April 27, 1948. W. H. PAYNE 2,440,380

MEANS FOR AUTOMATICALLY CONTROLLING ARC FURNACE ELECTRODES

Filed Dec. 23, 1944 2 Sheets-Sheet 1

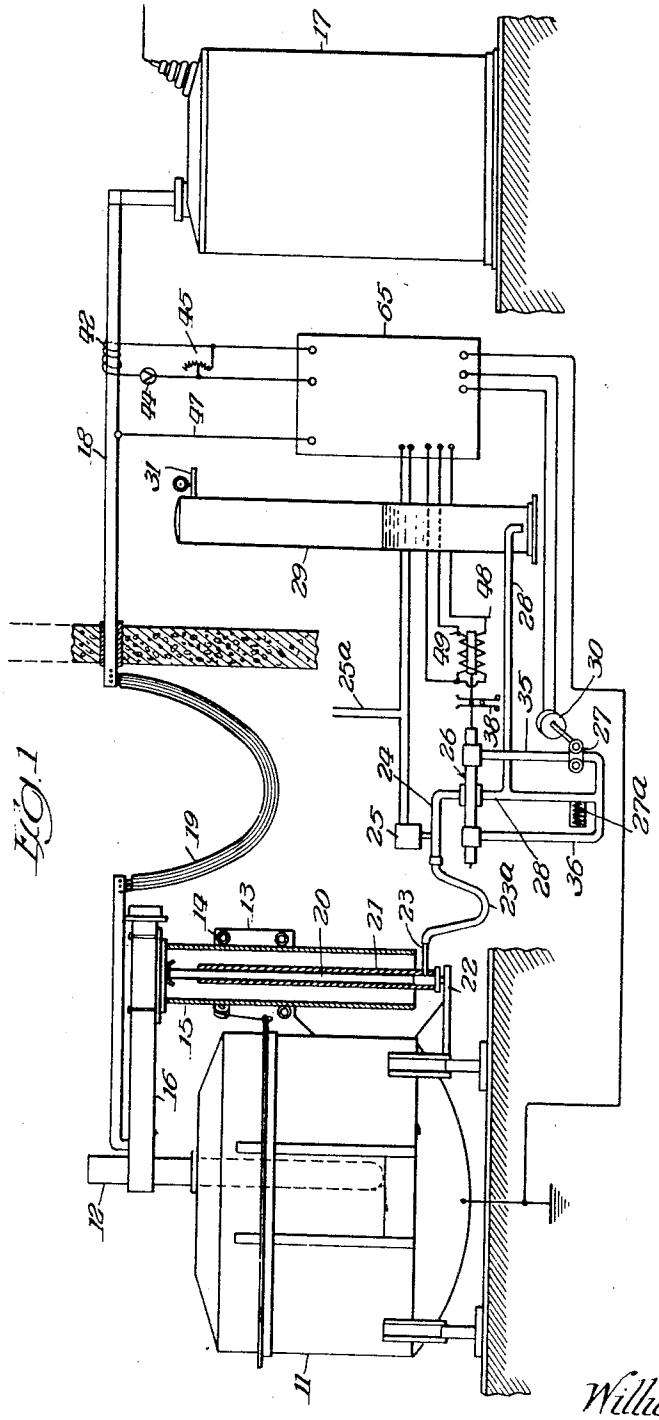


FIG. 1

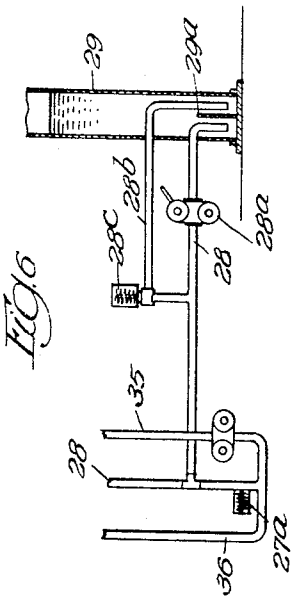


FIG. 6

INVENTOR.

William Harvey Payne

By Reed & Gerlach

Attys.

April 27, 1948. W. H. PAYNE 2,440,380

MEANS FOR AUTOMATICALLY CONTROLLING ARC FURNACE ELECTRODES

Filed Dec. 23, 1944 2 Sheets-Sheet 2

Fig. 2

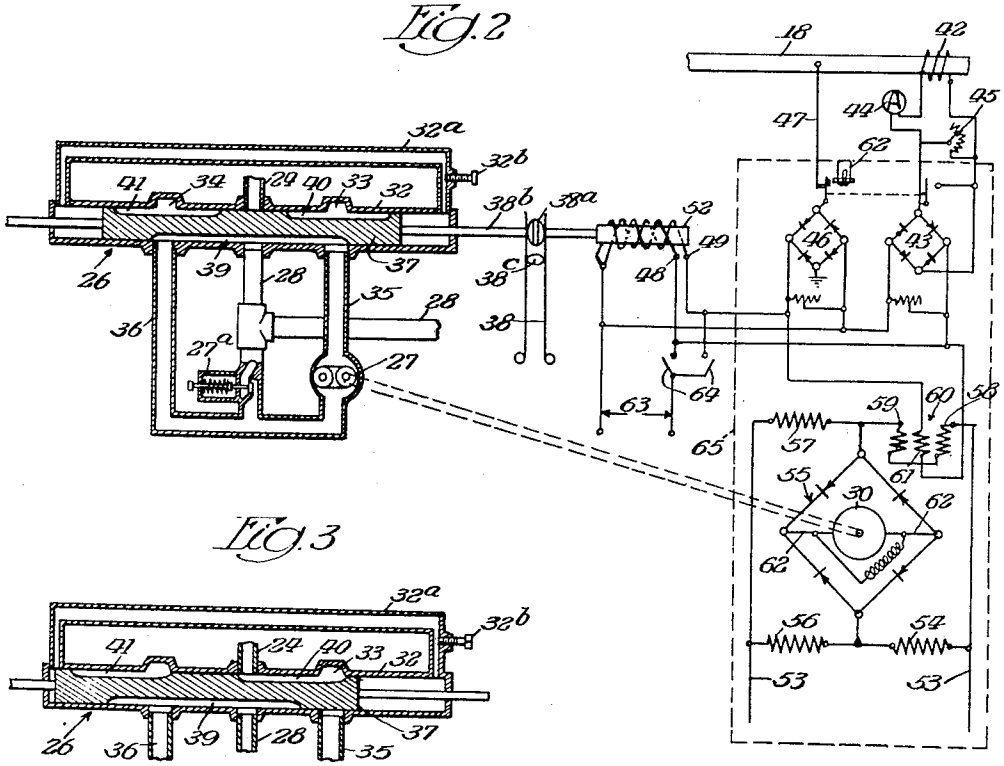


Fig. 3

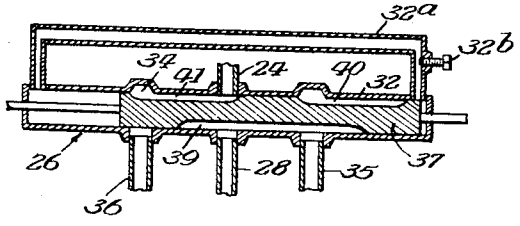
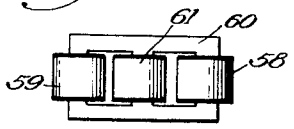


Fig. 4

Fig. 5



INVENTOR.
William Harvey Payne
By: Fred Gerlach
Atty.

