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ELECTRODE CONTROL

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Fig. 1.

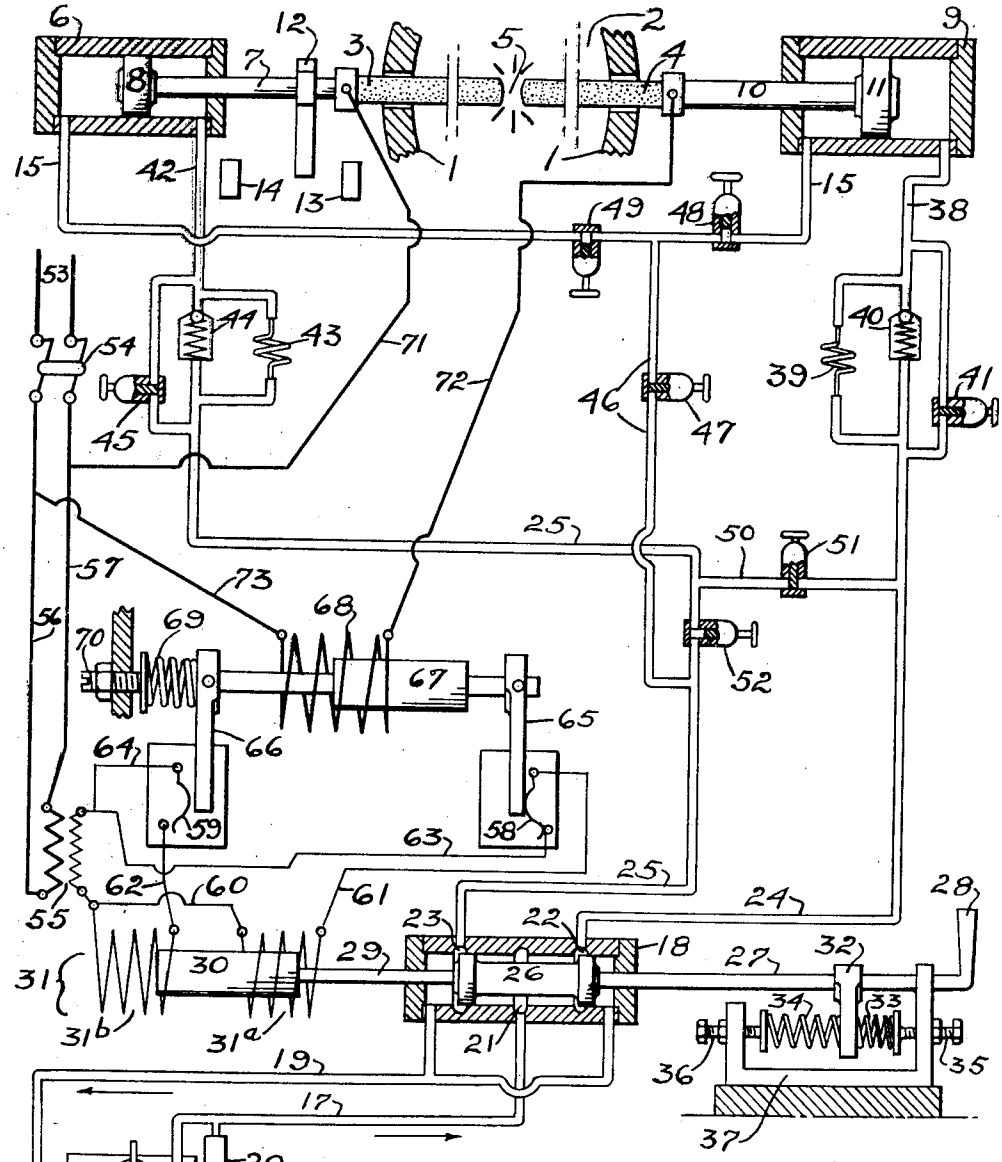
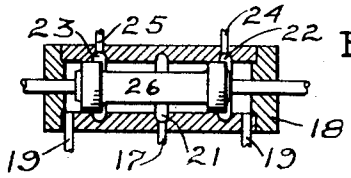


Fig. 2.



