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HYDRAULIC DEVICES FOR RECIPROCATING ELEMENTS HAVING HIGH INERTIA

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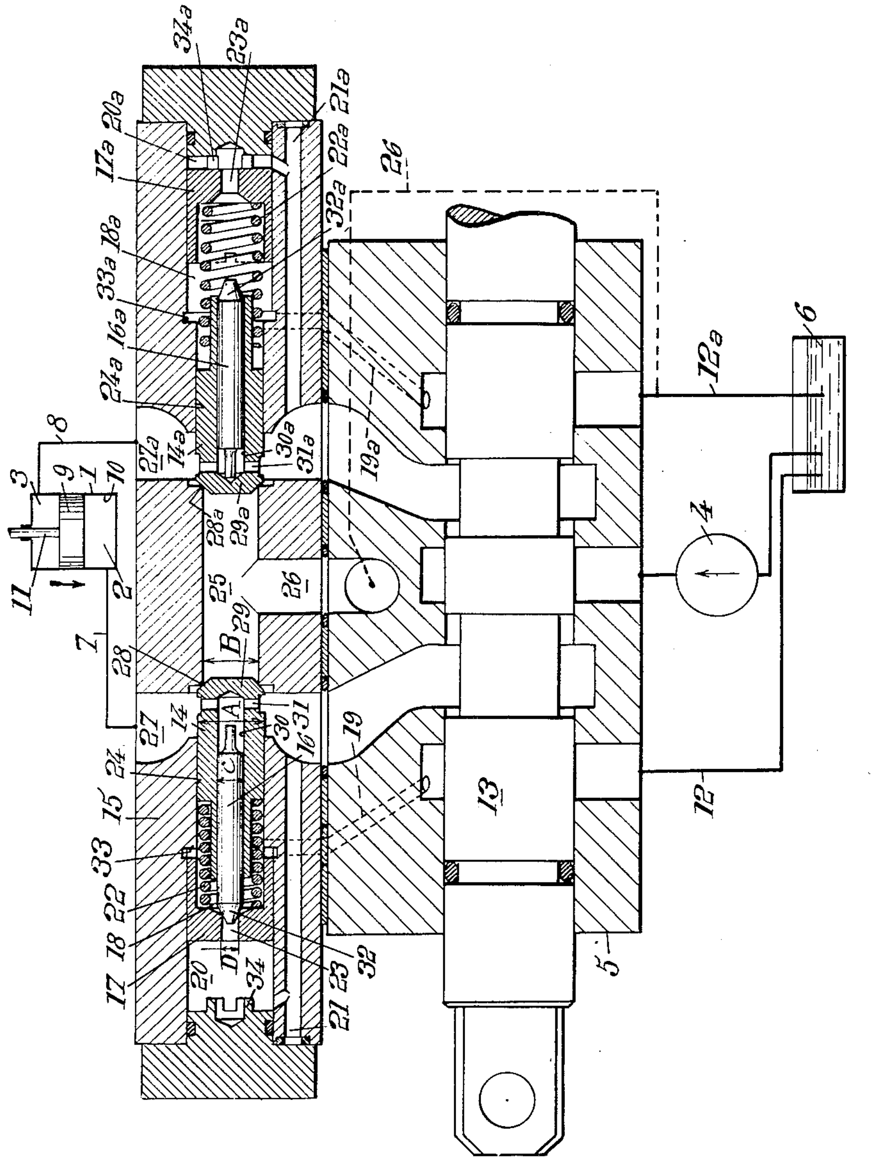

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HYDRAULIC DEVICES FOR RECIPROCATING ELEMENTS HAVING HIGH INERTIA

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This invention is for improvements in or relating to hydraulic devices for reciprocating elements having high inertia, the device comprising a bicameral hydraulic motor, a pressure liquid source and a distributor which in two of its positions connects such source to that of the two motor chambers which corresponds to the required direction of movement of the high-inertia element while connecting the other chamber to an unpressurised space, while in a third position the distributor closes the two ducts connecting the distributor to the respective two chambers of the motor and isolates the source.

Of course, when the distributor is moved from one of its two positions (movement of the high-inertia element) to the third of its positions (stoppage of such element), the pressure in the motor chamber which was previously connected to the unpressurised space via one of the ducts mentioned is abruptly increased by the kinetic energy of the high-inertia element, and unless the device had some safety provision it might be damaged, more particularly in the particular duct concerned and/or the distributor. The other motor chamber simultaneously experiences a temporary negative pressure because the high-inertia element does not stop immediately after the distributor has been operated.

