Nov. 24, 1942. K. C. MONROE 2,302,791

HORIZONTAL HYDRAULIC BROACHING MACHINE

Filed June 21, 1940 3 Sheets-Sheet 1

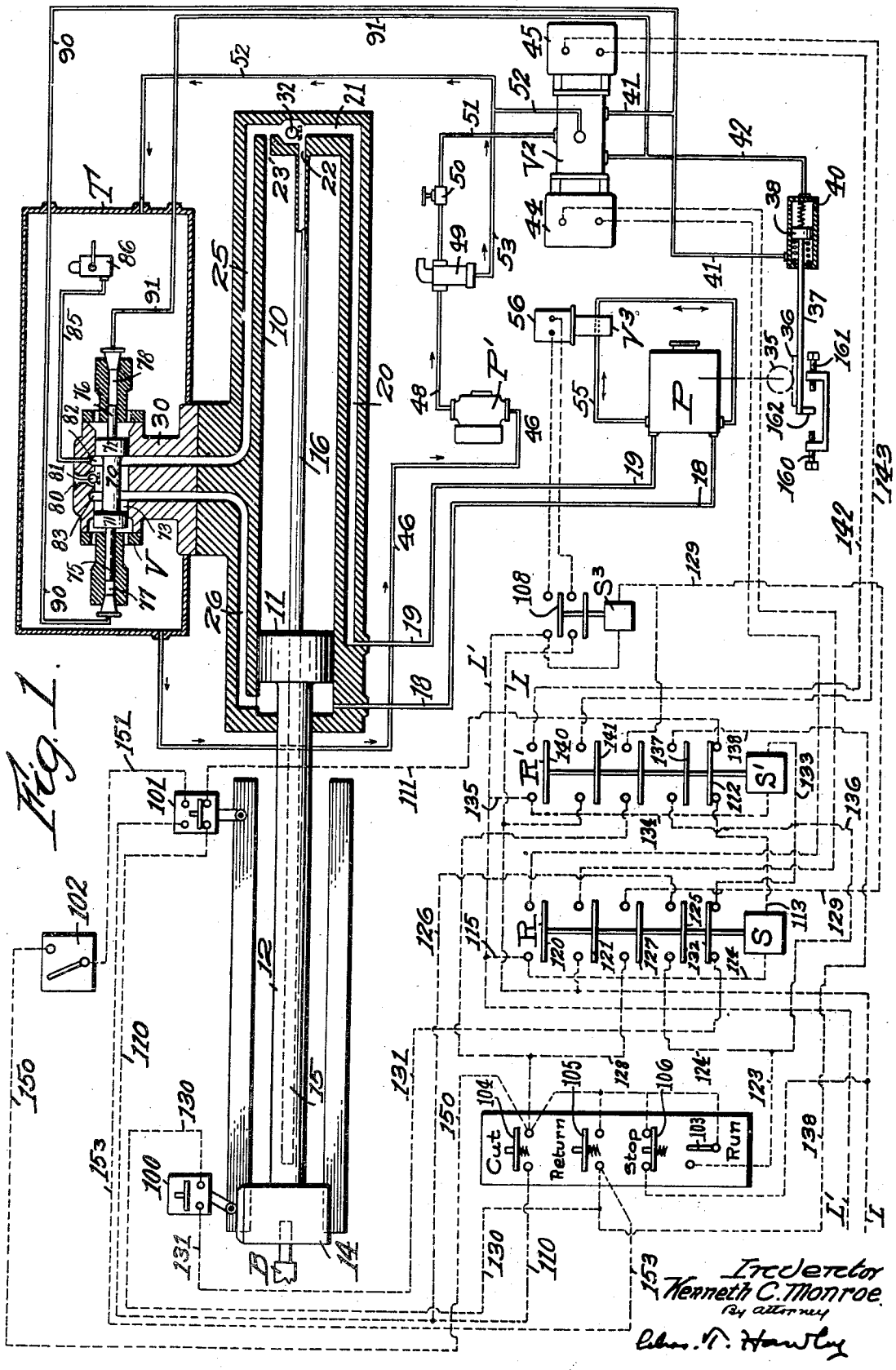


Fig. 1.

