Aug. 26, 1930. L. TAGLIAFERRI 1,774,213

ELECTROMAGNETICALLY CONTROLLED HYDRAULIC GOVERNOR FOR ELECTRIC AND OTHER ARC FURNACES

Filed Dec. 12, 1928 3 Sheets-Sheet 1

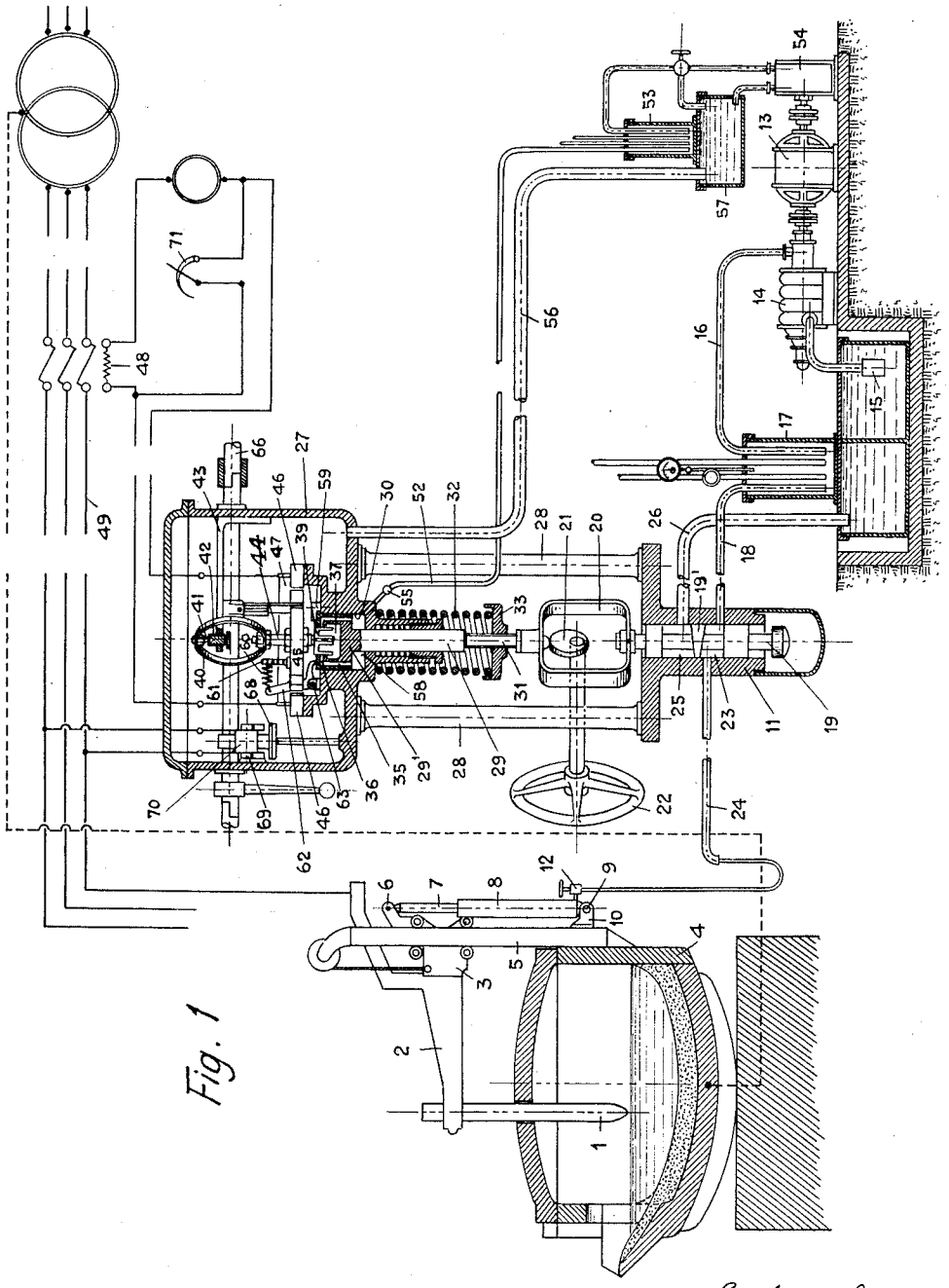

Fig. 1

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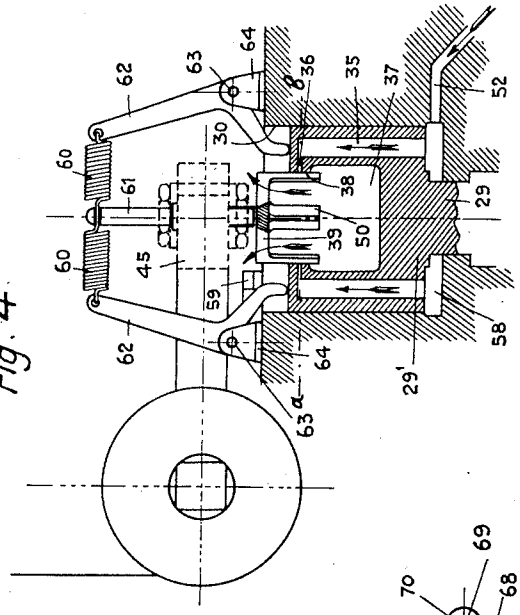


