

May 13, 1952

W. E. MOORE
ELECTRIC ARC FURNACE

2,596,708

Filed May 17, 1947

2 SHEETS—SHEET 1

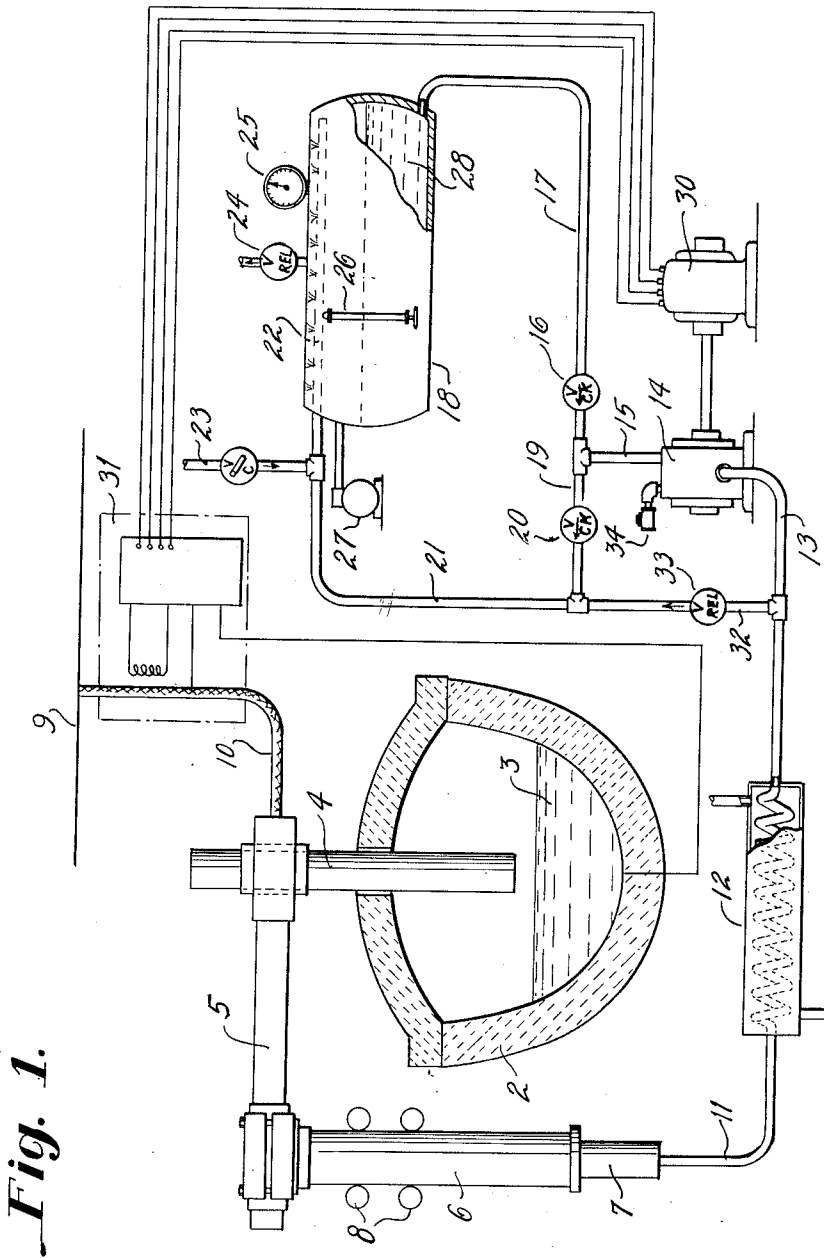


Fig. 1.

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HIS ATTORNEYS

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2 SHEETS—SHEET 2

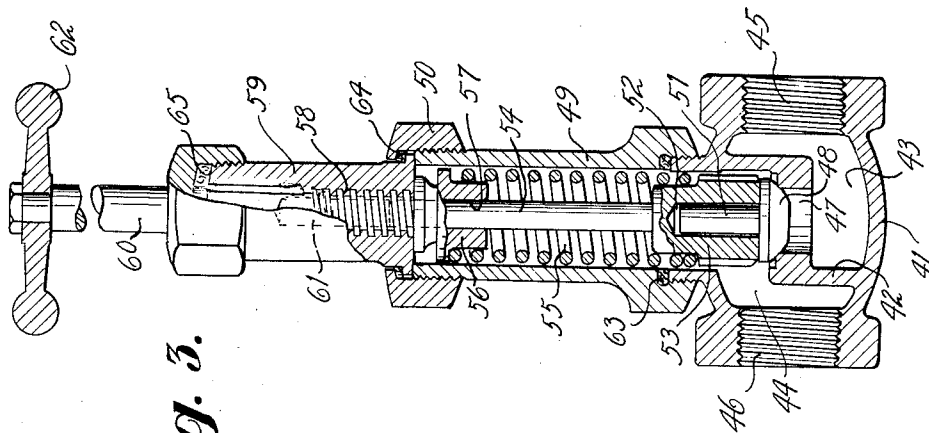


Fig. 3.

