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MEANS FOR AUTOMATICALLY ADJUSTING ARC FURNACE ELECTRODES

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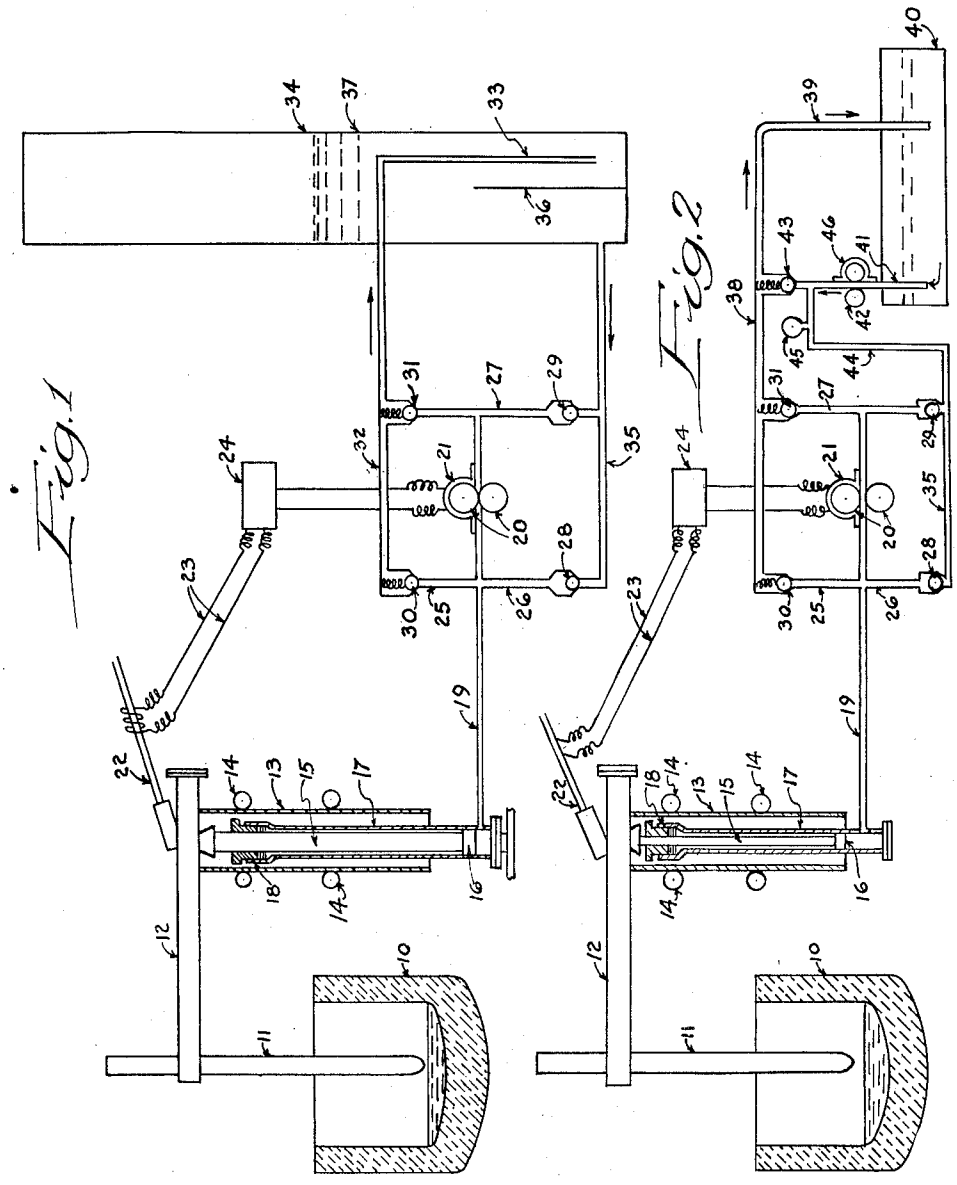


Fig. 1

Fig. 2

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MEANS FOR AUTOMATICALLY ADJUSTING ARC FURNACE ELECTRODES

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1 Claim. (Cl. 314—61)

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This invention is directed to means employing a liquid medium under pressure for raising and lowering an arc furnace electrode in response to variations in the length of the arcing gap, occasioned by the melting down of scrap or other materials within the furnace. Resulting effects require instant readjustment of the electrode to the normal arcing position in order to maintain substantial uniformity in the power input to the electrode under conditions which are well understood in the art, but which are set forth in full detail in my Patent No. 2,296,734, issued September 22, 1942, while the present invention also embodies certain of the principles defined in my Patent No. 2,258,468, issued October 7, 1941. However, the present invention involves numerous features of improvement over the patent last mentioned in that the whole structure is much simplified, and the counterbalancing pressure more directly and advantageously applied, with resulting reductions in weight and cost of building and maintainance, and increased reliability in operation.