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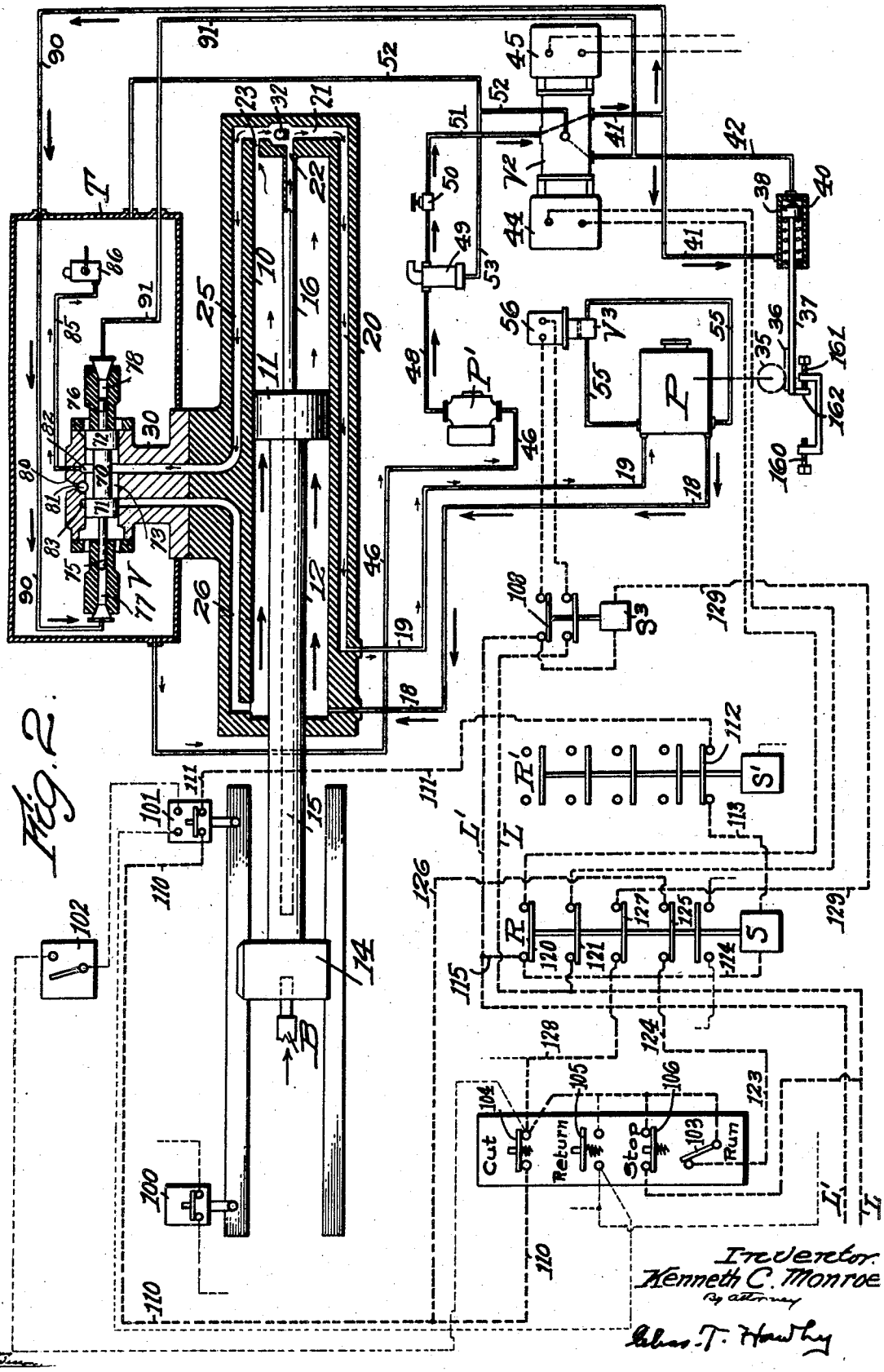


Fig. 2.