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ELECTRODE CONTROL

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10 Claims. (Cl. 219—8)

This invention relates to electric apparatus of the type in which two electrodes are connected into an electric circuit and spaced apart to provide a gap across which current flows to create an electric arc, such as an electric furnace or a welding machine.

One or both of the electrodes may be a carbon bar, as in a furnace, or one or both electrodes may be the material to be acted upon by the heat of the arc, as in a welding machine.

The current flowing through the electrodes varies in accordance with variation in the width of the gap, and one or both of the electrodes are movable to adjust the width of the gap.

An object of this invention is to provide means for adjusting the width of the gap and for maintaining the adjusted width substantially constant.

Another object is to provide apparatus of this character which is operated hydraulically.

Another object is to provide operating mechanism which is susceptible of close control.

Another object is to provide operating mechanism which may be adjusted to operate at high speed.

According to the invention as ordinarily applied and embodied in practice, the electrode is moved by a hydraulic motor which is automatically controlled in response to variations in the current flowing through the electrode.

The invention is embodied in the electric furnace illustrated diagrammatically in the accompanying drawing in which the views are as follows:

Fig. 1 is a diagram of the hydraulic and electric circuits and shows the several parts in the positions occupied when the electrodes are being advanced toward each other.

Fig. 2 is a longitudinal section through a control valve shown in Fig. 1 but showing its plunger in the position occupied when the electrodes are being retracted.

The electric furnace is shown schematically as having side walls 1 enclosing a heating chamber 2 and provided with suitable openings through which two carbon electrodes 3 and 4 extend in axial alinement with each other and with the inner ends thereof spaced apart a short distance to provide a gap 5 across which electric current flows from one electrode to the other to create an arc therebetween.

Both of the electrodes 3 and 4 are shown as being movable in order to maintain the gap 5 at or near the center of the chamber 2, but the invention is fully applicable to apparatus in which only one electrode is movable.

The electrode 3 is advanced and retracted toward and from the electrode 4 by a hydraulic motor 6 which has its cylinder arranged in a stationary position and the rod 7 of its piston 8 connected to the electrode 3 and suitably insulated therefrom.

The electrode 4 is advanced and retracted toward and from the electrode 3 by a hydraulic motor 9 which has its cylinder arranged in a stationary position and the rod 10 of its piston 11 connected to the electrode 4 and suitably insulated therefrom.

The movement of one or both electrodes in each direction is limited as by an adjustable stop 12 fixed upon the piston rod 7 to engage abutments 13 and 14 which are arranged in predetermined stationary positions.

The motors 6 and 9 are connected in series by a pipe 15 which connects the rod end of the motor 9 to the head end of the motor 6, and the motors are ordinarily so proportioned relatively to each other that the displacement of the rod end of the motor 9 is exactly the same as the displacement of the head end of the motor 6. Consequently, when liquid is delivered to the head end of the motor 9 to advance the electrode 4 a predetermined distance, the required volume of liquid is forced from the rod end of the motor 9 into the head end of the motor 6 to advance the electrode 3 exactly the same distance and, conversely, when liquid is delivered to the rod end of the motor 6 to retract the electrode 3 a predetermined distance, the required volume of liquid is forced from the head end of the motor 6 to the rod end of the motor 9 to retract the electrode 4 exactly the same distance.

Liquid for operating the motors 6 and 9 is supplied by a pump 16 which delivers its output through a supply pipe 17 to a control valve 18 which controls the delivery of liquid from the pump to the motors, and liquid is returned to the pump through a return pipe 19 which is connected to both ends of the control valve 18.

The pump may deliver liquid at a predetermined rate and exhaust its excess delivery through a high pressure relief valve 20 shown as being connected between the supply pipe 17 and the pump casing, but the pump ordinarily employed has the characteristic of delivering liquid at a predetermined maximum rate until it creates a predetermined maximum pressure which is lower than the pressure required to open the relief or safety valve 20 and to then automatically reduce its output until it is delivering just sufficient liquid to maintain that maximum pressure constant,

such as the pump disclosed in Patent No. 1,775,613, issued September 9, 1930, to John P. Ferris.

