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HYDRAULIC CONTROL SYSTEM

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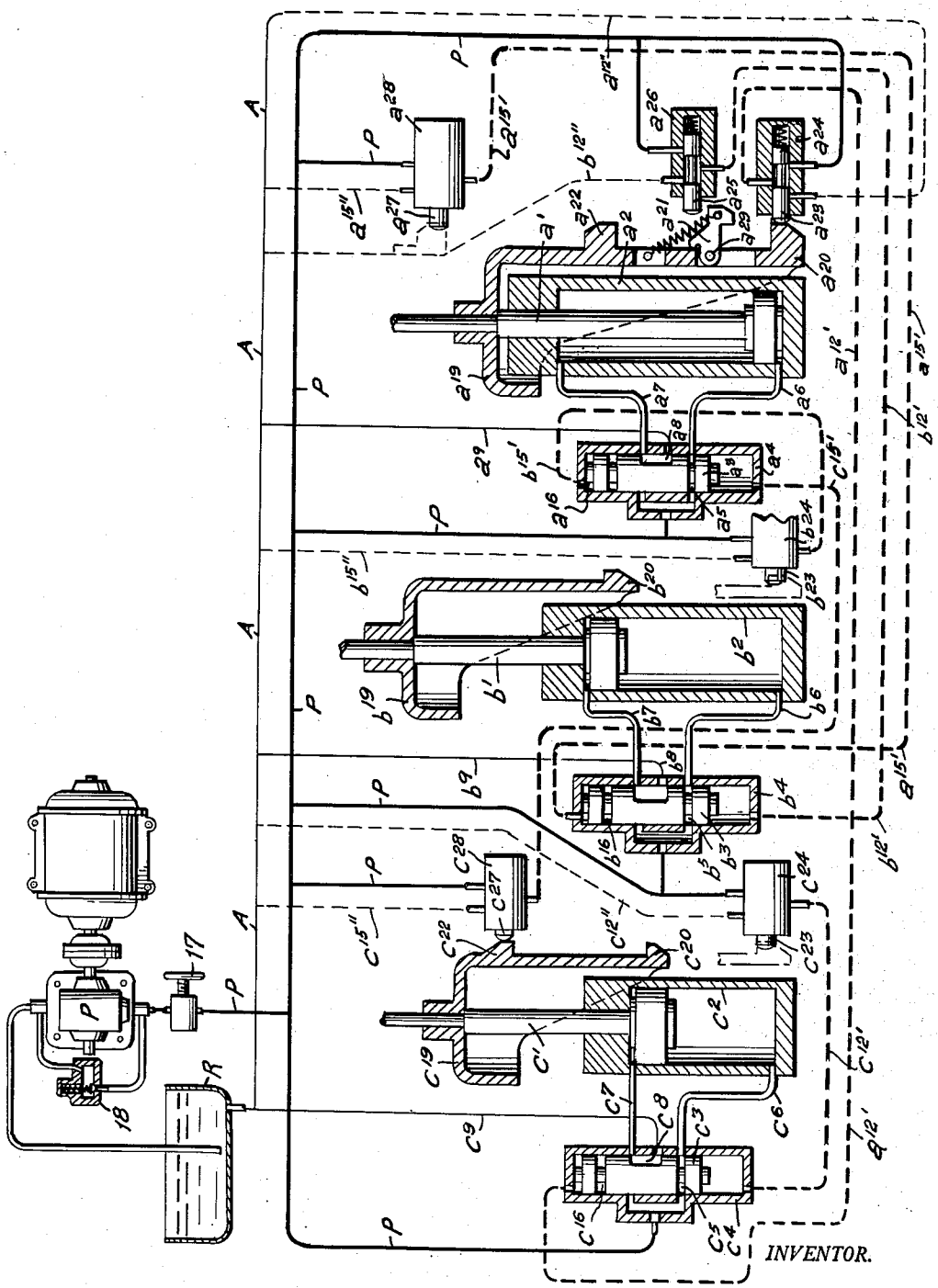

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HYDRAULIC CONTROL SYSTEM

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4 Claims. (Cl. 60—97)

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The present invention relates to a hydraulic control system adapted to control movable parts.

More particularly, this invention relates to an improvement in the system disclosed in my earlier filed co-pending application Serial No. 613,664, filed August 30, 1945, now abandoned.

