Oct. 8, 1968 M. SIVET 3,405,219

TILT RESPONSIVE AND WEIGHT RESPONSIVE MEANS TO PROTECT ARC FURNACE ELECTRODES FROM ACCIDENTAL BREAKAGE

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FIG. 3

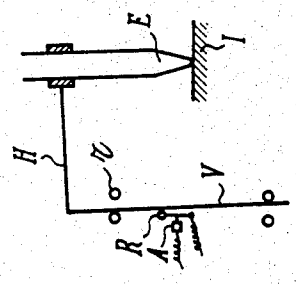


FIG. 6

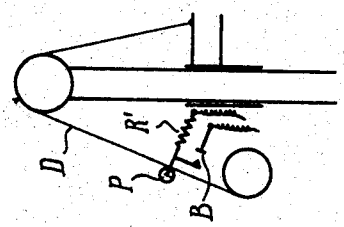


FIG. 2

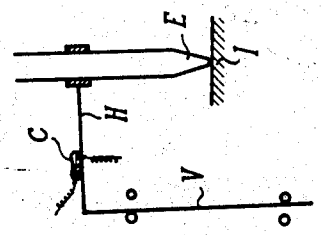


FIG. 5

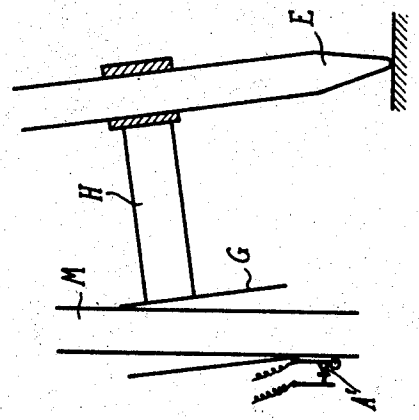


FIG. 1

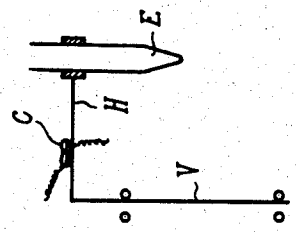
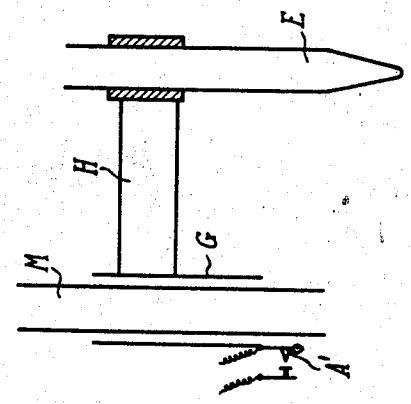


FIG. 4



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Fig. 7

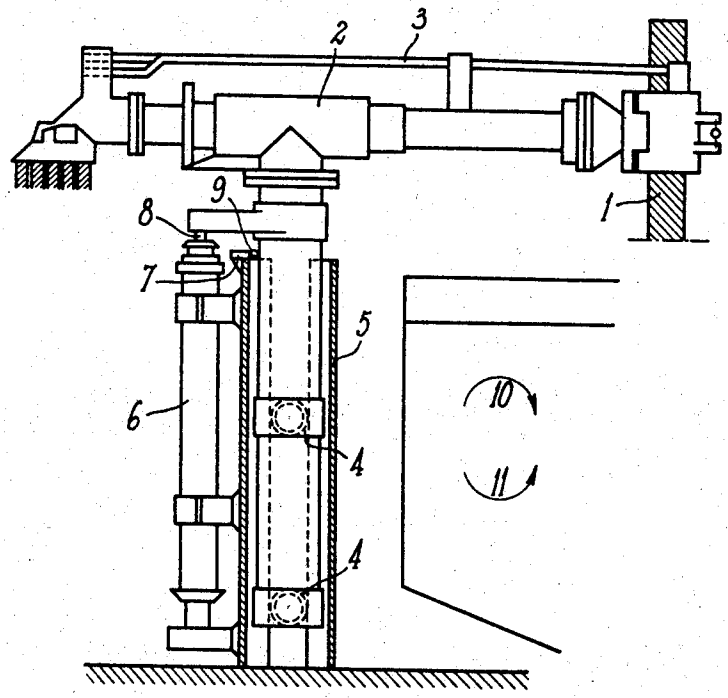
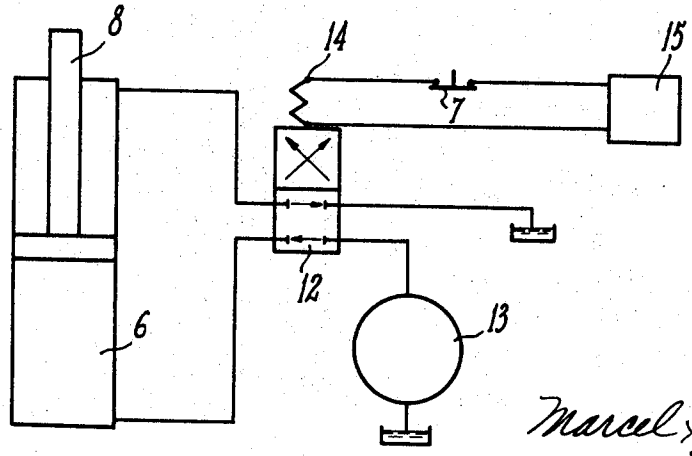


