Feb. 8, 1955 W. R. GILBERT 2,701,446

ELECTRIC-HYDRAULIC PUSHER MECHANISM FOR HEAT TREATMENT FURNACES WITH SAFETY STOP CONTROL

Filed Jan. 10, 1952 4 Sheets-Sheet 1

FIG. 1

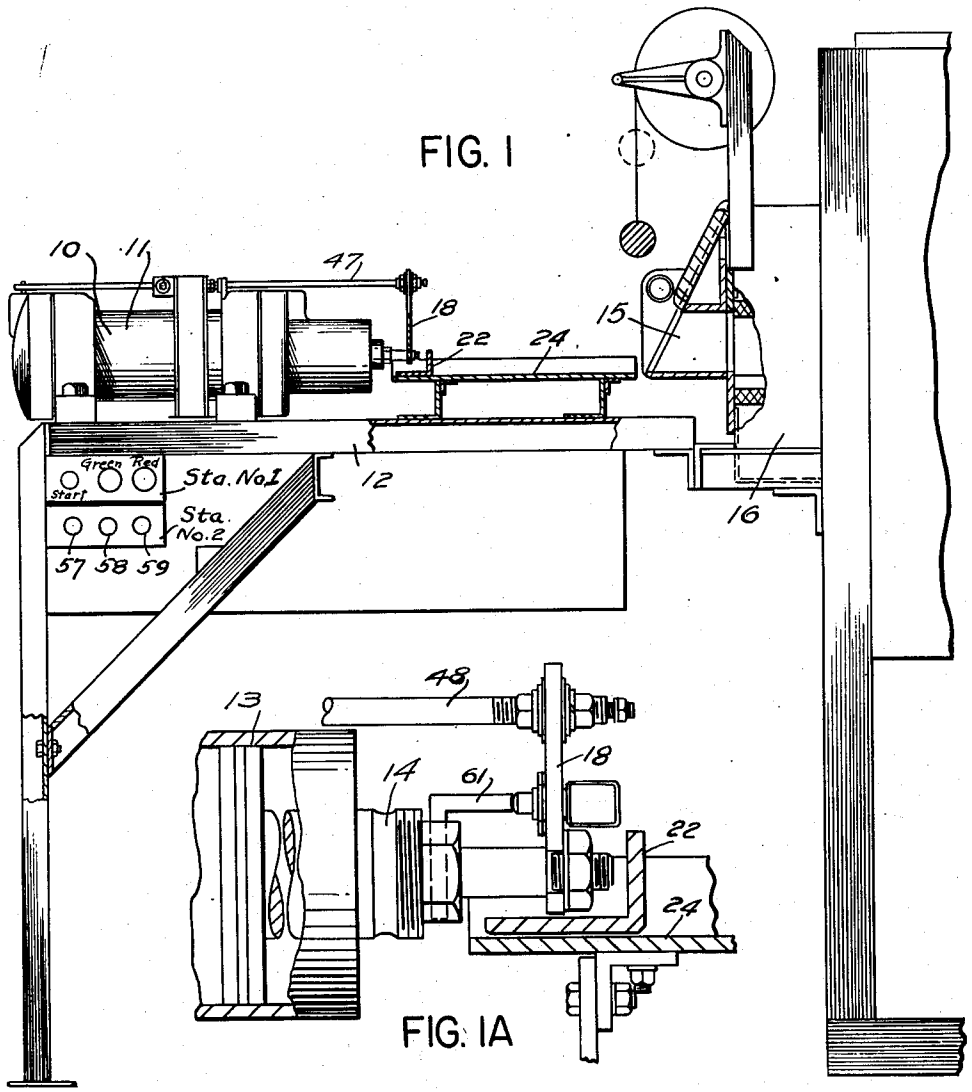






FIG. 1A

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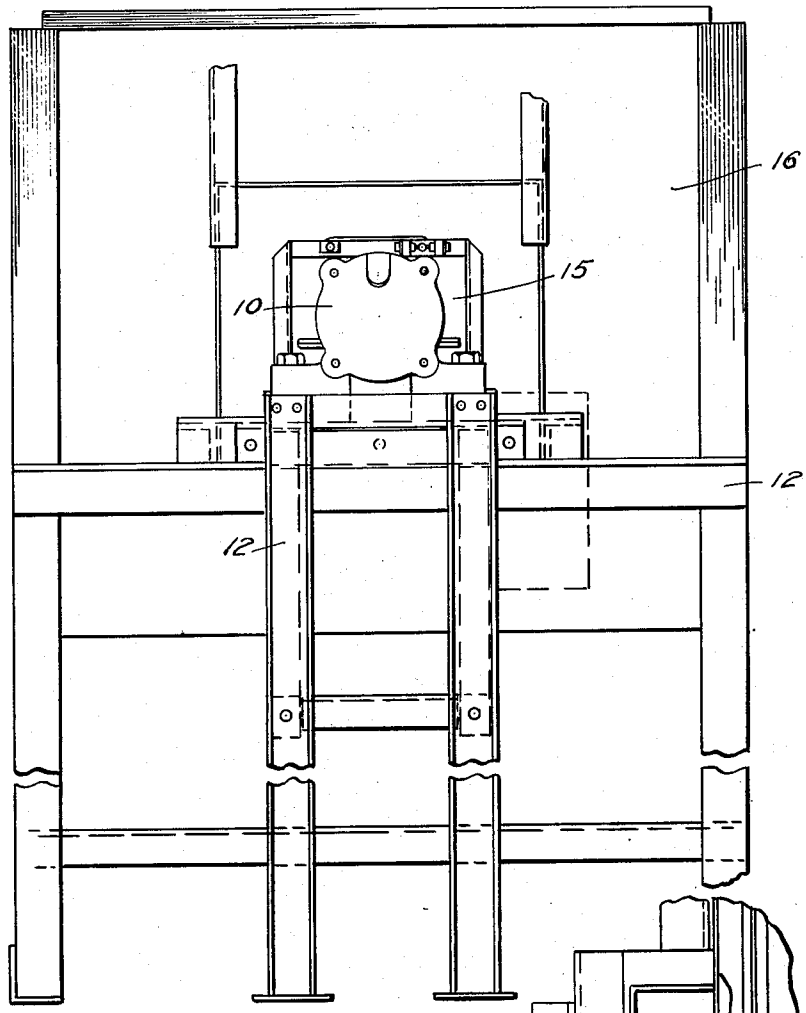