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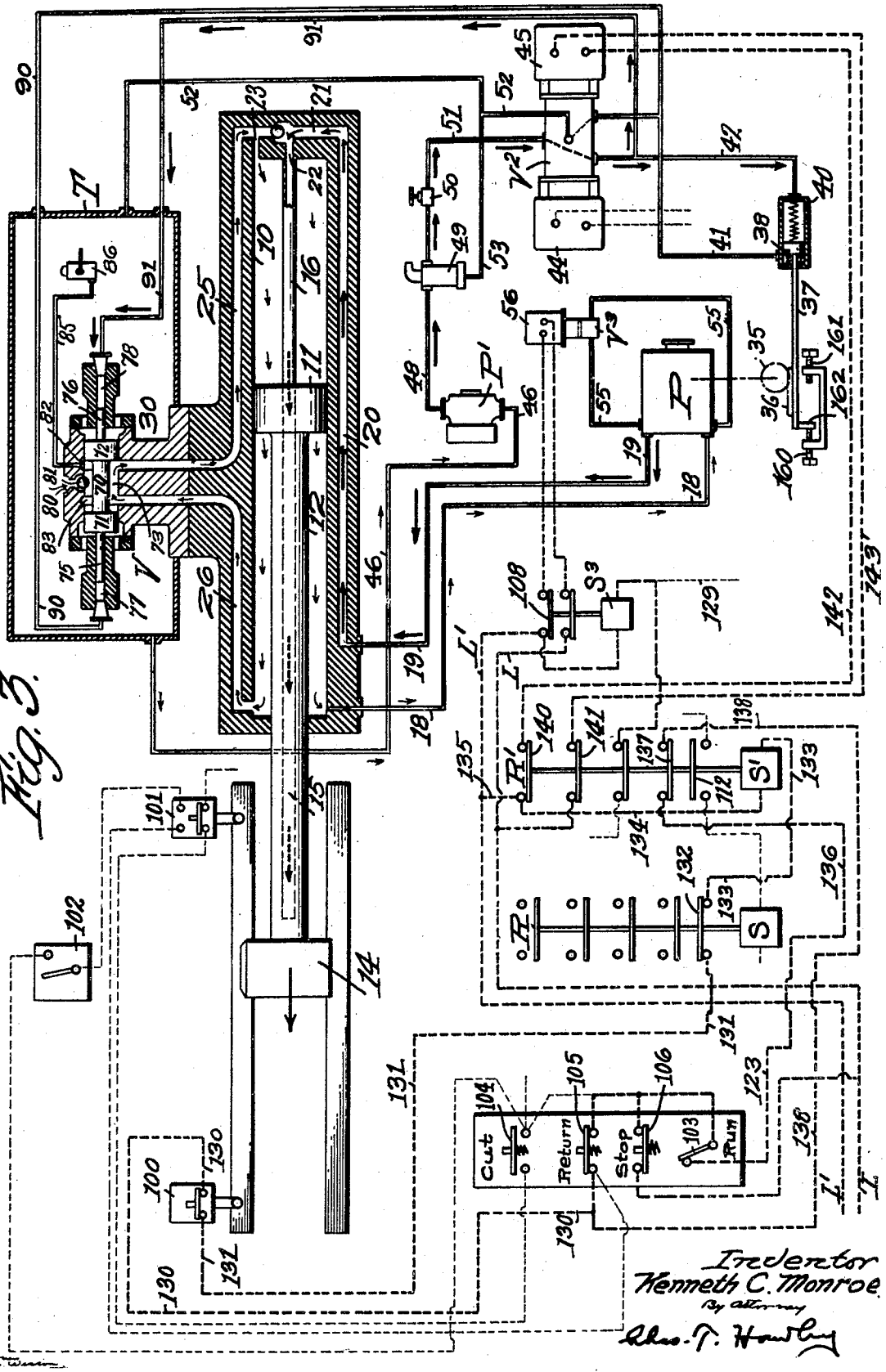


Fig. 3.

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Patented Nov. 24, 1942 2,302,791

UNITED STATES PATENT OFFICE

2,302,791

HORIZONTAL HYDRAULIC BROACHING MACHINE

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Application June 21, 1940, Serial No. 341,770

12 Claims. (Cl. 90—33)

This invention relates to broaching machines of the horizontal type which are provided with hydraulic operating mechanism.

It is the general object of my present invention to provide a horizontal hydraulic broaching machine in which the different parts of the machine are so controlled or interlocked that unintended, harmful or dangerous operation of the machine is substantially impossible.

To the attainment of this object, one feature of the invention relates to a system of electrical controls so designed that the machine will stop if the various control circuits are not closed and opened in predetermined order, and will also stop on any failure of current in the control circuits. I have also provided control devices which may be set to stop the machine after each broaching stroke and each return stroke, or only after each return stroke, as desired.

