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(71) Applicants
Centre De Recherches Metallurgiques - Centrum Voor Research in De Metallurgie,
47 rue Montoyer,
1040 Brussels,
Belgium.
(72) Inventors
Bernard Mairy
(74) Agents
Marks & Clerk

(54) Measuring the surface temperature of a body

(57) A body 28, e.g. a continuously cast strand, has a surface zone cleaned by subjection to repeated percussion by a percussion device including pins 15 to which the impacts of a hammer 4 are transmitted. A pyrometer adjacent the percussion device receives thermal radiation from the cleaned zone through a tubular shield.

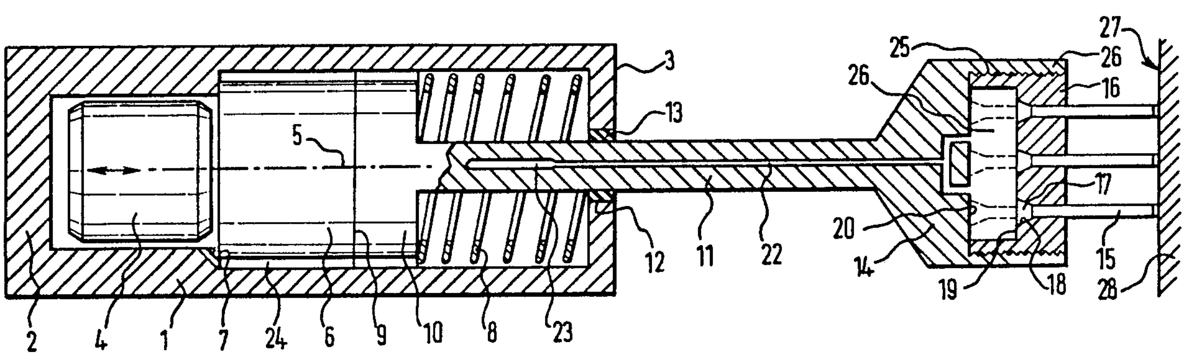

FIG.1a.

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

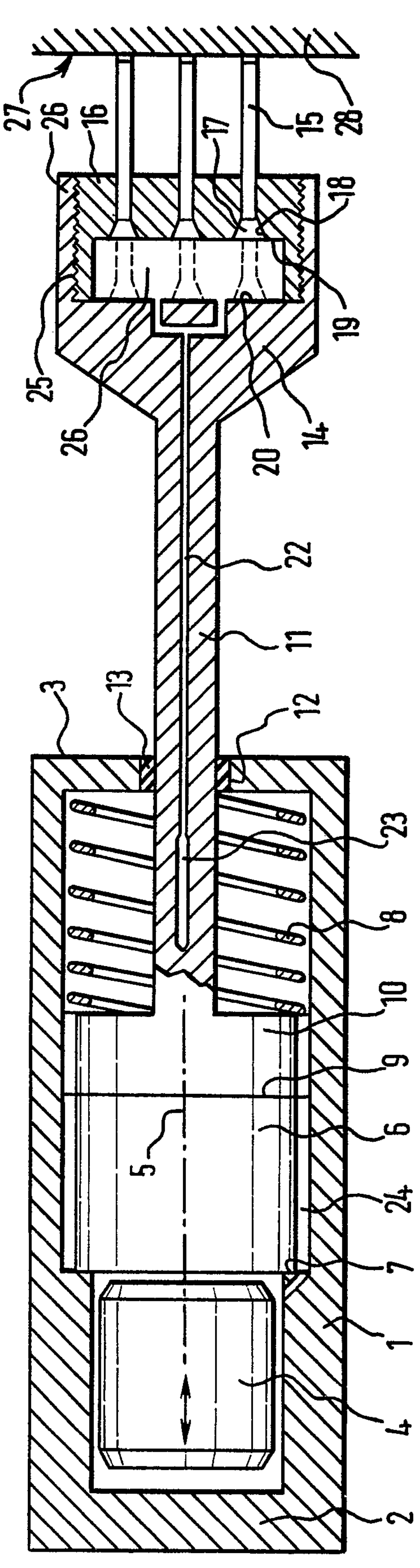

FIG.1a.