FIG. 2

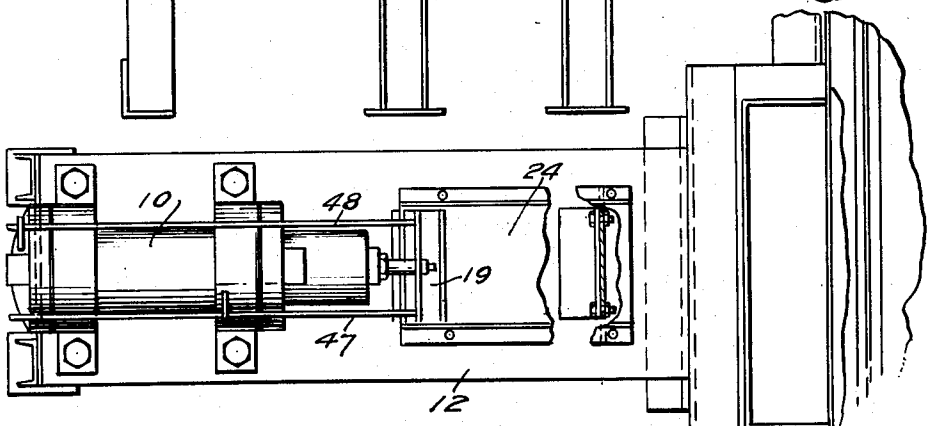



FIG. 3

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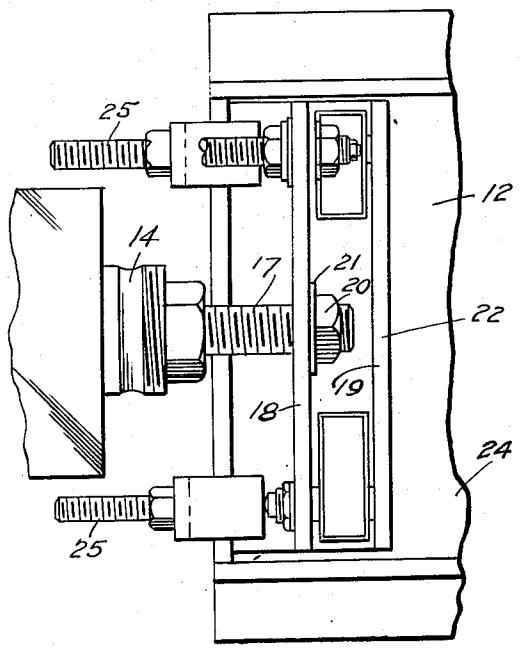



FIG. 4

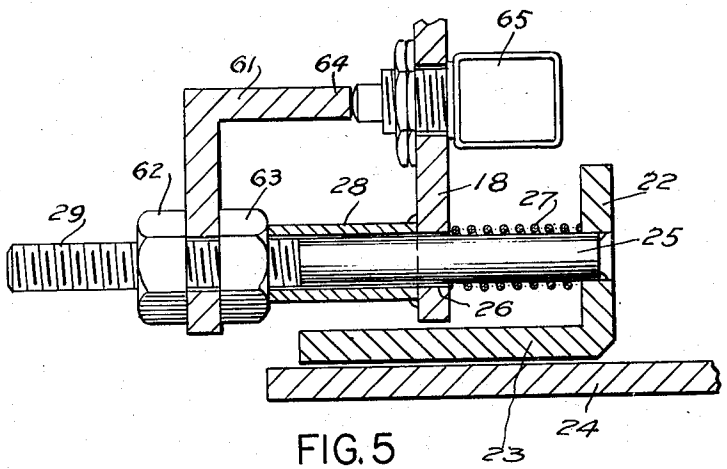



FIG. 5

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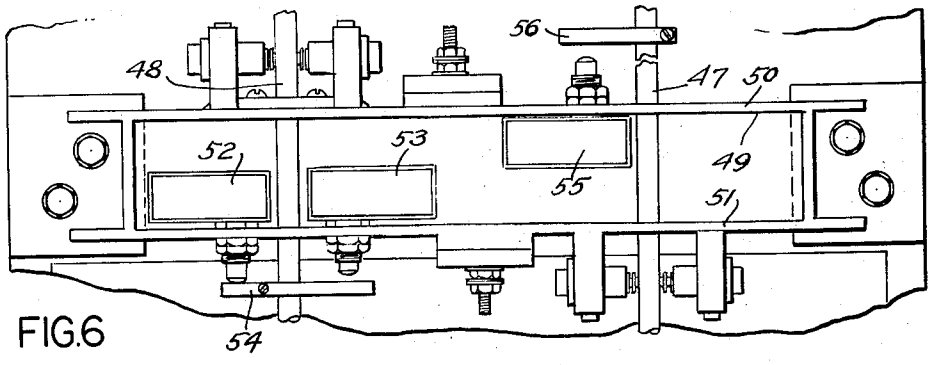