The principle advanced by said co-pending application embodied controlling of the movement of parts of certain machines by hydraulic pistons actuating and locking one another and so arranged that the initiation of movement of the several pistons is possible only when the controlling piston has moved a distance corresponding to the work that it must perform. This mutual controlling and locking of the pistons was effected by first utilizing the translatory movement of each piston and by providing one or more passages in the piston rods which at the proper moment provided communication with other passages provided in the cylinders to transmit fluid under pressure to distributing valves controlling the pistons to be moved.

In some instances, the passages provided in the piston rods permitted liquid to be driven out of the cylinders. Also, in the instance where a long working stroke of a piston is involved, the length of stroke would require an elongated passage the length of which contributed to the escape of fluid under pressure from the cylinder.

Additionally, when it is necessary that one actuating piston initiate the movement of another piston before the forward or return stroke of the first piston is accomplished, the fact that the movement of said other piston is initiated utilizing a port provided in the piston rod of the actuating piston, results in initiation of the movement of the said other piston on two occasions, first, toward the end of the forward stroke of the actuating piston and again on the beginning of the return stroke thereof or vice versa.

The present invention, therefore, has for an object to provide a hydraulic control system of the type disclosed in said co-pending application but structurally organized so as to eliminate the aforementioned deficiencies attendant with providing passages in the piston rods.

It is an additional object to provide a hydraulic control system in which the control passage providing communication between the source of fluid under pressure and the distributing valves are embodied in independent members associated with the working pistons and cylinder and including movable means actuated in response to the movement of the pistons.

In accordance with the present invention the

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control system comprises a number of similar units each embodying a hydraulic motor, the piston of which has at least one cam member fast to the piston rod or to another member fixed to the piston rod, at least one releaser actuated by the cam and a distributor controlling the hydraulic motor, the said distributor being controlled in turn by a releaser associated with any one of the units.

This combination which may be utilized for actuating the movable parts of a machine tool or other automatic apparatus permits the following operations, the total effect of which cannot be obained with known control systems:

(1) All of the pistons are interlocked, so that in a given sequence of movement where the stroke of each piston is conditioned upon the attainment of a given movement by the preceding piston none of the pisons can initiate its working stroke so long as the said preceding piston has not accomplished its function.

(2) A given sequence of motion may be automatically repeated.

(3) The speed of movement of all of the pistons, or in other words the speed at which the entire cycle of movement is performed, can be regulated by means of a single control valve.

(4) Each piston can initiate the movement of several other pistons simultaneously and by utilizing yieldable cam members controlling at least one releaser can initiate the movement of several other pistons successively.

(5) Each piston can control its proper stroke.

Further and more specific objects will be apparent from the following description taken in connection with the accompanying drawing diagrammatically illustrating an embodiment of the invention.

In the drawing the control system includes three hydraulic motors each including driving or working pistons and their associated rods a^1, b^1 and c^1 reciprocable respectively in cylinders a^2, b^2 and c^2. Each piston rod has mounted fast thereon the support members a^{19}, b^{19} and c^{19} which reciprocate with the pistons. The flow of pressure fluid to the respective cylinders is controlled by distributors associated therewith and including the distributor valves a^3, b^3, and c^3 having pistons at the opposite ends thereof reciprocable in the cylinders a^4, b^4 and c^4 respectively. Each of the last mentioned cylinders includes a chamber on opposite sides of the associated valves and an orifice communicating with the bottom or base of each chamber. Likewise associated with the respective hydraulic motors are

releasers controlling fluid flow from the pressure source to the distributors. Each of the releasers embodies a movable member adapted to be actuated in response to the stroke of the working pistons, as will be set forth in detail hereinafter.

On the member or support a^{19} are mounted cam members a^{20}, a^{21} and a^{22} so arranged as to engage and depress at the proper time plungers a^{23}, a^{25} and a^{27} respectively embodied with releasers a^{24}, a^{26} and a^{28}, the depressing of these plungers permitting fluid to flow through the particular releaser to the distributors in communication with that releaser.

Additional cams are provided on the support members b^{19} and c^{19}. The cam b^{20} at the lower edge of support b^{19} cooperates with and depresses plunger b^{23} of the releaser b^{24} while support c^{19} has lower and upper cams c^{20} and c^{22} cooperating respectively with the plungers c^{23} and c^{27} of the releasers c^{24} and c^{28}.

In the drawing the thick, solid lines denote pressure lines having their origin at a source of pressure constituted by a motor driven pump p drawing working fluid from a tank r which is in communication with the atmosphere and delivers fluid under the control of a shut-off gate valve 17. The pressure lines P on the delivery side of valve 17 lead to the releasers and to the distributors. The thick, broken lines denote conduits providing communication between the releasers and the distributors and the line A denotes a return pipe to the reservoir which is at atmospheric pressure. Conduits a^6 and a^7 provide communication between the distributor cylinder a^4 and the opposite ends of the working cylinder a^2 and similar arrangements embodying conduits b^6, b^7 and c^6, c^7 provide communication between the distributors b^4, c^4 and working cylinders b^2, c^2, respectively.

