

Sept. 7, 1965

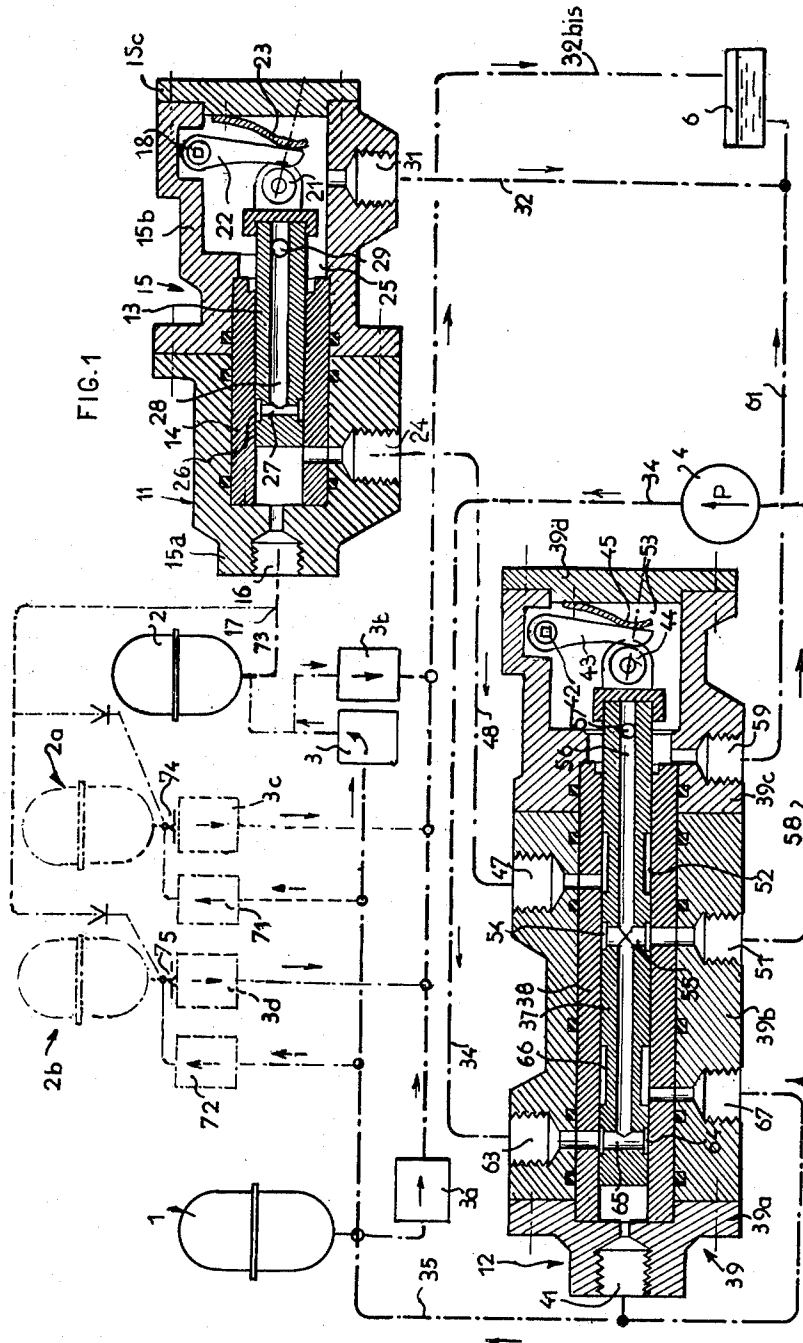
P. E. MERCIER

3,204,573

HYDRAULIC INSTALLATIONS WITH MULTIPLE PRESSURES

Filed Aug. 22, 1963

4 Sheets-Sheet 1



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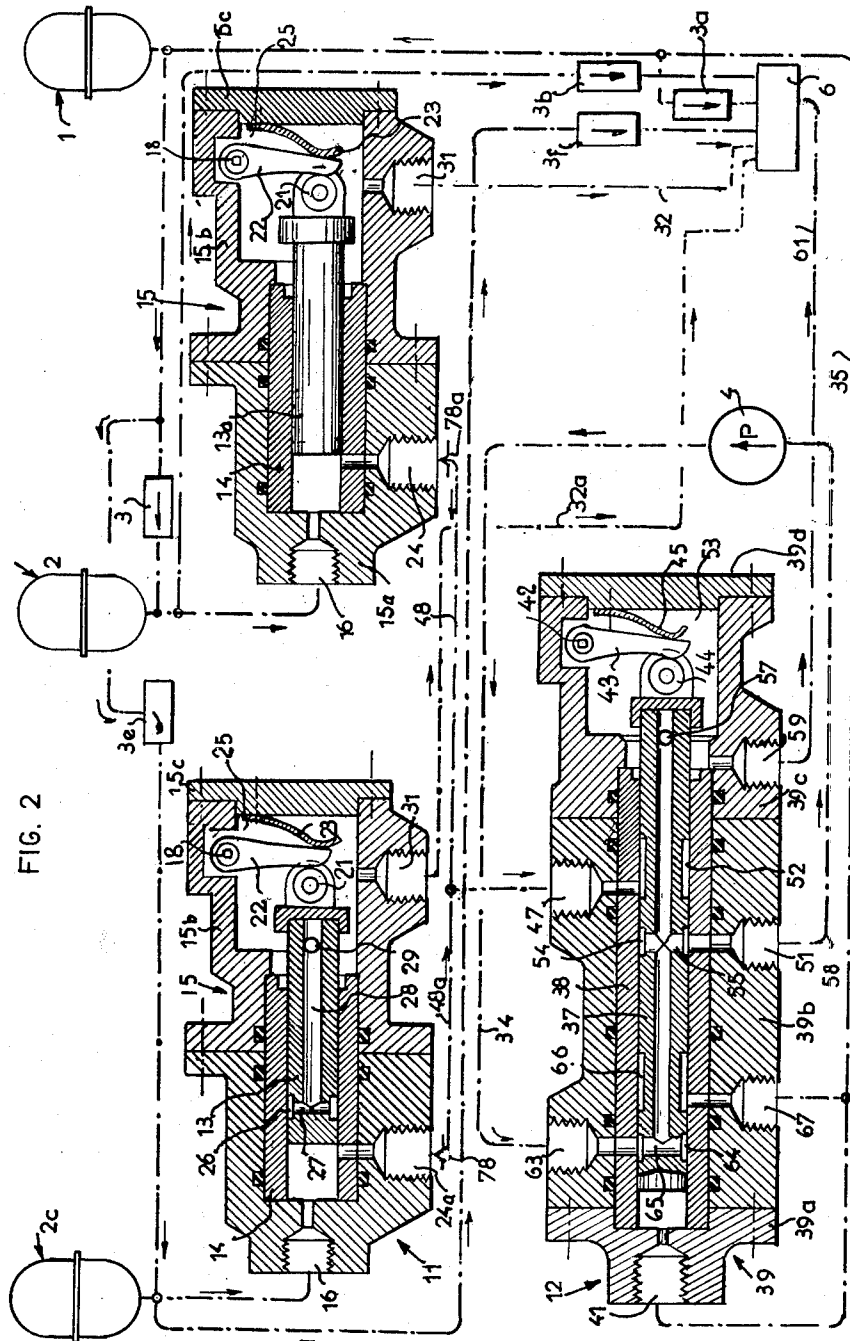