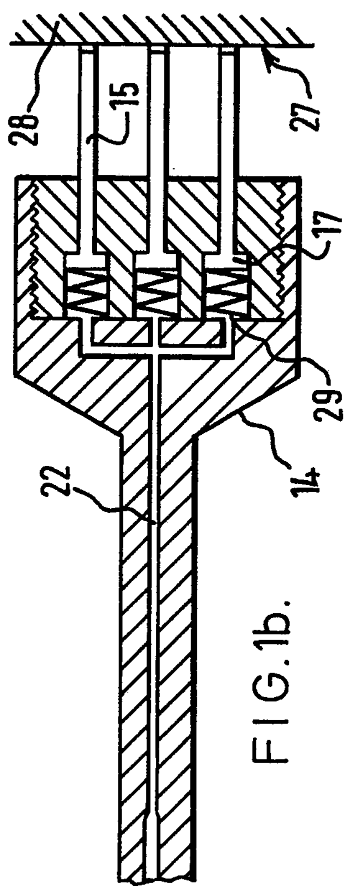

FIG.1b.

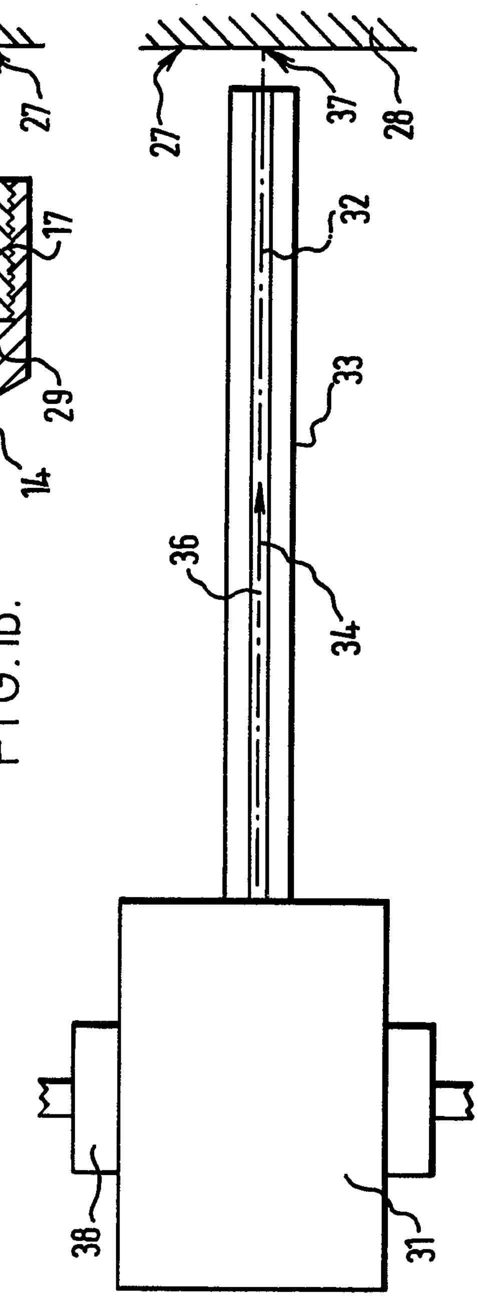

FIG.1c.