Fig. 8



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Fig. 9

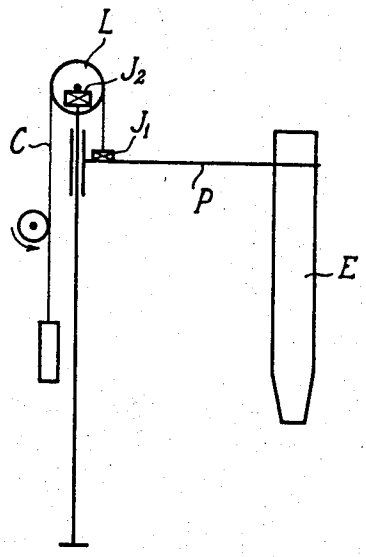
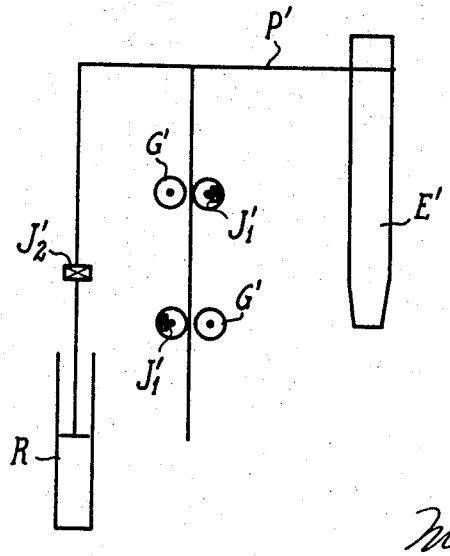


Fig. 10



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TILT RESPONSIVE AND WEIGHT RESPONSIVE MEANS TO PROTECT ARC FURNACE ELECTRODES FROM ACCIDENTAL BREAKAGE

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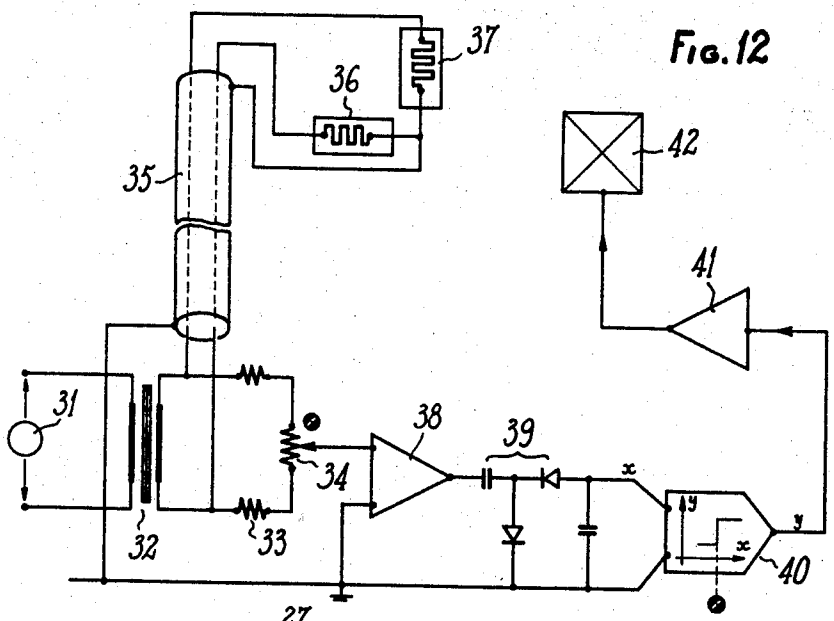