FIG.6

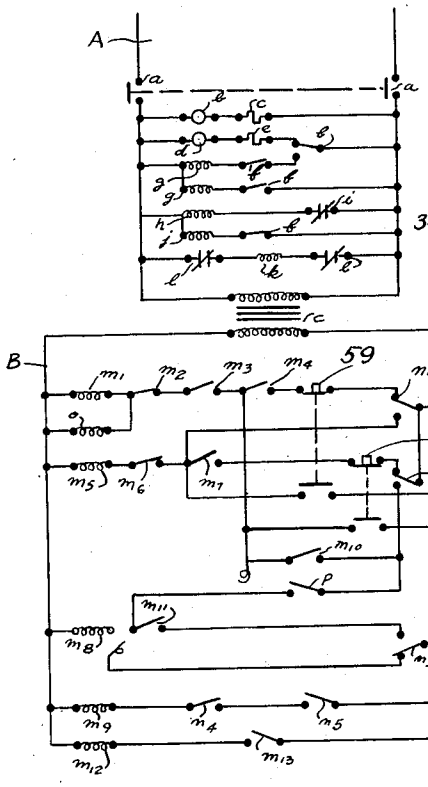



FIG.7

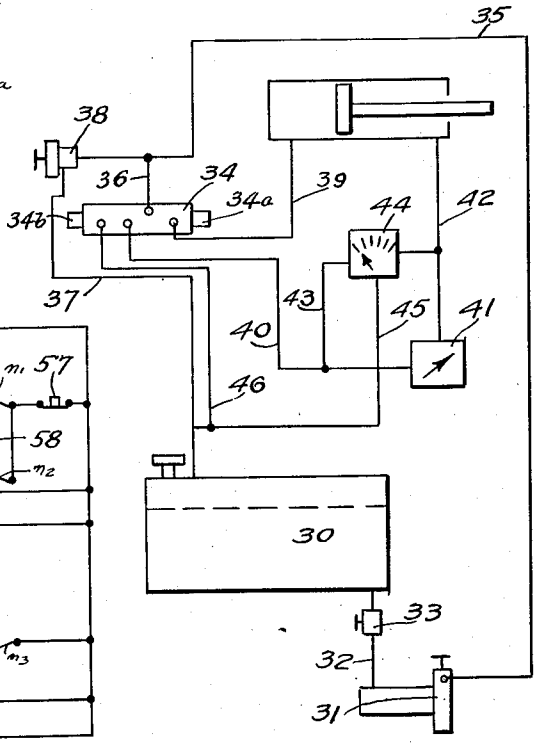



FIG.8

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2,701,446

# ELECTRIC-HYDRAULIC PUSHER MECHANISM FOR HEAT TREATMENT FURNACES WITH SAFETY STOP CONTROL

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3 Claims. (Cl. 60—52)

The present invention relates to the heat treatment art, and has particular reference to a novel construction for a pusher mechanism for a heating furnace.

The principal object of the invention is to provide a hydraulic pusher mechanism which has a slow forward linear motion and a quick return motion.

Another object of the invention is to provide a hydraulic pusher mechanism operated by a hydraulic system having means for controlling fluid flow to provide a slow forward movement.

A further object of the invention is to provide a hydraulic pusher mechanism of the reciprocating type with drive operated electrical controls.

Another object of the invention is to provide a hydraulic pusher mechanism with safety means for automatically stopping forward linear motion when jamming occurs.

An additional object of the invention is to provide a hydraulic pusher mechanism having alternative automatic or manual drive controls.

A further object is to provide a hydraulic pusher mechanism with a hydraulic flow circuit of large capacity and an adjustable back pressure control.

It has been found desirable to provide a heat treatment furnace with a hydraulic pusher mechanism which advances work very slowly into the heating furnace. To this end, I have devised a novel hydraulic system whereby fluid under high pressure is pumped into the head end of a large pusher motor against regulated back pressure to provide a very slow forward linear motion of the pusher piston rod, and then into the rod end to produce a rapid return of the pusher piston rod, the hydraulic flow being controlled by a hydraulic solenoid valve. The solenoid valve is shifted by drive operated electric controls to change the direction of fluid flow to the pusher cylinder so as to selectively provide in and out-strokes of the piston, a safety device being associated with the piston rod whereby any jam or obstruction to forward motion of the pusher mechanism automatically stops the movement. The electrical circuit which controls operation of the solenoid valve includes a relay system to automatically time each cycle of the pusher operation, the system having limit switches and a cycle timer which is manually regulated.

With the above and other objects and advantageous features in view, the invention consists of a novel arrangement of parts more fully disclosed in the detailed description following, in conjunction with the accompanying drawings, and more specifically defined in the claims appended thereto.