The control valve 18 has an admission port 21, which is arranged intermediate the ends of its casing in communication with the supply pipe 17, and two distributing ports 22 and 23 which are arranged upon opposite sides of the port 21 in communication, respectively, with two pipes 24 and 25 through which liquid is delivered to the motors and returned therefrom. The flow of liquid through the control valve 18 is controlled by its plunger 26 which controls communication between the distributing ports and the admission port and between the distributing ports and the return pipe 19.

The plunger 26 is provided upon one of its ends with a stem 27, which has a handle 28 arranged upon the outer end thereof for manual operation of the valve, and upon its other end with a stem 29 which is fixed to the core 30 of a solenoid 31 for automatic operation of the valve.

The stem 27 has an arm 32 fixed thereon and engaged upon its opposite sides by the inner ends of two springs 33 and 34 the outer ends of which are engaged, respectively, by two adjusting bolts 35 and 36 threaded through the ends of a stationary frame 37 one end of which functions as a guide for the valve stem 27. The springs 33 and 34 urge the plunger 26 to its central or neutral position at which time it closes the ports 22 and 23 and no liquid can be delivered to the motors or returned therefrom.

When the plunger 26 is moved to the right of its central or neutral position as shown in Fig. 1, pressure liquid flows from the supply pipe 17 to the pipe 24 and exhaust liquid flows from the pipe 25 to the return pipe 19. When the plunger 26 is moved to the left of its neutral position as shown in Fig. 2, pressure liquid flows from the supply pipe 17 to the pipe 25 and exhaust liquid flows from the pipe 24 to the return pipe 19.

Liquid from the pipe 24 may be delivered to the head end of the motor 9 through a pipe 38 which has one of its ends connected to the motor cylinder and its other end connected to the pipe 24 through a choke 39, a check valve 40 and a shutoff valve 41 which are connected in parallel with each other.

Liquid from the pipe 25 may be delivered to the rod end of the motor 6 through a pipe 42 which has one of its ends connected to the motor cylinder and its other end connected to the pipe 25 through a choke 43, a check valve 44 and a shutoff valve 45 which are connected in parallel with each other.

The shutoff valves 41 and 45 are normally closed, and the check valves 40 and 44 permit liquid to be exhausted freely from the motors 6 and 9 but compel liquid delivered to the motors to pass through the chokes when the shutoff valves are closed.

When the plunger 26 is moved to the right of its central or neutral position, liquid from the supply pipe 17 flows through the pipe 24, the choke 39 and the pipe 38 to the head end of the motor 9 and moves the piston 11 slowly toward the left to advance the electrode 4 towards the electrode 3 at a rate determined by the resistance of the choke 39. The piston 11 expels liquid from the rod end of the motor 9 and this liquid flows through the pipe 15 to the head end of the motor 6 and moves the piston 8 toward the right to advance the electrode 3 toward the electrode 4 at the same rate that the electrode 4 moves toward the electrode 3. The piston 8 exhausts liquid from the rod end of the motor 6 and this liquid flows freely through the pipe 42, the check valve 44, the pipe 25 and the valve 18 to the return pipe 19.

When the plunger 26 is moved to the left of its central or neutral position as shown in Fig. 2, liquid from the supply pipe 17 flows through the pipe 25, the choke 43 and the pipe 42 to the rod end of the motor 6 and moves the piston 8 slowly towards the left to retract the electrode 3 from the electrode 4 at a rate determined by the resistance of the choke 43. The piston 8 expels liquid from the head end of the motor 6 and this liquid flows through the pipe 15 to the rod end of the motor 9 and moves the piston 11 toward the right to retract the electrode 4 at the same rate that the elecrode 3 is retracted. The piston 11 exhausts liquid from the head end of the motor 9 and this liquid flows freely through the pipe 38, the check valve 40, the pipe 24 and the valve 18 to the return pipe 19.

If the shutoff valves 41 and 45 are open, liquid will be bypassed around the chokes 40 and 43 and flow freely to the motors 6 and 9 to operate the same at high speed.