Patented Apr. 27, 1948

2,440,380

UNITED STATES PATENT OFFICE

2,440,380

MEANS FOR AUTOMATICALLY CONTROLLING ARC FURNACE ELECTRODES

William Harvey Payne, Hinsdale, Ill.

Application December 23, 1944, Serial No. 569,443

21 Claims. (Cl. 314—61)

1

The present invention relates in general to control equipment and has more particular reference to control means for raising, lowering and adjusting an electrode of an electric arc melting furnace.

This invention, in particular, relates to hydraulically operated electrode mechanism of such a furnace, wherein an electrode element is supported on a movable mounting which, in turn, is supported on an actuating piston operating in an hydraulic cylinder, the piston being moved in the cylinder, to thus raise and lower the electrode mounting, by delivering and withdrawing regulated quantities of a suitable hydraulic medium to and from the cylinder. To accomplish accurate electrode adjustment, the liquid hydraulic medium is forced into and withdrawn from the operating cylinder by suitable pump means operating in response to variations in the electric power input to the furnace, which in turn is a function of variations in the arc formed by the electrode in the furnace when it is in operation.

Among the various operational difficulties encountered in control apparatus of the character mentioned is accurately and speedily positioning the electrode, electrode mounting and operating piston, such difficulty being expressly due to the considerable weight and inertia of such parts.

Systems heretofore provided for positioning the extremely heavy mountings and associated parts, require large powerful and heavy motors for pump driving purposes. Because of the large motor required and its great reversing inertia plus the heavy mounting and associated moving parts the electrodes cannot be positioned accurately and at desirable speeds. This means greater electrode usage and carbon pickup therefrom, and power surges, and lower power factor, and load factor of this important melting unit.

To overcome the foregoing defects, I decrease the inertia of the apparatus to a minimum by using a unidirectional motor driving a hydraulic pump, in combination with a simple valve for controlling the direction of oil flow. In the new system described herein, the unidirectional motor and pump operate at a speed in proportion to the degree of arc power off balance from the desired setting, and furnish the small necessary hydraulic pressure to overcome friction and low inertia of a gas counterbalanced moving system, to a high degree of accuracy. Such a non-reversing metering motor system, using a valve for direction changes, has exceedingly low inertia and will provide for most accurate electrode positioning.

Another operational defect inherent in elec-

2

trode positioning apparatus heretofore provided, is the tendency of the electrode and mounting combination to drift because of seepage through a rotary pump in a direction from the side which has the highest oil pressure. Conventional pumps used in these systems are fluid moving means and are not intended to act as valves, even when new. This defect is overcome in the present control apparatus by means of the valve more fully described hereinafter.

An important object of the present invention is to provide a new and improved hydraulic positioning apparatus or system wherein the maximum counterbalancing of the hydraulically supported parts is accomplished by the use of back pressure on the hydraulic medium feeding the pump so that the pump and its driving motor may be small with low inertia and still not be over loaded in its work of positioning the electrode and associated parts.

Another important object of the invention is to provide an improved hydraulic apparatus system wherein drifting of the electrode and its mounting is substantially eliminated.

Still another important object of this invention is to provide a hydraulic system wherein a unidirectional metering pump is used with a directional valve, to deliver oil to raise the electrode and parts, as well as to withdraw oil to lower the electrode, all at a speed in proportion to the degree of off balance of the arc power setting, such pump having back pressure on its inlet side for counterbalancing purposes; a further object being to effect a considerable simplification in the electrical parts of an arc furnace control by the use of a unidirectional motor and pump. The hydraulic speed metering pump described herein does not have to stop and start with each electrode reversal, nor does it have to come to a dead stop even when its power is shut off, as in the case of arriving at a desired arc power input setting.

Another object of the present invention is the use of back pressure on the inlet side of the electrode moving unidirectional pump, such back pressure serving as a counterbalancing means. Counterbalancing may be accomplished by the use of gas, such as air, on the storage tank for the hydraulic medium, operating as a closed system, or by the use of a separate source of hydraulic medium pressure, such, for instance, as a motor-driven, continuously operating pump, discharging against a load valve, the medium back pressure being on the inlet side of the electrode metering

pump, or by the use of both air and medium pressure for counterbalancing purposes.

Another important object of the invention is to provide a new and improved limit control switch for stopping the pump motor in the event that the pressure in the operating cylinder exceeds a preselected maximum, as when the piston reaches the upper limit of its travel. The limit switch also serves to stop the motor, in response to pressure below a preselected minimum, as when the piston approaches the low limit of its operating stroke, or in the case of an electrode "bottoming" or "hanging," while in operation, thus reducing the electrode supporting pressure by weight decrease.

Among other important objects, advantages and inherent functions of the invention, is to provide electrode adjusting mechanism of new and improved construction in an arrangement characterized by high operating efficiency, low cost and simplicity of design accomplished through use of a back pressure counterbalanced undirectional metering pump operating in conjunction with a piston valve.

The foregoing and numerous other important objects, advantages and inherent functions of the invention will become more apparent from a consideration of the following description, which, taken in connection with the accompanying drawings, discloses a selected embodiment of the invention for the purpose of demonstrating the same.

Referring to the drawings:

Figure 1 is a schematic view of an electric arc furnace and electrode control apparatus embodying the present invention, showing one phase of a normally multiphase electric arc melting furnace only;

Figure 2 is an enlarged and more detailed diagrammatic showing of the control apparatus in Figure 1, showing the valve in its blocking position;

Figures 3 and 4 are sectional views through the piston valve shown in Figure 2, showing the same in its shifted positions;

Figure 5 is a view of a saturable transformer forming a part of the apparatus shown in Figure 2; and

Figure 6 is a diagrammatic view of a modified form of back pressure counterbalancing means for the control apparatus.

