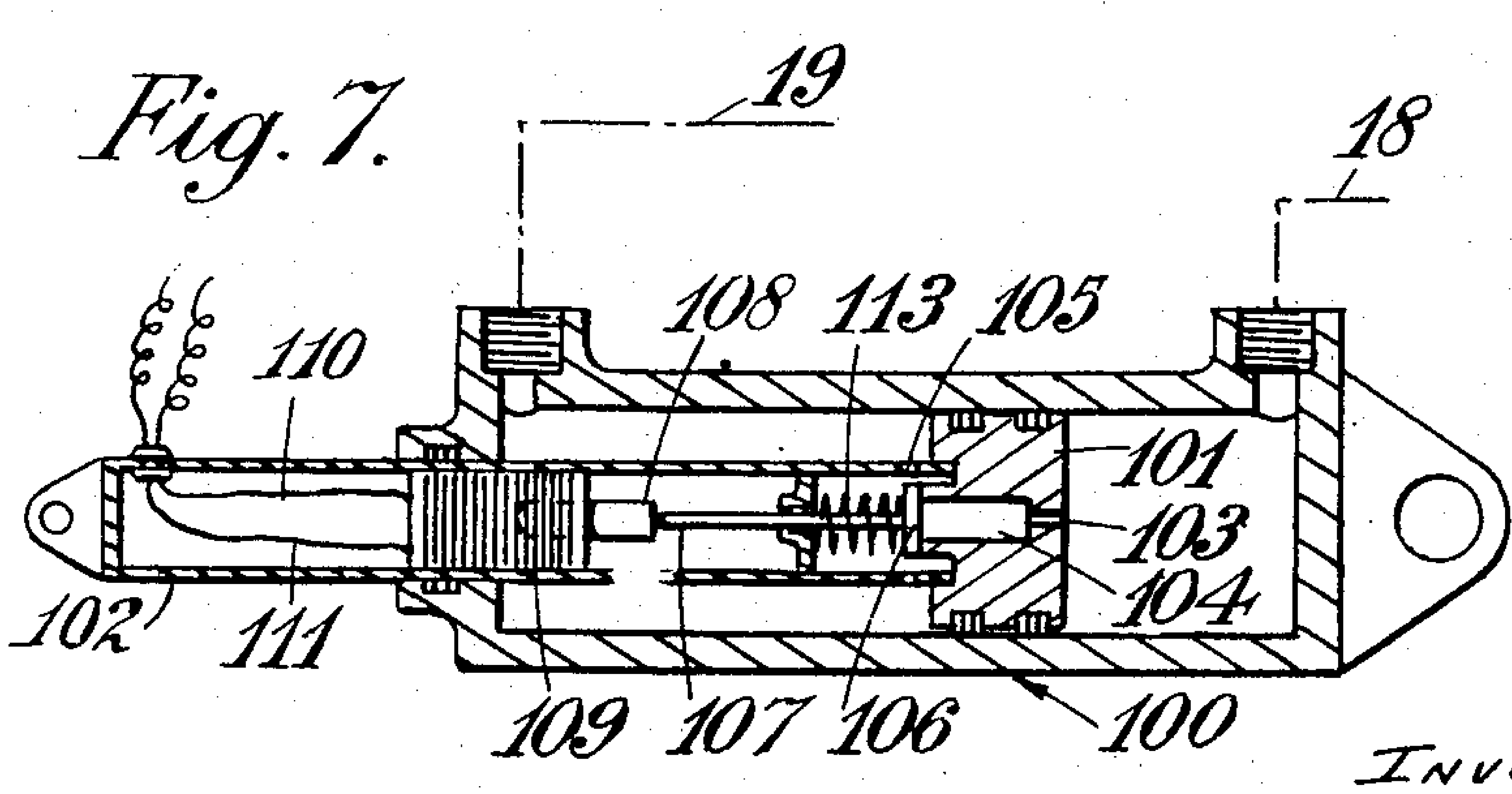


Fig. 7.



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HYDRAULIC POWER SYSTEM

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2 Claims. (Cl. 60—52)

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This invention comprises improvements in or relating to hydraulic power systems. It is an object of the invention to provide means whereby excessively low temperature of the system is prevented whether freezing up, or such thickening of the hydraulic liquid interferes with proper operation of the system. While the system herein described is particularly applicable to aircraft, where low temperature presents an especial problem, the system is also capable of being applied in other connections.

