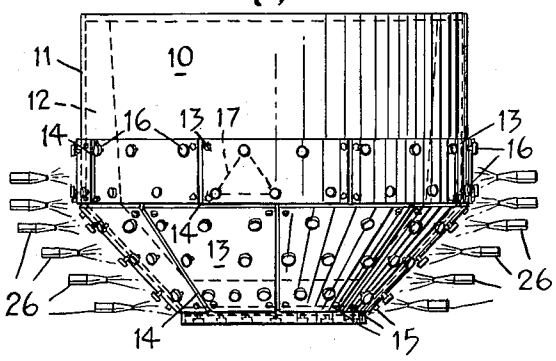
March 13, 1962 V. T. BROWN 3,024,657

MEANS FOR DETERMINING DEFECTS IN FURNACE WALLS

Filed April 23, 1958

Fig. 1



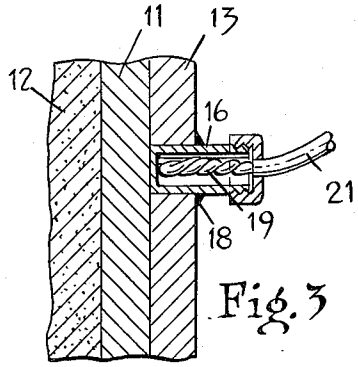
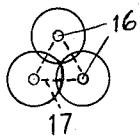


Fig. 3

Fig. 6



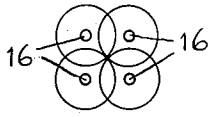


Fig. 7

Fig. 2

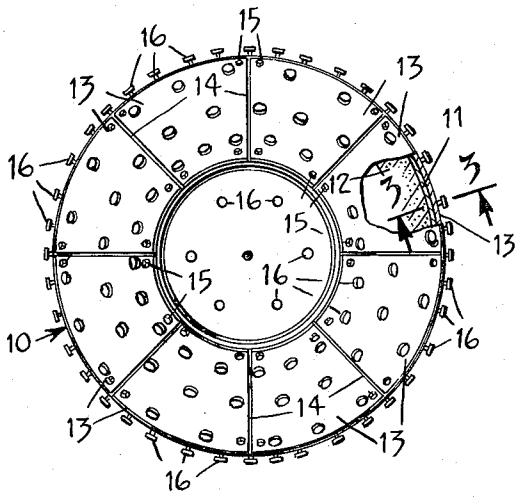


Fig. 4

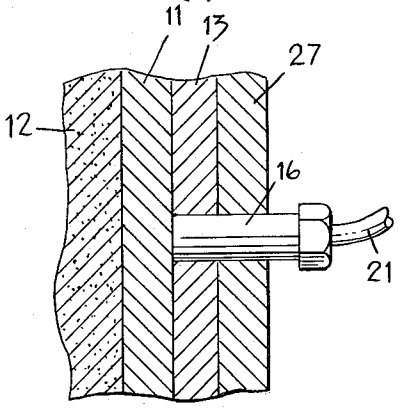
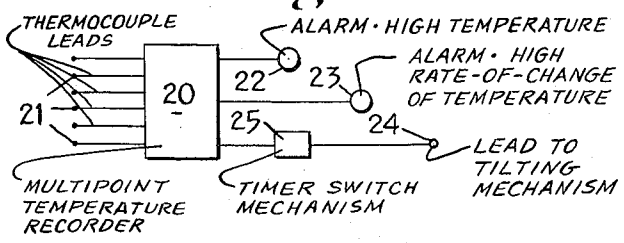


Fig. 5



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MEANS FOR DETERMINING DEFECTS IN FURNACE WALLS

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This invention relates to means for determining defects in a refractory-lined, steel-encased wall of a furnace, and more particularly to a temperature sensing means for detecting a potential "burn-through" in the refractory lining of the furnace wall.

In the metallurgical and other industries where it is necessary to smelt, refine, melt or re-melt materials at high temperatures, there exists the problem of rupture or failure in the refractory lining of the crucible or other type furnace and the subsequent melting of the outer steel wall of the furnace, causing the spilling or discharge of the molten contents of the furnace outside the furnace walls. In that type of furnace, which incorporates sprays for directing water or other type coolant against the outer walls of the furnace, the accidental discharge of the molten metal coming in contact with the water forms steam and volatile gases which create a dangerous condition to equipment and persons working or assembled in the vicinity. Such a phenomenon is commonly referred to in the industry as "burn-through."

