Aug. 1, 1950 W. E. MOORE 2,517,528

FURNACE ELECTRODE REGULATOR

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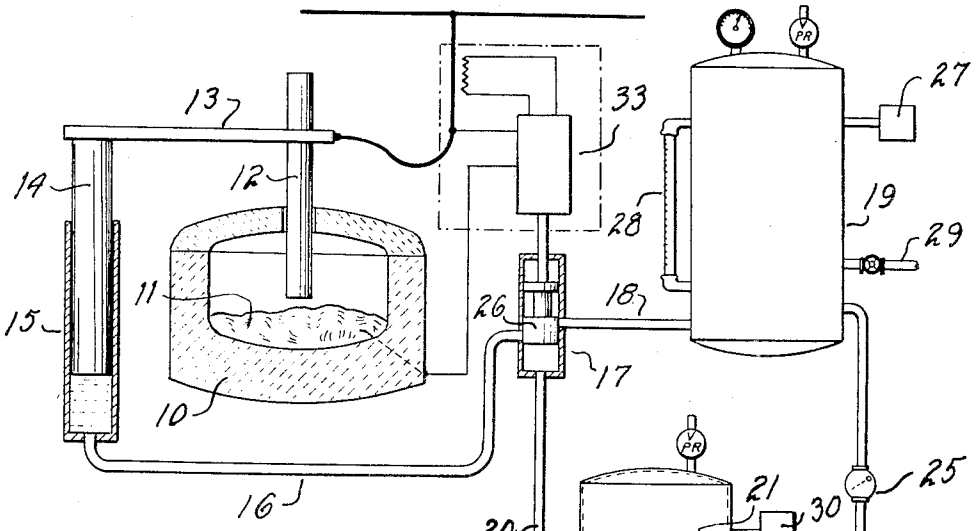


Fig. 1

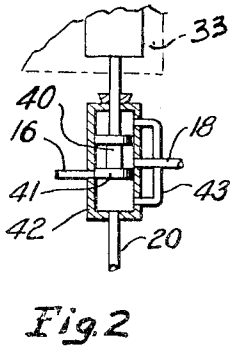


Fig. 2

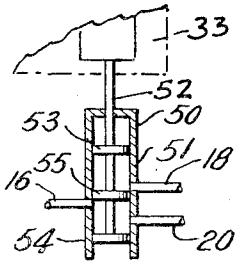


Fig. 3

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FURNACE ELECTRODE REGULATOR

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5 Claims. (Cl. 314—61)

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This invention relates to a furnace electrode regulator for electric arc furnaces of the type in which the position of the movable electrodes is automatically adjusted by means of a fluid operated regulator. The regulator is controlled by apparatus which responds to variations in the electric current supply to the furnace.

This application is a continuation of my copending application entitled "Furnace Electrode Regulator," Serial No. 498,317, filed August 12, 1943.

The variations of the electric current are employed through the medium of suitable apparatus to control the power supplied to a fluid operated motor, the operation of which will cause the electrode to which it is connected to move toward or away from the metal charge in the furnace.

In many installations the weight of the electrode and electrode gear is quite considerable and various counterbalancing means have been used to cushion this weight so as to avoid shocks or application of undue weight on the electrode when it meets the furnace charge, and permit prompt movement of the electrode proportional to the change in the current and/or voltage of the electric power supplied to the electrode.

Most of these arrangements have been either complicated, expensive, and difficult to maintain, or they have rendered unsatisfactory service, whereas the system I have invented requires relatively little equipment, affords very satisfactory electrode control, is inexpensive and substantially trouble free.

One object of my invention is to provide an automatic regulator for the electrodes of an electric arc furnace which will ensure that a substantially constant supply of current or power is taken from the furnace electric supply system, and that the electrode is moved gently.

Another object is to provide apparatus which is operated by fluid power, and which is susceptible to close control.

A further object is to provide an electrode control system which is simple in construction, durable, inexpensive to construct and operate, and which affords a high load factor operation.

According to my invention, the electrode is moved by a fluid operated cylinder piston which is automatically controlled in response to variations in the power flowing through the electrode and the weight of the electrode and connected parts is balanced so that no great weight will be transferred to the electrode.

Broadly speaking, my invention comprises a fluid motor operatively connected with a furnace

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electrode and adapted to move it to adjust the length of the arc, means controlled by the electric condition of the electrode current for controlling the operation of the motor, and balancing means for the electrode.

In the accompanying drawings in which I have shown for purposes of illustration only the presently preferred embodiment of my invention,

Figure 1 is a diagrammatic view of one embodiment of my invention;

Figure 2 is a schematic view of a type of control valve suitable for use in my invention; and

Figure 3 is a schematic view of still another type of control valve suitable for use in my invention.

The drawing, Figure 1, shows an electric furnace 10 containing a usual charge 11 of metal, and an electrode 12 connected to an electrode arm 13. The arm is insulated from and supported by a plunger or ram 14 which is slidably received in a fluid operated power cylinder 15. The piston and cylinder arrangement is commonly referred to as a hydraulic servo-motor.