According to the present invention, an hydraulic system is provided with controlled leakage in an operated element or elements of the system, the leakage being adequate to provide such heat as is necessary under normal working conditions to prevent such excessively low temperature of the system. Wherever leakage occurs in an hydraulic system, heat is necessarily generated due to the waste of energy. It is the operated elements of the system which are normally liable to become frozen or put out of practical operation by thickening of the hydraulic medium, and by providing controlled leakage in these elements sufficient energy is set free in them to prevent trouble. The resultant flow of hydraulic fluid from the pump and on return to the reservoir of the system also keeps the pipes clear.

In order to prevent waste of energy when the operated elements of the system are being used, the leakage is preferably effected through a leakage channel or channels which are only open when the operated element or elements are in a normal position of rest. For example, there may be an operated element in the form of a jack and the leakage channel may comprise a leakage port opened automatically by the jack-piston on reaching the end of its stroke. Preferably the leakage channel is located in the piston itself and closed by a lift-valve in the piston, which valve is opened automatically by tappet-action when the piston reaches one end of its stroke.

In one form of the system according to the present invention, an auxiliary pump is provided of capacity adequate to supply the leakage, in addition to the main supply pump of the system. The auxiliary pump can be kept running when the parts are in their normal positions of rest and will supply the energy necessary to prevent freezing up while the main pump will be set in operation when the parts are to be actuated. This obviates using the large pump continuously, which would be disadvantageous because either excess energy would have to be wasted or the pump would have to be kept alternately on and

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off load for the whole time, and not only when parts are to be actuated.

In an alternative form of the system according to the present invention, the by-pass to the main pump delivery is provided with throttling means under thermostatic control with the object of ensuring that sufficient heat is developed to keep the liquid in the main supply tank at a suitable temperature.

Preferably, in a jack constructed as above described, in addition to the said valve there is a fixed leakage aperture of restricted bore provided in series with the valve so that when the valve is opened a substantial proportion of the pressure drop through the leak takes place at this aperture. The pressure drop across the restricted aperture is proportional to the square of the velocity of flow therethrough. If therefore the aperture itself should become partly frozen up and so restricted further, the effect will be to raise very substantially (more than in direct proportion to the degree of restriction) the pressure on the receiving side of the aperture, assuming the normal type of pump is employed for producing the pressure, which has a substantially constant rate of delivery, irrespective of pressure, at a given speed of operation. The result is increased power applied at the aperture, and increased evolution of heat, so that the aperture is rapidly thawed.

Furthermore, preferably an additional valve is provided in series with the aperture and the lift valve aforesaid, which is spring-urged against the leakage flow. Such a valve may be called a spill-valve and acts to ensure maximum energy dissipation. The spill-valve also automatically prevents return flow through the leak when the jack is operated in the reverse direction.

The following is a description by way of example of specific constructions in accordance with the invention.

In the accompanying drawings:

Figure 1 is a diagram of hydraulic connections;

Figure 1*a* is a detail to an enlarged scale of a part of said diagram;

Figure 2 is a longitudinal section through one end of a jack constructed to operate in accordance with the present invention;

Figure 3 is a similar view of another jack;

Figures 4 and 5 are similar views of alternative constructions, and

Figure 6 is a longitudinal view to an enlarged scale of a further construction showing such a jack in greater detail.

Figure 7 is a detail of a solenoid controlled leak.

Referring to Fig. 1, a main pump 11 is driven by a motor 11a connected to supply wires 120 and 121 and controlled by a switch 122. The pump 11 delivers through a pipe 12 to a pressure controlled by-pass valve 13 of known type and then through a pipe 14 to a distributor 15 which regulates the movements of a jack 16. The distributor 15 will be of known type and details of its construction are of no importance for the purpose of the present invention. It is shown for convenience as a four-way valve having a control handle 17 and capable of connecting the supply pipe 14 at will by way of pipes 18 or 19 to either end of the jack 16. One of the pipes 18, 19 which is not connected to the pressure will be by the distributor 15 connected to a return pipe 20 leading to a sump 21. The pump 11 draws from the sump 21 through a pipe 22 and the by-pass valve 13, in known manner, when the pressure in the delivery pipe 14 exceeds a predetermined amount, returns the output of the pump 11 to the sump 21 through a return pipe 23.

The jack 16 contains a piston 24 operating a jack rod 25 and if the installation is located on an aircraft the jack rod 25 will be connected to any suitable device which is to be operated, as for example the undercarriage frame, bomb doors, wing flaps or the like. As will be readily understood branches from the main supply pipe 14 lead to other distributor valves and jacks similar to the valve 15 and jack 16 but adapted for operating other pieces of apparatus upon the aircraft.