Fig. 4

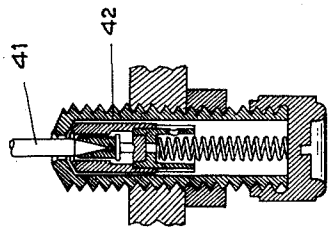


Fig. 3

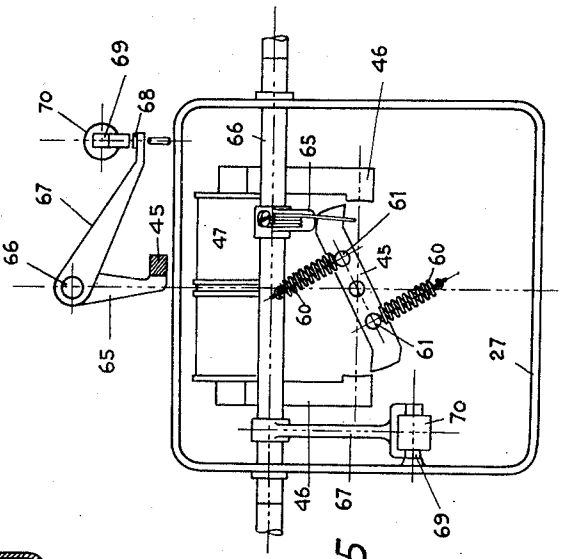


Fig. 5a

Fig. 5

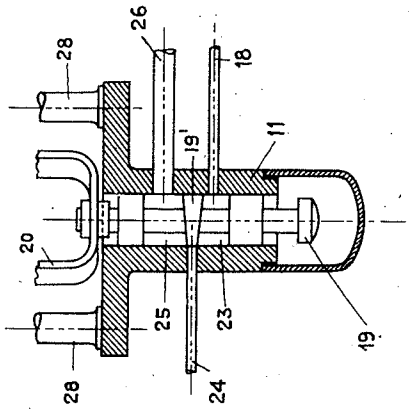


Fig. 2

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Fig. 7

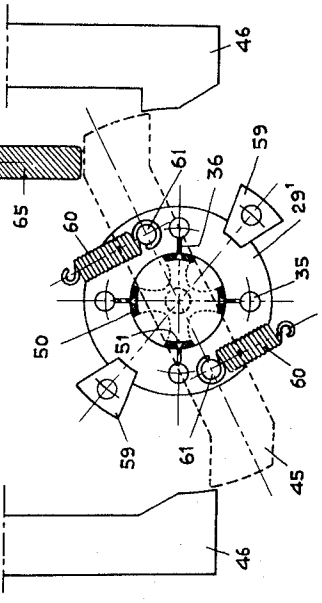



Fig. 8

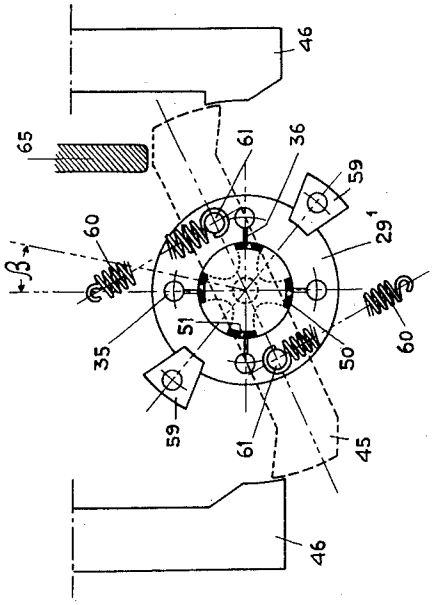
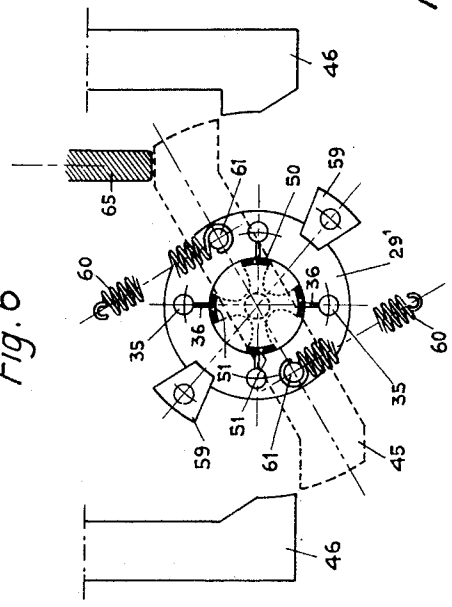



Fig. 6

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# UNITED STATES PATENT OFFICE

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## ELECTROMAGNETICALLY-CONTROLLED HYDRAULIC GOVERNOR FOR ELECTRIC AND OTHER ARC FURNACES

Application filed December 12, 1928, Serial No. 325,535, and in Germany December 12, 1927.

The present invention refers to an electromagnetically controlled hydraulic governor for electric arc furnaces.

In the known governors of this kind, on account of the instability of the arc the controlling means always enter into action too late so that considerable fluctuations of the load takes place in the current network which are liable to cause damage to the installation. In order to prevent the unavoidable peaks in the load exceeding a certain inadmissible limit, it has until now been necessary for the safety of the installation for the average current strength of the arc to be kept at a comparatively low value.

Moreover, the known governors, on account of their delicate construction are not suitable for the extremely rough service connected with the operation of an electric arc furnace. The object of the present invention is to remove these disadvantages and to provide a governor for furnaces having an arc, by means of which a quick and safe control is obtained and in which the automatic regulation is entirely independent of the manual control.

The invention is illustrated by way of example in the accompanying drawings in which:

Figure 1 shows a general arrangement of a governor according to the invention employed in connection with an electric furnace and a diagram of the electric conductors.

Fig. 2 is a sectional detail view of the water cylinder under pressure with vertical piston.

Fig. 3 is a sectional detail view of a known elastic suspension.

Fig. 4 is a vertical sectional middle view across the upper part of the differential piston with control valve on an enlarged scale.

Fig. 5 is a top view of the governor with the cover taken off.

Fig. 5[a] is a side elevation of an armature control shown in plan view in Fig. 5.

Figs. 6, 7 and 8 show different positions of the movable armature and of the control valve with a section along the line *a—b* in Figure 4.

In these figures 1 is the electrode of the electric furnace, fastened on the movable support 2, slidably fastened in its turn by means of the slide 3 upon a rail 5 secured to the furnace. Upon the slide 3 is jointly connected at 6 the piston 7 of the hydraulic lifting cylinder 8 which at its lower end is jointly connected at 9 upon the bearing 10 rigidly secured to the furnace. The hydraulic lifting cylinder 8 is single acting; the water under pressure coming from the control cylinder 11 enters the cylinder 8 through a cock 12.