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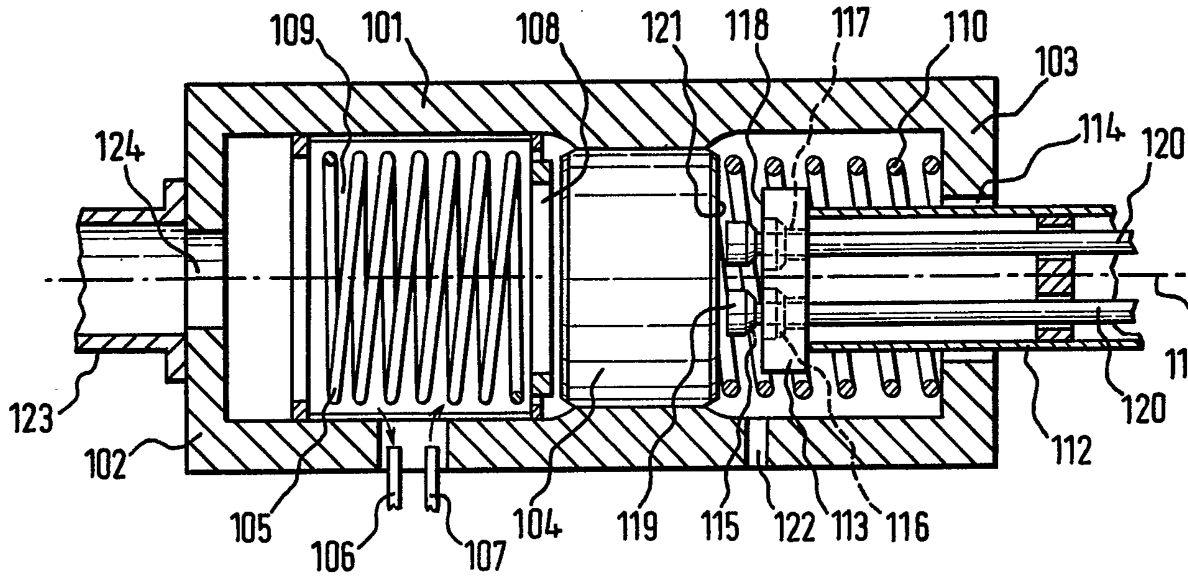
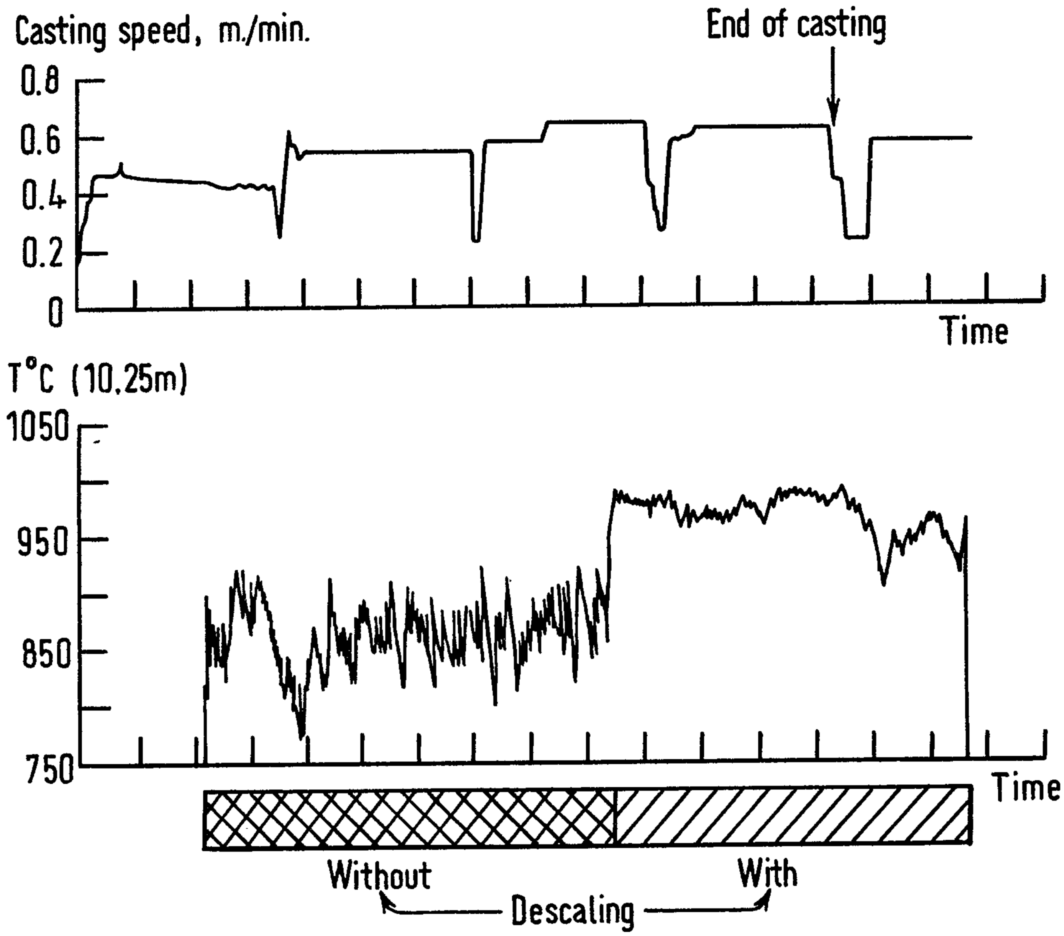


FIG.2.

FIG.3.