It is an object of the invention to provide simply constructed and reliably operating safety devices for hydraulic devices of the kind specified. According to the invention, therefore, a safety valve is connected between a discharge space and each of the ducts connecting the chambers of the hydraulic motor to the distributor and is formed by a combination comprising a closure member slidable in a valve member, a plunger freely slidable inside the closure member, and a piston which separates two chambers inside the valve member—i.e., a first chamber which is also bounded by the assembly formed by the closure member and the plunger thereof and which communicates with the discharge space, and a second chamber communicating with the particular duct concerned of the ducts which extend from the distributor to the chambers of the hydraulic motor; a spring is disposed in the first chamber of the valve member between the closure member and the piston; a communicating passage controlled by the plunger is provided between the two chambers of the valve member; and the plunger surface other than the surface helping to bound the first chamber of the valve member experiences the pressure in the particular duct concerned of the ducts which extend from the distributor to the chambers of the hydraulic motor.

The complete system, more particularly the various cross-sections of the closure member, plunger and piston, is and/or are such that:

When the particular duct concerned experiences a positive pressure, the plunger closes the communicating passage so that the positive pressure can act first in the second chamber of the valve member to urge the piston in the direction which compresses the spring operative on the closure member, and then on only one of the closure member surfaces in order to open the closure member when the positive pressure exceeds a value corresponding to the thus increased calibration of the spring, so that the particular duct concerned can discharge and the positive pressure is limited; and when the particular duct concerned experiences a negative pressure, the plunger opens the communicating passage and decompresses the spring by the return of the piston so that the negative pressure can be operative on the two surfaces of the closure member to open the same, so that liquid can be sucked into the duct from the discharge space to destroy the negative pressure.

For a better understanding of the invention and to show how the same may be carried into effect, reference may now be made to the single figure forming the accompanying drawing which is a diagrammatic sectioned view of a hydraulic device according to the invention. The following or some similar procedure is followed if it is required to provide a hydraulic device for reciprocating, for instance, the table of a machine tool. The device in general can be embodied so as to comprise a hydraulic motor **1** having two chambers **2**, **3**, a pressure liquid source **4**, and a distributor **5** which in two positions can connect the source **4** to that of the two chambers **2**, **3** which corresponds to the required direction of movement of the machine tool table while connecting the other chamber to a pressureless space **6**, while in a third position, which is the position illustrated in the figure, the distributor **5** closes the two ducts **7**, **8** which extend from the distributor to the two chambers **2**, **3** respectively and isolates the source **4**. It will be assumed by way of example that the hydraulic motor is embodied as a double-acting ram or the like whose piston **9** subdivides a cylinder **10** into chambers **2**, **3**. As a rule, rod **11** of piston **9** extends through only one chamber, **3**, of the ram or actuator or the like so that volume variations are less in the chamber **3** than in the other chamber **2** for a given piston travel. Alternatively, the hydraulic motor can be of the rotary kind.

It is also assumed that the pressure liquid source **4** is a pump (the direction of circulation is diagrammatically illustrated by an arrow in the drawing) and that the pressureless space **6** is a tank from which the pump **4** draws and to which the distributor **5** can route via ducts **12**, **12*a*** the liquid expelled from the chambers **2**, **3** respectively. The distributor **5** can either be of the slider kind **13**, as shown, or of the rotary kind.

As described in the foregoing, when the valve **13** is moved from the position (on the left in the drawing) in which it was supplying the chamber **3** (piston **9** moving in the direction indicated by the arrow) into the position (the position shown) in which it closes the two ducts **7**, **8** and the chambers **2**, **3**, a positive pressure is produced in the chamber **2** and the duct **7** while a negative pressure is produced in the chamber **3** and the duct **8**. If the piston **9** stops when moving in the opposite direction, a positive pressure is produced in chamber **3** and duct **8** and a negative pressure in chamber **2** and duct **7**.

To reduce the unwanted effects of excessive positive pressures, according to the invention a safety valve is connected between a discharge space—advantageously, the tank **6**—and each duct **7** and **8**. The safety valve comprises in combination a closure member **14** slidable in a valve member **15**, a plunger **16** freely slidable inside the closure member **14**, and a piston **17** which separates off two chambers inside the valve member **15**—i.e., a first chamber **18** which is also bounded by the assembly comprising the closure member **14** and its plunger **16** and which communicates with the discharge space via a channel or the like **19** and a second chamber **20** communicating with the particular duct **7** or **8** concerned via a channel or the like **21**.

A spring **22** is provided in the chamber **18** between the closure member **14** and the piston **17**, a communicating passage **23** controlled by the plunger **16** is provided between the two chambers **18** and **20**, and the plunger surface other than the surface helping to bound the chamber **18** experiences the pressure in the particular duct **7** or **8** concerned. In the drawing the references for the safety valve elements associated with the actuator chamber **3** and with the duct **8** have the index "*a*" to distinguish them from the safety valve elements associated with the chamber **2** and with the duct **7**.

