United States Patent

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[54] **THERMOCOUPLE FAILURE INDICATING DEVICE**
4 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **73/344,** 73/359, 136/234, 340/227, 340/228
[51] **Int. Cl.** **G01k 1/08,** G01k 7/02
[50] **Field of Search** .... 73/344, 359, 341; 136/232, 233, 234; 340/227 (C), 228

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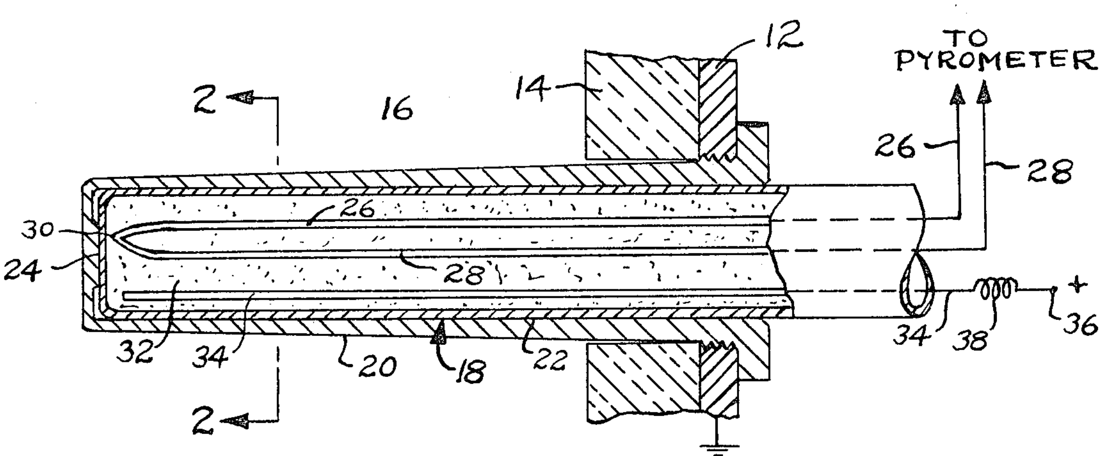
ABSTRACT: A thermocouple for immersion in a bath of molten metal, or other liquid, comprising a closed-ended sheath having crushed ceramic insulation packed therein to thermally insulate certain hot junction wires contained within the sheath. A special auxiliary conductor is arranged within the sheath to energize an alarm circuit should a rupture develop in the sheath wall. Such rupture causes the molten metal to saturate the ceramic and electrically connect with the conductor for developing the alarm signal.



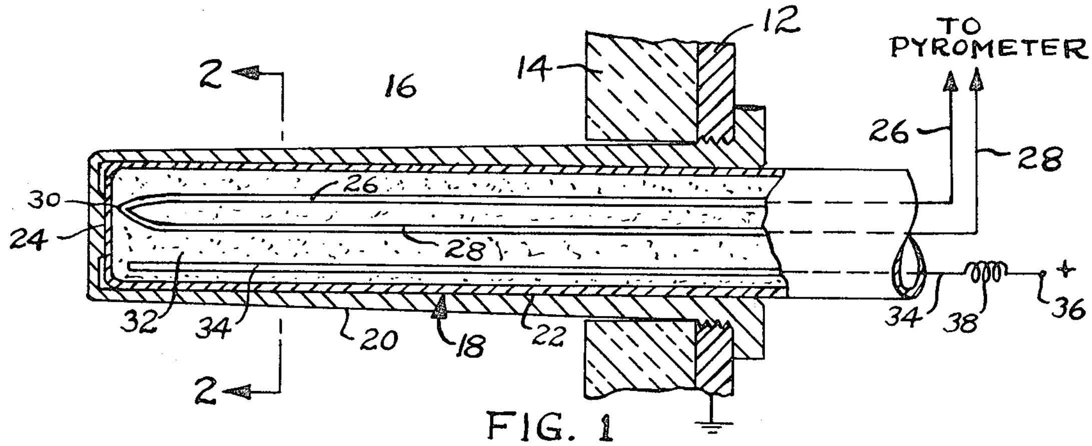
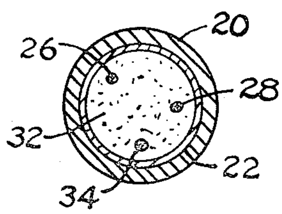