SPECIFICATION

Measuring the surface temperature of a body

The present invention relates to a method and apparatus for measuring the surface temperature of a body, in particular for the continuous measurement of the surface temperature of a metal strand obtained by continuous casting.

The problems of measuring the surface temperature of bodies at high temperatures, for example in the temperature range of 500°C to 2000°C, have in most cases been solved by using the known techniques of pyrometry, and in particular optical pyrometry. When the temperature measurements are carried out in favourable conditions, for example when there is no distrubance of any type on the optical path used for the measurement, the results of the measurements in effect correspond to the values to be measured.

This does not apply however when, according to circumstances, measurements must be carried out in an atmosphere contains possibly varying amounts of disturbing elements, such as dusts of various types, vapours (for example steam), and various mists. The presence of such elements on the path of an optical pyrometric measurement necessarily impairs to a greater or lesser extent the accuracy of the results obtained, and, in addition, means they cannot be reproducible. In such conditions, the remedy is obviously to eliminate as far as possible these disturbing elements, or more advantageously to suppress the causes of their appearance.

It is, however, frequently the case that temperatures must be measured at locations where the production or the passage of disturbing elements such as powders and cooling sprays and the presence of an oxide layer are fundament aspects of the operation in question, or are even the conditions for the correct functioning of this operation. It is therefore, in this case, impossible to eliminate these disturbing elements as this would modify the process being carried out; the problem of temperature measurement is therefore not satisfactorily resolved.

In respect of this matter, we have already proposed a device which enables surface temperature measurement to be carried out on a continuously cast strand, by means of a sighting instrument along an optical path protected by a suitable casing, the zone of the strand whose temperature is to be measured being subjected to a scraping operation. A device of this type and its corresponding method of operation are described in the Belgian Patent No. 840 761 and British patent specification No. 1 561 614.

The present invention relates firstly to a method (different from the above method) also enabling a surface temperature measurement to be carried out by sighting a body whose temperature is to be measured, this method enabling the prevention of both the drawbacks due to the presence of an inevitable, although necessary, disturbing atmosphere in the immediate vicinity of the sighting point, and those drawbacks due to the presence of parasitic elements (for example an oxide layer) on the surface of the body at the point at which the temperature is to be measured.

The present invention provides a method in which a surface temperature measurement is carried out by means of a sighting instrument and the optical path of sighting is protected, preferably by a suitable casing on at least one portion of the path starting at the sighting instrument, and in which the zone whose temperature is to be measured is subjected to an operation consisting in repeated percussive actions; this operation removes from the zone in question any element or parasitic layer making its clean surface in the field of view of the sighting instrument used for the temperature measurement.

In the present specification, the word "percussion" should be understood in its widest scope to indicate any physical phenomenon such as mechanical shock, striking, hammering, and vibration (excluding shaving, scratching, and scraping) for physical removal of a parasitic layer, for example oxide, located on the body, in particular a steel strand being discharged from a continuous casting mould.

According to an advantageous embodiment of the invention, the percussion of the zone in question is carried out in a continuous manner by means of a striking element of a hard material caused to strike the said zone at a predetermined, possibly variable, repetition frequency.

It has been found advantageous to control, by a suitable means, the force or pressure of the striking element on the said zone in such a way as to adapt it to the hardness of the zone and possibly to the speed of displacement of this zone.

The process being carried out around the apparatus is not modified in any way and the temperature measurement is not disturbed by this process, the complete insulation of the sighted zone from the surrounding process being readily obtainable by means of a non-oxidising gaseous blanket which may be readily and completely applied to any local configuration of the sighted body.

In the particular case in which the above-mentioned method is applied to the measurement of the surface temperature of a metal strand being discharged from a continuous casting mould, the sight axis is preferably subjected to displacement, simultaneously with the strand, so as to sight for a given period a given point of the strand.

The present invention also provides apparatus for carrying out the above-mentioned method, which is particularly suitable for use with a high temperature strand being discharged from a continuous casting mould, the apparatus comprising:

- a conduit or housing with an aperture which enables the passage of a support, which is at least partially tubular, for pins or needles which are substantially parallel and which are terminated at their working end by an end of suitable shape, advantageously of a hard material, and at their support end by a head or boss also of suitable shape, each pin sliding freely inside the pin support, a solid element or hammer being located within the conduit or housing and slidable therein and disposed in such a way that it may come into intermittent and repeated contact directly or indirectly with the said heads or bosses;

- means for causing the hammer to move in an alternating rectilinear manner during which it causes the movement of the pins by means of a solid insert or anvil and possibly the support itself, which needles are designed to come into contact with the zone to be cleaned during their movement;

- means for observing the zone which has just been cleaned and for measuring its temperature.