To illustrate the invention, the drawings show an electric arc furnace comprising a shell 11 provided with a roof formed with an opening for the reception of an electrode 12. Ordinarily there are several electrodes, each with its separate operating apparatus, but since the operating and control mechanism is the same for each electrode, it will be sufficient to describe one electrode and its associated equipment.

The shell 11, on one side, carries a bracket 13 which is fitted with rollers 14 and forms therewith a guide for a hollow vertical extension 15 having a horizontal supporting arm 16 at its upper end. The arm 16 is electrically insulated from the vertical extension 15 and has its outer end positioned above the opening in the roof of the furnace. Said outer end of the arm is provided with any suitable clamp means (not shown) for holding the electrode so that it extends vertically through the roof opening into the furnace shell. The vertical extension and arm constitute a vertically movable mounting for the electrode. By moving the mounting upwards and downwards with respect to the bracket 13 on the furnace shell, the electrode may be raised and lowered in its arcing operations.

The shell 11 may be of any standard or conventional design and is lined with refractory material, as well understood in the art. It is adapted to contain a charge of metal to be melted and embodies a pouring spout (not shown) by means of which the molten contents of the furnace may be poured out usually by tilting the furnace. Electrical power is supplied to the electrode 12 from a suitable power source, shown in the drawings as a transformer 17.

The secondary coil of the furnace transformer 17 is electrically connected by a bus bar 18 and a flexible conductor 19 to the arm 16 which in turn is electrically connected to the electrode 12. With a normal metal scrap charge in the furnace electric power will be applied to the electrode when the transformer 17 is energized. When the electrode is adjusted to contact the scrap, electric current will flow through the scrap from the electrode 12 and then through the other electrodes of the furnace, causing arcs to be formed under the electrodes as the same are slightly withdrawn from contact position. Heat from the arcs serve to melt the charge in a manner well known to the art.

To move the mounting in order thus to raise or lower the electrode 12 in the furnace, a piston 20 and a cooperating cylinder 21 are provided within the hollow vertical extension 15. The electrode arm is carried on the upper end of said piston 20, which extends into the closed cylinder. The lower end of the cylinder 21 is mechanically supported, as on a bracket 22, at the bottom of the shell, so that all of the above described equipment moves with the shell 11 when the same is tilted in connection with pouring of the molten metal. The lower end of the cylinder projects below the working end of the piston, and is connected to a pipe 23 through which a liquid hydraulic fluid may enter or be withdrawn from the cylinder in order to move the piston therein, to raise or lower the electrode in the furnace.

The pipe 23 connects with a flexible section 23*a* to accommodate tilting of the furnace in pouring. This flexible section 23*a*, in turn, is connected with a rigid pipe 24 to which a pressure switch 25 is connected. The pipe 24 is connected to a piston valve 26, which, in turn, is connected by a pipe 28 to a supply reservoir or tank 29 containing a hydraulic medium, such as oil or other suitable liquid. The tank 29, as shown in Figure 1, contains gas under pressure for counterbalancing the electrode and associated parts.

Air for counterbalancing purposes may be supplied to the tank 29 through a fitting 31, which may comprise valve means for obtaining a desired pressure of air in the tank. The tank may also be filled with air under pressure from a shop air pressure system or directly from a compressor and storage tank. Alternate counterbalancing of the electrode and mounting may be accomplished by the arrangement shown in Figure 6. In such arrangement the tank 29 contains oil at atmospheric pressure or under air pressure to any desired extent, and the pipe 28 which extends between, and serves to connect, the tank 29 and the control valve 26 is provided with a continuously operating motor driven back pressure pump 28*a*. A return pipe 28*b* is connected to the pipe 28 between the pump 28*a* and the control valve 26 and leads back to the tank 29. This return pipe includes a spring or weight loaded valve 28*c* which, in connection with operation of the pump

28a, serves to maintain the oil in the pipe 28 under the desired back pressure for counterbalancing purposes. In connection with operation of the arrangement of Figure 6, oil is circulated continuously through the return pipe 28b back to the tank, and the load valve 28c, as previously pointed out, functions to maintain in the pipe 28 a constant pressure of sufficient magnitude to effect the desired back pressure action which, in turn, serves to counterbalance the electrode and mounting when the control valve 26 is in any position other than its hereinafter described neutral or blocking position. In the arrangement shown in Figure 6 the tank is preferably provided with a baffle 29a between the discharge end of the return pipe 28b and the inlet end of the pipe 28. In this disclosure I have described a movable piston and a fixed cylinder as the means for moving an electrode by hydraulic power. It is clear that the piston may be fixed, and a movable cylinder may do this same work, although I prefer the fixed cylinder as described herein, and movable piston because this is the lightest member of the cylinder-piston combination. The invention, however, is not necessarily limited to any particular means for applying counterbalancing back pressure in the hydraulic medium and any suitable preferred or convenient means for accomplishing the same may be employed.

An operating pump 27, preferably in the form of a small standard gear pump, is connected to be driven by a unidirectional variable speed motor 30 and with the control valve 26 serves to control the position of the electrode.

The cooperating piston valve 26 may be operated rapidly to move to any one of three operating positions. In one position, as shown in Figure 3, the pump is allowed to withdraw oil from under the piston 20 and return it to the tank 29, thus lowering the electrode. In another position, as shown in Figure 4, the pump delivers oil from the tank to the underside of the piston 20, thus raising the electrode. The position shown in Figure 2 is the center or blocking position of the valve in which liquid movement to and from the cylinder is prevented, whereby to eliminate drifting or shift of the electrode when the control is static. The tank 29, if designed for air on oil counterbalancing, preferably is a tall closed tank of sufficient volume to store the hydraulic liquid medium, and at the same time maintain a quantity of counterbalancing air of such pressure and volume that even with maximum oil volume change, the air counterbalancing back pressure will vary only a small percent, thus not using or wasting any air in normal operation. Shop system makeup air may be supplied through valve 31 to replace any air losses. Therefore, the system as shown in Figure 1, comprises an air counterbalanced liquid tank 29, pipe connected to a motor driven unidirectional metering pump 27, which, in turn, is pipe connected to a reversing valve 26 and thence to the cylinder 21 and its telescoping piston 20, on which the electrode arm 16 and the electrode 12 rest by gravity. The parts cooperate so that the unidirectional motor and pump furnish oil under pressure to raise the electrode when the valve is in one position, as shown in Figure 4, and lower it, when the valve is in its other operating position, as shown in Figure 3. The cylinder oil line is blocked when the valve is in the mid-position shown in Fig. 2. Oil flow for such electrode movements, being effected by the unidirectionally operated pump and motor, is proportional to the degree of off balance of the arc

power setting, and the flow is cut off by the valve, instantly when arc power reaches a desired value, or when hand switched for a dormant non-automatic condition, as is hereinafter described.