It is therefore an object of this invention to overcome the dangers of the above phenomenon by providing an apparatus which will give adequate advance warning of any potential burn-through in the refractory lining of a furnace wall.

Another object of this invention is to provide a temperature sensing means for immediately indicating any overheated localized area in the furnace wall in adequate time for precautionary measures to be taken to prevent a burn-through.

A further object of this invention is to provide an apparatus for indicating a potential burn-through in a furnace wall by mounting temperature sensing devices in a spaced gometrical pattern upon the outside of the wall and by providing means for immediately communicating an excessive temperature in any portion of the wall to one of the temperature sensing devices.

Another object of this invention is to provide a temperature sensing means for indicating a potential burn-through in a furnace wall which will indicate a predetermined maximum temperature or a predetermined maximum increase in temperature.

Another object of this invention is to provide a temperature sensing means for detecting a potential burn-through in a furnace wall and for actuating a mechanism for tilting the furnace to discharge its contents before the burn-through can occur.

A further object of this invention is to provide a temperature sensing means for detecting a potential burn-through in a furnace wall and which is immediately responsive to an overheated condition in any portion of the wall.

Another object of this invention is to provide a temperature sensing means for detecting a potential burn-through in a furnace wall in which a minimum number of temperature sensing devices are equally spaced apart and mounted in a highly thermal conductive shell in intimate contact with the furnace wall.

Other objects and advantages of the invention will be apparent from the following description taken in conjunction with the drawings, wherein:

FIG. 1 is a side elevation of the invention;

FIG. 2 is a bottom plan view of the invention;

FIG. 3 is a section taken along the lines 3—3 of FIG. 2;

FIG. 4 is a view similar to FIG. 3, disclosing a modification of the invention;

FIG. 5 is a schematic diagram showing means for indicating a high temperature or high increase in temperature for any of the thermocouples and the controls for tilting the furnace;

FIG. 6 is a schematic diagram indicating the relative areas covered by each thermocouple disposed in an equilateral triangle; and

FIG. 7 is a schematic diagram indicating the relative areas covered by each thermocouple disposed in a square.

Referring now to the drawings in more detail, FIGS. 1 and 2 disclose a furnace or crucible **10** for high-temperature metallurgical operations, and although it is not disclosed, the furnace **10** is preferably of the type which may be tilted when the molten metal is ready to be poured. The walls of the furnace, both side and bottom, comprise an outer metal shell portion **11**, preferably made of steel, the inside of which is lined with a refractory material **12** designed to come in contact with the high temperature molten metal to protect the steel walls **11**. The constant exposure of the refractory lining **12** to the high temperatures of the molten metal and the continuous heating and cooling and pouring of the metal contents from the furnace gradually erodes the refractory lining to eventually expose the outer steel wall **11** to direct contact and consequent melting by the molten metal contents.

In order to detect such a burn-through, a shell, preferably formed from metal plates **13** having a high thermal conductivity, is mounted in intimate contact with the outside of all portions of the furnace walls, both side and bottom, which are subject to attack by the molten metal contents. The edges of these plates **13** are almost abutting, leaving sufficient spacing **14** to permit the thermal expansion of the plates relative to the steel walls **11**. These plates **13** are preferably made of copper, copper alloy or any other type metal having a thermal conductivity approximately equivalent to or higher than that of copper. The plates **13** may be secured to the outside of the steel walls **11** by bolts **15**, and the bolt holes should be slotted in order to provide oversize bolt holes to prevent shearing of the bolts **15** because of any movement of the plates **13** resulting from thermal expansion.

A plurality of thermocouple wells **16** are inserted into each of the copper plates **13** in a triangular pattern. Each thermocouple well **16** is located at the apex of an equilateral triangle as indicated at **17**, FIG. 1. This triangular pattern is continuous over all the plates **13**. The purpose of such an arrangement is to afford immediate thermal communication between any point on the outer steel wall **11** and at least one thermocouple well **16**, in order that a potential burn-through may be instantly detected. It is believed that by use of the copper plates **13** or other type metal having at least the equivalent thermal conductivity, and the triangular spacing of the thermocouple wells **16**, that a minimum number of thermocouples could be employed with a maximum efficiency. A comparison of the areas of coverage of thermocouples arranged in the pattern of an equilateral triangle (FIG. 6) and in the pattern of a square (FIG. 7), reveals that there are fewer overlapping areas of coverage where the thermocouples are arranged in equilateral triangular patterns than for square or higher polygonal patterns.