The plant providing the water under pressure includes an electromotor 13, operating a rotary pump 14. This draws water from the receptacle 15 and forces it through the conduit 16 into the accumulator 17, into which projects one end of the water outlet pipe 18, the other end of which is connected with the hydraulic control cylinder 11

The accumulator 17 is provided for the purpose of damping the fluctuations in the pressure which may arise during the operation and also to allow the electrodes in the furnace to be still lifted should the pump 14 be put out of operation. In this case a non-return valve will be closed in the suction pipe of the pump and the electrode will be lifted by the pressure in the receptacle.

The distributing device for water under pressure or main servo-motor comprises a cylinder 11 within which moves the vertical piston 19 which can be displaced manually by the stirrup 20; the cam 21 and the hand wheel 22.

In the position indicated in the drawing, the distributing disc 19′ of the vertical piston 19 is in its extreme upper position: in this position of the piston the water, admitted through the pipe 18, after having passed the chamber 23, can pass to the pipe 24 and enters through the open cock 12 into the hydraulic lifting cylinder 8, so as to lift the piston and with it the electrode. By the rotation of the cam 21, the vertical piston is lowered under the pressure of the spring 32, until the distributing disc 19′ for a determined position, perfectly closes the inlet of the pipe 24, whereby the electrode becomes stationary. By further rotating the cam 21 the vertical piston 19 is moved further down,

so that the pipe 24 is put into communication through the chamber 25 with the discharge pipe 26. The piston 7 now descends under the weight of the electrode 1, the support 2 and the slide 3 and the water is discharged through the discharge pipe 26. The distributing disc 19′ of the vertical piston 19 is of wedge like shape. This shape is selected in order to obtain an increased sensitiveness for the regulating action and a considerable increase in the possibilities of regulating and this is obtained by a rotation of the piston within the cylinder when the apparatus is being assembled and adjusted initially and by maintaining the same pressure and the same axial position of the piston during the working of the apparatus.

The manual regulation is therefore simply effected by the rotation of the handwheel 22. 27 is a casing which is connected by the columns 28 with the hydraulic cylinder 11. 29 is a differential piston which passes through the bottom of the casing 27 and the thickened upper end 29′ of which moves within a cylindrical bore 30 in the bottom of the casing 27. 31 is a threaded shank of the differential piston, which is rigidly connected with the piece 20. 32 is a helical spring, which surrounds the differential piston and which bears at one end against the bottom of the receptacle 27 and at the other end against a disc 33 threaded upon the shank 31. The differential piston is therefore also rigidly connected with the vertical hydraulic piston. The head 29′ of the differential piston moves within the cylindrical bore 30 of the casing 27 and is supplied with a number of axially extending ports 35, each of which communicates through a small radially directed hole 36 with a chamber 37 in the interior of the head of the differential piston. In a cylindrical bore 38 (Figure 4) in the head of the differential piston is arranged the distributing valve 39 of the auxiliary distribution system so as to be rotatable through a small angle. The valve 39 is of special construction and is fastened by means of a ring 40, a point 41, a threaded pin 42 upon the bracket 43 fastened to the casing 27 by a resilient bearing of known construction as illustrated in Figure 3. Upon the shaft 44 of the valve 39 is arranged a movable armature 45, belonging to the electromagnet 46, the stationary armature of which is arranged on the casing 27. The winding 47 of the magnet is connected with the secondary circuit 48 of the transformer, the primary circuit of which is connected in series in the phase conductor 49, which connets the furnace feeding transformer with the electrode. Within the valve body 39 are arranged within the four axially running ribs 50, the longitudinal ports 51, each of which, in a certain position, as shown in Figure 7, registers with one of the radial holes 36 in the differential piston 29. At the lower end of the cylindrical bore 30 of the casing is provided an opening which communicates through a pipe 52 with the receptacle 53. In this receptacle there exists a certain over pressure to compensate for fluctuations in pressure and to allow, should the oil pump stop, the differential piston to be raised, whereby the electrode is also lifted by the servo-motor. The receptacle 53 is connected with the oil pump 54 operated in its turn by the motor 13. If the longitudinal grooves 51 of the valve 39 are in register with the radially extending holes 36 in the differential piston 29, the oil from the pump 54, which may be conveniently regulated in quantity by the adjustment of the cock 55, can flow into the interior of the casing 27 and return by the discharge pipe 56 into the oil receptacle 57 connected with the oil pump 54. As by means of this connection no oil pressure can be generated in the chamber 58, the spring 32 keeps the differential piston in its lowest position; it is understood that when the automatic control is to be used the cam 21 will have to be turned to a position which is displaced through 180° with respect to the position shown in the drawing.