The operating piston valve 26 shown in Figure 2 comprises a fixed casing or sleeve 32 and a longitudinally slidable piston 37. The ends of the sleeve are fitted with covers having central openings for slidably receiving a shaft 38b which extends longitudinally through the piston 37. The pipe 24 is connected at one end to the central portion of the sleeve 32 and the other or opposite end of the pipe 24 connects with the lower end of the cylinder 21 through the flexible hose 23a and the pipe 23.

Diametrically opposite its connection with the pipe 24, the sleeve 32 is connected with the pipe 28 which leads to the tank 29. Suitably equidistant on each side of the connections with the pipes 24 and 28, the sleeve 32 is formed with inner annular chambers 33 and 34 respectively, which are connected with pipes 35 and 36 leading to the intake and outlet of the operating pump 27.

The piston 37 of the operating valve 26 is yieldingly maintained in its centered or so-called blocking position when the piston operating power is at zero value, by means of a pair of laterally spaced upstanding leaf springs 38. The lower ends of these springs are suitably anchored or mounted and the upper central portions of the springs are positioned in straddled relation with a fixed post 38c. The upper ends of the springs 38 are operatively related to the piston shaft 38b through the medium of a collar 38a on said piston shaft. When the piston 37 is slid in one direction from its centered or blocked position one of the springs is deflected and tends to retract the piston to its centered position and when the piston is shifted in the opposite direction the other spring is deflected and tends to center the piston 37.

The piston 37, in its side that faces the valve end of the pipe 28, has a longitudinally elongated passage forming flat 39, equidistant from its ends. On its side facing the valve connected end of the pipe 24, the piston has two equal length longitudinally extending passage forming flats 40 and 41 suitably located and spaced to be able to port for oil entrance and withdrawal from the pipe 24 when the piston is moved, in performing its intended operations, as hereinafter described.

When the piston occupies its centered or blocking position, under the influence of the centering springs 38 and while the piston operating force is zero, the pipe 24 connecting the valve sleeve to the electrode operating cylinder 21 is closed, so that the electrode stands still and cannot drift. In centered valve position the passage forming flat 39 connects the incoming unidirectional oil pipe 36 to the outgoing one-way oil pipe 35, so that even though the electrode cannot move, because its oil line is piston-blocked, the unidirectionally operated pump and its motor can still pass some oil and is not choked to a dead stop each time. Thus the small metering pump 27 and its unidirectional motor 30 are given easy working conditions because they are not mechanically or dynamically braked or "bucked" to a dead stop each time the electrode is piston stopped.

The piston 37 is powered to move to either extreme position when the electrode arc power is off the desired control balance, so that the rate of electrode actuating oil flow is not a function of valve 26 porting area, but is controlled entirely by the speed of the pump. When the piston 37 is po-

sitioned to the left, as shown in Figure 3 of the drawings, oil is arm weight pressure fed through the pipe 24 to the valve 26 and passes along piston flat 40, to annular chamber 33, and thence discharges through the pipe 35 to the feed side of the pump 27, which meters the discharge rate. The oil passes thence to the pipe 36 and along the flat 39 to the tank discharge pipe 28 into the oil tank 29, against the counterbalancing air pressure, thus lowering the electrode. When the piston 37 is positioned to the right, as shown in Figure 4 of the drawings, oil is pressure fed through the pipe 28, thence along the flat 39, through the pipe 35 to the pump 27 and is discharged with operable pressure, through the pipe 36, through the annular chamber 34 and the piston flat 41 to the pipe 24. The oil is fed thence to the underside of the electrode piston 20, to raise the electrode. The electrode is raised at a speed controlled by the metering pump, which, in turn, is driven at a speed proportional to the degree which the electrode arc power is off balance of its desired setting.

As a safety precaution I prefer to interpose an emergency unloading valve 27*a* between the discharge side of the pump 27 and the pipe 28 that leads to the tank 29. The valve 27*a* is preferably spring loaded and also serves to smooth out a positive pump delivery as the piston is crossing ports. A surge pipe 32*a* is provided to shunt oil from one end of the valve sleeve 32 to the other as the piston moves in the sleeve. A choke screw 32*b* in the surge pipe may be used to limit unnecessary fluctuations of the piston. The surge pipe is so connected to each end of the valve sleeve 32 as to provide an oil cushion for the piston to impinge against.

Since this directional valve 37 can change quickly from any one of three positions in relation to arc power control off balance, with a "through" by-pass in the center position, the motor can drift from its small inertia or run slowly, and thus avoid the necessity of mechanical and/or dynamic braking to come to a dead stop each time. Therefore, this small pump and its motor become solely a unidirectional speed metering device, furnishing only enough power to overcome the low inertia and friction of fully or average counterbalanced moving parts as is described herein.

While several mechanical forms of reversing valves, with "blocking" and through type center positions may be used, I prefer the piston valve arrangement for this design, and though the piston type valve is described, it is understood that plate type swinging valves or rotary valves may be used.

To shift the valve piston 37 into any one of its three positions in response to control power off balance, an electrical system such as shown in Figure 2 of the drawings, may be used, although, of course, other modified electrical systems may be utilized, and the present invention is not necessarily limited to the electrical system described herebelow.

The control actuating source, illustrated in Figure 2 of the drawings, comprises a secondary current transformer 42, and this is inductively coupled to the bus bar 18 and has associated with it a current flow indicating ammeter 44, and a current adjusting rheostat 45. The control actuating source also comprises a voltage lead 47 from the bus bar 18. The small power from the current transformer offers its output in direct proportion to arc current flow through the electrode 12, shown in Figure 1, and the power from the

voltage lead offers its output in inverse proportion to arc current flow.

A permanent magnet solenoid core 52 is attached to one end of the piston shaft 38*b* and is slidably supported to move the piston in response to predominating coil force as is described hereinafter.