In the means here involved, I impart to a column of liquid, preferably oil, a constantly maintained pressure which exerts a lifting thrust on the piston or equivalent means, which, when supplemented, acts directly to raise or lower the mounting for the electrode. This constantly maintained pressure, being insufficient, unless augmented to overcome the weight of the electrode and its mounting, serves however as a substantial counterbalance therefor, so that a relatively slight addition thereto will cause the electrode-arm combination to be moved. Means are therefore provided for augmenting this lifting effect in immediate response to variations in the electrical power input, which variations are instantly reflected in the operation of a reversible motor driven metering pump, which in turn augments the normal counterbalancing pressure to the degree and for the period required to lift the electrode to the extent necessary to reestablish normal arcing conditions, or, as occasion requires, reverses the action to cause lowering of the electrode by gravity where the augmented pressure is withdrawn.

The employment of an incompressible liquid column, under constant counterbalancing pressure close to that required to effect moving of the electrode and its mountings, enables a prime mover, such as a reversible motor of small power, to be employed for the operation of a metering pump which is thus required only to augment the pressure sufficiently to overcome the differential,

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thus reducing inertia to a minimum and speeding a prompt response to variations in current conditions requiring a readjustment of the electrode. Since almost instant reversals of the motor and pump are required at frequent intervals to prevent "hunting" or lag in the sequence of operations and to keep the adjustments of the electrode in step with current conditions, it is of major importance to reduce inertia to a minimum and to simplify the scheme of operations as much as possible. It is also important to regulate the speed of the motor and pump in ratio to the extent to which the arcing gap deflects from its normal length so that the speed of its return will progressively diminish as it approaches its normal position, and it is likewise important to maintain uniformity in the action of the apparatus regardless of the burning away of the electrode which depletion may result in variations of as much as thirty percent (30%) in the weight of the electrode and its mountings. These factors render it important to employ a metering pump which will at all times maintain a flow of oil in direct ratio to the speed of the motor which latter will accurately reflect the degree of maladjustment of the electrode and vary its speed in ratio thereto. Thus a reversing prime mover unit may properly be called a meter motor because it meters and controls the electrode movement and speed through power applied to it in direct proportion to power input through its electrode. The present invention conforms fully to the above conditions and requirements.

Further details will be apparent from the following description in conjunction with the accompanying drawing, wherein:

Figure 1 is a diagram illustrating one form of apparatus embodying the present invention; and

Figure 2 is a similar diagram illustrating an alternate form of apparatus.

Referring to Fig. 1, an electric furnace 10 is provided with an electrode 11 carried by an arm 12 mounted upon a frame 13 vertically adjustable between guide rollers 14. The arm is acted upon by a thrust rod 15 having at its lower end a piston 16 operable within a cylinder 17. The thrust rod is preferably of a diameter closely approximating the internal diameter of the cylinder, so that only a narrow clearance is afforded between the two. The cylinder is closed at its upper end by a packing gland 18, and the nature of the present invention is such that the piston itself need not be provided with packing rings or the like, since the easily accessible packing at the upper end of the cylinder will pre-

vent the escape of any appreciable quantity of oil or equivalent liquid. Oil is supplied to the lower end only of the cylinder through a main duct 19 which is fed toward the cylinder or drawn away therefrom, as occasion requires, by the action of a metering pump 20, such, for instance, as a close fitting gear pump, which acts to meter the oil through in the required direction without appreciable leakage and at a computed rate, so that the action of the pump, both as to the direction of flow imparted to the oil and the amount delivered, will bear direct ratio to the speed imparted to the gears or equivalent metering elements.

The pump in the present instance is driven by a prime mover in the form of a reversible electric motor 21, the speed of which, in either direction, will be controlled by the degree of readjustment required to bring the electrode to its normal arcing position. Such control of the motor is effected by means which are instantly responsive to variations in the power input supplied to the electrode through electrical cables 22 which, through suitable apparatus of known character, including a control circuit 23 and control appliances 24, will energize the motor 21 in proportion to arc changes of the electrode. Such devices may be responsive to changes in voltage or amperage, or various combinations of these two factors and further description thereof is deemed unnecessary.