Fig. 12

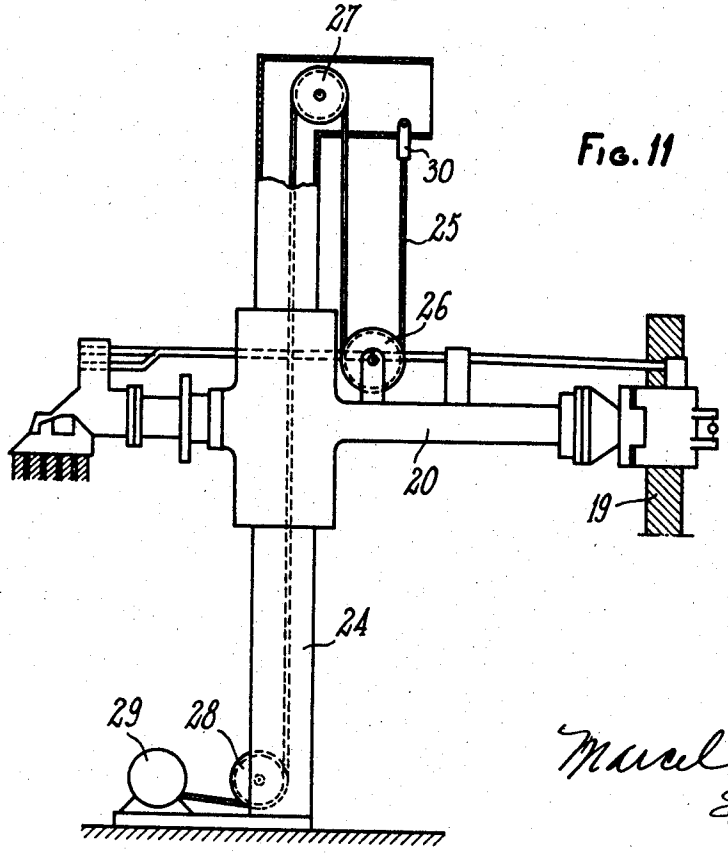


Fig. 11

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3,405,219

TILT RESPONSIVE AND WEIGHT RESPONSIVE MEANS TO PROTECT ARC FURNACE ELECTRODES FROM ACCIDENTAL BREAKAGE

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Claims priority, application France, Jan. 15, 1964, 960,377; Sept. 22, 1964, 988,868
11 Claims. (Cl. 13—1)

ABSTRACT OF THE DISCLOSURE

An automatic device for protecting electrodes against accidental breakage in a steel melting arc furnace by detecting when an electrode contacts an insulating solid body. Means having an electrode holder arm is provided for mounting the electrode. Such means are movable when the electrode strikes an insulating solid body in the furnace to a tilting or vertical position and an electrical contact or stress gauges are operated by said means upon movement of said means when said electrode presses against an insulating solid body, whereby a warning signal may be triggered, the power feed cut off to the furnace or an automatic regulation device activated to move said electrode.

It is known that when one compares, from the economic angle the various steel melting processes, the cost of the calories to be supplied to the metal is the greatest disadvantage which is opposed to the electric furnace which on the other hand exhibits considerable metallurgical advantages.

It is less known that the price of the graphite electrodes which are consumed during the melting and refining of steel represent about as much as one-third of the total cost of these calories.

The electrodes consumption of a given arc furnace is therefore in no way a negligible element of the cost price of a ton of steel produced in said furnace.

Now, in spite of many fruitful studies which have been devoted to this question and in spite of their efforts to solve this problem, many electric steelworks are unable to reach the remarkably low consumptions to which some others get.

It seems that the primary reason of these differences in consumption from one steelwork to the next one lies in accidental ruptures of electrodes resulting from "hammering" on non conductive materials contained in the charge.