As shown in the drawing, Figure 2, power from the secondary current transformer 42 is converted to direct current through a rectifier 43 and passes to a solenoid coil 48 around the core 52, where it is matched against similar ampere turns of opposing power from a voltage circuit rectifier 46 and its concentrically wound solenoid coil 49, also around the core 52. Both coils 48 and 49 are connected to give opposing instantaneous polarity. The coil 48 is so connected and arranged that when its magnetism predominates over that of the opposing coil 49, its polarity is so related to the polarity of the permanent magnet solenoid core 52 that the core and valve piston 37 are shifted to the right as shown in Figure 4, and hence the valve 26 is so ported that the pump 27 operates to effect raising of the electrode 12. Conversely, the coil 49 is so connected and arranged that when its magnetism predominates over that of the coil 48, its polarity is so related to the polarity of the core 52 that the core and valve piston are shifted to the left as shown in Figure 3, and hence the valve 26 is so ported that the pump serves to effect lowering of the furnace electrode. When the magnetic pull in the opposing coils 48 and 49 is equal, as in the case of arriving at the desired arc power control input, the magnetic pull of the coils 48 and 49 is neutralized and therefore the coils have no effect on the core 52 and the piston 37 thus returns to its middle or blocking position (see Figure 2) under the influence of the centering springs 38, thus holding the electrode static until the next arc power unbalance.

The metering unidirectionally operated pump 27 may be driven by any suitable motor, although for purposes of illustration I have shown a shunt type variable speed direct current motor 30. This motor is connected to drive the pump 27. The purpose of this motor is to rotate or drive the metering pump in one direction only so that it furnishes enough oil under sufficient pressure to raise or lower the electrode when the valve 26 is ported due to arc current or voltage changes, as described above.

The motor 30 is powered from direct current leads 62 which are fed through a rectifier assembly 55. The rectifiers of the assembly, in turn, are energized through a bridge which comprises four legs, three of which comprise coils 54, 56 and 57, the fourth leg comprising coils 58 and 59. The bridge is powered with alternating current from an external source through leads 53, and is so constructed that the voltage drop across each of the legs is equal under normal conditions, that is to say, when desired arc conditions prevail. With equal voltage drop across all four legs of this bridge, there is zero voltage across the motor leads 62 and so zero motive power. The coils 58 and 59 may be wound on the outer legs of a saturable transformer core 60, as shown in Figure 5.

An upsetting direct current coil 61 is connected in parallel to the valve operating solenoid coils 48 and 49, and is, therefore, energized from arc current voltage changes, from minimum to maximum value, with feeding current transformer changes, and also from minimum to maximum value, with feeding voltage circuit changes, a minimum value exists in the coil 61 when the

power in the coil 48 is equal to the power in the coil 49.

The upsetting direct current coil 61 is wound on the middle leg of the saturable transformer core 60, and inductively related to the associated bridge control coils 58 and 59, so that a variation of power in the direct current upsetting coil 61, will, by changing the transformer core magnetic load, so upset the voltage drop across the bridge leg coils 58 and 59, as to control the bridge power input to the motor 30. The speed of the motor and the driven pump is consequently always proportional to the degree of off balance of the desired arc control setting.

The arrangement described above thus uses the relatively small upsetting current in the coil 61 to control a substantially larger source of alternating current and apply it to the motor 30 which drives the pressure fed unidirectionally operated pump 27, which operating through the reversing valve 26, serves accurately and rapidly to raise or lower the electrode, through hydraulic means, at a speed proportional to the degree of arc off balance from the desired control setting.

It will be noted that this system has exceedingly low overall electrode moving inertia. The system employs a single direction small motor, which does not necessarily stop as a result of ordinary arc changes, thereby substantially reducing inertia problems. This system uses a low inertia back pressure feed to the pump intake, which requires the motor to only overcome friction plus the inertia of the electrode and its associated moving parts, in its speed control of the electrode movements.

The Hi-low pressure limit switch 25 shown in Figure 1 may be of any suitable form, although it preferably comprises a normally open single pole electrical switch. This switch is closed by either an excessively high oil pressure, such as may be occasioned by the electrode 12 reaching its "top" position, or by an unduly low pressure, such as may be occasioned in lowering an electrode when it "bottoms" or hangs accidentally in operation, or when the electrode arm weight is removed from the piston top as when the electrode comes all of the way down. Either extreme oil pressure condition serves to close a contact in switch 25, which is connected in series with a low voltage power circuit 25*a*, and is connected to the coil of a magnetic contactor 62. This contactor 62 is connected so as simultaneously to open the voltage circuit, and short out the current circuit instantly to render static all control apparatus, until an operator comes to correct the fault and re-start the control.

Any one of several means may be used to hand switch and raise or lower the electrode. This is desirable when preparing or charging the furnace. Such hand operation may be accomplished by means of a separate direct current power source, as shown at 63, with hand switches 64 for controlling power to the coils 48, 49 and 61.

The elements of the electrical system, except the limit switch 25, the motor 30, the transformer 42 and the solenoid coils 48 and 49, may be, and preferably are, mounted on a common panel 65, the excepted devices being connected in the system by suitable electrical conductor or cable means as indicated in Figure 1.

The control apparatus described herein fulfills its intended purpose efficiently and effectively and is characterized by simplicity and long life. It is essentially simple in design and can be manufactured at comparatively low cost.

It should be understood that the invention is not necessarily limited to the details herein set forth since the same may be modified and numerous changes made within the scope of the appended claims, without departing from the spirit or scope of the invention.

Having thus described the invention, what I claim as new and desire to secure by Letters Patent is:

1. Mechanism adapted to position an electric arc furnace electrode and comprising a cooperating cylinder and piston connected to move the electrode in opposite directions in response to delivery or withdrawal of a hydraulic medium to and from the cylinder, a storage tank for the hydraulic medium, a pump, means for driving the pump in one direction only, and cooperating valve means operable, in one position, to connect the intake and delivery side of the pump respectively with the storage tank and said cylinder, to deliver the medium to the cylinder and cause the electrode to move in one direction, said valve means being operable, in another operating position, to connect the intake and delivery sides of the pump respectively with the said cylinder and tank, to withdraw the medium from the cylinder and effect movement of the electrode in the opposite direction, the speed of electrode movement being controlled by the pump delivery rate.

2. Mechanism adapted to position an electric arc furnace electrode and comprising a cooperating cylinder and piston connected to move the electrode in opposite directions in response to delivery or withdrawal of a hydraulic medium to and from the cylinder, a storage tank for the hydraulic medium, a pump, means for driving the pump in one direction only, and cooperating valve means operable, in one position, to connect the intake and delivery side of the pump respectively with the storage tank and said cylinder, to deliver the medium to the cylinder and cause the electrode to move in one direction, said valve means being operable, in another operating position, to connect the intake and delivery sides of the pump respectively with the said cylinder and tank, to withdraw the medium from the cylinder and effect movement of the electrode in the opposite direction, and means to maintain the hydraulic medium in the storage tank at a selected pressure.