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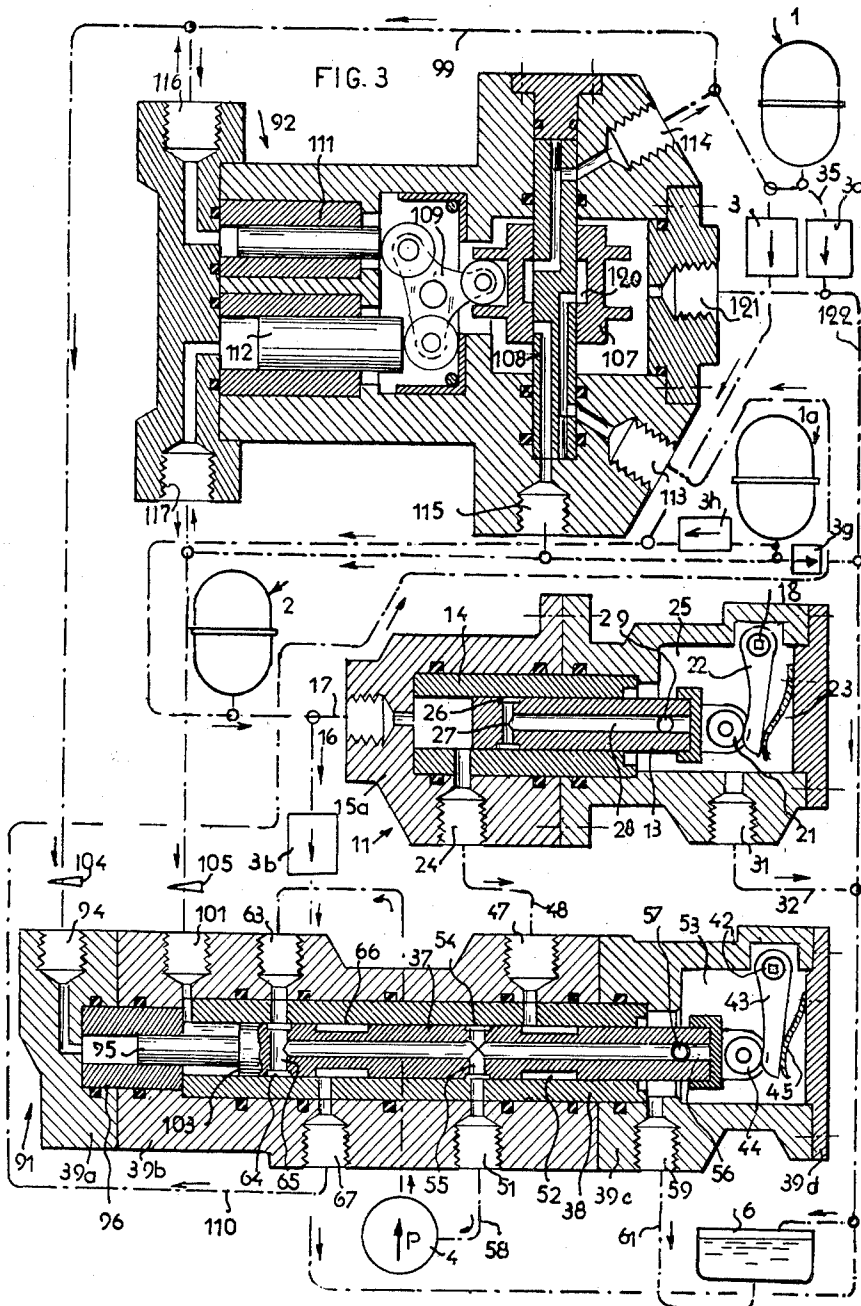
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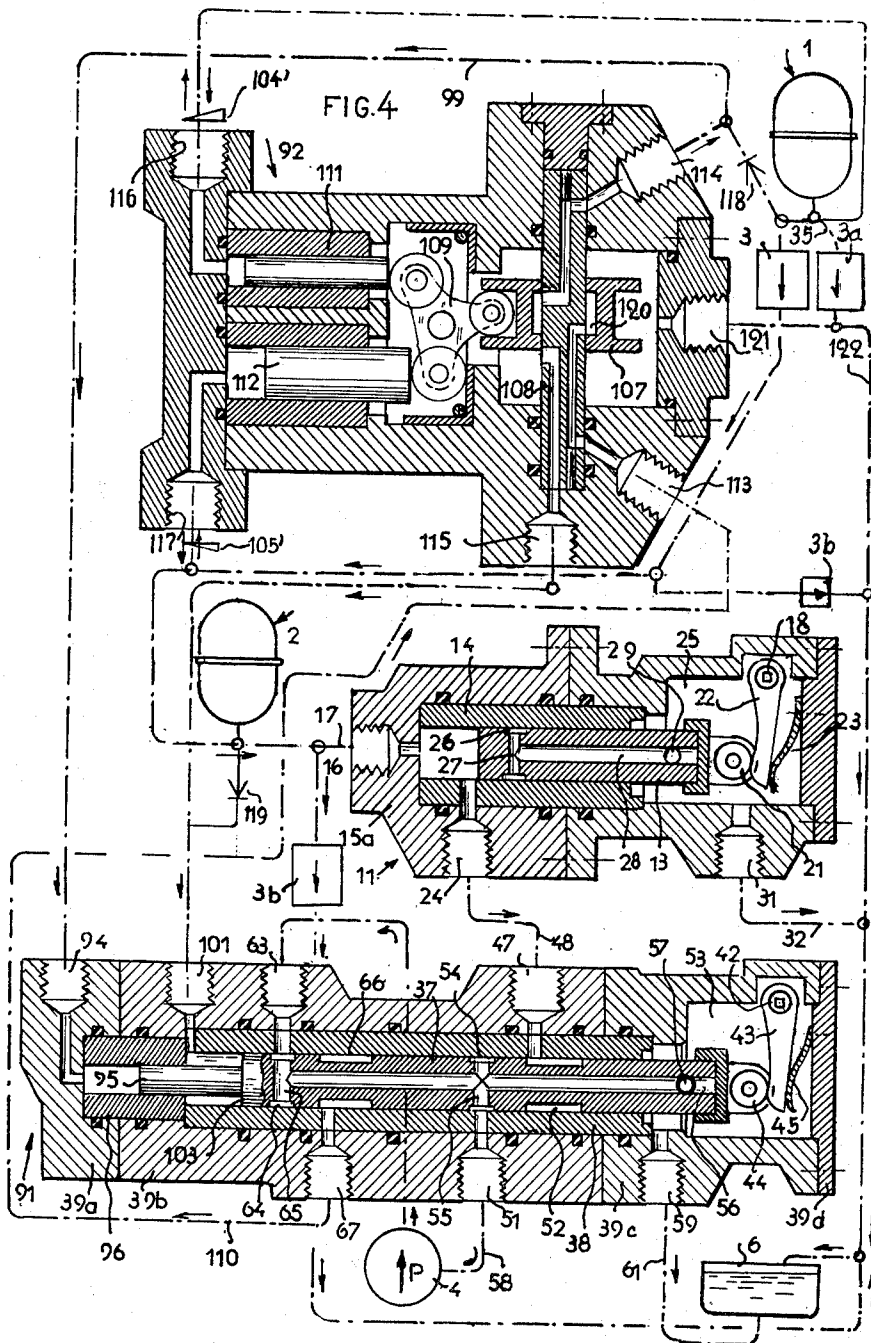
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HYDRAULIC INSTALLATIONS WITH MULTIPLE PRESSURES