As a matter of fact, all the systems for regulation of steelmelting arc furnaces are practically all aimed at keeping the electric intensity of the arc at the required value by acting upon the length of the arc: if the effective intensity is lower than required, the electrode comes down. If on the reverse, the effective intensity is higher than required, the electrode is raised.

Now it is frequent that solid charges introduced in arc furnaces contain some non conductive pieces on which the arc cannot start such as:

recovery steel scrap covered with paint or cement,
lime or limestone introduced on purpose in order to build a protective slag,
slag coated metallic scrap from preceding melts, etc.

When below an electrode the only elements to be met are such non conductive ones then the arc does not start.

The effective intensity being zero, the automatic regulation device depresses the electrode. The latter propped against the non conductive object breaks by flexion.

This phenomenon is well known and steel people do

their best in order to prevent the presence of insulating bodies under the electrodes. But the precautions taken aiming at this are often ineffective.

The present invention is aimed at automatic protective devices against accidental breakage of electrodes in steel melting arc furnace which operate through detection, by measurements of a phenomenon linked to its mechanical balance or equilibrium, of the fact that an electrode, instead of being only held by its holder, also bears against a solid body.

In one form of the invention the device consists in providing an electrical contact operated through means which are holding the electrode or operate its moves in such a way as it closes or opens when the electrode is biased away from the vertical and operates a warning signal or interrupts the power supply to the furnace or also operates the automatic regulation in order to cause the electrode to be raised when it presses on a solid insulating body.

In another form of the invention, the device consists in detecting the fact that, when the tip of an electrode comes in contact with a non conducting solid body, the forces which cooperate to keep in equilibrium the electrode holder arm are modified and this detection of such variations is advantageously performed with the help of stress gauges placed at the points where these forces apply.

Other features and advantages will appear from the following description which, in regard to the enclosed drawings illustrate some forms of carrying out the invention which are only given by way of non limitative examples.

In the drawings:

FIGS. 1 and 2 are diagram sketches pertaining to a first form of the invention,

FIG. 3 represents a modification of the form of FIGS. 1 and 2,

FIGS. 4 and 5 are relative to a second form of the invention,

FIG. 6 shows a third form of the invention,

FIG. 7 represents in detail the modification of the form of the invention which is represented diagrammatically in FIG. 3,

FIG. 8 is the diagram sketch of the principle of the electrical and hydraulic part of the device of FIG. 7,

FIG. 9 is a diagram showing another form of the invention,

FIG. 10 illustrates a modification of the form of the invention of FIG. 9,

FIG. 11 represents in detail the form of the invention shown diagrammatically in FIG. 9, and

FIG. 12 is a sketch of the electrical part of the device of FIG. 11.

In accordance with FIGS. 1 and 2, a quick-silver contact C is affixed on the horizontal arm H which holds the electrode. When, accidentally, an electrode E presses, during a downwards movement on a solid body I, the clearance which exists in the guiding of the electrode holder arm H is sufficient to cause the angle between the arm H and the horizontal line to vary so that the quicksilver by moving closes the contact.

In accordance with the modification of FIG. 3 the clearance, which exists in the guiding of the electrode holder arm when the electrode presses against a solid body I, is detected through an electrical contact A, operated by a roller R situated at the end of a linked arm situated in the guiding zone of a vertical pole V solidly built with the electrode holder arm H. In effect this vertical pole V moves downwards and its clearance between its guiding rollers r is always superior to the 2 mm. which are necessary to operate the device.

If the electrode holder arm H (FIGS. 4 and 5) is made

solid with a guiding means G sliding on a vertical pole M, the clearance between the guiding means G and the vertical pole M is still sufficient to detect, by means of an electric contact A' such as above, any contact of the electrode E on a solid body.

Another form of the invention is applied when the vertical movement of the electrode is driven by a cable D (FIG. 6). According to this form of the invention one detects the moment when the cable is tightened or not by means of an electric contact B the opening or closing of which is obtained through a spring R' which is biassed in tension through a pulley P situated on the cable D.

All these devices for the detection by electrcal contact make it possible, by way of example, to warn the operator, at the moment when the electrode presses on a solid body, through a horn, or to cut off the circuit switch which feeds power to the furnace or further to act upon the automatic regulation in order to raise the electrode when it presses on a solid insulating body.