According to the present invention in the piston 24 of the jack 16 there is an aperture 26 which is closed by a tappet valve 27 having a stem 28 which projects beyond the piston towards one end of the cylinder. The tappet valve is of a balanced type or is held closed by a strong spring, not shown, and so will normally remain closed during movement of the jack in either direction. When, however, the jack piston 24 is urged by pressure supplied through the pipe 19 so as to move in the direction to carry the jack rod 25 inwards, at the end of the stroke the tappet 28 of the valve 27 comes in contact with the end wall of the jack cylinder and is caused to open. If the jack valve 27 opened fully the effect would be that the pressure supplied through the pipe 19 would be able to get away through the passage 26 in the piston 24 to the pipe 18 which is connected to the exhaust 20. The result would be that the piston 24 would be no longer urged by pressure adequate to keep it in place and it would tend to return. The return movement would close the valve 27, the pressure would no longer be able to leak away through the aperture 26 and the piston 24 would be again pressed on with the full pressure from the pipe 19 and urged upwardly so as to open the valve 27 and release the pressure. In practice the piston 24 will take up a position in which the valve 27 is opened just sufficiently to allow the pressure to leak away to a point at which the piston is held in place at the end of its stroke. Under these conditions there will be a leakage through the aperture 26 and the pressure lost at the leakage will be reflected in the liberation of energy in the hydraulic liquid, which will heat the liquid and keep it from freezing.

The amount of the liquid supply required for maintaining the leakage necessary to prevent freezing is quite small and if the apparatus so far described were the only apparatus in the system the result would be that the by-pass valve 13 would open frequently and the pump 11 would be kept running, with most of its output discharging through the valve 13 and only a small proportion of its time would be occupied in supplying the leak through the valve 27.

To obviate wasteful running of the large pump 11 there is provided an auxiliary pump 30 driven by an electric motor 31 from a source of electrical supply 32 through supply wires 33, 34 controlled by a switch 35. The auxiliary pump 30 draws from the sump 21 through a pipe 36 and delivers to the pipe 14 through a delivery pipe 37. The auxiliary pump 30 has a by-pass valve 38 connected between the pipe 37 on the one hand and a pipe 20 on the other which returns the liquid to the sump 21. The auxiliary pump 30 is adequate to supply the leaks through the various valves 27 in the system without passing large quantities of hydraulic liquid through the by-pass valve 38 and when the system is operating, unless the jacks 16 are actually in use, the pump 11 is thrown out of action and reliance placed entirely upon the auxiliary pump 30.

The switches 35 and 122 are ganged at 123 providing selectively operable manual means for insuring opening of one switch with a simultaneous closing of the other switch for selective operation of the pump 11 or the auxiliary pump 30.

It will be appreciated that the development of energy which occurs in the jack 16 through the leakage by way of the valve 27 and aperture 26, not only keeps the jack 16 warm but also prevents the liquid in the pipe 20 and in the sump 21 from freezing.

The by-pass or unloading valve 13 is, as already described, connected to the sump by pipe 23 and on the end of the pipe 23 there may be a throttle valve 40, an enlarged view of which is shown in Figure 1a. The valve 40 is in the form of a box with an inlet 41 from the pipe 23 and an outlet 42 to the sump 21. The inlet 41 is closed by a ball valve 43 supported by a spring 44 so that a certain pressure is required to open the ball valve and the resultant pressure loss causes a development of heat and warms the liquid in the sump 21 which is circulated by the pump 11. It is desired that the heat thus supplied should be dependent upon the temperature of the liquid in the sump 21. To this end the valve box 40 contains a lever 45 on which is mounted a seating member 46 for the spring 44. The lever 45 is urged upwardly so as to compress the spring 44 by a stronger spring 47 and it is urged downwardly by a bellows 48 filled with an expansible fluid such as air. The valve box 40 is enclosed in the sump 21 so that it attains the same temperature as the sump and the bellows 48 will expand or contract in accordance with the temperature. The lower the temperature the more the spring 47 is able to push the lever 45 upwards and compress the spring 44 so that a greater loss of energy will occur at the valve 43. On the other hand, if the temperature of the liquid goes up beyond what is desired the bellows will expand and urge the lever 45 downwardly so that when a certain temperature is reached there will be little or no pressure on the spring 44 and the heating due to this source will disappear. The thermostatically controlled leak could be arranged to operate on the by-pass from the auxiliary pump 30 if desired instead of or in addition to operating on the by-pass from the main pump 11.