An advantageous embodiment of the apparatus comprises, in addition, means for adjusting the pressure of the pins on the section, and means for cooling the housing, both around its periphery and in its centre.

The means for actuating the hammer are advantageously pneumatic for reasons of flexibility. However, it has also been found advantageous to use electrical and/or magnetic means to cause this movement, which movement may be of a vibratory type.

The above-mentioned apparatus is advantageously combined with an element for measuring the temperature of the zone in question, disposed in such a way that it enables sighting of the zone which has already been cleaned; in a preferred embodiment, sighting is carried out through the interior of the apparatus by means of an optical fibre, one end of which is disposed in the vicinity of the zone in question and the other end of which is optically associated with a pyrometer.

According to a first advantageous structural embodiment, the tubular portion of the support is partially disposed in the said conduit or housing and is rigid (on the conduit side) with a guide bushing provided with as many holes as there are pins, the said bushing being disposed between and in contact, on one side, with the anvil (a free space being, however, provided on this side in the bushing to enable the pin heads or bosses and therefore the pins to slide to a limited extent), and, on the other side, by a spring supported on a stop block which is part of the outlet end of the said conduit or housing.

Advantageously, the bushing is of a metallic antifriction material and the tubular portion of the support is itself provided over at least the major portion of its length with as many apertures as there are needles; this enables the said needles to be maintained substantially parallel to one another, to reduce their tendency to buckle and to enable, more readily, evacuation of the detached particles of scale or other material, the transverse dimensions of the apertures preventing, however, passage of the pin heads or bosses.

According to a second advantageous structural embodiment, the tubular portion of the support is located outside the conduit or housing and is maintained on the axis of the latter by means of a rod rigid, on one hand, with the said support and, on the other hand, with a piston mounted to slide in the conduit or housing between the anvil and a spring supported on a stop block rigid with the outlet end of the said conduit or housing, the said rod preferably also being itself supported on and sliding within a wall serving to close the said conduit or housing (outlet end) and to block the spring.

According to a variant of this second embodiment, the tubular portion of the support advantageously comprises coaxially to itself a guide bushing comprising as many holes as there are needles, the said bushing having on the housing side a free space enabling the pins to slide until the boss or head abuts against a stop rigid with the tubular portion, possibly by means of suitable springs.

According to this variant, the rod serves to convey a compressed gas inlet communicating with the space between the bushing and the stop and which gas may escape between the needles and their apertures in the bushing. This gas is advantageously supplied by a pneumatic device for actuating the hammer by way of grooves (or the like) provided in the anvil and the piston and/or the internal wall of the conduit or housing. This gas enables free sliding of the pins to be maintained and prevents the entry of dust.

The arrangement of the pins may be designed in several ways: in an annular manner, possibly having the optical sighting element for the temperature measurement in the centre of this arrangement; in a linear manner one behind another; or in a staggered formation with the optical sighting element downstream of the pins in respect of the movement of the body being observed. The shape of the working ends of the pins is adapted to the work to be carried out; it is not necessarily the same for all the pins or for all bodies.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1a is a longitudinal section through a device for subjecting the surface of a continuously cast strand to repeated percussion;

Figure 1b is a longitudinal section through part of a similar device;

Figure 1c is a diagrammatic side view of a pyrometric arrangement;

Figure 2 is a longitudinal section through part of a device similar to the device of Figure 1; and

Figure 3 is a diagram showing, as a function of time, the speed of casting of a strand and the surface temperature measured, with and without removal of scale.

With reference to Figures 1*a* to 1*c*, the surface temperature of a continuously cast steel strand is measured with the aid of apparatus comprising the percussion device of Figure 1*a* or Figure 1*b* and the pyrometric arrangement of Figure 1*c*. The pyrometric arrangement comprises a pyrometer 31 whose optical axis 32 is protected from obscuration by tubular shield 33 purged of dust and hot air by non-oxidising gas blow along the tubular shield 33 as indicated by the arrow 34. An optical fibre 36 extends along the tubular shield 33. The surface zone 37 observed by this arrangement is downstream of the device of Figure 1*a* or *b*. The pyrometer 31 (rigid with the shield 33) is mounted on a carriage 38 by which it is intermittently moved parallel to and in synchronism with the strand 28, and then returned to its initial position.