The form of the invention which has been briefly descirbed above with reference to the diagrammatic sketch of FIG. 3 will now be described in detail.

FIG. 7 to which this description makes reference represents an electrode holder of an electric furnace. In this form of the invention the movement of the electrodes is driven by an hydraulic jack.

The electrode **1** is held by the arm **2** which bears a pipe **3** which feeds water and electric power to the electrodes.

This arm comprises four rollers **4** which guide it in the guiding sleeve **5**.

A jack **6** is affixed to the guiding sleeve **5** and rod **8** is fixed to an arm which drives the upward or downward movement of the electrode holder arm **2** and therefore of the electrode **1**.

A rolling contact **7**, which is closed if its roller **9** is not pressed on and is open if the roller is pressed on, is secured to the guiding sleeve **5**.

When there is no upward thrust on the electrode, the arm under the action of its weight is biassed towards tilting in the direction indicated by the arrow **10** (this tilting movement being prevented by the rollers **4**).

When there is an upward thrust on the electrode, the arm is inclined to tilt in the direction indicated by the arrow **11**.

Therefore when the tendency towards tilting in the direction defined by the arrow **10** changes into a tendency to tilt in the direction defined by the arrow **11** there occurs a displacement of the arm **2** within the sleeve **5** owing to the play between the rollers **4** and their guiding in the sleeve **5**.

The contact **7** is secured in such a way that it is closed when the tendency to tilt is the one defined by the arrow **10** and it be open when the tendency to tilt is the one defined by the arrow **11**.

FIG. 8 shows how the information obtained from the contact **7** operates so that the arm is raised (the electrode **1** bearing then against a solid body) when the tilting tendency of the arm is the one defined by the arrow **11**.

The part of the electric and hydraulic circiut pertaining to the invention has been diagrammatically figured in FIG. 8.

The jack **6** which operates the electrode's ascending and descending movements is actuated through a sliding valve by a pump **13**.

Valve **12** is a two position electric valve. If the solenoid **14** of this valve is energized its slide gets into a position which is such as to bring the rod **8** of jack **6** (and therefore the electrode) down.

If the solenoid is not energized, the slide of valve **12** is in such a position as to cause the rod **8** of jack **6** (and therefore the electrode) to go upwards.

The device of the invention is made by connecting the device operating the automatic regulation indicated at **15** (which function is, as known to keep the electric intensity of the arc at the level which the operator wants, by acting upon the length of the arc; if the effective intensity is lower than desired the electrode comes down, if on the contrary the effective intensity is superior than desired, the electrode goes up) of solenoid **14** through rolling contact **7**.

It has been established that, with a device of the type described above, in reference to FIGS. 5, 7 and 8, acting upon the automatic regulation system, an electrode has been able to ram during nine minutes on an insulating body without breaking. As soon as the electrode pressed on this body, the device of the invention caused it every time to go up through the action of the automatic regulation.

The electric intensity being zero, i.e. inferior to the operator's desired intensity, the regulation device made the electrode come down and hit again the insulating body and so on. After nine minutes of ramming, the charge collapsed and covered the insulating body. The arc was struck again normally at the tip and the fusion proceeded normally without any further incident.

The other forms of the invention represented in the FIGS. 9 to 12 are based on the following principle: it is possible to be automatically warned that the tip of the electrode is bearing on a non conductive body (limestone, scrap, painted scrap, etc.) and so is exposed to be broken, by detecting, thanks to stress gauges, the fact that the forces which cooperate to the balance of the electrode arm are modified by this incidental contact. This possibility can be used to operate the automatic upward movement of the electrode which is pressing on a non conducting object, according to the invention.

A first example of this form of the invention is diagrammatically represented on FIG. 9. In this example the movement of the arm P is driven by cables C (as is most frequently the case). The tension of cable C is measured by inserting a stress gauge J_1 at the point where the cable is fastened to the arm P. It is a matter of fact that whatever the regulation of the arm drive be, i.e. electrical or hydraulic, the tension of cable C which, before the electrode E contacted a non conducting body, was equal to the weight of the arm, becomes, once the electrode contacts, equal to the weight of the counter weight (if any) lessened by the stress which is exerted on the cable in the "downwards" direction by the regulation system.