Another feature of my invention relates to the provision of mechanism for automatically holding the machine in operation after a working or return stroke has been started and until the stroke has been completed, or, alternately, for stopping the machine at any point in a stroke whenever the cut or return switch is opened.

I also provide improved hydraulic devices for handling excess oil delivered from the main cylinder during the high speed return stroke.

My invention further relates to arrangements and combinations of parts which will be hereinafter described and more particularly pointed out in the appended claims.

A preferred form of the invention is shown in the drawings, in which

Fig. 1 is a diagrammatic plan view of the operating parts of my improved broaching machine, together with the hydraulic connections and electrical control devices, all shown in idle or neutral position;

Fig. 2 is a view similar to Fig. 1 but showing various parts in the positions assumed during the cutting stroke; and

Fig. 3 is a view similar to Fig. 1 but showing the parts in the position assumed during the return stroke.

Referring to the drawings, I have shown the essential parts of a horizontal hydraulic broaching machine comprising a main cylinder 10 in which a piston 11 is reciprocated. The piston 11 is connected by a piston rod 12 to a broaching or puller head 14, in which a broach B may be detachably secured. The piston rod 12 has a relatively small axial bore or recess 15, and the cylinder 10 has a fixed tubular rod 16 mounted therein and slidable in the passage 15.

The left-hand end of the cylinder 10, as viewed in Fig. 1, is connected by a pipe 18 to one of the discharge openings of a variable discharge reversible main pump P. The other discharge opening of the pump P is similarly connected by a pipe 19 and passage 20 to a recess or chamber 21 in the right-hand end of the cylinder 10. This recess or chamber 21 is connected by a port 22 to the inside of the fixed tubular rod 16, and by a port 23 to the right-hand end of the cylinder 10.

Passages 25 and 26 connect the recess 21 and the left-hand end of the cylinder 10 respectively to the cylinder 30 of a differential valve V, which is mounted above the main cylinder 10 and within a storage tank or reservoir T to which surplus oil may be delivered or from which oil may be withdrawn by the pumps.

A check valve 32 in the recess or chamber 21 prevents flow of oil upward from the passage 20 to the port 23 or to the passage 25, but permits free flow in the opposite direction.

The pump P is provided with suitable devices such as a pinion 35 and rack 36, by which the pump P may be set to discharge at any desired rate and in either direction. The rack 36 is shown as connected by a piston rod 37 to a piston 38 slidable in a pump control cylinder 40 and normally spring-centered therein by centering devices of any usual construction.

The ends of the cylinder 40 are connected by pipes 41 and 42 to a solenoid-operated control valve V^2 which is normally spring-centered in neutral position but which may be displaced to the position shown in Fig. 2 if the solenoid 44 is energized, or to the position shown in Fig. 3 if the solenoid 45 is energized.

Oil under pressure for actuating the pump control cylinder 40 is supplied from a continuously operating auxiliary pump P', which receives a supply of oil through a pipe 46 from the tank T and which delivers oil under pressure through a pipe 48, relief valve 49, needle valve 50 and pipe 51 to the solenoid operated valve V^2. The valve V^2 also has a discharge pipe 52 which discharges oil at atmospheric pressure to the tank T, and to which pipe is connected the discharge pipe 53 of the relief valve 49.

The pump P is preferably provided with a bypass circuit 55 having a normally open valve V^3 controlled by a solenoid 56. When the machine is operating, either on a cut or return stroke, the solenoid 56 is energized and the valve V^3 is closed

as shown in Figs. 2 and 3, but when the machine is idle, the valve V^3 opens and the pipe 55 then provides a by-pass or shunt circuit for any small amount of oil which may be discharged by the pump P if the pump control cylinder should not set the pump in exactly neutral position. This by-pass thus prevents any creeping of the piston 11 and broaching head 10 in either direction while the machine is idle.

The differential valve V includes a piston 70 slidable in the cylinder 30 and having spaced piston elements 71 and 72, with an interposed annular space 73. The piston valve 70 is provided with piston rod extensions 75 and 76 at its two ends, which extensions are slidable in axial openings or passages 77 and 78 in the heads of the valve V.

A port 80 opens into the cylinder 30 and is provided with an inwardly opening vent or check valve 81. The passages 25 and 26 previously described open into annular ports 82 and 83 in the wall of the cylinder 30, and the port 82 connects to the tank T through a relief pipe 85 and back pressure valve 86.