In order that the motors 6 and 9 may be operated independently of each other, the pipe 15 is connected to the pipe 25 by a pipe 46 having a normally closed shutoff valve 47 connected therein. A normally open shutoff valve 48 is connected into the pipe 15 between the motor 9 and the pipe 46, a normally open shutoff valve 49 is connected into the pipe 15 between the motor 6 and pipe 46, the pipe 24 is connected to the pipe 25 by a pipe 50 having a normally closed shutoff valve 51 connected therein, and the pipe 25 has a normally open shutoff valve 52 connected therein between the pipes 46 and 50.

If the valves 49, 51 and 52 are closed, liquid cannot be delivered to or escape from the motor 6 and the electrode 3 is retained in the stationary position. Then, if the valve 47 is open, liquid may flow to or from each end of the motor 9 and permit it to be operated in either direction independently of the motor 6 and, if the valve 41 is open, the operation may be accomplished at high speed.

If the valve 48 is closed, liquid cannot be delivered to or escape from the rod end of the motor 9 and the electrode 4 is retained in a stationary position. Then, if the valves 47, 49 and 51 are open and the valve 52 is closed, liquid may flow to or from the rod end of the motor 6 through the pipes 24, 51, 25 and 42 and liquid may flow to or from the head end of the motor 6 through the pipes 25, 46 and 15, thereby permitting the motor 6 to be operated in either direction independently of the motor 9 and, if the valve 45 is open, the operation may be accomplished at high speed.

Electric current for operating the furnace is supplied from a power line 53 through a switch 54, and current for operating the solenoid 31 is supplied by a transformer 55 which has the ends of its primary winding connected to the terminals of the switch 54 by two conductors 56 and 57.

The solenoid 31 has two separate windings 31^a and 31^b. The winding 31^a is controlled by a switch 58 and, when energized, will cause the core 30 and the control valve plunger 26 to move to the right. The winding 31^b is controlled by a switch 59 and, when energized, will cause the core 30 and the plunger 26 to move to the left.

The windings 31^a and 31^b are each connected at one end thereof to one end of the secondary winding of the transformer 55 by a conductor 60,

the other end of the winding 31^a is connected to one terminal of the switch 58 by a conductor 61, the other end of the winding 31^b is connected to one terminal of the switch 59 by a conductor 62, and the other terminals of the switches 58 and 59 are connected, respectively, by conductors 63 and 64 to the other end of the secondary winding of the transformer 55.

The switches 58 and 59 are operated, respectively, by two arms 65 and 66 which are rigidly connected to the core 67 of a solenoid 68 and urged to the right to open the switch 59 and close the switch 58 by a spring 69 which has its tension adjusted by a bolt 70.

The solenoid 68 has its winding connected in series with the electrodes 3 and 4 so that the magnetic force exerted upon the core 67 is proportional to the current flowing through the electrode, and this force tends to move the core 67 to the left against the resistance of the spring 69 to open the switch 58 and close the switch 59. The circuit through the electrodes and the solenoid is established through a conductor 71 which connects the electrode 3 to the conductor 57, a conductor 72 which connects the electrode 4 to one end of the winding of the solenoid 68, and a conductor 73 which connects the other end of the solenoid winding to the conductor 56.

Assuming that the width of the gap 5 has been properly adjusted, the shutoff valves adjusted as shown in Fig. 1, the switch 54 closed and that the pump 16 is running, current will flow across the gap 5 and create an electric arc, the transformer 55 will deliver current to the winding 31^a of the solenoid 31 which will move the control valve plunger to the right, liquid from the pump 16 will flow to the head end of the motor 9 through the choke 39 and advance the electrode 4 slowly, liquid expelled from the rod end of the motor 9 will enter the head end of the motor 6 and advance the electrode 3 slowly, and the liquid expelled from the rod end of the motor 6 will return to the pump.

If the motors 6 and 9 advance the electrodes 3 and 4 faster than the adjacent ends thereof are consumed by the arc, the width of the gap 5 will decrease and the current flowing through the electrodes will increase and, as this same current flows through the solenoid 68, the magnetic force exerted upon its core 67 will increase in proportion to the increase in current and, when this force reaches a predetermined maximum as determined by the adjustment of the spring 69, it will move the core 67 to the left and open the switch 58 to deenergize the winding 31^a and permit the spring 33 to return the valve plunger 26 to its neutral position and halt the advance of the electrodes.