This tension of the cable can also be measured by inserting stress gauges J_2 under the bearing of the return pulley L nearest to the fastening point on the arm (FIG. 9).

Another example of this form is illustrated by FIG. 10. The example relates to an electrode holder device in which the arm P' is driven by an hydraulic regulation system R with which it is connected (FIG. 10). The pressure exerted by the weight of the arm P' on the axles of the latter's guiding rollers is taken through stress gauges J'_1 placed on these axles. This pressure is cancelled if the electrode E' bears on a non conducting solid body.

It is even possible in this case, according to another feature of the invention, to insert a stress gauge J'_2 on the piston axle of the hydraulic drive R which operates the movement of arm P'.

FIGS. 11 and 12 show an example of this form of the invention. FIG. 11 represents an electrode holder device of the type diagrammatically represented on FIG. 9, in which the electrode is cable driven. The device according to the invention applied to this electrode holder detects when the electrode is hitting something by detecting a variation in the vertical reaction of the arm on its electrode driving system.

The electrode **19** is held by arm **20** which slides on a pole **24** and is held by a cable **25** winding on pulleys **26, 27, 28** and on a hoist **29**.

The furnace equipped with a device according to the invention differs from a conventional furnace only by the fact that the cable **25** is secured to the pole **24** by a tie **30** on which stress gauges have been stuck.

By way of example two gauges have been stuck, one of them being disposed in the longitudinal direction, the other in the transverse direction in order to, according to a classical method, eliminate the influence of temperature on the resistance of the gauges.

On FIG. 12 has been represented the electrical diagram of the system which makes it possible, when the tension on the cable comes below a certain value, to actuate the hoist **29** engine in the direction which moves the arm upwards.

Hereafter are only explained the means which are to be made use of in order to set, by way of example, the following working conditions:

if the tension on cable **25** is superior to a predetermined value, the coil of a contactor is not energized;
if the tension on the cable becomes inferior to a predetermined value, the coil of a contactor is energized.

It is evident that if this is realised, it will be possible with conventional means to make it so that if the coil is energized the engine turns in the direction which causes the arm to go upwards.

On FIG. 12 is represented diagrammatically one method of making use of these means.

On this figure:

31 is a alternative tension source, the peak-to-peak value of which is supposed to be sufficiently stabilised. (The circuits which possibly provide this stabilisation have not been represented.)

32 is an isolation and adaptation transformer.

33 is a resistance network, which forms with the potentiometer **34** and stress gauges **36** and **37** a Wheatstone's bridge.

34 is a potentiometer which makes it possible to balance the bridge.

35 is a screened wire connecting the apparatus with the stress gauges **36** and **37.**

36 is a temperature compensation gauge placed perpendicular to the direction of the main stress.

37 is the active gauge the variation of the relative resistance of which is proportional to the stress in the tensile test piece.

38 is a tension amplifier which gain is sufficient to feed the demodulator **39.**

39 is a rectifying circuit which delivers a continuous voltage about equal to the peak to peak tension of the alternative signal feed to its admission.

40 is a gating circuit of the Schmitt tilting type or equivalent.

41 is a power amplifier which outlet signal is sufficient to operate the operating device **42.**

42 is the contactor coil.

The functioning and the adjustment of this device are extremely simple, which provides a great operating safety adjustment:

(a) During a blank standstill operation the electrode **19** is somewhat overstressed so that the maximal possible value of the stress which can occur during normal operation is imposed on the tensile test piece.

The bridge (**33, 34, 36, 37**) is balanced with the help of potentiometer **34.** This balance is controlled by a voltmeter mounted parallel on the admission connection terminals of device **40.**

(b) After having unloaded electrode **19** from the overstresses which had been previously introduced for the former adjustment, it is slightly raised with the help of a dynamometrical hook or any equivalent device. Once the maximal effort, beyond which it is desired that the electrode's upward movement be provoked has been performed, the threshold for device **40** is adjusted.

During normal operation, the tensile test piece is subjected to an important stress, near to, but inferior to the one which had been created while doing adjustment (a). The Wheatstone's bridge is therefore set out of balance, but rather slightly: the unbalance voltage is therefore weak, device **40** is beneath its triggering point.

If the arc is not struck, the electrode comes down and comes to rest on the charge: the tensile test piece is unloaded. The Wheatstone's bridge is then strongly put out of balance, the unbalance voltage is high, device **40** reaches its triggering point, controlling device **32** is energized, contractor **42** is energized and the electrode goes up.