FIG. 1

FIG. 2



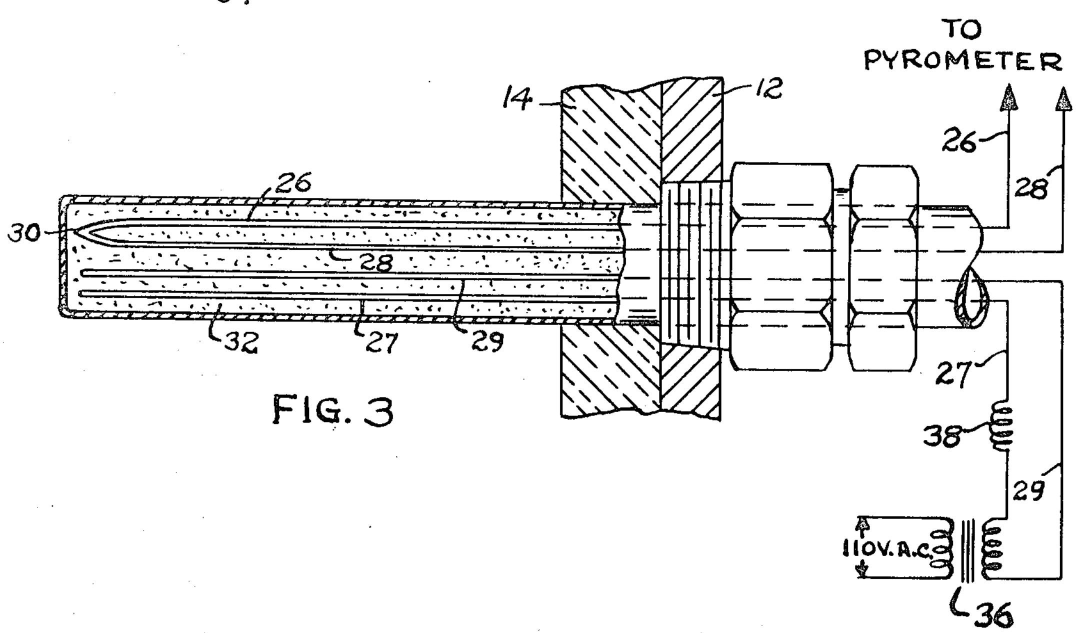


FIG. 3

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THERMOCOUPLE FAILURE INDICATING DEVICE

THE DRAWINGS

FIG. 1 is a view of one embodiment of the invention, partly sectional and partly schematic.

FIG. 2 is a sectional view taken on line 2–2 in FIG. 1.

FIG. 3 is a schematic representation of a second embodiment of the invention.

DRAWINGS IN DETAIL

FIG. 1 shows a furnace or crucible **10** comprising an outer metallic wall **12** having refractory lining **14** for containing a bath of molten material, designated **16**; the molten material may be aluminum, iron, magnesium. A heating means and/or cooling means (not shown) maintains the molten material at one or more selected temperatures for such operations as meltdown, refining, alloying, impurity removal, or annealing, etc. Control of the crucible heating means or cooling means requires that the bath temperature be continually sensed for product quality control and reasonable crucible life.

In the FIG. **1** arrangement bath temperatures are sensed by a thermocouple **18** disposed within a well **20**. Thermocouple **18** includes a tubular metallic sheath **22** having a closed end **24**. Disposed within the sheath are two dissimilar wires **26** and **28** having their ends fused together at **30** to define a hot junction. Thermal and electrical insulation for the wires is provided by crushed ceramic **32** packed into the sheath.

Wires **26** and **28** may be formed of various material combinations, including chromel and alumel, iron and constantan, or rhodium and platinum, as dictated by the operating temperature range of the bath. Sheath **22** may be formed of such materials as inconel or various stainless steels. Ceramic **32** may be magnesia, zirconia, beryllia, or alumina, etc.

Manufacture of the thermocouple preferably includes initial formation of the ceramic as individual compacted pellets or beads. These beads are formed with holes therethrough, whereby individual beads can be strung onto wires **26** and **28** while outside the sheath. The bead-wire assembly is inserted into the sheath, and the sheath is then run through a swaging machine having a die which reduces the sheath diameter. The constricting action of the die crushes the ceramic beads and causes the crushed ceramic to substantially fill the sheath interior, thus providing a dense fill insulation (thermal and electrical) for the wires **26** and **28**.