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4 Sheets-Sheet 4



3,204,573 HYDRAULIC INSTALLATIONS WITH MULTIPLE PRESSURES

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7 Claims. (Cl. 103—223)

This invention relates to hydraulic installations with multiple pressures.

According to the invention there is provided a hydraulic installation comprising in combination at least two accumulators calibrated to clearly differing pressures, at least two utilization circuits of which one is branched between the two accumulators and at least one other is branched between the accumulator of highest pressure and a zone of lower pressure, a pump drawing a part of the time from the accumulator of lowest pressure and supplying the accumulator of highest pressure, and means for completing the delivery of the pump, directed towards this accumulator of highest pressure, by a contribution formed from the zone of lower pressure.

By virtue of such a combination of means, when certain utilization apparatuses operate between two extreme pressures substantially remote from the highest pressure and the lowest pressure of the installation, it is possible to branch them between the two aforementioned accumulators, instead of branching them between the high pressure accumulator and the reservoir, thus avoiding an expenditure of pressure at a high potential which is then permitted to deteriorate to the reservoir and the recharging of the accumulators by a fresh pumping up to the calibration pressure, that is to say an unnecessary energy expenditure. Furthermore, since the pump sucks from an accumulator already under pressure, instead of from the reservoir, there is no fear of cavitation phenomena.

It is clear that the utilization of an accumulator at intermediate pressure lends itself to multiple uses, and that more particularly it is possible to use it either as receiver in relation to a utilization circuit interposed between the accumulator and the accumulator of relatively higher pressure, or as source of pressure fluid for a utilization circuit interposed between it and the lower pressure zone. If on the average the operation as receiver of the intermediate pressure accumulator is predominant, the installation possesses no particular innovation; if on the contrary in the operation of the accumulator at least one circuit interposed between it and the lower pressure zone is predominant, the installation will utilize a distributor element of a type identical with that which was described in French Patent No. 1,344,926 entitled "Hydraulic Installation With Multiple Pressures."

Finally if in succession and by periods of time the intermediate pressure accumulator operates as receiver and as source of fluid under pressure, particular arrangements are provided in the present invention, which complete those of the preceding case above envisaged.

In one embodiment the pump, under the control of a first distributor, sucks from the lower pressure zone or from the accumulator of relatively lower pressure, according to whether the pressure in the latter is below or above a predetermined pressure, while a second distributor directs the oil delivered by the pump into the zone of lower pressure or into the relatively high pressure accumulator, according to whether the pressure in the latter is above or below a predetermined value, while in all these cases means prevent the accumulators from dis-

charging through the circuit of the pump when it is not operating.