In the drawings,

Fig. 1 is a side view of the front of the furnace showing the novel hydraulic pusher mechanism, parts being in section;

Fig. 1*a* is an enlarged detail of the pusher mechanism thrust device and its associated parts;

Fig. 2 is a view, partly broken away, of the front of the furnace;

Fig. 3 is an enlarged view of the hydraulic pusher mechanism and thrust device, the thrust slide being broken away;

Fig. 4 is a top plan view of the thrust device and its associated safety mechanism;

Fig. 5 is a side view of Fig. 4;

Fig. 6 is a view of the electrical timing for controlling reciprocation of the thrust device;



Fig. 7 is a schematic view of the electrical control circuit showing the relay system; and

Fig. 8 is a schematic view of the hydraulic system.

*The hydraulic pusher mechanism*

The pusher mechanism **10** is illustrated in Figs. 1, 1*a*, 2 and 3, and includes a cylinder **11** mounted on an elevated support **12**, and having a reciprocable piston **13** provided with a piston rod **14**, the parts being aligned with the inlet **15** of the heat treatment furnace **16**. The outer end **17** of the piston rod is threaded to receive the back plate **18** of a thrust device **19**, the back plate being locked in place by a lock nut **20** and washer **21**.

The thrust device **19** includes a front plate **22**, see Fig. 5, and a slide base **23** which is slidably positioned over a work receiving table **24** mounted on the support **12**. The front plate **22** is secured to two similar spaced support rods **25** which are slidably received in bearing openings **26** in the back plate **18**, compression springs **27** encircling the rods **25** between the back and front plates to exert an adjustable resilient thrust on the front plate as the back plate is advanced by the forwardly moving piston rod. Each support rod **25** has a guide shell **28**, see Fig. 5, which is secured to the back of the back plate, and the rear end **29** of each rod is threaded, for mounting an adjustable safety device as hereinafter described.

*The hydraulic system*

The hydraulic system for reciprocating the piston and piston rod and the thrust device is diagrammatically illustrated in Fig. 8. It includes a tank **30**, a pump **31** connected to the tank by a conduit **32** having a shut-off valve **33**, and a control valve **34** which is connected to the pump by conduits **35**, **36** and to the tank **30** by a conduit **37** having a relief pressure control valve **38**. The control valve **34** is connected to the head end of the cylinder **11** by a conduit **39**, and to the rod end of the cylinder **11** by a conduit **40**, a check valve **41**, and a conduit **42**.

A by-pass conduit **43** connects the conduits **42** and **40**, and includes an adjustable flow metering valve **44** as shown in Patent No. 2,051,052; a drain conduit **45** connected to the flow metering valve and a return flow conduit **46** connected to the head end portion of the control valve connected to the conduit **37**.

The control valve **34** is shifted by an inflow solenoid **34***a* and an outflow solenoid **34***b*, to alternatively supply pressure fluid to the head end of the cylinder at a pressure in accordance with the setting of the pressure control relief valve **38** while exhausting fluid from the rod end of the cylinder through the flow metering valve **44**, or supply pressure fluid through the check valve **41** to the rod end while exhausting fluid from the head end through the conduit **46**. The flow meter **44** is manually set to establish a desired back pressure in the rod end while the piston is moving forwardly, whereby a very slow movement of the piston and the thrust device can be obtained. A shift of the control valve to neutral position by a break in the solenoid operating circuit cuts off the pressure fluid to hold the piston stationary.

*The electrical circuit for the control valve*

The electrical contacts for controlling reciprocation of the piston are illustrated in Fig. 6, the complete electric circuit being schematically illustrated in Fig. 7 and includes a primary circuit A, a secondary circuit B and a transformer C. The primary circuit A has push button station selector switches *a*, a green pilot light *b*, a resistor *c* for operating the green pilot light *b*, a red pilot light *d*, a resistor *e* for operating the red pilot light *d*, relays *f*, four-way solenoid valves *g*, a timer *h*, a limit switch *i*, a timer solenoid operated clutch *j*, an hydraulic pump motor starter *k*, and overload switches *l*. The secondary circuit B has relays $m_1$ through $m_{13}$, micro switches $n_1$ through $n_5$, a bell *o* and a timer load contact *p*. The back plate **18** of the thrust device **19** is provided with two rearwardly extending parallel rods **47**, **48** which are slidably mounted in a switch support **49** and engage fixed brush contacts, to eliminate wiring connection difficulties, the switch support including a

front panel 50 and a rear panel 51 and being secured to the support 12 intermediate the cylinder ends as shown in Fig. 1.