The pipes 41 and 42 controlled by the solenoid-operated valve V^2 are connected by branch pipes 90 and 91 to the outer ends of the passages 77 and 78 respectively in the differential valve V.

The electrical control devices comprise limit switches 100 and 101, an automatic return switch 102, and manually operated switches 103, 104, 105 and 106 designated "Run," "Cut," "Return" and "Stop" respectively.

The electrical control devices also include relay switches R and R', operated by solenoids S and S' and each controlling four circuits which are simultaneously opened or closed. I also provide a double pole switch 108 adapted to be closed by a solenoid S^3 and controlling the solenoid 56 previously described. The operating current for the electrical control devices is supplied through the line wires L and L'.

In Fig. 1 I have shown all parts of the machine in neutral or inoperative position and with the automatic return switch 102 open, so that automatic return will not take place. It will be noted that the stop switch 106 is normally closed, while the cut and return switches 104 and 105 are normally open, as are also the relay switches R and R' and the pump by-pass control switch 108.

In order to start the machine on the cutting stroke, the operator first closes the run switch 103, which switch will remain closed until manually opened. The cut switch 104 is then closed by the operator. This connects the line wire L through the stop switch 106, the cut switch 104, a wire 110, the lower contacts of the limit switch 101, a wire 111, a lower switch element 112 of the relay switch R', a wire 113, the solenoid S and wires 114 and 115 to the line wire L'. The solenoid S is thus energized and the relay switch R is thus raised and closes the four upper circuits controlled thereby, as shown in Fig. 2.

The two upper switch elements 120 and 121 of the relay switch R connect the solenoid 44 of the pump control valve V^2 to the line wires L and L', thus energizing the solenoid 44 and shifting the valve V^2 to the position shown in Fig. 2. The auxiliary pump P' then supplies oil under pressure through the pipes 51 and 91 to move the piston 38 to the right, setting the pump P to deliver oil through the pipe 18 to the left-hand end of the main cylinder 10 and to thus move the piston 11 to the right for a broaching or cut stroke.

As soon as the solenoid S has operated the relay switch R, the cut switch 104 may be released, as a parallel holding circuit is then closed through the run switch 103, wires 123 and 124, a switch element 125 of the relay switch R, and a wire 126. The holding circuit thus closed forms a shunt around the cut switch 104 and will hold the solenoid S energized after the cut switch is opened.

The remaining switch element 127 of the relay switch R closes a circuit from the line wire L through a wire 128, the switch 127 and a wire 129 to the solenoid S_3 and line wire L'. The double pole switch 108 is thus closed, energizing the solenoid 56 and moving the valve V^3 to close the by-pass 55.

The broaching machine will now continue to operate on its broaching or cut stroke until the broaching head 14 engages the double limit switch 101, opening the lower contacts which connect the wires 110 and 111, and closing the upper contacts which are positioned in an automatic return circuit to be described.

Assuming that the automatic return switch 102 is open as shown in the drawings, the opening of the lower contacts of the limit switch 101 will break the circuit through the solenoid S, allowing the relay switch R to move downward and open the four operating circuits controlled by the switch elements 120, 121, 125 and 127. Opening of the switch elements 120 and 121 deenergizes the solenoid 44, whereupon the pump control valve V^2 returns to neutral position and the piston 38 returns to mid position, setting the pump P at neutral or no-discharge.

When the switch 127 is opened, the solenoid S^3 is deenergized, opening the switch 108 which deenergizes the solenoid 56 and allows the by-pass valve V^3 to open the by-pass 55. The parts are then in their original position, except that the limit switch 100 is now closed and the lower contacts of the limit switch 101 are now open.

In order to start the return stroke, the operator presses the return switch 105, which initiates a series of similar operations to effect a return stroke. Closing of the switch 105 completes a circuit from the line wire L through the stop switch 106, a wire 130, limit switch 100, a wire 131, the lower switch element 132 of the relay switch R, a wire 133, the solenoid S' and wires 134 and 135 to the line wire L'.

The solenoid S' is thus energized, closing the four upper circuits controlled thereby.