In one particular form of embodiment the pump is connected to the second distributor through a circuit which comprises elements of the first distributor adapted to isolate the second distributor and consequently the accumulator of lowest pressure from the pump, when the latter delivers into the zone of lower pressure, that is to say when the accumulator at the highest pressure is charged, in order that the accumulator at the lowest pressure may not discharge into the zone of lower pressure through the pump.

In other embodiments the installation comprises a plurality of accumulators at relatively lower pressure, of which at least one of the two maximum and minimum utilization pressures is different, but the predominant operation of which is of the receiver type.

In a modification comprising a plurality of accumulators at relatively high pressure, the means described and represented in the aforementioned patent are further utilized, permitting on the one hand a delivery of liquid under pressure towards the accumulators at relatively high pressures, from the single pressure source, when the pressure in at least one of the accumulators drops below a predetermined value, and on the other hand the distribution of this delivery among the accumulators in accordance with a predetermined law.

Finally in another modification the accumulator at intermediate pressure operates between three pressures P_1 , P_2 , P_3 staged in increasing order. When the pressure of the intermediate pressure accumulator is lower than P_2 , it operates as source of fluid under pressure between P_1 and P_2 , and a selector element permits its recharging by the pump as source of pressure fluid concurrently with the high pressure accumulator; when the pressure of the accumulator is greater than P_2 , it operates as receiver and if its pressure is sufficiently close to P_3 the pump sucks therefrom when it is under charge.

In this case the distributor element intervenes to recharge the intermediate pressure accumulator only if the pressure of the latter is between P_1 and P_2 , while the first distributor, which permits sucking from the intermediate pressure accumulator when its pressure is between P_2 and P_3 , isolates the intermediate pressure accumulator from the suction of the pump, which accumulator furthermore is preferably connected through a non-return valve to the delivery conduit which corresponds thereto on the distributor. It then suffices that the second delivery conduit of the distributor, which corresponds to the relatively high pressure accumulator, is also provided with a non-return valve so that the distribution valve of the distributor can reconnect to the reservoir that of the two delivery pipes mentioned above which is not under charge, feeding directly from these two pipes the staged pistons of the circuit-closer so that the latter is subjected when the pump is under charge only to that of the pressures which corresponds to the accumulator which is being recharged.

The invention is illustrated by way of example in the accompanying drawings, in which:

FIGURE 1 represents diagrammatically a hydraulic installation comprising an accumulator at a relatively high pressure and at least one accumulator at a lower pressure, branched in a particular fashion, recharging being effected by a single pump, the accumulator or accumulators at intermediate pressure operating in predominant manner as receivers;

FIGURE 2 represents a modification comprising two accumulators at lower pressures differing from one another;

FIGURE 3 represents another modification comprising two accumulators at relatively high pressures but dif-

ferent from one another, and a third accumulator of lower pressure operating essentially as receiver of fluid issuing from at least one utilization circuit fed by one of the two accumulators of relatively high pressure, and

FIGURE 4 is similar to FIGURE 3, in its general principle, but comprises only one accumulator at relatively high pressure and one accumulator at intermediate pressure functioning between three pressures P_1 , P_2 , P_3 .

The installation of hydraulic accumulators as represented in FIGURE 1 comprises a high pressure accumulator 1 and an intermediate pressure accumulator 2, calibrated at pressures for example 120 kg./sq. cm. and 80 kg./sq. cm. approximately. The major part of the utilization circuits designated as a whole by 3 is intended to be branched between the high pressure accumulator 1 and the intermediate pressure accumulator 2. However the installation can also comprise as accessories utilization apparatuses 3a, 3b, branched between these accumulators and a zone 6 of lower pressure called the reservoir, through the intermediary of appropriate pipes terminating on the one hand at the accumulators 1 or 2 and on the other hand at the reservoir (tube 32 bias).

Through the intermediary of apparatuses which will be described, a pump 4 delivers the liquid, in the present case oil, always into the high pressure accumulator 1, while it sucks from the intermediate pressure accumulator 2, as long as the pressure in the latter is above a predetermined lower limit, whereafter if necessary, that is to say if the pressure in the high pressure accumulator 1 is not yet sufficient, the pump continues to suck but from the reservoir designated by 6.

A low pressure may prevail incidentally in the reservoir 6, especially if the installation comprises a charging pump delivering into the said reservoir.

The apparatuses in question are constituted by two hydraulic distributors 11, 12 which hereinafter will be called reverser and make-and-break respectively. The reverser serves for permitting the pump 4 to suck either from the intermediate pressure accumulator 2 or from the reservoir 6.

This reverser distributor is constituted by a slide valve 13 which can slide in a cylinder 14 fixed in a body 15 constituted, for reasons of manufacture and assembly, of three parts 15a, 15b and 15c. One of the ends of the slide valve 13 is subjected, through a conduit 16 and a pipe 17, to the pressure prevailing in the intermediate pressure accumulator 2, while its other end is pushed in the opposite direction by a return spring constituted in this example by a square torsion bar in extension of a spindle 18, one end of which is fitted into the body 15, while its other end is fixed to the spindle 18 per se fast with a cam lever 22 which presses against the roller 21 carried by the corresponding end of the slide valve. In order to ensure stability of function of this distributor, that is to say a very free movement in both directions, the assembly is designed in such fashion that as the slide valve 13 through its roller 21 pushes back the cam lever 22, the elastic force opposing the movement of the slide valve 13 decreases despite the increase of the resistance due to the spring of square section extending the spindle 18.

When the slide valve 13 occupies its extreme left position, it cuts off communication between the two conduits 16 and 24 and at the same time it places the latter in communication with chamber 25 of the body through the intermediary of an annular groove 26, a radial channel 27, a longitudinal channel 28 and another radial channel 29 of the slide valve.

The chamber 25 of the body 15 is permanently connected to the reservoir 6 through a conduit 31 of the body and a pipe 32.