By the rotation of the valve 39 through a small angle the ribs 50 are brought into a position in which they close the radial holes 36 in the differential piston. As the oil is now prevented from passing out, it is collected in the chamber 58 and presses on the head of the differential piston. This overcomes the force of the spring 32 and the piston is lifted for such an amount as to push against the stops 59 which limit the upper extreme position of the differential piston. The rotation of the valve 39 which is rigidly connected with the movable armature 45 of the electromagnet is produced by the varition in the intensity of magnetic force in the armature, this flux density being proportional to the current strength in the conductor which leads the current from the transformer to the furnace. 60 are two helical springs symmetrically arranged with respect to the axis of the movable armature 45, which springs by exerting a tangential opposite effort on this armature, prevent the formation of friction between the contact surfaces of the valve 39 and the differential piston 29. These springs are directly connected at one end with the movable armature 45 by means of pins 61 and at the other end with a bell crank lever 62 which has its fulcrum at 63 upon the bracket 64 and the shorter arm of which bears against the upper surface of the differential piston. This lever arrangement has for its object to hold the movable armature 45 against the end of the lever 65 and also to control the hunting oscillations of the controlling parts.

In the inoperative condition, that is to say in the condition in which the furnace is not

connected to the source of supply, the movable armature 45, as illustrated in Figures 5 and 6 bears under the effect of the opposite springs 60 against the end of a lever 65, which is fastened upon the shaft 66 supported on the casing 27. Upon the shaft 66 is also fastened a lever 67 on the end of which is provided the movable armature 68 which belongs to the electromagnet 69, the winding 70 of which is connected across the supply conductors of the furnace. If the installation should remain without tension, that is to say, is placed in the zero tension condition, it will be necessary that the electrodes are lifted from the metal bath. In this case the armature 68 drops from the tensionless electromagnet 69 and provocates the movement of the lever 65, so as to allow to the armature 45 to be displaced as shown in Fig. 6 and to close the oil passage. In Figure 6 is indicated the position of the movable armature 45 for which the furnace and therefore the two electromagnets are without current. In this position of the armature the grooves 51 of the valve 39 do not register with the radial holes 36 in the differential piston and the armature 45 bears against the end of the lever 65. If the pump 54 is now put into operation, pressure is produced in the chamber 58 by the admission of oil, which pressure lifts the differential piston and with it the vertical piston of the main servo-motor. As soon as the furnace is connected to the supply, the armature 68 is attracted by the electromagnet 69. The lever 65 displaces the armature 45 into the position shown in Figure 7, for which the grooves 51 of the valve 39 register with the radial holes 36 in the differential piston. The latter drops and with it the electrode until the electrode touches the charge formed.

The electromagnet 46 is now energized and the movable armature 45 and the valve 39 will rotate under the influence of the magnetic attraction, for instance through an angle B and the parts will then occupy the position shown in Figure 8.

In this position of the movable armature 45 the grooves 51 in the valve 39 no longer register with the radial holes 36 in the differential piston. Pressure is again produced under the piston, whereby the admission of water under pressure takes place in the hydraulic lifting cylinder, thus lifting the electrode to strike the arc.

As the lifting of the electrode continues the length and therefore the resistance of the arc are increased; the current strength decreases, whereby the movable armature 45 under the influence of the springs 60 returns to its original position shown in Figure 7.