The upper switch elements 140 and 141 connect the line wires L and L' through wires 142 and 143 to energize the solenoid 45 and set the valve V^2 in the return position shown in Fig. 3. Oil under pressure is then supplied from the auxiliary pump P' through the pipes 51 and 42 to the right-hand end of the pump control cylinder 40, causing the piston 38 to move to the left and thereby setting the pump P to discharge through the pipe 19 to the chamber 21 connected to the right-hand end of the main cylinder 10.

Oil under pressure is thus delivered direct from the pump P through the tubular rod 16 to the piston rod passage 15. Because of the small capacity of these parts, the piston 11 and broaching head 10 are returned at high speed to their idle or left-hand positions.

As soon as the solenoid S' has been energized, the return switch 105 may be opened, but a holding circuit will remain closed through the run

switch 103 wires 123 and 136, the switch element 137 of the relay switch R', and a wire 138, which collectively constitute a shunt circuit around the return switch 135 and maintain the solenoid S' energized.

As the broaching head 14 approaches its left-hand limit of travel, it will engage and open the limit switch 100, thus breaking the circuit through the solenoid S' and allowing the relay switch R' to open. This in turn breaks the circuit through the solenoid 45 of the valve V^2, which then returns to neutral as shown in Fig. 1, whereupon the pump P is also returned to neutral or no-discharge position. Opening of the switch R' also breaks the circuit of the solenoid 56 and allows the valve V^3 to open the by-pass 55, thus restoring all parts to the position shown in Fig. 1.

If it is desired to provide an automatic return stroke immediately following the working stroke, rather than stopping the machine with the broaching head 14 in right-hand position, the automatic return switch 102 (Fig. 2) will be closed.

As the broaching head 14 then approaches its right-hand limit of travel, it will open the lower contacts of the switch 101 as previously described, releasing the solenoid S, but at the same time by closing the upper contacts of the switch 101 it will complete a parallel or shunt circuit through a wire 150, the switch 102, a wire 151, the switch 101 and a wire 153 around the return switch 105. This will have the same effect as closing the return switch 105, and will automatically initiate a return stroke, instead of stopping the machine with the head 14 in right-hand position.

This method of operation is sometimes desirable where the work is of such a nature that it can be allowed to drop out of the broaching fixture as soon as the broach is drawn therethrough and before the return stroke commences. No such automatic reversal is provided at the end of the return stroke; as it is always necessary for a broaching machine to stop at this point, so that the broach may be detached for insertion through a new piece of work.

If it is desired to have the machine entirely under manual control as to starting and stopping in either direction, the run switch 103 may be opened, in which event the holding circuits are disabled and the machine will run only so long as either the cut switch 104 or the return switch 105 is held closed. This arrangement is convenient for "jogging" the broaching head in one direction or the other when setting up the machine.

The stop switch 106 is not used in the ordinary operation above described but is in the nature of an emergency switch, which may be manually opened at any time and which will stop the machine at any point, regardless of whether the run switch 103 is open or closed and regardless of the direction of movement of the broaching head.

It will be understood that the limit switches 100 and 101 are adjustable lengthwise of the machine, so that the machine may be operated with any desired length and locus of stroke.

Suitable stops may be provided to determine the operative position and discharge rate of the pump P for both cut and return strokes. Such devices are indicated diagrammatically in Fig. 1 as adjustable stop screws 160 and 161, engaged by a lug 162 associated with the rack bar 36. By adjusting the screws 160 and 161, the rate of discharge of the pump P may be independently adjusted for the cut and return strokes.

The operation of the differential valve V in the tank T is as follows:

The valve piston 70 is freely slidable in the valve cylinder 30, as each cylinder head is vented to prevent trapping of air or oil therein. The piston 70 will remain in any position in which it is set, until positively moved therefrom. When the machine is at rest, as shown in Fig. 1, the vent valve 81 will open, permitting any air trapped in either end of the main cylinder 10 to escape by direct upward flow to the atmosphere. This is an important advantage, as it clears the cylinder of air after each operation thereof.

The pipe 90 connected to the left-hand end of the differential valve is also connected to the pipe 41 leading to the left-hand end of the pump control cylinder 40, and is thus under pressure when the machine is set for a broaching or cut stroke. At the same time, the pipe 91 is open to exhaust through the pipe 42, valve V^2 and return or exhaust pipe 52.

