

The invention relates to an early warning system for detecting molten metal breakthrough on the ceramic furnace linings of smelting furnaces, more particularly induction smelting furnaces, with electrodes or electrode network which is/are to be mounted on the relevant furnace lining, more particularly on the outside thereof, wherein the electrodes are divided into two groups of different polarity, are arranged at intervals from each other and are connectable with an evaluator unit to determine the electrical temperature-dependent resistance of the furnace lining between the two groups of electrodes. (FR-A 2427569).

With smelting furnaces of the said kind the ceramic furnace linings are subjected in operation to very hard thermal, chemical and mechanical stresses. This causes scouring and possibly cracks which in the case of an induction smelting furnace can penetrate through to the inductor. If the breakthrough of the fluid molten metal to the inductor is not detected in good time then it can lead to considerable damage to the induction smelting furnace and in extreme cases even result in an explosion-type emptying of the smelting assembly.

In order to be able to recognize such defects in induction smelting furnaces in very good time early warning systems of the above kind are known which use the principle of the resistance measurement. This is based on the knowledge that the electrical resistance between any two contact points of the ceramic furnace lining for example on the outside is dependent on the temperature in that the resistance drops considerably as the temperature increases, namely by several tenths percent in the high ohmic area. If a breakthrough point opens up in the wall of the furnace lining then a local temperature increase always takes place which can be determined through resistance measurement with a suitable

5 distribution of the electrodes on the furnace lining and on the outer wall. The problem lies in being able to arrange the electrode network sufficiently close-meshed on the outside of the ceramic furnace lining to allow a reliable early warning of the melt breakthrough which is beginning to appear.

10 With a known early warning device of the generic kind for an induction smelting furnace the electrode network is mounted in grooves on the outside of a so-called finishing crucible which is inserted in an induction furnace as a prefabricated part and is enclosed there by a ceramic back pestle mass in order to fill out the necessary ring gap towards the inductor wall. The electrode network does indeed hereby lie
15 at a sufficient distance from the inductor wall in order to be able to signal in good time the start of a breakthrough point without the inductor suffering any damage. In practice however the use of finishing crucibles is very slight since generally a conventional furnace blocking-up is preferred where the furnace lining is built up at the place
20 of use from the ceramic material.

25 With this type of blocking-up process there are considerable difficulties in being able to install the electrode network for signalling breakthrough points at an acceptable expense so that a reliable accurate early detection of a faulty point is possible. The conventional blocking-up process has managed with the use of rod electrodes which were arranged vertically aligned between a heat barrier layer and the crucible material along the circumference of the crucible,
30 see DE 27 18 016-A1. Also here the reduction in the electrical resistance of the at least partially sintered ceramic crucible material between the adjoining electrodes was evaluated and analyzed as a result of the temperature increase. The disadvantage of this known system lies in the
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danger of a short circuit of the inductor voltage as well as an influence on the measuring voltage through the vertical electrodes in the case of a damp heat barrier layer, and on the other hand the installation and connection of the electrodes is expensive. As far as the reliability regarding indication is concerned the known system also has drawbacks since the penetrating molten metal is detected relatively late.

10 The object of the present invention is to provide an early warning device of the kind already mentioned which allows a simple attachment of the electrodes in the outside of the furnace lining and which guarantees a high indicator reliability of the entire system.

15 This is achieved with an early warning device of the generic kind according to the invention in that at least one of the electrodes is mounted as an electrode network on one side on a ceramic foil. This ceramic foil is mounted on the furnace lining either with the side having the electrode network or
20 with the side remote therefrom. In the first case the foil has a lower heat conductivity and in the second case it has a somewhat similar or higher heat conductivity and a somewhat similar or higher electrical conductivity compared
25 with the ceramic material of the furnace lining. It is fundamentally of no importance whether only one of the electrodes of the two groups of electrodes or the electrodes of the two groups are formed by the electrode network. The decisive feature is the arrangement of the electrode network
30 on the ceramic foil.