3. Mechanism adapted to position an electric arc furnace electrode and comprising a cooperating cylinder and piston connected to move the electrode in opposite directions in response to the delivery or withdrawal of a hydraulic medium to and from the cylinder, a storage tank for the hydraulic medium, a pump, motor means for driving the pump in one direction, cooperating valve means operable, in one operating position, to connect the tank to the said cylinder through said pump, to move the electrode in one direction, said valve being operable in another of its operating positions, to connect the cylinder through said pump to said tank, to withdraw hydraulic medium from the cylinder and effect movement of the electrode in the opposite direction, and control means for said motor means and responsive to arc heat value at the electrode for driving the pump at maximum speed when the position of the electrode is farthest from the position giving a desired arc heat value and at decreasing speeds as the position giving the desired arc heat value is approached.

4. Mechanism adapted to position an upstanding electric arc furnace electrode and comprising

mounting means for the electrode, a cooperating cylinder and piston connected to move the electrode vertically in opposite directions in response to the delivery or withdrawal of a hydraulic medium to and from the cylinder, a storage tank for the hydraulic medium, a pump, means for driving the pump in one direction only, cooperating valve means operable, in one operating position, to connect the tank to the said cylinder through the pump to deliver the medium at sufficient pressure to the cylinder to raise the electrode, said valve means, when in another of its operating positions, serving to connect the cylinder to the tank through the pump, to withdraw hydraulic medium from the cylinder and lower the electrode, and means responsive to arc heat value at the electrode for controlling the delivery rate of said pump in proportion to the degree that arc heat is off from a desired value, said liquid medium in the tank being under a pressure which serves as a counterbalance to the electrode and mounting means when the valve means is in either of its said operating positions.

5. Mechanism adapted to position an electric arc furnace electrode with mounting means therefor and comprising a cooperating cylinder and piston connected to move the electrode in opposite directions in response to delivery or withdrawal of a hydraulic medium to and from the cylinder, a storage tank for the hydraulic medium, a pump, variable speed motor means for driving the pump in one direction only, cooperating valve means operable, in one operating position, to connect the tank to the cylinder through the pump to deliver the hydraulic medium to the cylinder at sufficient pressure to move the electrode in one direction, said valve means, when in another operating position, serving to connect the cylinder with the tank through said pump to withdraw the hydraulic medium from the cylinder and move the electrode in the other direction, and means responsive to arc heat value at the electrode for controlling the speed of the motor means to maintain maximum speed, in either electrode direction, when the position of the electrode is farthest from the position giving a desired arc heat value, and to decrease motor speed as the position giving the desired arc heat value is approached, and to disable the motor when the position giving the desired arc heat setting is reached.

6. Mechanism adapted to position an electric arc furnace electrode with mounting means therefor and comprising a cooperating cylinder and piston connected to move the electrode in opposite directions in response to delivery or withdrawal of a hydraulic medium to and from the cylinder, a storage tank for the hydraulic medium, a pump, variable speed motor means for driving the pump in one direction only, cooperating valve means operable, in one operating position, to connect the tank to the cylinder through the pump to deliver the hydraulic medium to the cylinder at sufficient pressure to move the electrode in one direction, said valve means, when in another operating position, serving to connect the cylinder with the tank through said pump to withdraw the hydraulic medium from the cylinder and move the electrode in the other direction, means responsive to arc heat value at the electrode for controlling the speed of the motor means to maintain maximum speed, in either electrode direction, when the position of the electrode is farthest from the position giving a desired arc heat value, and to decrease motor speed as the position giving the desired arc heat value is approached, and to disable the motor when the position giving the desired arc heat setting is reached, and means to maintain the hydraulic medium on the intake side of the pump under a pressure which serves to counterbalance the electrode and mounting means when the valve means is in either of its said operating positions.

7. Mechanism adapted to position an electric arc furnace electrode with mounting means therefor and comprising a cooperating cylinder and piston connected to move the electrode in opposite directions in response to delivery or withdrawal of a hydraulic medium to and from the cylinder, a storage tank for the hydraulic medium, a pump, variable speed motor means for driving the pump in one direction only, cooperating valve means operable, in one operating position, to connect the tank to the cylinder through the pump to deliver the hydraulic medium to the cylinder at sufficient pressure to move the electrode in one direction, said valve means when in another operating position, serving to connect the cylinder with the tank through said pump to withdraw the hydraulic medium from the cylinder and move the electrode in the other direction, means responsive to arc heat value at the electrode for controlling the speed of the motor means to maintain maximum speed, in either electrode direction, when the position of the electrode is farthest from the position giving a desired arc heat value, and to decrease motor speed as the position giving the desired arc heat value is approached, and to disable the motor when the position giving the desired arc heat setting is reached, and gaseous pressure means for maintaining the hydraulic medium in the tank under a pressure substantially sufficient to counterbalance the electrode and mounting means when the valve means is in either of its said operating positions.

8. Mechanism adapted to position an electric arc furnace electrode with mounting means therefor and comprising a cooperating cylinder and piston connected to move the electrode in opposite directions in response to the delivery or withdrawal of a hydraulic medium to and from the cylinder, a storage tank for the hydraulic medium, a pump, a variable speed electric motor for driving the pump in one direction only, cooperating valve means operable, in one operating position, to connect the tank to said cylinder through the pump to deliver the medium at sufficient pressure to the cylinder to move the electrode in one direction, said valve means, when in another of its operating positions, serving to connect the cylinder to the tank through the pump to withdraw hydraulic medium from the cylinder and effect movement of the electrode in the opposite direction, electrical control means for the motor and responsive to arc heat value at the electrode whereby to drive the pump at a delivery rate proportional to the degree that the arc heat is off from desired value, and means for placing the liquid medium on the intake side of the pump under a sufficient pressure substantially to counterbalance the electrode and mounting when the valve means is in either of its said operating positions.

9. Mechanism adapted to position an upstanding electric arc furnace electrode and comprising a cooperating cylinder and piston connected to move the electrode vertically in opposite directions, a pump, means for driving the pump in one direction only, valve means to connect the

pump to deliver or withdraw a hydraulic medium to and from the cylinder to raise or lower the electrode, said valve means being operable, in one position, to deliver the pump forced medium to the cylinder to raise the electrode, and being operable, in another position, to allow the pump to withdraw the medium from the cylinder to lower the electrode, said valve means serving to block the cylinder from the pump so that the electrode cannot drift in its adjusted position when said valve means is in a neutral position, means normally urging said valve means toward said neutral position, and means responsive to variations in electrical conditions due to the electrode being off desired setting for moving the valve means to one or the other of said operating positions.