The cylinder 15 is connected at its lower end by a pipe 16 to a control valve 17. The control valve is connected by means of a pipe 18 to the lower end of an air cushion hydraulic tank 19, sometimes referred to as the pressure tank, and by means of the pipe 20 to the lower end of another air cushion fluid tank 21, sometimes referred to as the equalizing or balancing tank. The lower end of tank 21 is connected to the tank 19 by a pipe or conduit 22 which is provided with a pump 23 driven by an electric motor 24. A check valve 25 is located in the pipe 22 between the pump 23 and the tank 19.

The control valve 17 includes a slide valve or piston 26 which is slidably movable to regulate the supply of liquid medium from tank 19 and pipe 18 to pipe 16 and cylinder 15 or the liquid exhaust from cylinder 15 and pipe 16 to pipe 20 and I prefer to so arrange the openings from the regulator to the pipes 16 and 18 so that the valve 26 may close both openings at the same time.

A suitable source of air under pressure, for example, an air compressor 27, supplies air at a convenient predetermined pressure above the liquid in pressure tank 19, so that the tank is only partially filled with liquid, such as a hydrocarbon oil, over which is an air cushion. The compressor 27 keeps the air pressure at a desired level so that the liquid is under a pressure sufficient to overcome the weight, friction and inertia of the plunger or ram 14 and the supported equipment. The

tank 19 has a sight gauge 28, and a valve controlled liquid supply pipe 29 connected to it.

A suitable source of air under pressure, for example, an air compressor 30, supplies air at a convenient pressure above the liquid, such as a hydrocarbon oil, in tank 21. A sight gauge 31 and a valve controlled liquid supply pipe 32 is connected to the tank as shown. The pressure in tank 21 is sufficient to substantially counterbalance the weight of the plunger 14 and the weight of the equipment supported thereby so that when the piston 26 is positioned to allow the flow of liquid from pipe 16 through the valve 17 and pipe 20 to be established, the liquid will flow from cylinder 15 to tank 21 and the plunger 14 and its connected electrode 12 will move slowly and gently downwardly.

The position of the piston 26 is controlled by an automatic regulator 33 which is actuated in accordance with the electric power supply to the electrode 12 in a manner well-known in the art. Typical of such regulators are CR4913 Amplidyne-type Electrode Regulator for Arc Furnace Control (General Electric Co.), and the Automatic Current Regulator for Electric Arc Furnaces (Westinghouse Electric and Manufacturing Company). The construction and operation of such devices are well-known. Suffice it to say that if the electrode 12 approaches too closely to the charge 11, the power supply to the furnace will be unduly high, and the regulator will cause the piston 26 of valve 17 to be moved downwardly so as to permit liquid to pass from the pressure tank 19, pipe 18, valve 17 and pipe 16 to the cylinder 15 and cause the electrode to be raised, thus lengthening the arc, until the power input is that desired, whereupon the piston 26 will be moved upwardly to shut off the flow from pipe 18. When the electrode is too far away from the metal charge, the current will drop and the regulator 33 will lift the piston 26 so as to allow fluid to pass from the cylinder 15 through the pipe 16, valve 17 and pipe 20 to the equalizing tank 21 until the power input reaches the desired valve, whereupon the piston 26 is lowered so as to cut off the fluid discharge through pipe 16.

When the liquid is being discharged into tank 21, the level of the fluid in the tank will rise and operate the float valve switch or control device 34 and thus start the flow of electric energy to the motor 24 which will operate pump 23 to force the liquid through pipe 22 and check valve 25 to the high pressure tank 19. The flow to tank 19 will continue so long as liquid is moved from the cylinder 15 to the tank 21.

Instead of using air compressors 27 and 30, any other source of air supply may be employed, for example, the ordinary shop air supply, with suitable reducing valves. Suitable air pressures, for example, may be about 200 p. s. i. on tank 19 and about 100 p. s. i. on tank 21 when the pressure in cylinder 15 caused by the pressure of supported parts is about 125 p. s. i.

It is also possible to elevate the tanks 19 and 21 so as not to require air pressure on top of the liquid, but even in this case, the pump 23 will be required to force the liquid from the tank 21 at a lower level to tank 19 at a higher level.

The balancing tank or reservoir 21 is normally maintained at a pressure insufficient to effect positive operation of the servo-motor 15. The pump 23 is used to draw fluid out of the reservoir 21 and return it through tank 19 and valve 17 to the line at a higher pressure.

In Figure 2 I have shown schematically a control valve 40 which may be used in place of the control valve 17 shown in Figure 1. The control valve 40 includes a slide valve or piston 41 which is slidably movable in a cylinder 42 to regulate the flow of liquid from pipe 18 to pipe 16, or the flow of liquid from pipe 16 to pipe 20. The valve 41 is connected to and controlled by the regulator 33. The control valve includes an equalizing pipe 43 for substantially equalizing the pressure between the bottom of the cylinder 42 and the top thereof. The openings of the pipes 16, 18 and 20 to the cylinder 42 are so arranged that the three openings cannot be opened at the same time, nor can openings to pipes 18 and 20 ever be opened together. Thus, fluid may flow from pipe 16 to pipe 18 at one time, or from pipe 16 to pipe 20, or vice versa.