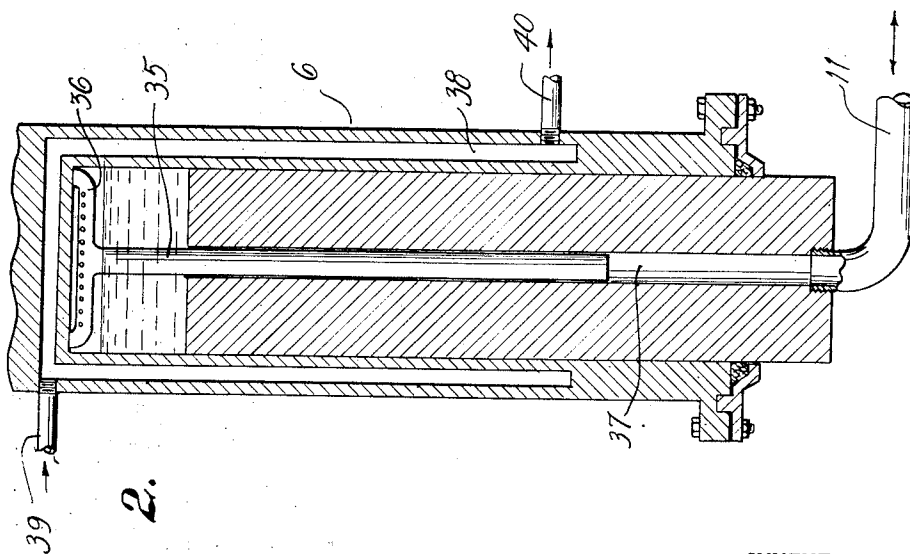


Fig. 2.

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UNITED STATES PATENT OFFICE

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ELECTRIC ARC FURNACE

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4 Claims. (Cl. 314-61)

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This invention relates in general to electric arc furnace and particularly to electrode operating gear for automatically controlling the movements of the electrodes of an electric arc furnace for the purpose of maintaining the positions of the electrodes relative to the charge so that the arc may be maintained at relatively constant length and the furnace operated efficiently.

Variations in the arc or spark gap causes variations in the electric power supply to the furnace, and my invention employs such power variations to control the operation of fluid-actuated mechanism to move the electrode toward or away from the furnace charge so that the arc or gap may be kept as uniform as possible, thus contributing to the satisfactory operation of the furnace.

There is provided a reversible electric motor which is instantly responsive to variations in the arc of the furnace, and which is directly connected to pump mechanism adapted to control the flow of a liquid under pressure from a reservoir to a hydraulic motor which is used to quickly regulate the movement of the electrode arm and associated electrodes. The pump, when reversed, causes a prompt reversal of the liquid flow while the motor is instantly responsive to variations in the electric current supplied to the electrode either in the amperage or voltage or to a combination of them, depending on the current-responsive mechanism which is used to control the motor operation. I prefer to counterbalance the weight of the electrode arm and associated movable structure by the use of a fluid-operated motor connected to a source of liquid preferably under a predetermined pressure. This will enable the position of the electrode to be adjusted by a relatively small application of power applied to the pressure fluid since it is only necessary to exert sufficient pressure to overcome the inertia of the movable parts. The control which I contemplate is of such a nature that when the electrode is positioned so as to provide the determined arc, the pump motor will be inactive. In the operation of systems of this character it is not unusual to find that air becomes entrapped in the hydraulic motor and causes a "jumpy" action of the electrode. I provide means whereby entrapped air is removed by the action of the pump when lowering the electrode.

My invention will be illustrated as applied to one electrode of a well known electric arc furnace, but the arrangement is the same for each electrode whether there be two or more (usually three) employed.

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The invention may be more fully understood by reference to the accompanying drawings in which I have shown for purposes of illustration only certain more or less schematic views of an electric furnace showing the presently preferred embodiment of my invention. In the drawings:

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

Figure 2 is a view chiefly in section, of the fluid motor which I use; and

Figure 3 is a view partly in section of a suitable valve which I may employ.