The rear panel 51 has two travel limit micro-switches 52, 53 secured thereto, the switch 52 being set to be contacted by an arm 54 adjustably locked to the rod 48 at a point slightly before the desired thrust device travel and to provide for future delay in order to allow a timer to reset on instigation of a stroke, and the switch 53 being contacted by the arm 54 at the limit of the stroke. The completion of the circuit by contact of the arm 54 with micro-switch 53 at the outer limit of the return stroke operates a relay to shift the outflow solenoid into a neutral position and start a timer which will initiate another stroke at completion of the electrically timed cycle.

A third micro-switch 55 is secured to the front panel 50, to be contacted by an arm 56 adjustably set on the rod 47 when the piston rod and the thrust device reach the desired stroke limit. The completion of the circuit by contact of the arm 56 with the micro-switch 55 operates the relay to shift the inflow solenoid and thus initiate the return stroke.

In addition, the electric circuit may be manually operated by a push button 57 to stop the stroke movement at any point, and other push buttons 58, and 59 are provided to reverse, and begin forward movement as desired. Referring to the schematic illustration of the drive control circuit, as shown in Fig. 7, the layout comprising equipment of conventional type, the operation is as follows: Before the power is turned on, the drive is in the extreme out-stroke position, the out-stroke limit switches $n_2$ and $n_3$ are in operated position (opposite from normal position shown), and the head safety switches $n_4$ and $n_5$ are in operative position. When power is turned on by closing selector switch *a*, the green pilot light *b* lights, the timer motor *h* runs, the timer clutch solenoid *j* is energized, engaging the clutch and starting the cycle, the motor starter operating coil *k* is energized, the transformer C is energized, pushing head thrust overload relay $f_4$ is energized, closing contacts $m_3$ in in-stroke relay *f*, circuit.

When timer *h* times out, the timer load contacts *p* close completing a circuit through 57, $n_2$ and *p* to *ms*.

*The thrust device safety control*

The thrust device safety control is illustrated in Fig. 5. The threaded rear ends 29 of each thrust device support rod 25 adjustably support micro-switch contact angles 61 which are locked in position by lock nuts 62, 63. The angles 61 are set so that spring pressure of the compression springs 27 press the front thrust plate forwardly to contact the forwardly projecting portions 64 of the angles 61 with micro-switches 65 mounted on the back plate 18; when an excessive thrust pressure develops on the front thrust plate, the support rods are thrust back to break the micro-switch contact, whereupon the circuit is broken and the control valve shifts to neutral position to stop the forward movement and remain stopped until manually started.

The operation of the hydraulic pusher mechanism is now clear. The selector switch located on push button station No. 1 is closed to start automatic drive operation. The green light signals that the drive is in operation.

The motor driven hydraulic pump forces fluid from the fluid supply tank through the piping system under an operating pressure, preferably set at 75 lbs. per sq. in., to the hydraulic solenoid valve which has been energized and shifted to permit fluid flow to the pusher cylinder for the in-stroke movement of the piston and its piston rod. Upon completion of the in-stroke movement, the in-stroke limit switch is actuated and the solenoid valve is shifted. The fluid now flows through the solenoid valve directly to the rod end of the pusher cylinder for the out-stroke movement, which is stopped at completion by operation of the second limit switch, thus completing the hydraulic cycle and initiating a new cycle as described above, upon completion of the electrically timed cycle.