The percussion device shown in Figure 1*a* comprises a cylindrical housing 1, closed at one end 2 and having an axial aperture 12 at its other end 3. In the housing 1 there is a solid cylindrical hammer 4 which may be caused to move alternately along the axis 5 of the housing 1 under the action of any means known *per se* (not shown), for example a pneumatic system. Under the action of this alternating movement, the hammer 4 periodically strikes a cylindrical anvil 6 normally maintained against a shoulder 7, provided in the housing 1, by the force of a spring 8 supported between the end 3 of the housing 1 and a piston 10 resting against the surface 9 of the anvil 6. The piston 10 is rigid and coaxial with a support rod 11 which extends through a seal 13 in the aperture 12. The rod 11 terminates in an enlarged portion serving as a support 14 for staggered rows of percussion pins 15 guided by means of an antifriction metal sleeve 16 drilled with as many bores as there are pins 15. The bearing sleeve 16 is screwed rigidly at 25 in to the front end 26 of the support 14. Each pin 15 completely traverses the sleeve 16 at its rear end 17 is constituted by a head which, as it housed in a corresponding recess 18 in the rear portion of the sleeve, prevents the pin 15 from being forwardly escaped. Between the main rear surface 19 of the sleeve 16 and the front face 20 of the support 14 there is a free space 21 enabling the pins 15 to move freely in a reverse direction until they contact the face 20 (as indicated in broken line). An axial conduit 22 disposed along the axis of the rod 11 is supplied with air or oiled air through a port 23 and conduits 24, from air introduced into the housing 1 (by means not shown) in order to actuate the hammer 4. The conduit 22 extends to the free space 21; the air which enters the space 21 escapes through the bores in the sleeve 16, by flowing past the pins 15.

The percussion device constructed in this way functions as follows. After the pins 16 have been brought into contact with the surface 27 of a strand 28 to be cleaned, the body 1 is supplied with compressed air causing the hammer 4 to reciprocate along the axis 5. During this movement, the hammer 4 periodically strikes the anvil 6, which transmits the shock to the piston 10, then to the rod 11, and finally to the support 14 and the pins 15. The spring 8 partially deadens the shocks and returns the anvil 6 into contact with the shoulder 7. The repeated striking action is transmitted to the pins 15 as long as they are maintained against the strand 28 (their heads 17 contacting the support 14).

According to a variant of this device, shown in Figure 1*b*, the heads 17 of the pins 15 (arranged in a line) are themselves urged, either singly (as shown) or in groups, against a rear surface of the sleeve 16 under the action of springs 29 bearing against the support 14. This arrangement enables the removal of scale or any other material on the strand 28 to be carried out more efficiently on the most affected surfaces.

According to another constructional embodiment of this device, shown in Figure 2, the housing 101 again comprises a closed end 102 and an open end 103. The hammer 104 is constituted by a permanent magnet and is located in the alternating magnetic field of a fixed winding 105 having a magnetizable metallic core 109 and supplied to terminals 106,107 with alternating electrical current of suitable frequency. The hammer 104 is urged against an annular stop 108, which is non-magnetizable and which rigid with the core 109, by means of a spring 110 bearing against the end 103 of the housing 101; the hammer 104 is slidable in the housing about its axis 111. A tubular casing 112 provided with a rear sleeve 113 passes through the aperture 114 in the end 103 and is fixed in a leak-tight manner in the aperture. A number of percussion pins 120 are housed in the casing 112 and arranged in the form of a ring. The rear end of each pin 120 has a head 115 which may be received in a corresponding cavity 116 provided in the rear surface 118 of the sleeve 113, the pin 120 itself passing through a bore 117 in the sleeve 113. Each head 115 is capped with a permanent magnet 119 whose polarity is opposite to that of the hammer 104.

Under the action of the alternating magnetic field caused by the winding 105, the hammer 104 oscillates along the axis 111, exerting a repulsive effect on the magnets 119 carried by the heads 115 of the pins 120, which it therefore repeatedly pushes against the surface to be cleaned. Advantageously, this action may be readily quantified by fixing the intensity of the permanent magnetization of the hammer 104 in such a way that, under the action of the alternating induction field, the force of repulsion may be sufficiently weak for the magnetized heads of the pins 120 to come readily into contact, under the action of an impact, with the front face 121 of the hammer 104 and thus more readily acquire a kinetic energy capable of having an improved cleaning effect on the zone of the strand being subject to percussion, and possibly benefiting from the amount of movement of the hammer 104.