The main duct 19 connects with a valve assembly which is shown diagrammatically, and which includes lateral ducts 25 and 26 and a cross header 27, all of which are in communication with the main duct. The lateral duct 26 and the adjacent end of the cross header are provided with check valves 28 and 29, respectively, and the lateral duct 25 and adjacent end of the cross header are provided with relief and load valves 30 and 31, respectively. The relief and load valves are normally closed by springs having a tension slightly in excess of the normal operating pressure in the pipe 19. Relief and load valves 30 and 31 communicate with an oil return pipe 32 terminating in a down-turned elbow 33 which discharges near the bottom of a normally closed and sealed oil pressure tank 34. A supply pipe 35 leads from the base of the tank and communicates with the lateral pipe 25 and header 27 through check valves 28 and 29, respectively. A baffle plate 36 extends upwardly from the base of the tank between the end of the return elbow 33 and the supply pipe 35. Within the tank is a body of oil 37 under pressure of a volume of gas (preferably air) which is trapped in the upper part of the tank and which constantly acts upon the column of oil exerting an upward thrust against the piston and thus acting as a constant partial counterbalance against the weight of the electrode and its mountings.

For an apparatus of normal standard size a differential of approximately thirty (30) pounds between the down-thrust on the piston occasioned by the weight of the electrode and mountings and the up-thrust against the underside of the piston is deemed satisfactory, it being understood that the weight should be sufficient only to ensure a prompt lowering of the electrode when augmented pressure is being withdrawn and the constant pressure only is effective, due account being taken of the fact that the aggregate load will vary within limits due to the progressive depletion of the electrode.

With the apparatus above described the method involved in regulating the arcing gap is as follows: Under normal arcing conditions the mountings for the electrode will stand stationary with a column of oil under pressure trapped within the pipe 19, and with back-flow prevented by the check valve 28, the metering pump 20 and the load valve 31, which latter should be loaded to a degree in excess of the assumed thirty (30) pounds preponderant weight on the top of the piston, as, for instance, a loading of thirty-five (35) pounds.

In the event the normal arcing gap is reduced and a prompt lifting of the electrode is required, the control appliances will instantly respond and impart an infeeding rotation to the motor and metering pump which will increase the pressure in the liquid column causing additional oil to enter through check valve 29 to the intake side of the pump, so that the weight of the electrode and mountings will be overcome and the piston will rise until the approach and final restoration of normal arcing conditions slows down and finally stops the operation of the motor. Conversely, if an abnormal increase in the length of the arcing gap requires a lowering of the electrode, the motor and pump will be reversely operated and the pressure lowered by withdrawing a measured quantity of oil through pipes 19 and 27 and through relief valve 31 to the tank 34, and this action will continue until normal arcing conditions have been reestablished and the motor stopped, which will trap the column of oil acting on the piston since the incompressible oil will act to positively block further movement.

The operations above described will occur in almost instantaneous accord with variations in the power input and no lag will be occasioned by the employment of such devices as electrically controlled valves which are objectionable for the reason that the necessary valve overlap in other types of apparatus requires a preliminary readjustment before the valve begins to act effectively with a corresponding lag in the readjustment of the electrode itself, which is highly objectionable. Furthermore, an electrically operated valve in the present art is not a metering device since the weight and friction of the electrode and support combination constitutes a substantial variable factor so that a controlled variation in the valve aperture does not accurately control the adjustment of the electrode. The use of a pump which meters oil in direct relation to power input through its direct connection with a variably speeded reversible motor or the like overcomes these objections, and by maintaining the oil or equivalent liquid under constant pressure as a partial counterbalance and by the employment of gas (air) of negligible inertia as the pressure medium, a small motor and pump of low inertia may be employed which permits sudden reversals and prompt response to conditions in the power input.

The form of apparatus shown in Fig. 2 conforms in principle of operation to that previously described but is particularly designed for use in circumstances which render undesirable the employment of a closed system under air pressures which may be safely maintained to afford the partial counterbalancing effect which permits the use of a small motor. The use of a gaseous medium also requires the employment of a special pressure surge tank 34 and a relatively large piston and cylinder because of the relatively low oil pressures which are limited by the air pressure in the tank. In Fig. 2 the maintainance of

a constant counterbalancing pressure is maintained, not by the provision of a volume of confined gas in a closed tank, but by the impulsion of a constantly operating pressure pump unit which produces a like effect on the column of oil. In the main, the apparatus is identical with that first described, insofar as concerns the location and operation of the metering motor and pump, and check, relief and load valves, but in place of the pipe **33** and tank **34**, the following equipment is provided.