If the electrodes have been advanced sufficiently to decrease the width of the gap appreciably, and thereby cause the current flowing through the electrodes to exceed materially the predetermined maximum, the force exerted by solenoid 68 will be sufficient to move the core 67 far enough to the left to close the switch 59 and cause the winding 31^b to be energized, thereby causing the valve plunger 26 to move to the position shown in Fig. 2 and reverse the delivery of liquid to the motors which will retract the electrodes and widen the gap 5, as previously described.

Widening the gap 5 causes a decrease in the current flowing through the electrodes and, when the gap has been widened beyond a predetermined width either by retraction of the electrode or by the consumption of material at the ends of the electrodes, the current will have decreased sufficiently to allow the spring 69 to move the solenoid core 67 to the right and close the switch 58, thereby causing the electrodes to readvance.

The apparatus thus responds automatically to variations in the current flowing through the electrodes and functions to confine the current fluctuations within a narrow range and to maintain the width of the arc gap substantially constant.

The invention herein set forth is susceptible of various modifications and adaptations without departing from the scope thereof as hereafter claimed.

The invention is hereby claimed as follows:

1. The combination, with a source of motive liquid, an electric power circuit and an electrical apparatus having two electrodes connected to opposite sides of said circuit for the passage of current from one electrode to the other and normally spaced apart to provide a gap therebetween and thereby cause said current to create an electric arc across said gap, of a hydraulic motor for moving one electrode relatively to the other to vary the width of said gap and thereby vary the current flowing through said electrodes, fluid channels connecting said motor to said source for delivering liquid to said motor to operate the same, means responsive to variations in the current flowing through said electrodes for controlling the delivery of liquid to said motor, means connected into one of said channels for restricting the flow of liquid to said motor while permitting liquid to escape freely therefrom to thereby limit the motor speed in one direction of motor actuation, and means for bypassing liquid around said restricting means to enable said liquid to operate said motor at high speed in both directions.

2. The combination, with an electric power circuit and an electrical apparatus having two electrodes connected to opposite sides of said circuit for the passage of current from one electrode to the other and normally spaced apart to provide a gap therebetween and thereby cause said current to create an electric arc across said gap, of hydraulic means for simultaneously moving both electrodes relatively to each other to vary the width of said gap and thereby vary the current flowing through said electrodes, means for delivering liquid to said hydraulic means to operate the same, and means responsive to variations in the current flowing through said electrodes to control said hydraulic means.

3. The combination, with an electric power circuit and an electrical apparatus having two electrodes connected to opposite sides of said circuit for the passage of current from one electrode to the other and normally spaced apart to provide a gap therebetween and thereby cause said current to create an electric arc across said gap, of two double-acting hydraulic motors connected in series for moving both electrodes toward and from each other to vary the width of said gap and thereby vary the current flowing through said electrodes, means for delivering liquid to said hydraulic means to operate the same, and means responsive to variations in the current flowing through said electrodes to control said hydraulic means.

4. The combination, with an electric power circuit and an electrical apparatus having two electrodes connected to opposite sides of said circuit for the passage of current from one electrode to the other and normally spaced apart to provide a gap therebetween and thereby cause said current to create an electric arc across said gap, two double-acting hydraulic motors con-

nected in series for moving both electrodes toward and from each other to vary the width of said gap and thereby vary the current flowing through said electrodes, means for delivering liquid to said hydraulic means to operate the same, a valve for controlling the delivery of liquid to said hydraulic motors, and an electromagnet responsive to variations in the current flowing through said electrodes for operating said valve.

5. The combination, with an electric power circuit and an electrical apparatus having two electrodes connected to opposite sides of said circuit for the passage of current from one electrode to the other and normally spaced apart to provide a gap therebetween and thereby cause said current to create an electric arc across said gap, of a double-acting motor for moving each electrode relatively to the other to vary the width of said gap and thereby vary the current flowing through said electrodes, means for delivering liquid to said motors to operate the same, a valve for controlling the delivery of liquid to said motors, an electromagnet responsive to variations in the current flowing through said electrodes for operating said valve, a choke for limiting the volume of liquid delivered to each motor to thereby cause the same to operate at slow speed in one direction, manually operable means for freely bypassing liquid around each choke to thereby permit each motor to be operated at higher speed in both directions, and means for operating said valve manually.