During the practical operation of the installation a certain condition of equilibrium is established between the current strength and the position of the armature, so that the vertical piston 19 is only displaced by a small amount from its middle normal working position and only rarely reaches its extreme positions in which the maximum admission and discharge of water occurs. In these extreme positions the most rapid regulating action for the arc can occur, as the water in the completely open pipes will assume the highest speed.

The feed device is so established that one pump is sufficient for the water feed and one for feeding the oil to feed at the same time the three electrodes of three phase current furnaces.

A regulating resistance 71 is connected in parallel with the winding 47 of the electromagnet 46 in order to enable the current strength to be regulated within the wide limits on which the automatic governor has to work.

I claim as my invention:

1. Arc furnace comprising in combination, an electrode, an electric circuit for said electrode, a liquid pressure operated servo-motor to produce the motive-power for said electrode, said servo-motor comprising a vertical cylinder, a recessed vertical piston valve with a wedge-like distributing disk between the end disks so as to operate upon movement the increasing pressure supply to the lifting cylinder, the maintainment of the pressure supply or the pressure discharge, a spring pressed stem rigidly attached to the said piston valve, a hand-controlled cam coacting with abutment means rigidly connected with said stem so to axially displace the piston valve, a hollow differential piston body attached to the upper end of said stem, passages in this body leading axially from its bottom and then radially to a valve seat, a suspended distribution valve placed in the cavity of the piston body and in correspondence with said seat and provided with longitudinal grooves which can be made to register with the radial holes of the piston, a cylinder body for the said piston body, a tight casing in which the top end of said cylinder opens, a feed pipe for an auxiliary pressure fluid opening into the bottom part of said cylinder, a fluid discharge pipe opening into the tight casing connected with the cylinder body and automatically electrically controlled means for varying the angular position of the said distributing valve, so that a small angular displacement thereof is sufficient to alternatively establish or check the passage of the said auxiliary pressure liquid.

2. Arc furnace comprising in combination, an electrode, an electric circuit for said electrode, a liquid pressure operated servo-motor to produce the motive power for said electrode, said servo-motor comprising a vertical cylinder, a recessed vertical piston valve having end disks and a wedge-like distributing disk between the end disks thereof, a pressure pump, a pressure accumulator in-

serted in the motive power fluid of the electrode, a spring pressed stem rigidly attached to the piston valve, a hand controlled rotating cam coacting with a stirrup rigidly connected with said stem, a hollow differential piston body attached to the upper end of said stem, said body having ports leading axially from its bottom and then radially to a valve seat of a yieldable suspended distribution valve placed in the cavity of the piston body and in correspondence with said seat and provided with longitudinal grooves adapted to register with the radial portions of the ports, a cylinder body for the said piston body, a tight casing in which the top end of said cylinder opens, a feed pipe for an auxiliary pressure fluid opening into the bottom part of said cylinder, a fluid discharge pipe opening into the tight casing connected with the cylinder body, a pressure pump and a pressure accumulator inserted in the auxiliary pressure fluid circulation, a movable armature of an electromagnet symmetrically arranged and carried by the suspended distribution valve, in which the winding of the magnet is connected with the secondary circuit of the transformer, the primary circuit of which is connected in series with the furnace feeding phase conductor.

3. Arc furnace comprising in combination, an electrode, an electric circuit for said electrode, a liquid pressure operated servomotor to produce the motive power for said electrode, this servo-motor comprising within a vertical cylinder a recessed vertical piston valve having end disks, a wedge-like distributing disk between the end disks of the piston, a pressure pump and a pressure accumulator inserted in the motive power fluid of the electrode, a spring-pressed stem rigidly attached to the piston valve, a hand controlled rotating cam coacting with a stirrup rigidly connected with said stem, a hollow differential piston body attached to the upper end of said stem, passages in this body leading axially from its bottom and then radially to a valve seat of an elastically suspended distribution valve placed in the cavity of the piston body and in correspondence with said seat and provided with longitudinal grooves adapted to register with the radial passages of the piston, a cylinder body for the said piston body, a tight casing in which the top end of said cylinder opens, a feed pipe for an auxiliary pressure fluid opening into the bottom part of said cylinder, a fluid discharge pipe opening into the tight casing connected with the cylinder body, a pressure pump and a pressure accumulator inserted in the auxiliary pressure fluid circulation, a movable armature of an electromagnet symmetrically arranged and carried by the suspended distribution valve, two opposite helical springs symmetrically arranged with respect to the axis of the movable armature which are in equilibrium for a determined current strength, with the attractive force exerted on the armature by the magnetic flux of force, the armature when under no voltage adhering against a movable stop at closed passage of the auxiliary liquid, whereby by the insertion of the tension of the current the armature secures the opening of the passage and during fluctuations of current the valve is alternatively displaced from the open to a new closed position and vice versa.