In the drawings the furnace 2 is of conventional design. A usual charge of metal 3 is shown. A single electrode is illustrated at 4, but there may be any desired number of such electrodes (usually three), but for present purposes it will be sufficient to describe the furnace as having only one electrode. The electrode 4 is made of carbon or graphite, and is supported by and electrically connected to an electrode arm 5, which arm is physically connected to, but insulated from the closed end or head of the hydraulic power cylinder 6 in which there is a cooperating plunger or ram 7. The ram 7 is held stationary relative to the furnace 2 by suitable framework and moves with the furnace. The cylinder is guided in rollers 8 which are secured to the side of the furnace, but which, for clearness of illustration, are only conventionally shown in Fig. 1. Movement of the cylinder 6 relative to the fixed piston 7 will cause the electrode 4 to approach or withdraw from the metal charge 3. The cylinder travels through adjustable rollers by 8 or other guides in a direction parallel to the longitudinal axis of the electrode 4 and ram 7. Electric power from a line 9 is supplied to the electrode through a cable 10.

Connected to the bottom of the ram 7 and to a passage which extends axially therethrough is a supply pipe 11 which passes through a water-cooled heat exchanger 12 and thence through pipe 13 an extension of supply pipe 11 to one side of a reversible metering pump 14, which is of any usual or preferred construction, such as a gear type or eccentric type. The opposite side of the pump 14 is connected to a feed pipe 15, a valve 16, and a feed pipe 17, to a fluid pressure reservoir 18. The pipe 15 has a branch pipe 19 which leads through a valve 20, and a discharge pipe 21 to a spray pipe 22 located close to the inside upper portion of the tank 18. By means of this spray pipe, oil or other liquid may be forced against the upper inside surface of the tank and thus cooled. The make-up liquid sup-

plied to the tank 13 may be furnished by a valve-controlled liquid supply pipe 23. A pressure relief valve 24, a pressure indicating gauge 25, and a fluid level sight indicator 26 is connected to the tank 13 as illustrated. An automatically regulated compressor 27 maintains a desired uniform pressure on the liquid 28 inside the reservoir 18 of such a magnitude that when transmitted through the pump 14, even when it is not being driven, will more or less balance the electrode mounting assembly so that the pump has only to supply the increased pressure needed to overcome the friction of the ram 7. For most operating conditions, I prefer to have the cylinder 6 and associated electrode assembly overbalanced by the fluid pressure so that in case of failure of the pump 14 or its motor or the motor power supply, the electrode assembly would be raised clear of the furnace charge 3 and thus prevent the carbon electrode from dipping into the bath and causing damage by carbonization of the charge and wasting away the electrode.

The reversible pump 14 is driven by a reversible motor 30, the operation of which is controlled by a control unit 31, electromagnetically or electronically operated by variations in the current supplied the electrode as indicated. Controls of this kind are well known in the art and are commercially available through suppliers, such as Westinghouse Electric and Manufacturing Company, General Electric Company, Allis-Chalmers Company, and others. The arrangement in general is such as to cause the pump to force fluid into the hydraulic motor when the furnace arc is too short, and to withdraw fluid when the arc is too long.

To avoid excessive over-pressure from the pump being exerted against the cylinder 6, such as would be caused when the cylinder reaches the top limit of its upward travel while the pump would still be running, I provide a relief pipe 32 connected at one end to the pipe 21 and at the other end to the pipe 13, and at a position between the pump 14 and the cooler 12. A pressure relief valve 33 opening toward pipe 21 is provided in relief pipe 32. Any pressure exerted by the pump 14 in the direction of the hydraulic motor, when the pressure reaches a predetermined value, deemed excessive, would cause the fluid to be by-passed through pipe 32, valve 33, and pipe 21 to tank 13. This condition may prevail when the electrode is raised to the upper limit of its travel.

The pump 14 is provided with a customary spring-adjusted vacuum breaker valve 34 usually mounted on the pump housing. This vacuum breaker valve will open and admit air to the pump and relieve its suction in case the pump should continue to operate after the lower limit of the stroke of the cylinder 6 has been reached. The pump will then fill with air to minimize the suction. Some of this air in turn might be discharged through the pipes 13 and 11 into the cylinder 6. Not infrequently air also will leak into cylinder 6. The presence of air in cylinder 6 where it gathers at the top tends to cause a bouncing or jumping motion of the cylinder and connected gear. Accordingly, it is one of the features of my fluid motor arrangement to provide for the evacuation of air which may accumulate in the top of cylinder 6. This I do by causing the pipe through which fluid passes to and from the cylinder 6 to terminate closely adjacent the top of the cylinder. While I could connect pipe 11 directly to the top of cylinder 6,