Stop push button station No. 1 may be manually operated at any time to stop the stroke and hold the pusher rod at rest. The push buttons at station No. 2 are for emergency "Stop," "Reverse," and "Forward." The "Stop" button will stop the stroke and the stroke may be restarted in either direction by operation of the respective "Forward" or "Reverse" button. The "Forward" or "Reverse" buttons may be operated at any time while a stroke is in progress to change its direction, without first stopping the stroke by an operation of the "Stop" button.

The thrust overload device which is part of the pushing mechanism at the end of the hydraulic piston rod, is arranged so that the pushing thrust is delivered to the work trays through the intermediate compression springs, the springs being adjusted to equalize the thrust and to provide a total thrust not exceeding one and one-half times the thrust required to move the load. The open limit switches are mounted on the back thrust plate so that the spring pressure normally holds their contacts closed; when the thrust pressure exceeds that for which the thrust adjustment is made, one or both switches will open to stop the drive, which remains stopped until the overload or jam is relieved and resumption of the movement is started manually. The safety device is necessary because a thrust of 1500 lbs. or more such as is needed for a typical heat treatment furnace for special steels will result from operation of a pusher mechanism with a six-inch piston, and will damage the furnace and the work should a jam occur, as the normal thrust required to push a full line of six-inch work trays does not exceed 20 lbs. This 1500 lbs. of thrust is the result of the 75 lbs. per sq. in. requirement of the metering valve to obtain a metering at the very slow motion of one-half inch per minute required for the operation. In order to get the minimum volume of flow which is meterable by the metering valve at this slow speed, it is necessary to use the large size cylinder with six-inch piston.

The hydraulic system which reciprocates the piston and piston rod of the hydraulic cylinder is controlled by the regulating valve, which is electrically shifted to make the necessary fluid line connections for the in and out strokes of the pusher piston. The control valve comprises an in-stroke solenoid and an out-stroke solenoid; when neither solenoid is energized, the control valve is spring centered, all flow ports are closed, and there is no motion of the pusher pump.

The motor driven hydraulic pump circulates fluid through the pressure relief valve and the fluid supply tank through flow conduits 35 and 32, as shown in Fig. 8. When the in-stroke solenoid is energized, the control valve shifts to connect the pump to the head end of the cylinder through conduit lines 35, 36 and 39, and to connect the rod end of the cylinder to the tank through conduit line 42, flow metering valve 44 and line 40. The flow of fluid is from the tank to the pump, to the control valve and pressure relief valve through lines 32 and 35. The relief valve will not open until the fluid pressure in line 35 reaches the pressure for which the relief valve is set, and thereafter passes excess fluid back to the tank through line 37 while maintaining the set pressure in line 35, the relief valve being preferably set to open at 75 lbs. per sq. in. The flow of fluid from the tank to the pump, to the control valve and to the head end of the hydraulic cylinder through line 39 maintains a fluid pressure on the head end corresponding to the relief valve setting, thus fluid pressure being transmitted through the piston to the rod end of the cylinder, and through line 42 to the metering valve, the check valve being closed, the metering valve being adjusted to permit a regulated escape of fluid through line 43, through the control valve and line 46 back to the tank, at a rate that provides a back pressure which results in the desired slow forward motion of the piston.

When the out-stroke solenoid is energized, the control valve shifts to connect the pump to the rod end of the cylinder through lines 35, 40 and 42, see Fig. 8, and the head end of the cylinder to the tank through lines 39 and 46. At this stage of the operation there is no back pressure restricting the movement of the piston, and the relief valve is inoperative as the pressure in line 35 builds up only to that required to move the piston and the fluid through the system. The flow of pressure fluid is from the tank through the pump, through the control valve, through the check valve, and to the rod end of the cylinder, the fluid being forced from the head end of the cylinder through the control valve to the tank through lines 39 and 46. There is

thus a rapid return movement of the piston, piston rod and thrust head.

It is clear that the novel hydraulic pusher mechanism described provides a very slow advancement of work into and through the furnace to comply with prescribed heating requirements. Moreover, the novel construction is time saving due to rapid return motion of the thrust head to permit feeding of additional work, which advances the preceding work through the furnace, thus keeping a steady flow of work through the heating furnace at the prescribed rate of feed necessary to accomplish the heat treatment operation.