The fine, solid lines a^9, b^9 and c^9 denote conduits connecting the distributors a^4, b^4 and c^4 with the return pipe A for evacuating liquid discharged through the distributors by the working pistons.

The fine broken lines $a^{12''}$, $b^{12''}$, $a^{15''}$, $b^{15''}$, $c^{12''}$ and $c^{15''}$ denote conduits through which liquid travels from the releasers to the return pipe. The liquid discharged by the upper end of distributing slide valve c^3 flows through conduit $a^{12''}$, thence through releaser a^{24} and conduit $a^{12''}$. The liquid discharged from the lower end of slide valve b^3 flows through conduit $b^{12'}$, releaser a^{26} and conduit $b^{12''}$. The discharge from the upper end of slide valve b^3 flows through conduit $a^{15'}$, releaser a^{28} and conduit $a^{15''}$. The discharge from the upper end of distributor valve a^3 flows through conduit $b^{15'}$, distributor b^{24} and conduit $b^{15''}$. The discharge from the lower end of slide valve c^3 passes through conduit $c^{12'}$, distributor c^{24} and conduit $c^{12''}$ and the discharge from the lower end of distributor slide valve a^3 passes through conduit $c^{15'}$, releaser c^{28} and conduit $c^{15''}$. As indicated in the drawings, all of the releasers are similarly constructed and the plungers thereof are spring pressed to a position in which the discharge from the releasers to the return pipe communicates with the inlet to the releaser from the associated distributing valve chamber. In other words, the resilient means urges the plungers to a position that the control bore of the releaser is in communication with the exhaust bore thereof, the inlet bore in communication with the pressure line P being normally closed.

The circuit of the pump p also includes a discharge valve or bypass 18 of a known type so as to prevent damage to the pump when the shut-off valve 17 is closed.

In the drawing the piston a^1 is at the lower point of its stroke. The slide valve a^3 of the distributor a^4 has just reached the upper point of its stroke so that the circular groove a^5 on the slide valve a^3 is in communication with the pressure line P extending parallel with conduit $b^{15''}$. The fluid in cylinder a^2 can escape therefrom through conduit a^7, chamber a^8 in the slide valve and return to the tank r through conduit a^9 and return pipe A.

With piston a^1 at the lower point of its stroke the cam a^{20} has contacted and depressed plunger a^{23} of the releaser a^{24} so that fluid under pressure can flow through the releaser out through conduit $a^{12'}$ into the upper end of distributing cylinder c^4 to act against the piston on the upper side of the distributing slide valve c^3, the upward movement of piston c^1 having caused the cam c^{22} to depress plunger c^{27} to permit fluid to flow from the pressure source through releaser c^{28} and conduit $c^{15'}$ to the under side of the piston on the lower end of distributing slide valve a^4.

When the pressure fluid has raised piston a^1 so that it reaches the upper limit of its stroke, the cam a^{22} will contact and depress plunger a^{27} of releaser a^{28} to permit fluid under pressure to flow from piping P through the releaser a^{88} into conduit $a^{15'}$, thence to the upper side of the piston on the upper end of distributing slide valve b^4 associated with the piston b^1. This piston b^1 being at the high point of its stroke in cylinder b^2, the slide valve b^3 of distributor b^4 is also at the upper end of its stroke so that fluid under pressure has passed through the groove b^5 into cylinder b^2 through piping b^6 to raise piston b^1. As indicated, when the pressure fluid controlled by releaser a^{28} flows through conduit $a^{15'}$ the slide valve b^4 will be moved downward and groove b^{16} will be placed in communication with conduit b^7 to permit pressure fluid entering the distributor b^4 from line P to force the piston b^1 downwardly. When the piston b^1 has reached the lower point of its stroke the cam b^{20} will engage and depress plunger b^{23} of releaser b^{24} so that fluid under pressure will flow through this releaser, thence through conduit $b^{15'}$ to the upper end of distributor a^4 for actuating the same downwardly.