4. Arc furnace comprising in combination, an electrode, an electric circuit for said electrode, a liquid pressure operated servomotor to produce the motive power for said electrode, this servo-motor comprising a vertical cylinder, a recessed vertical piston valve having end disks, a wedge-like distributing disk between the end disks of the piston for increasing the sensitiveness of regulation, a pressure pump and a pressure accumulator inserted in the motive power fluid of the electrode, a spring pressed stem rigidly attached to the piston valve, a hand controlled rotating cam coacting with a stirrup rigidly connected with said stem, a hollow differential piston body attached to the upper end of said stem, passages in this body leading axially from its bottom and then radially to a valve seat of an elastically suspended distribution valve placed in the cavity of the piston body and in correspondence with said seat and provided with longitudinal grooves which can be made to register with the radial holes of the piston, a cylinder body for the said piston body, a tight casing in which the top end of said cylinder opens, a feed pipe for an auxiliary pressure fluid opening into the bottom part of said cylinder, a fluid discharge pipe opening into the tight casing connected with the cylinder body, a pressure pump and a pressure accumulator inserted in the auxiliary pressure fluid circulation, a movable armature of an electromagnet symmetrically arranged and carried by the suspended distribution valve, two opposite helical springs symmetrically arranged with respect to the axis of the movable armature attached at one end to said armature and at the other ends each to the arm of a bell crank lever, the other arm of which presses against the upper face of the differential piston with the objects of holding the movable armature against the end of a lever and also controlling the hunting oscillation of the controlling parts.

5. Arc furnace comprising in combination, an electrode, an electric circuit for said electrode, a liquid pressure operated servomotor to produce the motive power for said electrode, said servo-motor comprising a pressure pump and a pressure accumulator inserted in the motive power fluid of the elec-

trode, a spring pressed stem rigidly attached to the piston valve, a hand-controlled rotating cam coacting with a stirrup rigidly connected with said stem, a hollow differential piston body attached to the upper end of said stem, passages in this body leading axially from its bottom and then radially to a valve seat of an elastically suspended distribution valve placed in the cavity of the piston body and in correspondence with said seat and provided with longitudinal grooves which can be made to register with the radial holes of the piston, a cylinder body for the said piston body, a tight casing in which the top end of said cylinder opens, a feed pipe for an auxiliary pressure fluid opening into the bottom part of said cylinder, a fluid discharge pipe opening into the tight casing connected with the cylinder body, a pressure pump and a pressure accumulator inserted in the auxiliary pressure fluid circulation, a movable armature of an electromagnet symmetrically arranged and carried by the suspended distribution valve, two opposite helical springs symmetrically arranged with respect to the axis of the movable armature attached at one end to said armature and at the other ends each to the arm of a bell crank lever, the other arm of which presses against the upper face of the differential piston with the objects of holding the movable armature against the end of a lever and also controlling the hunting oscillation of the controlling parts, a movable stop operated by the movable armature of an electromagnet, the windings of which are in connection with the tension of the installation that if the furnace is without voltage the stop keeps the movable armature of the passage controlling valve in an open position, thus lifting the electrode, and if the furnace is put under voltage the armature of the zero voltage electromagnet displaces the movable armature of the passage controlling valve into a closed position so as to lower the electrode.

In testimony whereof I have signed my name to this specification.

LEONE TAGLIAFERRI.