10. Mechanism adapted to position an upstanding electric arc furnace electrode and comprising a cooperating cylinder and piston connected to move the electrode vertically in opposite directions, a pump, an electric motor for driving the pump in one direction only, valve means to connect the pump to deliver or withdraw a hydraulic medium to and from the cylinder to raise or lower the electrode, said valve means being operable, in one position, to deliver the pump forced medium to the cylinder to raise the electrode, said valve means being operable, in another position, to allow the pump to withdraw the medium from the cylinder to lower the electrode, said valve means serving to block the cylinder from the pump so that the electrode cannot drift in its adjusted position when said valve means is in a neutral position, means normally urging said valve means toward said neutral position, and electrical control means responsive to displacement of the electrode from a desired setting for moving the valve to one or the other of said operating positions, said electrical control means serving to disable the pump motor when said valve means is in its neutral position.

11. Mechanism adapted to position an electric arc furnace electrode and comprising a movable mount for the electrode, cylinder and cooperating piston means connected with the mounting to support the same and the electrode thereon in adjusted position and to move the same in opposite directions in response to delivery and withdrawal of a hydraulic medium to and from the cylinder, a storage tank for the hydraulic medium, a pump, means for driving the pump in one direction only, valve means interconnecting the pump, cylinder and tank and comprising a sleeve-like casing and a piston valve mounted slidably in the casing, means normally urging the piston valve into a neutral position in the casing, said piston valve being movable in either direction in said casing from said neutral position, conduits connected, respectively, with said cylinder and tank and the casing, and pump inlet and discharge pipes connected to said casing, said piston valve being formed with passages therein positioned to place the conduits alternately in communication with said pipes when the piston valve is moved in one direction or the other from its neutral position, said piston valve being formed and adapted to block communication between the conduit, which connects the cylinder and the casing, and the pipes when said piston valve is in said neutral position.

12. Mechanism adapted to position an arc furnace electrode and comprising a movable mounting for said electrode, cylinder and cooperating piston means connected with the mounting to support the same and the electrode thereon in adjusted position and to move the same in opposite directions in response to delivery and withdrawal of a hydraulic medium to and from the cylinder, a storage tank for the fluid hydraulic medium, a pump and motor means for driving the same in one direction, valve means interconnecting the pump, cylinder and tank and comprising a sleeve-like casing and a piston valve slidably mounted in said casing, means normally urging the piston valve to a neutral position in said casing, said piston valve being movable in either direction in said casing from its neutral position, a tank conduit connecting said casing with said tank, a cylinder conduit connecting said casing with said cylinder, and intake and discharge pipes connecting the intake and discharge sides of said pump to said casing, respectively, on opposite sides of and equi-distant from the connections of said conduits to the casing, said piston valve being formed with fluid passageways disposed to make connection between the tank conduit and the intake pipe and between the cylinder conduit and the discharge pipe when the piston valve is shifted in one direction from the neutral position, and to connect the tank conduit with the discharge pipe and the cylinder conduit with the intake pipe when shifted in the other direction from said neutral position, said piston valve serving to seal the conduit between the cylinder and casing from said pipes when it is in its neutral position.

13. Mechanism adapted to position an electric arc furnace electrode and comprising a movable mount for the electrode, cylinder and cooperating piston means connected with the mounting to support the same and the electrode thereon in adjusted position and to move the same in opposite directions in response to delivery and withdrawal of a hydraulic medium to and from the cylinder, a storage tank for the hydraulic medium, a pump, means for driving the pump in one direction only, valve means interconnecting the pump, cylinder and tank and comprising a sleeve-like casing and a piston valve mounted slidably in the casing, means normally urging the piston valve into a neutral position in the casing, said piston valve being movable in either direction in said casing from said neutral position, conduits connected, respectively, with said cylinder and tank and the casing, and pump inlet and discharge pipes connected to said casing, said piston valve being formed with passages therein positioned to place the conduits alternately in communication with said pipes when the piston valve is moved in one direction or the other from its neutral position, said piston valve being formed and adapted to block communication between the conduit, which connects the cylinder and the casing, and the pipes when said piston valve is in said neutral position, said piston valve having a passage of such length and so arranged that, when the piston valve is in its neutral or blocking position, communication is established between the intake and discharge pipes.

14. Mechanism adapted to position an electric arc furnace electrode and comprising mounting means for the electrode, a cylinder and cooperating piston connected to move said mounting means and electrode in opposite directions, a fluid pump and motive means to drive the same in one direction, a storage reservoir for a hydraulic medium, and a flow control valve connected with said pump, reservoir and cylinder, said valve being positionable in one operating

position to connect the pump for delivery of the fluid medium from the reservoir to the cylinder to move the electrode in one direction, the valve being also positionable in another operating position to connect the pump for delivery of the fluid medium from the cylinder to the reservoir to effect shift of the electrode in the opposite direction, said valve being positionable in a neutral position to block delivery of the fluid medium to or from the cylinder whereby to prevent the electrode from drifting from an adjusted position, and means to maintain a desired counterbalancing back pressure on said medium at the reservoir connected side of said valve.

15. Mechanism adapted to position an electric arc furnace electrode and its mounting and comprising a cylinder and cooperating piston connected to move the electrode and its mounting in opposite directions, the storage tank for a hydraulic medium, a pump and motor means for driving the pump in one direction only, a flow control valve connected with said pump, tank and cylinder, said valve being operable, in one position, to deliver the hydraulic medium from the tank to the pump and from the pump to the cylinder in order to move the electrode in one direction, said valve being operable, in another position, to allow the pump to withdraw the medium from the cylinder and deliver the medium to the tank to effect shift of the electrode in the opposite direction, said valve serving, when in a neutral position, to block flow of the medium to and from the cylinder in order to hold the electrode in an adjusted position.

16. Mechanism adapted to position an electric arc furnace electrode and its mounting and comprising a cylinder and cooperating piston connected to move the electrode and its mounting in opposite directions, a storage tank for a hydraulic medium, a pump and motor means for driving the pump in one direction only, a flow control valve connected with said pump, tank and cylinder, said valve being operable, in one position, to deliver the hydraulic medium from the tank to the pump and from the pump to the cylinder in order to move the electrode in one direction, said valve being operable, in another position, to allow the pump to withdraw the medium from the cylinder and deliver the medium to the tank to effect shift of the electrode in the opposite direction, said valve serving, when in a neutral position to block flow of the medium to and from the cylinder in order to hold the electrode in an adjusted position, said valve comprising a sleeve-like casing and a piston slidably mounted in the casing, pipes connecting said casing to the cylinder and said tank, pump inlet and discharge pipes connected to said casing, said piston being formed with passageways therein connecting said pump inlet pipe with the tank connected pipe and said pump outlet pipe, with said cylinder connected pipe, when said piston is shifted axially in one direction to one operating position, said passageways serving to connect said pump inlet pipe with the cylinder connected pipe, and said pump outlet pipe, with the tank connected pipe when the piston is shifted axially in the opposite direction to another operating position, and means normally urging the piston to a neutral position wherein it serves to block fluid flow through said cylinder connected pipe.