The valve piston 70 then moves to the right-hand position shown in Fig. 2, closing the connection 26 to the left-hand end of the cylinder 10 which is under pressure, and connecting the passage 25 through the pipe 85 and back pressure valve 86 to the tank T which is at atmospheric pressure. As soon as pressure is developed in the differential valve cylinder 30, the vent valve 81 will automatically close.

I thus provide for escape of surplus oil from the right-hand end of the cylinder 10 and also arrange that this oil will escape only at a predetermined but reduced pressure, thus maintaining the desired back pressure in the right-hand portion of the main cylinder 10.

When the pump P is set for the return stroke, the pressures in the pipes 90 and 91 are reversed as indicated in Fig. 3, and the valve piston 70 is shifted to the left. The passage 26 is then connected through the annular space 73 to the passage 25. As only a relatively small amount of oil passes through the pump to the tubular rod 16, the surplus oil in the left-hand end of the cylinder flows through the passages 26 and 25 to the right-hand end of the cylinder 10. On account of the small size of the fixed rod 16, as compared to the piston rod 12, the oil thus bypassed from the left-hand end of the cylinder is not sufficient to fill the right-hand end of the cylinder and such additional oil as is needed will flow from the tank T through the vent valve 81 which is now open.

The differential valve thus performs three important functions. In the first place, it vents the main cylinder and prevents the trapping of air therein. In the second place, it provides a desired back pressure against the piston 11 during the working stroke, and in the third place it provides the surplus oil required to fill the right-hand end of the cylinder 10 during the return stroke.

Particular attention is called to the fact that the relay switches R and R' are both normally open and that they remain closed only so long as their respective solenoids S and S' are energized. Accordingly, any failure of current in the line wires L and L' will immediately cause these relay switches to open and the machine to stop in whatever position it may chance to occupy.

Also, any failure of current in the circuits controlling the solenoid valve V^2 will cause the valve

to return to neutral or inoperative position, whereupon the pump P will be immediately placed in neutral or no-discharge condition. Similarly, failure of current in the circuit controlling the solenoid 56 will allow the valve V^3 to open the by-pass 55.

All parts of the apparatus are thus so designed that they immediately set the machine in inoperative position as soon as any failure occurs.

Having thus described my invention and the advantages thereof, I do not wish to be limited to the details herein disclosed, otherwise than as set forth in the claims, but what I claim is:

1. In a horizontal hydraulic broaching machine having a main cylinder and piston, a broaching head actuated thereby and a normally-neutral, reversible-discharge pump for said cylinder, that improvement which comprises a hydraulic by-pass in parallel with said cylinder, a normally-open valve in said by-pass, a solenoid to close said valve, and two electrical control circuits selectively closable to effect setting of said pump for cut and return strokes respectively, said solenoid being energized to close said by-pass valve by the closing of either of said control circuits.

2. In a horizontal hydraulic broaching machine having a main cylinder and piston, a broaching head actuated thereby and a normally-neutral, reversible discharge pump for said cylinder, that improvement which comprises a hydraulic by-pass in parallel with said cylinder, a normally-open valve in said by-pass, a solenoid to close said valve, two electrical control circuits selectively closable to effect setting of said pump for cut and return strokes respectively, and holding means to maintain the selected circuit closed until the resultant stroke is completed, said solenoid being energized to close said by-pass valve by the closing of either of said control circuits.

3. In a horizontal hydraulic broaching machine having a main cylinder and piston, a broaching head actuated thereby and a continuously operating reversible-discharge pump for said cylinder having a normal neutral no-discharge position, that improvement which comprises hydraulic means to shift said pump from neutral to discharge in either of two selective positions, spring means to return said pump to neutral, two electrical control circuits each closable manually to render said hydraulic means operative to overcome said spring means and to shift said pump in a selected direction for a cut or return stroke, and electro-magnetic means to hold said electrical control circuit closed until the resultant stroke is completed, whereupon said spring means returns said pump to neutral.

4. In a horizontal hydraulic broaching machine having a main cylinder and piston and a broaching head, in combination, a normally-neutral, reversible-discharge pump connected to said cylinder, electrically controlled hydraulic means to set and hold said pump for cut or return strokes of said broaching head, means to release said electrically controlled hydraulic means at the end of each cut or return stroke, and a manually closable auxiliary circuit which, when inclosed condition, effects automatic reversal of pump discharge at the end of the cut stroke, whereby the piston and broaching head are immediately and automatically started on a return stroke.