Although I have described a specific constructional embodiment of my invention, it is clear that changes in the size, shape and arrangement of the parts may be made to suit different requirements, without departing from the spirit and the scope of the invention as defined in the appended claims.

I claim:

1. A hydraulic pusher mechanism for a heating furnace, comprising a pusher cylinder having a piston and including travel limit micro-switches, said piston having a piston rod, said piston rod having a back plate secured to its forward end, a micro-switch device mounted on said back plate, a pusher plate positioned forward of said back plate, means securing said back plate to said pusher plate including spring means urging said plates away from each other, contact elements on said securing means normally in contact with the back plate micro-switch device when the forward pusher plate is in its maximum spaced position away from the back plate and out of contact with the said micro-switch device when the forward pusher plate compresses the spring means in response to excessive pressure on the pusher plate, a hydraulic system including a fluid tank, a conduit circuit leading from said tank to the ends of the cylinder, a pump in said circuit whereby liquid is forced through the circuit, a pressure control valve, intermediate the pump and the fluid tank, whereby pressure flow through the control valve is maintained, a flow metering valve intermediate the exhaust end of the pusher cylinder and the fluid tank, whereby the rate of flow from the exhaust end to the tank is controlled, a check valve intermediate the exhaust end of the pusher cylinder and the fluid tank, whereby the fluid flow is forced through the metering valve, and an electrical circuit, said conduit circuit including a solenoid control valve for selectively controlling flow of liquid to the ends of the cylinder, said electrical circuit connecting the micro-switches on said pusher cylinder to the solenoid control valve for shifting the solenoids to selectively control the supply of liquid through the solenoid valve and the ends of the cylinder and the micro-switch device on said back plate to the solenoid valve for shifting the solenoids to neutral position to stop flow of liquid to the cylinder.

2. A hydraulic pusher mechanism for a heating furnace, comprising a pusher cylinder having a piston and including travel limit micro-switches, said piston having a piston rod, said piston rod having a back plate secured to its forward end, micro-switches and spaced guide sleeves on said back plate, rods slidably received within said guide sleeves, a pusher plate positioned forward of said back plate and secured to the rods, spring means on said rods positioned intermediate said back plate and said forward pusher plate and resiliently urging said plates away from each other, contact elements on said rods normally in contact with the back plate micro-switches when the forward pusher plate is in its maximum spaced position away from the back plate and out of contact with the said micro-switches when the forward pusher plate compresses the spring means in response to excessive pressure on the pusher plate, a hydraulic system including a fluid tank, a conduit circuit leading from said tank to the ends of the cylinder, a pump in said circuit whereby liquid is forced through the circuit, a pressure control valve, intermediate the pump and the fluid tank, whereby pressure flow through the control vale is maintained, a flow metering valve intermediate the exhaust end of the pusher cylinder and the fluid tank, whereby the rate of flow from the exhaust end to the tank is controlled, a check valve intermediate the exhaust end of the pusher cylinder and the fluid tank, whereby the fluid flow is forced through the metering valve, and an electrical circuit, said conduit circuit including a solenoid control valve for selectively controlling flow of liquid to the ends of the cylinder, said electrical circuit connecting the micro-switches on said pusher cylinder to the solenoid control valve for shifting the solenoids to selectively control the supply of liquid through the solenoid valve and the ends of the cylinder and the micro-switches on said back plate to the solenoid valve for shifting the solenoids to neutral position to stop flow of liquid to the cylinder.

3. An overload device for a hydraulic pusher mechanism consisting of a back plate adapted to be secured to the forward end of a piston rod and having a micro-switch device thereon, a pusher plate positioned forward of said back plate, means securing said pusher plate to said back plate and having a spring element urging said plates away from each other, said spring element being compressed when excessive pressure is exerted on the pusher plate, a contact on said securing means normally in contact with the micro-switch device when the pusher plate is in its maximum spaced position away from the back plate and out of contact with the micro-switch device when the pusher plate moves towards the back plate and compresses the spring element.

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