It is essential for an early warning device according to the invention that the ceramic foil can be prefabricated with the electrode network applied thereon for each relevant case
35 of use and can be used independently of whether the ceramic

furnace lining is constructed in the conventional block-up in the smelting furnace, such as an induction smelting furnace, or is fitted as a finished crucible into the furnace. The ceramic foil with the integrated electrode network can be easily attached in an equidistant arrangement from the inductor wall in the case of an induction smelting furnace wherein it can still additionally undertake the task of a heat barrier layer. The ceramic foil material used is preferably a fine felt-like fibre fleece of ceramic material as is already known per se and which in its mechanical properties can be roughly compared with a stiff paper or cardboard sheet.

According to the invention measurement is no longer carried out in the ceramic crucible material itself but from outside in the ceramic material, therefore it is essential that on the one hand with the arrangement of the ceramic foil between the electrode network and the outside of the ceramic furnace lining the ceramic foil material has a behaviour which is similar to that of the furnace lining. If on the other hand the electrode network is mounted between the ceramic foil material and the ceramic furnace lining then the heat resistance and the electrical resistance of the foil material must be higher, preferably very much higher than that of the furnace lining. From this it is apparent that a particularly advantageous further development of the invention lies in placing the electrode network between two such ceramic foils of which the foil to be arranged adjoining the outside of the furnace lining has roughly the same or higher heat conductivity and a lower specific resistance and the foil to be placed on the side remote from the furnace lining has a lower heat conductivity and a higher specific resistance than the ceramic material of the furnace lining. The thermal and electrical insulation properties of that ceramic foil which has the higher

resistance values thus make it possible even to save a separate barrier layer which is usually provided in the case of an induction smelting furnace between the inductor wall and ceramic furnace lining.

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The invention will now be explained below with reference to an embodiment shown in the drawings in which:

Fig. 1 is a diagrammatic longitudinal sectional view through an induction smelting furnace;

10 Fig. 2 is an enlarged view of the section of the furnace wall according to Figure 1;

Fig. 3 is a perspective view of a prefabricated ceramic mat as the element of an early warning device for breakthroughs of molten metal in the case of an induction smelting furnace according to Figures 1 and 2; and

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Fig. 4 shows the development of a lining of an induction smelting furnace with several mats according to Fig. 3 including an illustration of the connection with the associated electrical evaluating/ analysing unit.

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In detail is shown, on the induction smelting furnace illustrated in Figure 1, a smelting chamber 1 which is completely enclosed except for the upper opening by a furnace lining 2 which comprises a ceramic material which is liable to sintering. As can be seen further in Figure 2 the furnace lining 2 is adjoined radially on the outside by an intermediate layer 3 in which an electrode network 7 is embedded, which will be described in further detail below.

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The intermediate layer is further enclosed on the outside by a coil compensating mass 4 and behind this further radially on the outside there are an induction coil 5 and a magnet conductor 6 in the form of a yoke.

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The special feature of an induction smelting furnace of this kind lies in the design of the intermediate layer 3 between the ceramic furnace lining 2 and the coil compensating mass 4 because this intermediate layer 3 both undertakes a barrier function and has the said electrode network 7 which belongs to an electric monitoring system for the early signalling of breakthroughs of molten metal through the ceramic furnace lining 2. This electrode network 7 extends over the entire circumference along the outside of the ceramic furnace lining 2, as explained further below with reference to Figure 4. The intermediate layer 3 consists of one or more prefabricated component parts which will be described with reference to Figure 3.

Along the circumference of the furnace lining 2 the intermediate layer 3 is composed of several prefabricated ceramic mats 8 which extend over the height of the furnace lining 2. A ceramic mat 8 of this kind is shown in Figure 3 and can be a prefabricated component part which is matched to the relevant type of furnace for which it is to be used. It has an inner foil 9 and an outer foil 10 which each have a for example felt-type structure made from ceramic fibres. Both foils 9 and 10 have approximately the thickness and flexibility of cardboard and they can therefore be matched to the inner curvature of the furnace wall which is formed through the coil compensating mass 4 without blocking up (Figures 1 and 2). The foils 9 and 10 can therefore be called a sheet material because it can be cut off from longer sheets of the ceramic material.