The make-and-break 12 has a double function in that it serves firstly as reverser in order to connect the delivery

conduit 34 of the pump with either the conduit 35 for recharging the high pressure accumulator 1, when the pressure in the latter is insufficient, or with the reservoir in the contrary case, and furthermore it permits isolating the intermediate pressure accumulator 2 from the reservoir, while the pump delivers into the reservoir when the high pressure accumulator 1 is under a sufficient pressure so that, during this time, the intermediate pressure accumulator does not discharge into the reservoir, as will be explained hereinafter.

The make-and-break 12 comprises a cylindrical slide valve 37 mounted for sliding movement in a cylinder 38 fixed in a body designated generally 39 and constituted, for reasons of manufacture and assembly, of four parts 39a, 39b, 39c and 39d suitably assembled.

One of the ends of the slide valve 37 is subjected to the pressure of the high pressure accumulator 1 through the intermediary of a conduit 41 and the pipe 35. The other end of the slide valve is subjected to the action of a return spring 42 through the intermediary of a cam lever 43 and a roller 44 carried by the slide valve 37 in an arrangement similar to that described above for the reverser distributor 11, the cam lever 43 coming to bear, at the end of the stroke, against an elastic stop 45.

A conduit 47 of the make-and-break is connected through a pipe 48 to the conduit 24 of the reverser 11, and another conduit 51 of the make-and-break can be placed in communication according to choice either with the conduit 47, through a wide annular groove 52 of the slide valve 37, or with chamber 53 of the body 39 through an annular groove 54, a radial channel 55, a longitudinal channel 56 and a radial channel 57 of the slide valve. The conduit 51 is permanently connected to the suction tube of the pump 4 through a pipe 58 and also the chamber 53 is permanently in communication with the reservoir 6 through a conduit 59 and a pipe 61.

The circuit which permits the connecting of the pump 4 to the reservoir comprises the pipe 34, a conduit 63 of the body of the make-and-break, then in the slide valve 37, an annular groove 64, a radial channel 65, the longitudinal channel 56, the radial channel 57 and finally the chamber 53, the conduit 59 and the conduit 61.

The circuit which permits placing the pump 4 in communication with the high pressure accumulator 1, in order to recharge it, comprises the pipe 34, the conduit 63, a wide annular groove 66 of the slide valve, a conduit 67 and the pipe 35.

The positions of the various elements represented in the drawing signify that the pressure prevailing in the high pressure accumulator 1 is sufficient so that the latter has no need of being recharged for the moment. In fact the pressure prevailing in this accumulator is transmitted, through the pipe 35 and the conduit 41, to the corresponding end of the slide valve 37, against its return spring 42 fast with the spindle and the cam lever, so that the delivery of the pump is connected to the reservoir by the following path: pipe 34, conduit 63, annular groove 64, radial channel 65, axial channel 56, radial channel 57, chamber 53, conduit 59 and pipe 61.

If the pressure in the high pressure accumulator 1 drops below its minimum acceptable value, it is no longer sufficient to push back the slide valve 37 of the make-and-break against its return spring 42. The slide valve thus moves towards the left in relation to its position as represented in the drawing, so that the pump then delivers oil into the accumulator 1 by the following path: pipe 34, conduit 63, annular groove 66, conduit 67 and pipe 35. The oil is sucked by the pump either from the intermediate pressure accumulator 2, if the pressure prevailing therein is sufficient, or from the reservoir. The suction from the intermediate pressure accumulator 2 takes place by the following path: pipe 58, conduit 51, annular groove 52, conduit 47, pipe 48, conduit 24, cylinder 14, conduit 16 and pipe 17. If the pressure in the intermediate pres-

sure accumulator 2 is insufficient, the slide valve 13 closes the conduit 24 and consequently isolates the accumulator, while the suction of the pump then takes place from the reservoir by the following path: pipe 53, conduit 51, annular groove 52, conduit 47, pipe 43, conduit 24, annular groove 26, radial channel 27, longitudinal channel 28, radial channel 29, chamber 25, conduit 31, pipe 32 and reservoir 6.

Furthermore, the circuit of the intermediate pressure accumulator 2 is isolated from the reservoir irrespective of the pressure prevailing in the said accumulator. In fact if this pressure is relatively high, as represented in the drawing, that is to say sufficient to push back the slide valve 13 of the reverser 11, the accumulator 2 is in fact in communication with the conduit 24 of the distributor, but the latter is in communication only with the pipe 43, the conduit 47 and the annular groove 52 of the slide valve 37 of the make-and-break. Here two cases can arise: In the first case, the accumulator 1 is charged (position represented in the drawing) and the groove 52 is closed, and in the second case, if the accumulator 1 is discharged, it is in the course of recharging, so that the groove 52 is then connected to the suction side of the pump which, at this moment, no longer delivers into the reservoir but into the high pressure accumulator 1.

If the pressure prevailing in the accumulator 2 is relatively low, it is not sufficient to force back the slide valve 13 and then it is apparent that the accumulator is no longer connected to the conduit 24 and cannot be in communication with the reservoir.

In summary, the pump delivers always into the high pressure accumulator 1, it recharges the latter each time there is need, sucking oil either from the intermediate pressure accumulator 2, if the pressure in the latter is sufficient, or from the reservoir if the said pressure is insufficient.

By sucking oil from an intermediate pressure accumulator instead of sucking it from the reservoir, one avoids the phenomena of cavitation at the suction of the pump.

In a first modification, represented in the FIGURE 1, the installation comprises in addition to the apparatuses already described and represented in solid lines in this figure, other apparatuses represented in broken lines.

These supplementary apparatuses consist of a plurality (two in the example) of intermediate pressure accumulators 2a, 2b, calibrated at the same minimum pressure as the intermediate pressure accumulator 2, but intended to supply utilization circuits 71, 72 capable of functioning up to pressures which have risen to values different from one another and from the maximum pressure at which the utilization apparatuses 3b fed by the accumulator 2 can still work.