I prefer not to expose pipe 11 to the intense heat of the furnace which would injuriously affect the oil. I prefer to provide (see Figure 2) a pipe or supply tube 35 which is attached to the top head of the cylinder 6 by means of a spider casing 36 which is perforated along the top portion. The pipe 35 is slidably received inside a pipe or passage 37 connected to the lower end of the ram 7 and to the pipe by 11. It is evident that liquid will be transmitted directly to and from the top of the cylinder 6 by this telescoping pipe arrangement. The pump 14 on the first return operation of lowering the cylinder 6 must first draw any air that may be present from the top of the cylinder 6 and the liquid level will then rise sufficiently high to minimize the air cushion in the top of the cylinder 6 to the point where there is no objectionable jumping motion. The pumped air will finally pass into the top of the tank 18.

The hydraulic motor is mounted adjacent the furnace wall and is subject to considerable heat when the furnace is in operation. Motor-operating liquid, usually a hydrocarbon oil, when subjected to heat, tends to deteriorate, its fluidity is greatly increased, and there is a tendency to foaming. It is quite difficult to keep a hydraulic system fluid tight when "thin" oil is used. To obviate the undesirable effects of furnace heat on the oil, I provide a water jacket 38 for the cylinder, preferably for a distance generally equivalent to the piston travel. Cooling water may be supplied through a conveniently located inlet 39 and discharged through the outlet 40.

In ordinary operation, oil is delivered to the pump 14 through pipe 17, check valve 16 (opening toward the pump) and is forced through pipe 13, cooler 12, pipe 11, passage 37 and pipe 35 to the top of the cylinder 6 and causes the cylinder and attached electrode gear to rise and lengthen the gap between the electrode 4 and the furnace charge 3. When the cylinder 6 is being lowered, the pump 14 reverses, receives fluid from pipe 35, passage 37, pipe 11, cooler 12 and pipe 13, and discharges it through the check valve 20 (which opens away from the pump), through the pipe 21, spray pipe 22, into the top of tank 18.

Although valves 16 and 20 may be ordinary check valves, I prefer to use what I term a spring-relief-check-stop valve arranged as shown in Figure 3, so that by screwing up or down on the valve handle the valve may be set to operate as: (a) a spring-pressure-relief valve; (b) a check valve; (c) or (when screwed down) as a stop valve. The valve consists of a wall 41 which defines a chamber which is divided by a partition 42 into two compartments 43 and 44. The wall has two openings 45 and 46 leading into the compartments 43 and 44 respectively. The partition 42 has a valve opening 47 which may be closed by the valve plug 48. Upstanding from the wall 41 and threaded to it is a tubular housing or bonnet 49, the upper end of which is closed by a cap 50. The valve plug has a projecting guide portion 51 which is received in an axial opening 52 of a movable valve plug guide 53 which has serrated sides and an upwardly-extending axial stem 54. The valve plug guide 53 is urged downwardly by a coiled spring 55 which at its lower end bears against a shoulder of the guide 53 and at its upper end bears against a spring seat 56 which has an opening 57 through which the plug guide stem 54 extends. Threadedly received at 58 in the inside of a valve stem bonnet 59 is a valve stem 60 which passes through the cap 50

and at its lower end may bear against the upper surface of the spring seat 56. The lower portion of the valve stem 60 has an opening 61 in which the upper end of the plug guide stem 54 may be received. The valve stem is rotated by a valve handle 62, attached to the upper end. Necessary packings to make the joints fluid-tight are arranged at locations 63, 64 and 65.

If it is desired to use the valve as a stop valve, the valve stem 60 is turned so as to compress the spring 55 which will urge the valve plug against the seat of the valve opening. By subjecting the spring to sufficient pressure, the valve plug may be tightly seated and will resist movement by any pressure exerted by the fluid in compartment 43. If it is desired to use the valve as a pressure relief valve, the spring 55 is compressed to the extent that the plug 47 will not rise until a predetermined pressure is attained in the compartment 43. When used as a check valve to allow fluid to flow relatively freely from compartment 43 to compartment 42 but to prevent reverse flow, the spring pressure will be adjusted so as to allow the desired flow but will prevent its reverse flow. It is to be understood that whereas I have described a suitable type of valve for use where valves 16 and 20 are indicated, I may use an ordinary check valve at 16 and a pressure relief valve at 20, the latter valve also serving to prevent reverse flow through it. Also it is to be understood that various valves, drain valves and relief valves, may be placed in the system where desired for maintenance or other purpose.