The closure members **14, 14*a*** are disposed, preferably symmetrically, in passages **24, 24*a*** which are aligned with a central passage **25** communicating with the tank **6** via channels **26**. Channels **27, 27*a*** are formed in the valve member **15** and form part of the ducts **7, 8** respectively. The central passage **25** opens at each end into the channels **27, 27*a*** via seats **28, 28*a***; the closure members **14, 14*a*** have heads **29, 29*a*** which so co-operate with the seats **28, 28*a*** as to be adapted to isolate the channels **27, 27*a*** from the passage **25**.

The plungers **16, 16*a*** are so disposed as to be freely slidable in passages **30, 30*a*** which extend through the closure members **14, 14*a*** parallel with the sliding axis thereof as far as the chambers **18, 18*a*** and which communicate at their other ends with the channels **27, 27*a*** via transverse orifices **31, 31*a***, the passages **30, 30*a*** stopping before the closure member heads **29, 29*a***. The pistons **17, 17*a*** are formed with the orifices **23, 23*a***, and those ends **32, 32*a*** of the plungers **16, 16*a*** which extend into the chambers **18, 18*a*** are so shaped as to be adapted to close the last-mentioned orifices.

The cross-sections A, B, C, D of the passages **24, 24*a***, of the seats **28, 28*a***, of the passages **30, 30*a*** and of the orifices **23, 23*a*** decrease in the order mentioned.

The invention therefore provides a hydraulic device which operates as follows:

If a positive pressure is operative in the duct **7** and channel **27**, the plunger **16** reduces the differential cross-section over which the positive pressure can be operative to open the closure member **14**, for since the liquid in the channel **27** flows through the orifices **31**, the positive pressure acts via the cross-section C on the closure member **14**, to close the same, and also on the plunger **16**, to move the same towards the piston **17** since the other end of the plunger enters the chamber **18** where, because of the channel **19**, the pressure is little, if any. If there were no plunger **16**, the positive pressure tending to open the closure member **14** would act on the cross-section A–B, the resulting force having to be balanced by the spring **22** at a particular positive pressure. However, the presence of the plunger **16**, which is independent axially of the closure member **14**, reduces by the amount C the differential cross-section on which the positive pressure tending to open the closure member **14** is operative: in this case such differential section has the value

$$(A-B)-C$$

Consequently, for a given positive pressure and for a given cross-section $(A-B)$, the spring **22** can be smaller, more flexible and less bulky than previously.

The plunger **16**, when moved towards the piston **17** in the manner just described, closes the orifice **23**, whereafter the positive pressure transmitted to the chamber **20** via the channel **21** thrusts the now hermetic piston **17** as far as an abutment **33**, for the other piston face, communicating as it does with the channel **19**, has substantially zero pressure operative on it. This compresses the spring **22** loading the closure member **14** which is therefore "cocked."

The orifice **23** is kept closed by the plunger **16** which is forced against the piston **17** by the positive pressure operative in the required direction on the cross-section $C-D$. Because of the reduced loading which the spring **22** can withstand, the process just described is performed at a relatively low pressure, so that adequate safety margin is left for the closure member **14** to be "cocked" before the limit positive pressure at which the closure member must open is reached.

If, however, a negative pressure is operative in the duct **8** and channel **27*a***, the negative pressure acts first on the plunger **16*a*** by way of the differential cross-section $(C-D)$ and moves the plunger **16*a*** away from the piston **17*a***, whereafter, once the orifices **23*a*** is open, the negative pressure continues to act in the same direction as previously but over the whole cross-section C of the plunger **16*a***, since the entire end **32*a*** thereof is in the chamber **18*a*** which is initially at substantially zero relative pressure, and the plunger abuts the head **29*a*** of the closure member **14*a***. Simultaneously, the spring **22*a*** slackens and moves the piston **17*a*** which can continue to be moved by the negative pressure as far as an abutment **34*a*** even if the spring **22*a*** has gone completely slack beforehand. Since the orifice **23*a*** is open, the chamber **18*a*** also experiences an at least partial negative pressure because of load losses in the channel **19*a*** connecting the chamber **19*a*** to the tank **6**. Consequently, all the transverse surfaces of the closure member **14*a*** experience the negative pressure except for that part of the head **29*a*** which engages in the passage **25**. Clearly, therefore, the negative pressure can disengage the closure member **14*a*** from the seat **28*a***.

In any case, a positive pressure in the channel **27** (or **27*a***) can open the respective closure member **14** or **14*a*** when, by its action on the small cross-section $A-(B+C)$ it becomes sufficient to overcome the resistance of the spring **22** or **22*a*** cocked by the piston **17** of **17*a***. Similarly, a negative pressure in the channel **27** or **27*a*** can open the respective closure member **14** or **14*a***.