5. In a horizontal hydraulic broaching machine, a main cylinder and piston, a broaching head actuated thereby, a normally-neutral, reversible-discharge pump connected to said cylinder, self-centering hydraulic pump-shifting mechanism, a self-centering valve for said hydraulic mechanism controlling the direction of discharge of said pump to said cylinder, manually controlled electrical means to shift said valve in a selected direction for cut or return strokes, electrical devices to maintain said valve in shifted position until the end of the stroke, and automatic means to release said valve at the end of the stroke.

6. In a horizontal hydraulic broaching machine, a main cylinder and piston, a broaching head actuated thereby, a normally-neutral, reversible-discharge pump connected to said cylinder, a self-centering valve controlling the direction of discharge of said pump to said cylinder, manually controlled electrical means to shift said valve in a selected direction for cut or return strokes, devices to maintain said valve in shifted position until the end of the stroke, automatic means to release said valve at the end of the stroke, and additional optionally operative automatic means to cause said valve to be shifted immediately for a return stroke at the end of the cut stroke.

7. In a horizontal hydraulic broaching machine having a main cylinder and piston, a broaching head actuated thereby and a normally-neutral, reversible-discharge pump for said cylinder, that improvement which comprises hydraulic means to set said pump to actuate said piston and broaching head for cut and return strokes, two electrical control circuits for said hydraulic means, manual means to close one circuit for a cut stroke, manual means to close the other circuit for a return stroke, a shunt circuit parallel to said latter means, and optionally operative automatic means to close said shunt circuit and effect an immediate return stroke at the end of a cutting stroke.

8. In a horizontal hydraulic broaching machine, a main cylinder and piston, a broaching head actuated thereby, a tank for surplus oil mounted above said cylinder, a differential piston valve and cylinder in said tank, connections from each end of said main cylinder to the valve cylinder, hydraulic means controlling the supply of oil to said main cylinder, and connections from said hydraulic means to said differential valve, said connections being effective to reverse the position of said valve each time the oil supply is shifted from one end to the other of said main cylinder.

9. In a horizontal hydraulic broaching machine, a main cylinder and piston, a broaching head actuated thereby, a tank for surplus oil mounted above said cylinder, a differential piston valve and cylinder in said tank, connections from each end of said main cylinder to the valve cylinder, hydraulic means controlling the supply of oil to said main cylinder, connections from said hydraulic means to said differential valve, said connections being effective to reverse the position of said valve as the oil supply is shifted from one end to the other of said main cylinder, and a normally-open vent valve between said valve cylinder and said tank, which vent valve is automatically closed by pressure above atmospheric in said valve cylinder.

10. In a horizontal hydraulic broaching machine, a main cylinder and piston, a broaching head actuated thereby, a tank for surplus oil mounted above said cylinder, valve means in said

tank effective to transfer oil direct from the working end to the return end of said main cylinder during a return stroke, an automatic device to vent said valve means to atmosphere when neither end of the main cylinder is under pressure, and a back pressure device connected to said valve means and through which device surplus oil from the return side of the cylinder is discharged through said valve means to atmosphere at a predetermined reduced pressure during a working stroke of said broaching machine.

11. In a horizontal hydraulic broaching machine, a main cylinder and piston, a broaching head actuated thereby, a tank for surplus oil mounted above said cylinder, a differential valve submerged in oil in said tank and comprising a cylinder and piston, connections from each end of said main cylinder to the differential valve cylinder, a reversible discharge pump for said main cylinder, said piston being slidable in the differential valve cylinder and having piston rod extensions at its opposite ends, said valve having passages in which said rod extensions are slidable, and means to apply pressure in one or the other of said passages to shift said piston in accordance with the direction of discharge of the pump to the main cylinder.

12. In a horizontal hydraulic broaching machine having a main cylinder and piston, a broaching head actuated thereby and a normally-neutral, reversible-discharge pump for said cylinder, that improvement which comprises hydraulic means to set said pump to actuate said piston and broaching head for cut and return strokes, two electrical control circuits for said hydraulic means, manual means to close one circuit for a cut stroke, manual means to close the other circuit for a return stroke, and a separate electrical holding connection parallel to each manual closing means and effective to hold its associated electrical circuit closed to the end of the stroke after the manual means is opened.

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