17. Mechanism adapted to position an electric arc furnace electrode and its mounting and comprising a cylinder and cooperating piston connected to move the electrode and its mounting in opposite directions, a storage tank for a hydraulic medium, a pump and motor means for driving the pump in one direction only, a flow control valve connected with said pump, tank and cylinder, said valve being operable, in one position, to deliver the hydraulic medium from the tank to the pump and from the pump to the cylinder in order to move the electrode in one direction, said valve being operable, in another position, to allow the pump to withdraw the medium from the cylinder and deliver the medium to the tank to effect shift of the electrode in the opposite direction, said valve serving, when in a neutral position to block flow of the medium to and from the cylinder in order to hold the electrode in an adjusted position, means normally urging said valve toward its neutral position and control means responsive to electrical variation from desired electrode arc power conditions for moving the valve to a said operating position whereby to adjust the electrode to a position producing the desired arc power conditions.

18. Mechanism adapted to position an electric arc furnace electrode and its mounting and comprising a cylinder and cooperating piston connected to move the electrode and its mounting in opposite directions, a storage tank for a hydraulic medium, a pump and motor means for driving the pump in one direction only, a flow control valve connected with said pump, tank and cylinder, said valve being operable, in one position, to deliver the hydraulic medium from the tank to the pump and from the pump to the cylinder in order to move the electrode in one direction, said valve being operable, in another position, to allow the pump to withdraw the medium from the cylinder and deliver the medium to the tank to effect shift of the electrode in the opposite direction, said valve serving, when in a neutral position to block flow of the medium to and from the cylinder in order to hold the electrode in an adjusted position, means normally urging said valve toward its neutral position and control means responsive to electrical variation from desired electrode arc power conditions for moving the valve to a said operating position whereby to adjust the electrode to a position producing the desired arc power conditions, said control means being operable also to actuate the pump motor means at a speed proportional to the extent that arc power conditions vary from the desired conditions.

19. Mechanism adapted to position an electric arc furnace electrode and its mounting and comprising a cylinder and cooperating piston connected to move the electrode and its mounting in opposite directions, a storage tank for a hydraulic medium, a pump and motor means for driving the pump in one direction only, a flow control valve connected with said pump, tank and cylinder, said valve being operable, in one position, to deliver the hydraulic medium from the tank to the pump and from the pump to the cylinder in order to move the electrode in one direction, said valve being operable, in another position, to allow the pump to withdraw the medium from the cylinder and deliver the medium to the tank to effect shift of the electrode in the opposite direction, said valve serving, when in a neutral position to block flow of the medium to and from the cylinder in order to hold the electrode in an adjusted position, means

normally urging said valve to its neutral position, an electrical system for controlling the valve in response to conditions prevailing in the electrical arc comprising a pair of opposed solenoid coils operatively associated with said valve, circuit means to energize one coil in response to arc current conditions and the other in response to arc voltage conditions, whereby constituting said coils respectively as current and voltage responsive coils, said circuit means being adjustable to balance said solenoid coils when the arc is in a desired condition, said coils serving to shift the valve means to electrode raising or lowering position as the coil balance is disturbed by increase or decrease in arc current-voltage ratio.

20. Mechanism adapted to position an electric arc furnace electrode and its mounting and comprising a cylinder and cooperating piston connected to move the electrode and its mounting in opposite directions, a storage tank for a hydraulic medium, a pump and motor means for driving the pump in one direction only, a flow control valve connected with said pump, tank and cylinder, said valve being operable, in one position, to deliver the hydraulic medium from the tank to the pump and from the pump to the cylinder in order to move the electrode in one direction, said valve being operable, in another position, to allow the pump to withdraw the medium from the cylinder and deliver the medium to the tank to effect shift of the electrode in the opposite direction, said valve serving, when in a neutral position to block flow of the medium to and from the cylinder in order to hold the electrode in an adjusted position, means normally urging said valve to its neutral position, an electrical system for controlling the valve in response to conditions prevailing in the electrical arc comprising a pair of opposed solenoid coils operatively associated with said valve, circuit means to energize one coil in response to arc current conditions and the other in response to arc voltage conditions, thereby constituting said coils respectively as current and voltage responsive coils, said circuit means being adjustable to balance said solenoid coils when the arc is in a desired condition, said coils serving to shift the valve means to electrode raising or lowering position as the coil balance is disturbed by increase or decrease in arc current-voltage ratio, and means to actuate said pump motive means at a speed proportional to the extent that arc power conditions vary from the desired conditions.

21. Mechanism adapted to position an electric arc furnace electrode and its mounting and comprising a cylinder and cooperating piston connected to move the electrode and its mounting in opposite directions, a storage tank for a hydraulic medium, a pump and motor means for driving the pump in one direction only, a flow control valve connected with said pump, tank and cylinder, said valve being operable, in one position, to deliver the hydraulic medium from the tank to the pump and from the pump to the cylinder in order to move the electrode in one direction, said valve being operable, in another position, to allow the pump to withdraw the medium from the cylinder and deliver the medium to the tank to effect shift of the electrode in the opposite direction, said valve serving, when in a neutral position to block flow of the medium to and from the cylinder in order to hold the electrode in an adjusted position, said pump motive means comprising an electric motor and wherein said valve includes means normally urging the same towards neutral position, control means responsive to electrical variation from desired electrode arc power conditions for moving the valve to a said operating position whereby to adjust the electrode to a position producing the desired arc power conditions, and power supply means operable to actuate the pump motor at a speed proportional to the extent that arc power conditions vary from the desired arc conditions, said power supply means comprising a balanced bridge normally inoperative to energize the motor and including normally inactive upsetting means responsive to variation from desired arc power conditions for upsetting the balance of said bridge and conditioning the same to energize the motor at speeds proportional to the extent that arc power conditions vary from the desired conditions.

WILLIAM HARVEY PAYNE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
987,663	Wright	Mar. 21, 1911
1,692,771	Ferris	Nov. 20, 1928
1,711,565	Hatfield	May 7, 1929
1,952,265	Leland	Mar. 27, 1934
2,167,623	Britter	Aug. 1, 1939
2,192,778	Stacy	Mar. 5, 1940
2,209,565	Harris	July 30, 1940
2,276,511	Parsons	Mar. 17, 1942
2,278,480	Payne	Apr. 7, 1942
2,374,909	Williams	May 1, 1945