In Figure 3 I have shown schematically still another form of a control valve 50 which may be used in my invention. The valve 50 consists of a cylinder 51 having a centrally disposed piston rod 52 which is connected to and controlled by regulator 33. Rod 52 has two fluid-tight piston heads 53 and 54 spaced apart on the rod 52 and slidable in the cylinder 51. A slide valve 55 is mounted on the rod 52 between the heads 53 and 54 and is likewise fluid-tight with respect to the cylinder walls. The pipes 16 and 18 are received in openings in the cylinder walls and are covered or uncovered by the valve 55, depending upon its position. The pipe 20 is received in an opening in the lower part of the cylinder wall as shown between the lower head 54 and the valve 55. The valve 55 and the openings of the pipes 16, 18 and 20 are so arranged that fluid may flow from pipe 18 to pipe 16, or from pipe 16 to pipe 20, but not from pipe 18 to pipe 20 or vice versa. It will be observed that this valve arrangement is balanced so that it is responsive to comparatively small force exerted on the piston rod 52.

In the accompanying drawings I have illustrated diagrammatically an electrode regulating apparatus as applied to one of the electrodes of a well-known electric arc furnace, it being understood that a similar regulating device may be associated with each of the other furnace electrodes.

While I have described an exemplary embodiment of my invention, it is to be understood that various changes may be made within the scope of the claims.

I claim:

1. In an electrode regulator which includes a liquid pressure operated servo-motor having a piston for raising and lowering the electrode, a pressure tank for supplying liquid under pressure to the servo-motor as will move the piston to raise the electrode and an equalizing tank containing liquid under pressure sufficient to substantially counterbalance the weight on the piston to allow the electrode to lower the piston and cause flow of the liquid from the servo-motor to the equalizing tank; a pump having an inlet and an outlet, a pipe connecting the inlet directly to the liquid in the equalizing tank, a pipe connecting the outlet directly to the pressure tank, and a control device in the equalizing tank responsive to the liquid level in the equalizing tank for rendering said pump operable to pump liquid under the operating pressure existing in the equalizing tank directly from the equalizing tank and into the pressure tank.

2. In an electrode regulator which includes a liquid pressure operated servo-motor having a piston for raising and lowering the electrode, a

pressure tank for supplying liquid under pressure to the servo-motor as will move the piston to raise the electrode and an equalizing tank containing liquid under pressure sufficient to substantially counterbalance the weight on the piston to allow the electrode to lower the piston and cause flow of the liquid from the servo-motor to the equalizing tank; a pipe connecting the tanks, a power operated pump connected in the pipe for withdrawing liquid from the equalizing tank and forcing it at a higher pressure into the pressure tank, and a switch controlled by the level of liquid in the equalizing tank for controlling the supply of power to the pump.

3. For use in combination with an electrode regulator for the electrodes of an electric arc furnace, including a liquid operated servo-motor with a movable piston, for adjusting the length of the furnace arc, a pressure tank containing liquid under a pressure sufficient to move the piston so as to raise the electrodes, an equalizer tank containing liquid under pressure less than the pressure in the pressure tank but sufficient to slightly less than balance the weight on the piston; a pump having an inlet and an outlet, a pipe under the pressure in the equalizing tank connecting the lower part of the equalizing tank to the pump inlet, a pipe connecting the pump outlet to the pressure tank, a motor for driving the pump, and a control switch responsive to a change in the level of the liquid in the equalizing tank for controlling the flow of power to the motor.

4. For use in combination with an electrode regulator for the electrodes of an electric arc furnace, including a liquid operated servo-motor with a movable piston, for adjusting the length of the furnace arc, a pressure tank containing liquid under a pressure sufficient to move the piston so as to raise the electrodes, an equalizer tank containing liquid under pressure less than the pressure in the pressure tank but sufficient

to slightly less than balance the weight on the piston; a motor driven pump having an inlet and an outlet, a pipe connecting the equalizing tank to the pump inlet, a pipe connecting the pump outlet to the pressure tank, a check valve in one of said pipes to prevent flow of liquid from the pressure tank to the equalizing tank, and a switch operable by a change of level in the equalizing tank to control the flow of power to the pump.

5. The combination with a fluid pressure motor for regulating the position of an electric furnace electrode, an elevating tank having fluid therein under a higher pressure sufficient when connected with said motor to elevate the electrode, and an equalizing tank having fluid therein under a lower pressure sufficient when connected with said motor to counterbalance the electrode against movement; of a pump having an intake connected directly with said equalizing tank and subjected to the lower pressure of fluid therein, and an outlet connected directly with said elevating tank and subjected to the higher pressure of fluid therein, said pump being operable to supply fluid to said elevating tank from said equalizing tank against a net head representing the difference of said higher and lower pressures.

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