The supplementary intermediate accumulator 2a is supplied from the high pressure accumulator 1 through the intermediary of a utilization circuit 36 branched between these two accumulators.

In a similar manner the supplementary intermediate pressure accumulator 2b is intended to be supplied also from the high pressure accumulator 1 through the intermediary of a utilization apparatus 3d.

In order that the intermediate accumulators 2a and 2b are not in danger of delivering one into the other they are provided with non-return valves 73, 74, 75 respectively. On the other hand the accumulator 2, as in the case where it is employed alone, comprises no non-return valve. This cannot be otherwise since, when the piston 13 of the distributor 11 returns to the left and has masked in its first displacement the orifice bored in the cylinder 14 opposite the pipe 24, it could not complete its movement if liquid did not flow back towards the accumulator 2.

The use of a plurality of intermediate accumulators such as 2a, 2b, etc., is especially indicated in the case where the arrangement serves operational cycles, each of

the accumulators being for example allocated to a partial operation, and all these accumulators at the commencement of each cycle being at one and the same minimum pressure defined by the elastic device of the reverser 11, while when they have fulfilled their task the accumulators can possess variously staged pressures above this minimum pressure.

Such a staging of the pressures of the intermediate pressure accumulators at the end of the operations to which they are allocated, for each cycle, can be modified by the adjustment of the capacities of the accumulators with the aim of facilitating the regulation and flexibility of running of the servo-arrangement considered as a whole.

Obviously such arrangements are of more general use than that which is given only by way of example.

When the high pressure accumulator 1 needs to be recharged, the slide valve of the make-and-break 12 shifts towards the left, as explained above, and the pump delivers oil into the accumulator. The pressure of that of the three intermediate accumulators 2, 2a, 2b which is greater than that of the two others is transmitted, through the pipe 17 and the conduit 16, to the piston 13 of the reverser distributor 11. If this pressure is sufficient, the slide valve 13 is pushed back thereby and the pump consequently sucks from the intermediate accumulator in question.

On the other hand if this pressure is insufficient the slide valve 13 is not pushed back and the pump then sucks from the reservoir 6, through the intermediary of the internal channels of the slide valve 13 and of the chamber 25 of the reverser distributor 11.

It is quite apparent that the pressure of that of the intermediate accumulators which is highest keeps the two non-return valves of the other two accumulators closed. When the pump sucks from an intermediate accumulator, thus it sucks from that which is still at the highest pressure. The intermediate accumulators recharge themselves only from the high pressure accumulator 1, which is itself recharged by the pump.

In FIGURE 2 there is represented a modification of the installation according to FIGURE 1, with one single accumulator 1 at relatively high pressure and two accumulators 2 and 2c calibrated at lower pressures differing from one another, the pressure of the accumulator 2c being lower than that of the accumulator 2. There are always utilization apparatuses 3a between the accumulator 1 at highest pressures and the reservoir, utilization apparatuses 3b between the lower pressure accumulator 2 and the reservoir, utilization apparatuses 3 between the accumulator 1 and the accumulator 2 and furthermore there are utilization apparatuses 3e between the accumulator 1 and the accumulator 2c, and also utilization apparatuses 3f between the accumulator 2c and the reservoir.

In comparison with the embodiment according to FIGURE 1 there is no change as regards the accumulator 1 at relatively high pressure, the lower pressure accumulator 2 and the make-and-break 12 which permits the charging of the accumulator 1 from the pump 4. On the other hand the distributor 11a has a solid slide valve and serves now only to interrupt or permit connection between the conduits 16 and 24. There is simply added a reverser distributor 11 associated with the supplementary accumulator 2c exactly in the same manner as the reverser distributor 11 was associated with the accumulator 2 in FIGURE 1. However in order to avoid any one of the two accumulators 2 and 2c being able to discharge into the other, on the conduits 43 and 43a issuing from the two distributors 11 and 11a there have been disposed non-return valves 73 and 73a respectively.

The remainder of the installation, for which the same reference numerals have been retained for the designation of the same elements, will not be described.

The operation of this installation is entirely similar to

that according to FIGURE 1: When the accumulator 1 is charged, the make-and-break 39 causes the pump 4 to deliver in closed circuit into the reservoir. On the other hand when the accumulator 1 is discharged below a predetermined pressure, the make-and-break causes the pump to deliver into the accumulator, through the conduit 35.

If the lower pressure accumulators 2 and 2c are sufficiently charged, the corresponding distributors 11a and 11 permit the pump to suck from the accumulators and the suction incidentally will take place from that which is at the higher pressure. If the pressure in the accumulator 2 is not sufficient, the suction of the pump takes place through the intermediary of the reverser distributor 11, either from the accumulator 2c if its pressure is sufficient, or from the reservoir if the pressure of the accumulator 2c is insufficient.

In more general fashion, for any number of accumulators similar to the two accumulators 2 and 2c, only the distributor connected to the last accumulator, calibrated to the lowest pressure (namely the distributor 11 in the example as described) is a reverser distributor, while the others, similar to the distributor 11a, serve only to permit or interrupt the passage of the liquid between the corresponding accumulator and the pump.

In FIGURE 3 another modification is shown, wherein the installation comprises two accumulators 1 and 1a at relatively high pressures differing from one another, and an intermediate pressure accumulator 2, the principal utilization apparatuses, such as 3 and 3h, being branched between each of the two relatively high pressure accumulators 1 and 1a and the intermediate pressure accumulator 2 respectively.

Between each of the three accumulators and the reservoir 6 there are utilization apparatuses 3a, 3g and 3b respectively.

In this installation the intermediate pressure accumulator 2 is recharged from the two higher pressure accumulators 1, 1a, through the two corresponding utilization circuits 3 and 3h. The two relatively high pressure accumulators 1 and 1a are recharged from the pump 4, under the control of a device of the nature of that described in the aforementioned French patent.