It is also possible to operate my system without fluid pressure in tank 18, in which case the apparatus will be operated without the counterbalancing pressure normally supplied by the fluid in the tank. In such instance the valve 16 would be set as a check valve to admit fluid toward the pump 14, and valve 20 would be set as a pressure relief valve so that the cylinder and electrode gear would not settle by gravity when the pump 14 is not being operated. The weight of the cylinder and electrode gear would be sustained by means of the fluid pressure trapped in the cylinder and fluid connections by the valve 20. The valve 20 would be set so that only the added pressure which might be exerted by the pump 14 would cause it to open toward the tank 18. When the cylinder is to be lowered, the pump 14 would, in combination with the pressure exerted by the cylinder 6 and associated gear, provide sufficient pressure to open the valve 20 and allow the fluid to flow to the tank 18.

Certain features of the apparatus disclosed in this application are shown in my copending application Serial No. 498,317, filed August 12, 1943, now Patent #2,517,527, issued August 1, 1950, and in my copending application Serial No. 760,031, filed July 10, 1947, now Patent #2,517,528, issued August 1, 1950, to which reference is made for a more detailed showing of the common subject matter.

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

I claim:

1. In apparatus for elevating and lowering an electrode and supporting structure therefor in an electric arc furnace, an hydraulic motor comprising a stationary piston having its axis vertical and a longitudinally and vertically extending bore therein, a cylinder mounted on said piston and having a connection with the electrode support-

ing structure for imparting raising and lowering movements to the electrode, a pipe through which hydraulic liquid may be supplied to and exhausted from said cylinder, means mounting said pipe in said cylinder for movement therewith and with its lower end telescoping in said bore and its upper end terminating adjacent the vertically upper end of said cylinder, and means connected with said bore for controlling the flow of liquid to and from said cylinder through said pipe, the termination of the upper end of said pipe adjacent the upper end of said cylinder being effective to release entrapped air and gas from said cylinder prior to the exhaust of any liquid therefrom to thereby eliminate bouncing movement of the electrode due to such entrapped air and gas.

2. In apparatus for elevating and lowering an electrode and supporting structure therefor in an electric arc furnace, an hydraulic motor comprising a stationary piston having its axis vertical and a longitudinally and vertically extending bore therein, a cylinder mounted on said piston and having a connection with the electrode supporting structure for imparting raising and lowering movements to the electrode, a pipe through which hydraulic liquid may be supplied to and exhausted from said cylinder, means mounting said pipe in said cylinder for movement therewith and with its lower end telescoping in said bore and its upper end terminating adjacent the vertically upper end of said cylinder, means connected with said bore for controlling the flow of liquid to and from said cylinder through said pipe, the termination of the upper end of said pipe adjacent the upper end of said cylinder being effective to release entrapped air and gas from said cylinder prior to the exhaust of any liquid therefrom to thereby eliminate bouncing movement of the electrode due to such entrapped air and gas, and means responsive to the electrical operating conditions of said electrode for operating said control means.

3. In apparatus for elevating and lowering an electrode and supporting structure therefor in an electric furnace, a vertically extending hydraulic motor connected to the electrode and supporting structure for raising and lowering the same and comprising piston and cylinder elements cooperating to define a vertically extending and expansible chamber therebetween, means for supplying and exhausting hydraulic fluid to and from said chamber comprising a tube connected to one of said elements for movement therewith and having its upper end permanently positioned adjacent the upper end of said expansible chamber, the other of said elements having an opening therein in which the lower end of said tube is telescopically receivable, and means for supplying hydraulic fluid to and exhausting it from said tube to control the operation of said motor elements in effecting raising and lowering movements of said electrode, the positioning of the upper end of said tube being effective to remove entrapped air and gas from said chamber before the exhaust of any hydraulic fluid to thereby eliminate bouncing movement of the electrode due to such entrapped air and gas.

4. In apparatus for elevating and lowering an electrode and supporting structure therefor in an electric furnace, a vertically extending hydraulic motor connected to the electrode and supporting structure for raising and lowering the same and comprising piston and cylinder elements cooperating to define a vertically extending and expansible chamber therebetween, a part providing an inlet and exhaust port permanently

positioned adjacent the upper end of said chamber, said part being connected with one of said motor elements for movement therewith, and means operative through said port for supplying hydraulic fluid to and exhausting it from said chamber in effecting raising and lowering movements of said electrode, the positioning of said port adjacent the upper end of said chamber being effective to remove entrapped air and gas from said chamber before the exhaust of any hydraulic fluid to thereby eliminate bouncing movement of the electrode due to such entrapped air and gas.

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