The piston c^1 is also at the upper end of its stroke in cylinder c^2. The slide valve c^3 is at the top of its stroke in distributor c^4 so that the pressure fluid has passed through the distributor, the groove c^5 and the piping c^6 to the under side of piston c^1. As previously indicated, the downward stroke of the piston a^1 has actuated releaser a^{24} so that fluid will now flow into distributor c^4 at the top, and in the drawing the slide valve c^3 is about to be moved downwardly so that the circular groove c^{16} will serve for the passage of pressure fluid from the source into piping c^7 to the upper side of piston c^1 to lower the same.

When the piston c^1 reaches the lower point of its stroke the cam c^{20} will contact and depress plunger c^{23} of releaser c^{24} permitting pressure fluid to flow through this releaser c^{24} and conduit $c^{12'}$ to the under side of the piston on the lower end of distributing slide valve c^3 to raise this valve.

Briefly, therefore, in the drawing the piston c^1 has just reached the high point of its stroke and through the action of cam c^{22} on plunger c^{27} permitted fluid under pressure to flow through

conduit $c^{15'}$, resulting in the upward pressure displacement of slide valve a^3 of the distributor a^4. Fluid flow from the pressure source through groove a^5 and conduit a^6 will immediately move the piston a^1 upwardly.

When the piston a^1 reaches its upper position cam a^{22} will displace plunger a^{27} permitting fluid under pressure to flow through releaser a^{28} and conduit $a^{15'}$ into the upper end of distributor b^4 to displace distributor valve b^5 downwardly to place groove b^{16} in registry with conduit b^7 to permit the lowering of piston b^1 which, upon reaching its lower position through the cooperation of cam b^{20} with plunger b^{23} will permit fluid under pressure to flow through releaser b^{24} and conduit $b^{15'}$ to the upper end of distributor a^4 so that the resulting displacement of slide valve a^3 will permit pressure fluid to move piston a^1 downwardly.

As indicated in the drawing, the downward movement of piston a^1 controls slide valves b^3 and c^3 successively, the first shortly before the end of the downward stroke and the second at the end of the downward stroke. While the support member a^{19} is moving downwardly with piston a^1 the cam a^{21} engages and depresses plunger a^{25} of releaser a^{26}. As shown in the drawings, this releaser is displaced laterally out of alignment with the other two releasers associated with cylinder a^2 and the cam a^{21} which is pivoted to the cylinder projects outwardly of support a^{19} a distance greater than the extent of projection of cams a^{20} and a^{22} respectively. Cam a^{21} is provided with a tongue on its rear side which limits the pivoting movement thereof so that it cannot pivot upwardly beyond the position shown in the drawing and a spring urges the same to the position illustrated. On downward movement it is obvious that cam a^{21} actuates the plunger a^{25}, thus permitting pressure fluid to flow through releaser a^{26} into conduit $b^{12'}$ to the under side of distributing slide valve b^3 for raising distributing valve b^3 to permit fluid under pressure to enter cylinder b^2 to raise piston b^1. As previously set forth, the continued downward movement of piston a^1 effects the cooperation between cam a^{20} and plunger a^{23} to permit the pressure fluid to flow into the upper end of distributor c^4 displacing the valve c^3 permitting pressure fluid to lower piston c^1. The piston c^1 on arriving at its lower position actuates plunger c^{23} to effect the raising of slide valve c^3 and thus the return or upward stroke of the piston c^1. When piston c^3 reaches its upper position it again actuates the plunger c^{27} to permit fluid to again flow through conduit $c^{15'}$ to the lower side of distributor a^4 for further actuation of the slide valve a^3 and resulting in upward displacement of the piston a^1.

As described, the yieldable cam a^{21} is employed to effect the upward actuation of distributor valve b^3 before the downward movement of distributor valve c^3. This stop must be yieldable in one direction of movement of the pitston a^1 since otherwise the passage of liquid under pressure would occur twice, once when the piston a^1 comes down and again when it rises when the order of the actuation of the distributing slide valves would be disrupted.

As illustrated, on the upward movement of piston a^1 from the position shown, the cam a^{21} will rock about the axis a^{29} and not depress plunger a^{25}.

It is also to be noted that in the releasers which are in the depressed position, which as illustrated

is the case for the releaser corresponding to the position of the piston a^1 at its lower position and for the releaser corresponding to the piston c^1 at its higher position the liquid under pressure is admitted through one of the ports of the releaser for passage therethrough in order to actuate each distributor controlled by the said releasers.

On the contrary, the third port of said releasers which is connected with the return pipe for returning the liquid to the tank, is closed during the effective action of said releasers.

But as soon as this effective action ceases, that is to say as soon as a stop cam no longer engages the plunger of a releaser the inlet passage for the liquid under pressure is immediately closed while the passage for the return of liquid to the tank is immediately opened by the spring embodied with each releaser.