The return pipe **32** is carried beyond the load valve **31** in the form of an extension **38** terminating in a downturned elbow **39** opening near the base of an open oil tank **40**. A supply pipe **41** leads upwardly from the tank through the constantly operating pump **42** and makes connection with the pipe **38** through the relief valve **43**. Oil under constant pressure from the pump **42** is admitted to supply the pipe **35** through the branch pipe **44** provided with a gauge **45**. A constantly operating motor **46** operates the pump to force oil into the pipe **44** and thus maintain the column of oil which acts on the piston under constant pressure approximating, but not equalling, the weight of the electrode and the mounting therefor. Since the motor **46** is constantly operating in one direction only it may be of any required size and power to maintain the necessary constant uniform pressure on the oil, since problems attending the instant reversal of the motor **21** and the need for reducing inertia to a minimum have no bearing on the operation of the pressure motor **46**.

In this form of apparatus the oil under the constant pressure of the motor **46** (in lieu of the gas confined within the tank **34**) will, when supplemented by the feeding action of the motor **21**, serve to overcome the weight of the electrode and mountings and thus impart a lifting effect in amount and during the time required to reestablish normal arcing or conversely lower the electrode by a reversal of these operations. As the piston is lowered the excess of oil will be forced back through the pipes **19** and **27** and load valve **31**, and through the pipes **38** and elbow **39** to the tank **40**. This arrangement permits the use of a relatively small piston and cylinder and avoids the safety hazard which might attend the use of a large surge tank under the pressure of a constantly confined gas.

In each of these constructions provision is made for the idle circulation of oil through the system in the event the piston reaches the limit of its up or down travel while the motor **21** continues to operate. In such event on the upstroke of the piston, the continued feeding action of the pump would cause the relief valve **30** to open, thereby maintaining an oil flow through the pipe **32**, elbow **33**, pipe **27** and check valve **29**, back to the pump. On the downstroke of the piston, if the pump continued its reverse movement, the circulation would be maintained through the pipe **27**, load valve **31**, pipe **32** and elbow **33** (or the pipe **38** and elbow **39** in Fig. 2), and thence from the oil tank **34** (or **40**) and back through the check valve **28** to the pump. Thus adequate provision is made to permit the pump to operate in either direction without permitting the current flow to be blocked to an extent which would jam the pump and stall the motor.

By subjecting the column of oil or equivalent liquid to a constant pressure applied directly to the column itself, either by a trapped body of gas or by mechanical pumping effect, the employment of massive counterweights of high inertia is avoided and at the same time only a small differential in pressure is necessary to effect moving of the electrode so that mechanical and electrical complications are reduced to a minimum, and prompt and accurate adjustments of the electrode in close step with variations in the arcing gap are insured.

It will, of course, be understood that in all cases where a gaseous medium is referred to, the same will ordinarily be air under pressure and that where oil is mentioned water or any liquid equivalent may be employed which serves to maintain a substantially incompressible column for imparting movements to a piston or equivalent mechanism for imparting the required movements to the structure which carries the electrodes. It will also be understood that the two examples of mechanism here illustrated and described serve merely to exemplify the principles involved in the present electrode adjusting means, and that the same may find embodiment in structures involving numerous variations in the location and details of the operating parts.

I claim:

An electric arc furnace comprising a vertically movable mounting, an electrode carried by the mounting and provided with means for supplying it with electric power input, a liquid column and telescopic confining means therefor positioned to support the mounting, a source of liquid, a conduit between the source and the liquid, a reversible rotary metering pump connected to the conduit and adapted when driven in one direction to supply liquid from the source to the column in order to augment the latter and effect raising of the mounting and electrode and when driven in the opposite direction to remove liquid from the column and thereby effect lowering of said electrode, means for driving the pump in either direction, controlled automatically in response to variations in said electric power input, and means for maintaining the liquid in the portion of the conduit between the source and the metering pump under substantially constant pressure of said magnitude as substantially to counterbalance the weight of the mounting and electrode, said last mentioned means consisting of a power driven pump in said portion of the conduit and an open-ended branch conduit leading from the conduit at a point between the last mentioned pump and the metering pump and having a pressure responsive relief valve therein.

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