6. The combination, with an electric power circuit and an electrical apparatus having two electrodes connected to opposite sides of said circuit for the passage of current from one electrode to the other and normally spaced apart to provide a gap therebetween and thereby cause said current to create an electric arc across said gap, of a double-acting motor for moving each electrode relatively to the other to vary the width of said gap and thereby vary the current flowing through said electrodes, means for delivering liquid to said motors to operate the same, a valve for controlling said delivery of liquid and operable to direct liquid selectively to either end of each motor to move its electrode in either direction, an electromagnet responsive to variations in the current flowing through said electrodes for operating said valve, a choke for limiting the volume of liquid delivered to each of said motors to thereby cause the same to operate at slow speed, manually operable means for freely bypassing liquid around each choke to thereby permit each motor to be operated at higher speed in both directions, and means for operating said valve manually.

7. The combination, with an electric power circuit and an electrical apparatus having two electrodes connected to opposite sides of said circuit for the passage of current from one electrode to the other and normally spaced apart to provide a gap therebetween and thereby cause said current to create an electric arc across said gap, of two double-acting hydraulic motors connected in series with each other for moving said electrodes toward and from each other to vary the width of said gap and thereby vary the current flowing through said electrodes, means for delivering liquid to said motors to operate the same, a valve for controlling the delivery of liquid to said motors, an electromagnet for operating said valve, a switch for controlling said electromagnet, and another electromagnet connected in circuit with said electrodes for operating said switch.

8. The combination, with an electric power circuit and an electrical apparatus having two electrodes connected to opposite sides of said circuit for the passage of current from one electrode to the other and normally spaced apart to provide a gap therebetween and thereby cause said current to create an electric arc across said gap, of two double-acting hydraulic motors connected in series with each other for moving said electrodes toward and from each other to vary the width of said gap and thereby vary the current flowing through said electrodes, means for delivering liquid to said motors to operate the same, a valve for controlling said delivery of liquid and operable to direct liquid selectively to either end of each motor to move each electrode in either direction, resilient means tending to retain said valve in its neutral position, an electromagnet for operating said valve against the resistance of said resilient means, a switch for controlling said electromagnet, and another electromagnet connected in circuit with said electrodes for operating said switch.

9. The combination, with an electric power circuit and an electrical apparatus having two electrodes connected to opposite sides of said circuit for the passage of current from one electrode to the other and normally spaced apart to provide a gap therebetween and thereby cause said current to create an electric arc across said gap, of a hydraulic circuit, two hydraulic motors hydraulically connected in said hydraulic circuit in series with each other and each mechanically connected to one of said electrodes to move it toward and from the other electrode to vary the width of said gap and thereby vary the electric current flowing through said electrodes, a pump connected into said hydraulic circuit for delivering liquid to said motors to operate the same, a valve for controlling said delivery of liquid, electromagnetic means responsive to variation in the current flowing through said electrodes for operating said valve, means for operating said valve manually, and other valves connected into said hydraulic circuit for controlling the flow of liquid therethrough and enabling either motor to be operated in either direction independent of the other motor.

10. The combination, with an electric power circuit and an electrical apparatus having two electrodes connected to opposite sides of said circuit for the passage of current from one electrode to the other and normally spaced apart to provide a gap therebetween and thereby cause said current to create an electric arc across said gap, of a hydraulic circuit, two hydraulic motors hydraulically connected in said hydraulic circuit in series with each other and each mechanically connected to one of said electrodes to move it toward and from the other electrode to vary the width of said gap and thereby vary the electric current flowing through said electrodes, a pump connected into said hydraulic circuit for delivering liquid to said motors to operate the same, a valve for controlling said delivery of liquid, means for operating said valve automatically including an electromagnet connected in circuit with said electrodes, means for operating said valve manually, and other valves connected into said hydraulic circuit for controlling the flow of liquid therethrough and enabling either motor to be operated in either direction independent of the other motor.

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