It will be noted that, in view of the demodulator's conception the response of the electrode's protective device is very rapid, as it follows the load of the demodulator's condensers which occurs through the diode's direct resistance and is therefore practically instantaneous.

On the contrary the return to rest of the device is more lengthy, the discharge time constant of the same condensers being high.

In this way, a high starting speed of the protection is provided at the same time as a rather low oscillation frequency which is required according to the very principle of the invention.

As it can be seen the invention makes it possible to eliminate electrode breakage resulting from the latters ramming against nonconducting objects as the devices of the invention provide automatic raising of the electrode holder when the electrode meets a solid obstacle. So the devices of the invention makes it possible to reduce in a wide proportion the consumption of electrodes.

It is well understood that the scope of the invention is not limited to the forms of the invention which are described here but it covers all its forms.

What is claimed is:

1. An automatic device for protecting electrodes against accidental breakage in a steel melting arc furnace by detecting when an electrode contacts an insulating solid body, comprising means for mounting the electrode and movable when the electrode strikes an insulating solid body in the furnace, and an electrical contact operated by said means upon movement of said means when said electrode presses against an insulating solid body, whereby a warning signal may be triggered, the power feed cut off to the furnace or an automatic regulation activated to move said electrode.

2. An automatic device for protecting electrodes against accidental breakage in a steel melting arc furnace by detecting when an electrode contacts an insulating solid body, comprising means for mounting the electrode to be tiltable when the electrode strikes an insulating solid body in the furnace, and an electrical contact operated by said means upon tilting of said means when said electrode presses against an insulating solid body, whereby a warning signal may be triggered, the power feed cut off to the furnace or an automatic regulation activated to move said electrode.

3. An automatic device for protecting electrodes against accidental breakage in a steel melting arc furnace by detecting when an electrode contacts an insulating solid body, comprising means for mounting the electrode to stop the normal vertical downward movement of said electrode when the electrode strikes an insulating solid body in the furnace, and an electrical contact operated by said means upon stopping the normal downward movement of said electrode when said electrode presses against an insulating solid body, whereby a warning signal may be triggered, the power feed cut off to the furnace or an automatic regulation activated to move said electrode.

4. An automatic device according to claim **2** wherein said means for mounting the electrode comprises a horizontal electrode holder arm, means for guiding said arm with play sufficient so that said arm tilting relative to the horizontal plane varies when said electrode strikes an insulating solid body during a downward movement and said electrical contact is a mercury contact secured to said horizontal arm.

5. An automatic device according to claim **4** wherein

a roller is located adjacent the end of said arm and said roller controls said electrical contact to detect said play.

6. An automatic device as set forth in claim **3** wherein a cable controls the vertical movement of said electrode, a pulley associated with said cable controls said electrical contact and a spring urges said pulley against said cable so that the tension of said cable is checked by said electrical contact.

7. An automatic device for protecting electrodes against accidental breakage in a steel melting arc furnace by detecting when an electrode contacts an insulating solid body, comprising means for mounting the electrode having an electrode holder arm maintained in balance by cooperating forces, said forces being modified when the electrode strikes an insulating solid body in the furnace, and stress gauges located at the points of application of said forces when said electrode presses against an insulating solid body for detecting the variation in said forces, whereby a warning signal may be triggered, the power feed cut off to the furnace or an automatic regulation activated to move said electrode.

8. An automatic device according to claim **7** wherein said electrode holder arm is driven by a cable secured at one end to said arm, and the tension of said cable is

measured by one of said stress gauges situated at the point where said cable is secured to said arm.

9. An automatic device according to claim **8**, in which a return pulley cooperates with said cable and the tension of said cable is measured by inserting stress gauges under the bearing of said return pulley.

10. An automatic device according to claim **7** wherein a hydraulic regulation system is connected to and drives said electrode holder arm, guiding rollers for said arm and the pressure exerted by the weight of said arm on the axles of siad guiding rollers being taken with said stress gauges and said pressure being cancelled when said electrode bears on a solid body.

11. An automatic device according to claim **10**, in which a stress gauge is inserted on the axle of the piston of said hydraulic regulation system.

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