The bottom of each thermocouple well **16** should preferably be flush with the inside of the copper plate **13** and abut against the steel wall **11**, as best disclosed in FIG. 3. The thermocouple well **16** may be attached to the outside of the copper plate **13** by means of brazing **18** or by threading. Into each thermocouple well **16** is inserted a thermocouple **19**, which is capable of accurately indicating temperatures up to approximately 3000 degrees

Fahrenheit, such as platinum-platinum 13% rhodium. Each thermocouple communicates with a central indicating unit, such as a multi-point temperature recorder **20**, calibrated to read degrees Fahrenheit through water-tight conduits or cables **21**. Any of several conventional multi-point temperature recorders may be employed for the successful operation of this invention, such as the "General Electric Multipoint Precision Indicator (Bulletin GEC-1311)."

As best disclosed in FIG. 5, the temperature recorder **20** may communicate with an automatic alarm system of standard construction which could be adapted to warn the operator of the furnace or others in the vicinity of the imminence of a burn-through, such an alarm system being adapted to be actuated at a certain predetermined maximum temperature obtained in any portion of the steel wall **11**. **22** represents an electrical connection for an alarm designed to be actuated at a certain predetermined maximum temperature. **23** represents a connection for an alarm device which will be actuated by a predetermined maximum rate of increase in temperature. Connection **24** leads to a mechanism for automatically tilting the furnace **10** in order to discharge the contents of the furnace when a burn-through is imminent. **25** represents a timer switch mechanism, such as the "General Electric Electronic Timer CR7504–A142," for delaying the actuation of the tilting mechanism for a predetermined safe length of time in order to afford the opportunity for manually tilting the furnace.

The copper plates **13** in addition to providing for the rapid conduction of heat from the overheated steel wall **11** to a thermocouple well **16**, also provide for the rapid dispersion of heat from an overheated localized area, to reduce the possibility of the melting of the steel wall, particularly at points where the wall is thin or faulty.

It can also be readily understood that the spacing of the thermocouple wells **16** will be a direct function of the thickness and the thermal conductivity of the plates **13**.

The type of crucible or furnace **10** for which this invention is particularly adapted will incorporate water sprays **26**, disposed proximate to the outside of the furnace walls and adapted to discharge water or other type coolant to cool the furnace walls **11** and also the copper plates **13** in order to afford additional time in which the furnace may be discharged of its contents after a potential burn-through is detected.

A modification of the invention is disclosed in FIG. 4, in which an extra steel jacket or steel plates **27** is disposed in intimate contact with the outer surface of the copper plate **13**, with thermocouple well **16** extending entirely through both the outer steel jacket **27** and the copper plate **13** and abutting against the steel wall of the furnace **11**. The purpose of this construction is to allow the use of plates of a lesser thickness without destroying the effectiveness of the invention or reducing the strength of the furnace walls.

It will be apparent to those skilled in the art that various changes may be made in the invention, without departing from the spirit and scope thereof, and therefore the invention is not limited by that which is shown in the drawings and described in the specification, but only as indicated in the appended claims.

What is claimed is:

1. In combination with a furnace having refractory-lined, metal-encased walls and provided with means for spraying coolant upon the outside walls of said furnace, apparatus for detecting burn-throughs in the refractory-lined portions of said walls comprising, a shell of high thermal conductivity intimately secured in thermal-conductive relation to said walls, a plurality of spaced temperature sensing devices mounted in thermal conductive contact with said shell, each device being located at the apex of a substantially equilateral triangle, and means responsive to each temperature sensing device for actuating an alarm upon the indication of a substantial increase in temperature by any of the sensing devices.

2. The invention according to claim 1 in which the shell constitutes a plurality of plates comprising metal having a thermal conductivity substantially equivalent to or higher than that of copper, and bolts for securing the plates to the outsides of said furnace walls, said plates being proximately spaced from each other and having oversize bolts holes to receive said bolts to permit the thermal expansion of said plates.

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