Figures 2 to 6 show various forms of jack for use as the jack 16 shown in Figure 1. Referring to Figure 2 this shows a jack cylinder 16 containing a piston 24 which is connected to a hollow jack rod 25. The tappet system which corresponds to the valve 27 and tappet 28 of Figure 1 is arranged to operate in this case when the jack is extended, that is to say when it reaches the end corresponding to the pipe 19 of Figure 1. In the piston 24 is an axial bore 50 which is divided by a bushing 51 from a second axial bore 52. Through the bushing there is a passage 53 which constitutes a leakage aperture and in which is loosely fitted a valve 54 corresponding to the valve 27 of Figure 1. The valve 54 is closed by a light spring 55 beyond which is a screwed plug 56 containing a narrow leakage aperture 57. On the other side of the bushing 51 there is a valve-lifting member 58 which engages the stem of the lift valve 54 and which is backed up by a spring 59 which is stronger than the spring 55. Beyond the valve-lifting member 58 there is a tappet member 60 which backs up the spring 59, slides to and fro in the bore 50 and is connected by a cross pin 61 to a tappet sleeve 62 which surrounds the piston rod 25 and is capable of sliding thereon due to a slot 63 in the piston rod 25 through which slot the pin 61 passes.

The valve lifting member 58 is conical at its end portion as shown at 64 and the conical end portion of the lifting member can seat upon the material of the valve 24 surrounding the bushing 51 to block the leakage aperture 53 on the side remote from that upon which the head of the lift valve 54 seats. From the space around the conical end of the valve lifting member 58 there extends a passage 65 to the side of the piston 24 which is open to the pipe 19.

If the jack, with its piston so constructed, has a normal position of rest in which it is extended, that is to say with the piston rod 25 fully pushed out of the jack as shown in Figure 2 of the drawing, the tappet sleeve 62 engages the end of the jack cylinder 16 where it surrounds the hollow piston rod 25 and pushes the tappet member 60 to the left as viewed in the drawing, compressing the spring 59 and causing the valve lifting member 58 to push the lift valve 54 off its seat as shown. The valve 54 at first resists being pushed off its seat but the tappet 60 can engage the end of the valve-lifting member 58 when the spring 59 is compressed and will so force the valve off its seat after which the spring 59 expands again and pushes the valve 54 fully open. The conical end 64 of the valve lifting member 58 tends to seat on the bushing 51 but pressure fluid coming through the aperture 57 forces the conical end a little way off its seat and leakage takes place in succession through the aperture 57, the leakage aperture 53, past the conical end 64 and through the passage 65 to the pipe 19. The valve-lifting member 58 acts as a spill-valve in series with the leakage apertures 57, 53 and increases the total pressure loss when there is a considerable pressure drop through the aperture 57, that is to say if the viscosity of the liquid is high due to low temperature.

Referring to Figure 3, this shows a similar construction for the case when the leakage through the piston is to be controlled from the other end of the jack, that is to say the end remote from that at which the piston rod 25 projects. In this case the bushing 51, lift valve 54, spring 55, valve lifting member 60 and spring 59 remain as in Figure 2 and operate in the same manner. The plug 56 is, however, replaced by a passage 70 through the jack piston rod leading to the body of the jack cylinder 16 and the tappet member 60, instead of being connected to a sleeve such as 62, is provided with a tappet end 71 to engage the end of the cylinder 16 directly. A plug 72 containing a narrow leakage aperture 73, and corresponding in function to the plug 56 of Figure 2, is provided in the end of the passage 65. The operation is the same as Figure 2.

Referring to Figure 4, part of this corresponds to Figure 2 and as far as possible similar parts are similarly numbered in the drawing and will accordingly not be further described. However, instead of the lift valve 54 there is a ball valve 75 which floats between the two springs 55, 59 and the valve lifting member 58 is done away with. The ball valve 75 floats in an enlarged portion 76 of the bore 50 between seatings 77, 78. When pressure in the jack cylinder 16 is urging the piston to move from the left hand end of the jack towards the position shown in the drawing the tappet sleeve 62 will be pressed towards the right hand end of the slot 63, the compression of the spring 55 will be relaxed and the pressure in the cylinder 16, acting through the bore 57 will press the valve 75 on to the seating 77 and prevent leakage of hydraulic liquid through the piston. When the tappet sleeve 62 engages the end of the cylinder and the valve lifting member 60 is held from movement with the piston, the end of the valve lifting member 60 engages the ball 75 and also compresses the spring 59 and pushes the ball 75 off the seat 77. After this the ball 75 acts as a spill-valve against the seating 78.

Precisely the same action takes place in Figure 5 where, however, the tappet member 60 directly engages the end of the cylinder 16 and the parts are modified as compared with Figure 4 in the same way that the parts of Figure 3 are modified as compared with Figure 2.