As already stated, when the valve **13** is moved from the position corresponding to the chamber **3** being supplied and the chamber **2** being emptied (left-hand position in the drawing) into the central position (position shown) in which the distributor **13** closes the two chambers **2, 3**, a positive pressure is operative in the duct **7, 27** and a negative pressure is operative in the duct **8, 27*a***. If the positive pressure exceeds the aforementioned limit value, the closure member **14** opens briefly as hereinbefore described and allows some liquid from the chamber **2** to escape via the passage **25**. Meanwhile the actuator piston **9** follows the movement of the high-inertia element which it normally moves, and a quantity of liquid equal to the quantity of liquid displaced into the chamber **3** during such movement is sucked into the passage **25** after the closure member **14*a*** has disengaged from its seat. When some of the kinetic energy of the moving assembly has been dissipated, the positive pressure in the duct **7** drops below the safety limit and the closure member **14** closes. The piston **9** stops, so that the negative pressure ceases in the duct **8** and the closure member **14*a*** closes.

If the quantities of liquid displaced into the chambers **2, 3** are always equal, as with an actuator whose rod **11** extends through the two chambers, or as with a rotary hydraulic motor, there is simply an exchange of liquid through the passage **25** between the channels **27** and **27*a***. If such quantities of liquid are different from one another, compensation is provided by delivery to or sucking-in from the channel **26**.

Of course the safety devices hereinbefore described do not upset the normal operation of the hydraulic device, for when the distributor **5** allows pressure liquid to flow to any of the chambers **2** or **3** and connects the other chamber to discharge, the two closure members **14, 14*a*** are kept closed—the one on the supply side being kept closed by the respective spring **22** or **22*a***—since the pressure of the liquid is below the value at which such closure member is calibrated to open—while the other closure member, on the discharge side, is kept closed by the pressure maintained by load losses in the return path to the tank **6**. If, however, the element normally driven by the piston **9** becomes a motor and calls for more liquid than the pump **4** supplies, the negative pressure produced on the supply side enables the corresponding closure member **14** or **14*a*** to open and enables the pump delivery to be made up by liquid drawn directly from the tank **6** via the channels **12**_a_, **26**, in which event the positive pressure on the discharge side is, as a rule, insufficient to open the corresponding closure member **14** or **14**_a_.

In any case, the invention provides safety means which take up little space, more particularly because their return springs can be very flexible when in the inoperative state.

Of course, and as the foregoing shows, the invention is not limited to those of its applications or to those embodiments of its various parts which have been more particularly considered but covers all variants.

I claim:

1. A hydraulic device for reciprocating elements having high inertia comprising: a pressure liquid source; a hydraulic motor having two motor chambers corresponding to the required direction of movement of the high inertia element; a three position distributor disposed between the chambers and the pressure liquid source, the three positions respectively directing pressure liquid to the first motor chamber while connecting the second chamber to an unpressurised space, directing pressure liquid to the second motor chamber while connecting the first chamber to an unpressurised space and isolating both chambers from the pressure source; two ducts connecting respectively the chambers to the distributor; a discharge space; a single valve connected between the discharge space and each of the ducts, said single valve comprising a valve member; a closure member for the corresponding duct slidable therein; said last mentioned duct including a seat for said closure member; a plunger freely slidable inside the closure member; and a piston freely movable with respect to both said valve member and said plunger and fitting slidably in said valve member to separate therein; first and second chambers, the first chamber being bounded by the closure member and plunger and communicating with the discharge space and the second chamber communicating with one of said ducts extending from the distributor to the hydraulic motor; a single spring in said valve member, said spring being located in the first chamber between the closure member and the piston; a communicating passage controlled by the plunger between the chambers of the valve member, the plunger end opposed to that bounding the first chamber of the valve member bearing the pressure in the duct from the distributor to the corresponding chamber of the hydraulic motor.

2. The device specified in claim **1** wherein the communicating passage extends through the corresponding piston, the plunger ends which emerge into the first chambers being adapted to close the last-mentioned passages.

3. The device specified in claim **1** wherein the cross-section of the passages in which the closure members move, the cross-section of the seats co-opertating with such closure members, the cross-section of the passages in which the plungers move, and the cross-section of the communicating passages have gradually decreasing values.

References Cited by the Examiner

UNITED STATES PATENTS

2,165,966	7/39	Hall et al.	137—612.1
2,389,654	11/45	Van Der Werf	91—452
2,965,133	12/60	Rice et al.	91—451
2,980,136	4/61	Krehbiel	91—451

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