This is necessary in order for the liquid which is at one end of the slide-valves on the thrust side to escape when the direction of movement of the said slide-valves changes, so as not to oppose the movement of translation of the valves. When this change in the direction occurs the fluid which is forced back passes again through the releaser connected with the distributor under consideration in order to then return to the tank.

For stopping a machine controlled by actuating pistons themselves controlled by the device according to this invention it will be sufficient to interrupt the circuit of the fluid under pressure by means of the valve 17.

For starting again it will also be sufficient to open said valve, the motions then beginning to work without the intervention of any actuating organ with the exception of the pump or any other source of pressure delivering the fluid under pressure to the actuating pistons.

The velocity at which the strokes of all driving pistons are performed, can be controlled by throttling the flow of the fluid under pressure by means of the valve 17.

Through an examination of the preceding explanations and the figure of the drawing, it is apparent:

1. That the control of the movement of the pistons is effectively obtained as disclosed in the above-mentioned co-pending application but that the omission of the ports on the piston rods avoids any loss of fluid under pressure, more particularly through the openings provided in the upper part of said piston rods.

2. That in case it is necessary that an actuating piston controls the movement of another piston before the actuating piston completes its own "forward" stroke or "return" stroke, the new arrangement cannot release the desired movement twice since the releasing cam yields when the direction of the movement of translation of the support carrying the cam reverses.

3. Lastly, and as in the above-mentioned application if any incident locks any one of the actuating pistons none of the other actuating pistons incorporated with the same machine can start again after having accomplished its stroke.

I claim:

1. In an hydraulic control system adapted to control movable parts, the combination of a source of fluid under pressure having a delivery conduit, controlling means in the delivery conduit of said source, an exhaust conduit, a plurality of hydraulic motors each comprising a working cylinder having ports at its ends, a driving piston reciprocable in each of said working cylinders, a piston rod fast to each of said

pistons and to the movable part to be controlled; a plurality of releasers each including an inlet bore connected with said delivery conduit, an exhaust bore connected with said exhaust conduit, a control bore, movable means for connecting said control bore respectively with said inlet bore and said exhaust bore, and resilient means urging said movable means towards the position connecting said control bore with said exhaust bore; cam members fast to said piston rods and adapted to act upon their associated movable means at a given point of the stroke of said driving pistons; a plurality of slide valves each adapted to connect the ports of its associated cylinder respectively with said delivery conduit and said exhaust conduit, an actuating cylinder having an orifice in the bottom thereof disposed on each side of each slide valve, each actuating cylinder having a slidable piston therein fast to its associated slide valve, and transmitting conduits interconnecting said control bore to said orifices in a given order following the sequence of operations to be performed.

2. A hydraulic control system as claimed in claim 1, in which the control bore of at least one releaser is connected to the bottom orifice of an actuating cylinder of the slide valve associated with the working cylinder whose piston rod is adapted to act upon the movable means of said releaser.

3. In an hydraulic control system adapted to control movable parts the combination of a source of fluid under pressure having a delivery conduit, controlling means in the delivery conduit of said source, an exhaust conduit, a plurality of hydraulic motors each comprising a working cylinder having ports at its ends, a driving piston reciprocable in each of said working cylinders, a piston rod fast to each of said pistons and to the movable part to be controlled; a plurality of releasers each including an inlet bore connected with said delivery conduit, an exhaust bore connected with said exhaust conduit, a control bore, movable means for connecting said control bore respectively

with said inlet bore and said exhaust bore, and resilient means urging said movable means towards the position connecting said control bore with said exhaust bore; cam members fast to said piston rods and adapted to act upon their associated movable means at a given point of the stroke of said driving pistons; at least one cam member adapted to act upon at least one of the movable means in one direction of the movement of the corresponding driving piston, but to be tilted yieldingly to an inactive position in the other direction of the movement of the piston, a plurality of pressure operated slide valves, each controlling connection between the ports of each working cylinder and the delivery and exhaust conduits; each slide valve having an actuating cylinder disposed on opposite sides thereof, each actuating cylinder having an orifice in the bottom thereof, and transmitting conduits interconnecting said control bores to said orifices in a given order following the sequence of operations to be performed.

4. A hydraulic control system as claimed in claim 1 in which the working cylinders are arranged in series and include a first and a last cylinder and the control bore of one releaser of the last working cylinder is connected to the orifice of an actuating cylinder of the slide valve belonging to the first working cylinder so that the sequence of motions is automatically repeated.

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