Referring now to Figure 6 this shows a construction which in principle is the same as Figure 5 but is modified to include a locking device for the jack such as is known from British patent specification No. 527,225 of April 11, 1938, the complete accepted date of which was October 4, 1940. As far as possible parts in Figure 6 which correspond to Figure 5 are similarly numbered in the drawing, with a view of obviating unnecessary duplication of the description. It is, however, to be noted that the piston 74 carries a crown 80 of spring locking teeth similar to those described in the aforesaid patent specification No. 527,225, and that these engage a locking sleeve 81 held in the end of the cylinder 16 by end pressure exerted by an end cap 82 secured on the cylinder 16. The end cap contains a bore 83 for a locking piston 84 which is urged forward into locking position by a strong spring 85. The locking piston 84 is provided with a cylindrical bolt portion 86 which, as shown in the drawing, when the crown of the locking teeth or claws 80 are pushed fully home through the locking sleeve 81, is able to shoot forward into the space within the crown of locking claws and to prevent them from withdrawing. The spring-pressed bolt 86 constitues in effect the end of the jack cylinder and it is against the end of this bolt that the tappet member 60 engages. The valve member instead of being constituted by a ball 75 is constituted by a double-coned member 87 which plays between seatings 77, 78 and carries a stem 88 to engage an intermediate member 89 which is pressed on directly by the spring 59 and is operated by the tappet member 60. The passage 65 is represented in Figure 6 by flutes 90 cut in the outside of the tappet member 60 and the restricted aperture 57 is formed in a plug 56 on the pressure side of the valve member 87 instead of being formed in a plug such as 72 on the exhaust side thereof. Passages 91 in the walls of the hollow piston rod 25 permit access of the hydraulic fluid to the various passages and valves. The operation is the same as before.

Referring to Figure 7, this shows a jack 100 having a piston 101 which operates a hollow jack rod 102. Leakage is provided for by means of apertures 105 in the jack rod which lead to a space within the jack rod which is in communication by a passage 104 with the leakage aperture 103. The passage 104 is controlled by a valve 106 and the valve is connected by a valve rod 107 to the core 108 of a solenoid 109. The solenoid is operated by electrical connections 110, 111 which pass through the jack rod and are connected to any suitable control. The leakage passage 104 remains closed, owing to the action of a spring 113 which closes the valve 106; until the solenoid 109 is energised. This can be arranged to be effected either automatically when the piston 101 reaches the end of its stroke or under the control of the pilot or thermostatically by a temperature-controlled switch or by a combination of such controls as may be desired.

In practice in some aircraft it may be desirable to provide additional means for heating various parts of the circuit where the pipes pass through particularly cold parts of the aircraft. This may be done electrically or otherwise as desired.

We claim:

1. In a hydraulic power system including a primary intermittently operative circuit for fluid medium having a main circulating pump and drive motor therefor included therein, a secondary circuit for the fluid medium having an auxiliary pump and drive motor therefor included therein, selectively operable manual means rendering said secondary circuit inoperative when said primary circuit is operative and rendering said secondary circuit operative when said primary circuit is inoperative, and a jack having a cylinder connected to said means and a piston slidable in the cylinder, the provision of means for maintaining the fluid medium in said secondary circuit when operative at a desired working temperature, said last means comprising a leakage channel in the piston, a lift valve in the piston constructed and arranged to close the channel at all positions of the piston other than a predetermined end position in the cylinder, means for lifting said valve when the piston is at said predetermined end position, and a fixed leakage aperture in the cylinder of restricted bore in series with said lift valve.

2. In a hydraulic power system including a primary intermittently operative circuit for fluid medium having a main circulating pump and drive motor therefor included therein, a secondary circuit for the fluid medium having an auxiliary pump and drive motor therefor included therein, selectively operable manual means rendering said secondary circuit inoperative when said primary circuit is operative and rendering said secondary circuit operative when said primary circuit is inoperative, and a jack having a cylinder connected to said means and a piston slidable in the cylinder, the provision of means for maintaining the fluid medium in said secondary circuit when operative at a desired working temperature, said last means comprising a leakage channel in the piston, a lift valve in the piston constructed and arranged to close the channel at all positions of the piston other than a predetermined end position in the cylinder, a stem projecting from said lift valve beyond said piston toward the end of said cylinder corresponding to said end position of the piston, a fixed leakage aperture in the cylinder of restricted bore in series with said lift valve, a spill valve in series with said aperture, and spring means urging said spill valve to closed position.

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