As in the embodiment according to FIGURE 1, the pump 4 sucks from the intermediate pressure accumulator 2 under the control more especially of the reverser distributor 11, in such manner that when the pressure in the intermediate accumulator 2 drops below a predetermined lower value, the pump 4 instead of sucking from the accumulator sucks then from the reservoir, as described above.

Furthermore the pump 4 delivers oil under pressure into one or the other of the two relatively high pressure accumulators 1 and 1a, when the pressures therein become insufficient, this taking place under the control of two hydraulic distributors designated generally respectively 91 and 92, the hydraulic distributor 91 already comprising all the elements of the distributor 12 according to FIGURE 1 (for which the same reference numerals have been retained) and furthermore supplementary elements which permit it to be sensitive to the two pressures prevailing in the two accumulators 1 and 1a respectively.

These elements comprise a conduit 94 of the body of the distributor 91, which has the same task as the conduit 41 in FIGURE 1, but which for reasons of manufacture and assembly acts upon an extension 95 of the slide valve 37 of the distributor, the extension being constituted by an independent piston which slides in a cylinder 96 fast with the body of the distributor, the piston 95 pressing upon the corresponding end of the slide valve 37. The conduit 94 is permanently connected through a pipe 99 with the high pressure accumulator 1.

The body of the distributor 91, which again plays the part of a make-and-break, comprises another conduit 101 permanently connected to the other relatively high pressure accumulator 1a, and which is intended to subject an-

nular face 103, constituted by the part not covered by the piston 95, of the end of the slide valve 37 to the pressure of this accumulator.

The distributor 92 is of the type as described and represented in detail in the aforementioned French patent. It comprises essentially a reverser distributor constituted by a sleeve 107 mounted for sliding on a fixed hub 108 and operated through the intermediary of a rocker lever 109 by two pistons 111, 112, subjected permanently to the pressures of the accumulators 1 and 1a respectively.

The details of the structure and operation of the distributor 92 have been set forth in detail in the aforementioned patent, to which one can refer. It will be recalled simply that the arrival of oil under pressure takes place in conduit 113 and that under the control of the sliding sleeve 107 it is directed either into conduit 114 connected to the accumulator 1 or into conduit 115 connected to the accumulator 1a.

A chamber 120 and the radial passages terminating at the conduits 114 and 115 are established in such manner that in the middle position of the sleeve 107 the distributor offers to the pump a sufficient delivery section, a non-return valve possibly being disposed in the immediate vicinity of the conduits 114 and 115.

The operation of the installation is as follows:

The slide valve 37 of the make-and-break 91 is permanently subjected to the total of the pressures prevailing in the accumulators 1 and 1a and to the action of its return spring 42. When the pressure in at least one of the two accumulators 1, 1a drops below a predetermined value, the slide valve 37 of the make-and-break is pushed back by its return spring, so that the pump then delivers through the conduit 110 into the conduit 113 of the distributor 92. The latter directs the oil under pressure into that of the two accumulators 1 or 1a which is the more discharged.

As regards the suction of the pump, this takes place through the intermediary of the reverser distributor 11, either into the intermediate pressure accumulator 2, if the pressure prevailing therein is above a predetermined value, or into the reservoir 6 if on the contrary the accumulator 2 is discharged below this lower limit.

In FIGURE 4 there is represented the modification according to which there are available a relatively high pressure accumulator 1 and an intermediate pressure accumulator 2, principal utilization apparatuses such as 3, 3a, 3b, interposed respectively between the accumulator 1 and the accumulator 2, between the accumulator 1 and the reservoir 6, and between the accumulator 2 and the reservoir 6. According to the relative deliveries of the utilization apparatuses 3 and 3b, the accumulator 2 acts as receiver or as source of pressure fluid. Thus it will operate between three pressures P_1 , P_2 , P_3 , enumerated in the order of increasing pressures and designating its actual pressure by P_1 , if $P_1 < P_2$, it will have to be recharged by the pump 4, while if $P_1 > P_3$, it will furnish liquid to the pump 4 which will deliver it into P_1 if the pressure of P_1 is less than a specific pressure.

The elements represented in FIGURE 4 are identical with those according to FIGURE 3 as regards the make-and-break 91 and the element 11. The distributor 92 is also similar to that according to FIGURE 3 with the exception of the sleeve 107 sliding on the fixed hub 108, the length of which is reduced so as to uncover that of the radial conduits which is not in communication with the central annular cavity 120 of the sleeve 107 and the two conduits in question simultaneously in the middle position of the sleeve 107.

In these circumstances that of the conduits 114 or 115 which is not under charge is in communication with the reservoir through the conduit 121 and the conduit 122 (in the case of the figure it is the conduit 115 which is connected to the reservoir). The lay-out of the conduits between the two accumulators 1 and 2 and the three elements, the distributor 92, the reverser 11 and the make-and-break 91, is as follows: The accumulators 1 and 2 are

connected respectively, without interposition of non-return valves but with interposition of delay constrictions 104', 105', to the conduit 116 and 117 of the element 92 and to the entry orifices of the principal utilization apparatuses 3 and 3a for the accumulator 1, 3b for the accumulator 2. The exit orifices of the principal utilization apparatuses are connected respectively to the accumulator 2 for the utilization apparatus 3 and to the reservoir for the other two apparatuses. The conduits 114 and 115 of the distributor 92 are connected directly to the conduits 94 and 101 of the make-and-break without interposition of a constriction, and through the intermediary of the non-return valves 118 and 119 to the accumulators 1 and 2. All the other connections as in FIGURES 3 and 4 are unchanged.