The electrical monitoring system is based on the principle of resistance measuring of the ceramic furnace lining 2 between two electrodes 11 which form in a plurality in a special configuration the electrode network 7 which is mounted between the two ceramic foils 9 and 10. Measuring

must thus take place from the mat 8 adjoining the outside of the furnace lining 2 in the installation position into the ceramic material of the furnace lining. The foil 9 directly adjoining the furnace lining 2 therefore has electrical conduction properties and heat conduction properties which correspond or are at least similar to those of the furnace lining 2. The outer foil 10 lying away from the furnace lining 2 in the installed position has however barrier properties and thus has a very much lower electrical conductivity and heat conductivity compared to the inner foil 9. The specific resistances of the foils 9 and 10 required each time in relation to the ceramic material of the furnace lining 2 can be set by suitable additives which are mixed in with the ceramic material of the foils 9 and 10.

The electrodes 11 of the electrode network 7 consist of a material having a higher temperature exchange resistance, a high heat resistance and good anti-corrosion resistance; austenitic electrode wires can be considered here. The electrodes 11 are allocated to a first group 12 and a second group 13 wherein the electrodes 11 which adjoin one another belong to the different groups 12 and 13 and are arranged equidistant relative to each other. Therefore the electrodes 11 of the two groups 12 and 13 form a mutual comb-like structure which interengage in the direction of the comb teeth so that each one electrode 11 of one group 12 adjoins electrodes 11 of the other group 13. This complete electrode network 7 is located between the two foils 9 and 10 which are connected together in a suitable way whereby the electrode network 7 is fixed at the same time. On the mat 8 leads 14 and 15 emerge at a suitable point and are each connected to one of the electrode groups 12 and 13 which are biased with different polarities during operation.

As can be seen from Figure 4, several of the ceramic mats 8, such as for example 5, are arranged circumferentially round the furnace lining 2. In practice the mats 8 are placed along the inner wall of the inductor formed by the ceramic filling mass 4 to form an intermediate layer 3 (cf Figures 1 and 2) in front of the block-up of the furnace lining 2. In Figure 4 the level of the furnace lining to be monitored, thus to be covered by the mats 8 are marked by arrow A and the corresponding circumference by arrow B. So that for each of the mats 8 a breakthrough monitoring is partially possible, the relevant lead of one mat 8 is electrically connected to a separate input of an evaluator unit 16 whilst the remaining leads of the mats 8 are attached to a base potential. Each of these mats 8 forms a monitoring segment in itself so that along the circumference of the furnace lining any erupting molten metal breakthrough can be indicated zone-wise or segment-wise by the evaluator unit 16. Thus a localization of the erupting fault is possible. In a different way from the embodiment illustrated, the mats 8 can also be divided vertically relative to each other if it is desired to localize a fault erupting in the vertical direction of the furnace lining.

The two groups 12, 13 of the electrode network 7 (Figure 3) are biased through the evaluator unit 16 with a sinusoidal alternating voltage whose frequency is between 20 and 30 Hz. Taking into account the usual mains frequency of 50 Hz and the frequencies at which the inductor of an induction smelting furnace is operated, this frequency range has proved to be that where the lowest interferences occur as a result of top-wave, scatter effects and switching overloads. This is additionally linked with the complexity of the electrical resistances which lie between the electrodes 11 of the two groups 12 and 13 of the electrode network 7 and which have a capacitative component which is conditioned

by the relevant mat 8 in which the relevant electrode network 7 is embedded. Fault indications caused by a measuring continuous voltage and which are conditioned by polarization appearances in the material of the furnace lining are avoided through the said measuring alternating voltage.