The device may have, in addition, an internal air or gas flow introduced for example at 22 (for cooling and for preventing ingress of dust). A thermal radiation sighting element 123, axial to the device, sights through a quartz disc 124 and the axial zone of the winding 105 the hammer 104, and the sleeve 116, which are hollow or transparent for this purpose.

By way of example, Figure 3 shows, as a function of time, on one hand, the casting speed of a given strand and, on the other hand, the recording of the surface temperature measurement of the strand, in the first instance without scale removal and then with scale removal. The effect observed is obvious in terms of the quality of the measurement.

CLAIMS

1. A method of measuring the surface temperature of a body, comprising subjecting a given zone of the surface of the body to repeated percussion, receiving thermal radiation from the said zone along a given optical path by means of a sighting instrument, and protecting the optical path from obscuration.

2. A method as claimed in claim 1, in which the percussion is repeated continuously at a given

frequency.

3. A method as claimed in claim 3, including varying the said frequency.

4. A method as claimed in any of claims 1 to 3, in which the percussion is carried out by projecting a striking element against the said zone.

5. A method as claimed in any of claims 1 to 4, including adjusting the percussion force according to the hardness of the said zone.

6. A method as claimed in claim 5, in which the body is in motion, the percussion force being adjusted additionally in accordance with the speed of displacement of the said zone.

7. A method as claimed in any of claims 1 to 6, in which the body is a metal strand being discharged from a continuous casting mould, the method including displacing the sighting axis simultaneously with the strand in such a way as to sight a given point on the strand for a given period.

8. Apparatus for use in measuring the surface temperature of a body by subjecting a given zone of the surface of the body to repeated percussion, from which zone thermal radiation is to be received, the apparatus comprising: a housing, a hammer mounted for reciprocating motion in the housing, means for reciprocating the hammer, a support mounted on the housing, a plurality of pins slidably mounted in the support and retained in the support, the pins projecting from the support in order to contact the said zone, and means for transmitting kinetic energy from the reciprocating hammer to the pins whereby the said zone is subjected to repeated percussion.

9. Apparatus as claimed in claim 8, including means for adjusting the force of the pins on the said zone.

10. Apparatus as claimed in claim 8 or 9, including means for cooling the support.

11. Apparatus as claimed in any of claims 8 to 10, in which the means for reciprocating the hammer and pneumatic.

12. Apparatus as claimed in any of claims 8 to 10, in which the means for reciprocating the hammer are selected from electrical and magnetic means.

13. Apparatus as claimed in any of claims 8 to 12, further comprising a sighting instrument arranged to receive thermal radiation from the said zone.

14. Apparatus as claimed in claim 13, in which the instrument has a sighting axis passing through the support to the said zone.

15. Apparatus as claimed in claim 13 or 14, including an optical fibre one end of which is disposed adjacent the said zone and the other end of which is optically associated with a pyrometer.

16. Apparatus as claimed in any of claims 8 to 15, in which the support has a tubular portion located partially in the housing and rigid with a guide member in which the pins are slidable.

17. Apparatus as claimed in any of claims 8 to 15, in which the support comprises a rod rigid with a piston mounted to slide in the housing and urged towards the hammer by a spring.

18. Apparatus as claimed in any of claims 8 to 15 or claim 17, in which the support comprises a guide member having bores in which the pins are slidable, the rear ends of the pins facing a stop surface in the support.

19. Apparatus as claimed in claim 18, in which there is a spring between each pin and the stop surface.

20. Apparatus as claimed in any of claims 8 to 19, in which the pins are arranged in the form of a ring.

21. Apparatus as claimed in any of claims 8 to 19, in which the pins are arranged in the form of a line.

22. Apparatus as claimed in any of claims 8 to 19, in which the pins are arranged in the form of staggered rows.

23. A method as claimed in claim 1, substantially as described with reference to the accompanying drawings.

24. Apparatus as claimed in claim 8, substantially as described with reference to and as shown in Figure 1*a*, Figure 1*b*, or Figure 2 of the accompanying drawings.

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