The operation is easy to understand. If the pressure in the accumulator 2 is equal to its maximum value (the case in the figure), the piston 13 of the reverser is pushed fully to the right. The distributor is in the position of charge towards the accumulator 1, the pressure of the accumulator P_2 being maximum and pushing the piston 112 of the distributor 92. The charging of the accumulator 1 being completed, the make-and-break isolates the pump, its piston occupying its extreme right-hand position and the pump communicates with the reservoir on the delivery side through the conduit 63, the radial conduit 65, the axial channel of the slide valve 37, the radial channel 57, the chamber 53, the conduit 59 and the conduit 61, while it also sucks from the axial channel of the slide valve 37 through the conduit 51.

If the pressure in the accumulator 2 now drops below its intermediate value P_2 the piston 13 of the reverser 11 recoils towards the left and isolates the conduit 17.

It will be observed that in all the cases where the pump is charging, the make-and-break is subjected only to the action of the pressure prevailing in that of the accumulators towards which the distributor directs the charge (the accumulator 1 in the case of the figure). If the pressure in the accumulator 1 is sufficient, the distributor tilts the conduit 113 which receives the liquid delivered by the pump when it is charging, is placed in communication with the conduit 115 by the displacement downwards of the sleeve 107 driven by the rocking of the lever 109 of the distributor 92. During the rocking of the lever 109, which is retarded by the constrictions 104, 105, and by reason of the simultaneous uncovering of the two radial conduits of the hub 108, which control the conduits 114, 115 of the distributor, in the course of the rocking of the said lever 109 the conduits 94 and 101 of the make-and-break are temporarily and simultaneously connected to the reservoir, permitting the staged piston 37 of the make-and-break to return to the left under the action of the spring pushing the cam lever 43. In its new position the distributor valve of the distributor 92 thus directs upon the conduit 101 of the make-and-break a pressure equal to that prevailing in the accumulator 2 which is set to charge immediately and remains thus during an interval of time which depends upon the shape of the lever 109, the characteristics of the accumulators 1 and 2, of the utilization apparatuses, etc.

If the relative pressure ratios of the two accumulators are sufficiently modified before the accumulator 2 has reached its mean pressure P_2 , the distributor will recharge the accumulator 1 before completing the charging of the accumulator 2 in accordance with a procedure similar to that which has been described.

The invention is not of course limited to the forms of embodiment as described and represented. For example the installations could be equipped with a number of accumulators differing from those adopted in the installations as described.

I claim:

1. A hydraulic fluid pumping and storage plant for producing hydraulic forces comprising, in combination, a high pressure accumulator, at least one accumulator cali-

brated to a pressure lower than that of said high pressure accumulator, a liquid storage reservoir, a continuously operating pump having an inlet and outlet, said pump being adapted to supply liquid from said reservoir to each of said accumulators, a first valve having a first port communicating with said low pressure accumulator, a second port communicating with said reservoir, and a third port of the first valve, and second resilient means in one position to connect said third port with said first port and in another position to connect said third port with said second port, first resilient means in said valve to urge said member towards said another position thereof, said member being movable towards said one position thereof against the action of said resilient means in response to liquid pressure stored in said low pressure accumulator, a second valve connected with said high pressure accumulator, with the pump inlet, the pump outlet, said reservoir and with said third port of the first valve, a movable valve member for said second valve effective in one position to connect said pump outlet with said pump inlet and with said reservoir, and effective in another position to connect said pump outlet with said high pressure accumulator and said pump inlet with said third port of the first valve, and second resilient means in said second valve to urge said member of the second valve towards said another position thereof, said valve member of the second valve being movable towards said one position thereof against the action of said second resilient means in response to liquid pressure stored in said high pressure accumulator whereby said pump will suck liquid from said reservoir through said first valve and said second valve when the liquid pressure in said high pressure accumulator and in said low pressure accumulator is below a value determined by said first resilient means and by said second resilient means, but will suck pressure liquid from said low pressure accumulator through said first and second valves when the liquid pressure in said high pressure accumulator is below said value and the liquid pressure in said low pressure accumulator above said value, or said pump will suck liquid from the pump outlet through said second valve when the liquid pressure in said high pressure accumulator is above said value, and this irrespective of any pressure variation in said low pressure accumulator.

2. The plant as claimed in claim 1, further comprising means to prevent discharge of the accumulators to the pump when the latter is not operating.

3. The plant as claimed in claim 1, wherein said first resilient means and said second resilient means are so designed that the effort exerted by the same upon the corresponding movable valve member decreases as the latter are displaced in response to the liquid pressure stored in said accumulators, but increases when said valve members are moved under the action of said resilient means.

4. The plant as claimed in claim 3, wherein said first and second resilient means comprise each a pivotable lever having a cam-shaped end in contact with the corresponding movable valve member.

5. The plant as claimed in claim 1, comprising a plurality of low pressure accumulators calibrated to substantially the same pressure, each low pressure accumulator being connected to said first valve through a check valve preventing the flow of pressure liquid from the first valve to the low pressure accumulator, and a utilization device interconnected between said high pressure accumulator and each of said low pressure accumulators as well as between each of said low pressure accumulators and said reservoir.

6. The plant as claimed in claim 1, comprising two low pressure accumulators calibrated to different pressures, the accumulator calibrated to a pressure intermediate that of the other low pressure accumulator and that of said high pressure accumulator being connected to said pump through a valve adapted to interrupt said

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connection when the pressure of the intermediate pressure accumulator decreases below a predetermined value.

7. The plant as claimed in claim 1, comprising two low pressure accumulators calibrated to different pressures, means for causing delivery of pressure liquid from said pump to said two low pressure accumulators when the pressure in at least one of the two low pressure accumulators decreases below a predetermined value, and a distributor valve adapted to distribute said delivery of pressure liquid to said two low pressure accumulators and to said high pressure accumulator in accordance with a predetermined law.

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References Cited by the Examiner

UNITED STATES PATENTS

2,279,057	4/42	Reed	60—52
2,290,479	7/42	Mercier	60—51
2,802,336	8/57	Ball	60—51

FOREIGN PATENTS

540,183 10/41 Great Britain.

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