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CLAIMS:

1. Early warning system for molten metal breakthroughs on
5 the ceramic furnace linings of smelting furnaces, more
particularly of induction smelting furnaces with electrodes
(11) which are to be mounted on the relevant furnace lining
(2) wherein the electrodes are divided into two groups
(12,13) of different polarity which are arranged at
10 intervals from each other and which are connectable with an
evaluator unit (16) to determine the electrical temperature-
dependent resistance of the furnace lining (2) between the
two groups of electrodes (12,13),
characterised in that
15 at least one of the electrodes is mounted as the electrode
network (7) on one side on a ceramic foil (9,10) which is to
be mounted on the furnace lining (2) either with the side
having the electrode network (7) or with the side remote
from same, wherein the foil (9,10) has in the first instance
20 a lower heat conductivity and a lower electrical
conductivity and in the second instance roughly the same or
higher heat conductivity and roughly the same or higher
electrical conductivity compared with the ceramic material
of the furnace lining (2).
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2. Early warning system for molten metal breakthrough on
the ceramic furnace linings of smelting furnaces, more
particularly of induction smelting furnaces with a network
of electrodes to be mounted on the outside of the relevant
30 furnace lining wherein the electrodes are divided into two
groups of different polarity which are set spaced from each
other and are connectable with an evaluator unit to detect
the electrical temperature-dependent resistance of the
furnace lining,
35 characterised in that the electrode network (7) is mounted



on one side on a ceramic foil (9,10) which is to be mounted on the outside of the furnace lining either with the side having the electrode network (7) or with the side remote from same, wherein the foil (9,10) has in the first instance
5 a lower heat conductivity and a lower electrical conductivity and in the second instance roughly the same or higher heat conductivity and roughly the same or higher electrical conductivity compared to the ceramic material of the furnace lining.

10 3. Early warning system according to claim 1 or 2 characterised in that the ceramic foil (9,10) when mounted with the electrode network (7) adjoining the outside of the furnace lining (2)
15 has a lower specific electrical resistance than the ceramic material of the furnace lining (2) and when mounted with the electrode network (7) on the side remote from the furnace lining (2) has a higher specific electrical resistance than said ceramic material.

20 4. Early warning system according to claim 3, characterised in that the electrode network (7) is mounted between two ceramic foils (9,10) of which the foil (9) to be mounted adjoining
25 the outside of the furnace lining (2) has roughly the same or higher heat conductivity and a lower specific resistance than the ceramic material of the furnace lining (2) and the foil (10) to be mounted on the side remote from the furnace lining (2) has a lower heat conductivity and a higher
30 specific resistance than the said ceramic material.

35 5. Early warning system according to claim 4 characterised in that the two ceramic foils (9,10) are combined with the electrode network (7) inbetween into one prefabricated ceramic mat (8) with extended connecting pipes



(14,15) ready for installation.

6. Early warning system according to one of claims 1 to 5 characterised in that

5 several ceramic foils (9,10) or ceramic mats (8) are provided in the circumferential and/or vertical direction of the relevant furnace lining (2) and are each connectable per se with the evaluator unit (16) for the purpose of separate monitoring.

10 7. Early warning system according to one of claims 1 to 6 characterised in that

the two groups (12,13) of electrodes or electrode networks (7) are biased with alternating voltage.

15 8. Early warning system according to claim 7

characterised in that the two groups (12,13) of the electrode networks (7) of a foil (9,10) or mat (8) are biased with a sinusoidal alternating voltage whose frequency
20 is between 20 and 30 Hz.

9. Early warning system according to one of claims 1 to 8 characterised in that the electrodes (11) of one group (12,13) are comb shape and both electrode groups (12,13) are
25 mounted with the electrodes (11) arranged in the direction of the comb teeth engaging alternately with each other at equidistant intervals.

10. Early warning system according to one of claims 1 to 8
30 characterised in that one of the electrodes is formed by the electrode network (7) and the other electrode is formed by the melt.