As long as well **20** and sheath **22** are intact the hot junction **30** will provide a satisfactory thermoelectric current varying according to the bath **16** temperature. This current can be applied to a recording pyrometer, bridge circuit, etc. to provide a record of the bath temperature or a heat control function, all as under conventional practice.

As operations continue the high temperature bath has a progressively increased corroding and/or eroding effect on well **20**, sufficient in time to produce a break or rupture in the well wall. After a further period of operation the molten bath produces a rupture in the wall of sheath **22**, thus enabling the molten material to penetrate into the crushed ceramic and bridge the space between wires **26** and **28**. The thermoelectric circuitry is not completely impaired; instead the circuitry begins to produce an electric signal which is smaller than that due to the hot junction; the molten metal acts as a partial short circuit across the wires to reduce the signal at the pyrometer or controller. It is often unnoticed because the human operator or automatic controller raises the heat input to the crucible so as to bring the crucible temperature to the apparent control point or setting.

Because of the current draining effect of the molten metal the bath temperature must be raised appreciably to produce a satisfactory e.m.f. at the hot junction. A gradual change in calibration occurs, but net effect of the sheath rupture is to raise the actual bath temperature above the control temperature whereby the product quality suffers, and/or power requirements are increased, and/or crucible life is shortened.

The present invention proposes an alarm circuit which produces an electric output shortly after sheath rupture. As shown in FIG. **1** the alarm circuit includes a wirelike conductor **34** extending into the sheath in spaced relation to the sheath and wires **26** and **28**. Voltage source **36** (which may be a battery, transformer etc.) is connected to conductor **34** and to an electromagnetic coil **38**; coil **38** may be part of a meter movement, relay, bell circuit or other alarm device.

In operation, should a break develop in well **20** and sheath **22** the molten bath material will flow through the break and saturate the crushed ceramic within a fairly short period of time so as to bridge the space between conductor **34** and the sheath. The ceramic when dry and suitably compacted, may have a resistance on the order of 1 megohm, whereas ceramic saturated with molten metal may have a resistance less than 100 ohms. The approximately 10,000 to 1 change in resistance is sufficient so that coil **38** can be deenergized when the ceramic is dry and energized when the ceramic is wet. Device **38** can of course be something other than a coil such as a transistor, silicon controlled rectifier, etc. The alarm signal produced by the signal through device **38** will appraise the operator of the defective condition of the thermocouple so that he can replace the thermocouple and the well.

Conductor **34** preferably extends substantially the entire length of the sheath so as to be capable of sensing a rupture at any point along the sheath length. Conductor **34**, as shown in FIG. **1**, is offset from the sheath axis; therefore some points on the sheath surface are further away from conductor **34** than others. The molten bath material must in certain cases migrate through the ceramic greater or lesser distances before bridging the conductor **34**–sheath **22** space. However the difference in migration times is not great, and the protective function is achieved wherever the break takes place.

It will be understood that conductor **34** is assembled into the thermocouple during initial manufacture. Thus each of the ceramic beads is formed with three holes therethrough, whereby conductor **34** and the two operating wires **26** and **28** have the beads strung thereon in a single operation. Subsequent crushing of the beads by swaging, rolling, etc. of the sheath stabilizes the three conductors in their spaced-apart positions.

The alarm circuit shown in FIG. **1** uses the sheath as a ground. If desired the alarm circuit can use two conductor wires **27** and **29**, both insulated from the sheath, as shown in FIG. **3**. Alarm operation is the same as previously described except that the molten bath bridges wires **27** and **29** to energize the alarm device.

FIG. **1** illustrates the thermocouple within a well, whereas FIG. **3** shows the thermocouple without a well; the invention is believed applicable with either arrangement. One particular field of use is in crucibles for heating (melting) aluminum to temperatures near 1350° F. It is believed that other fields such as steel furnaces, catalytic reactors, pickling baths, etc. are applicable for use of the invention.

I claim:

1. A liquid bath temperature-detection thermocouple comprising a closed-ended sheath adapted for immersion within the bath; wires extending within the sheath, said wires being connected together adjacent the sheath closed end to define a hot junction responsive to the liquid temperature; crushed ceramic insulation packed into the sheath around the wires to completely fill the sheath interior space; and sheath-rupture detection means comprising at least one current conductor extending into the sheath in spaced relation to the sheath wall and aforementioned wires, and an external voltage source connected with the conductor; said ceramic insulation being packed around the current conductor to prevent current flow therethrough as long as the sheath is without rupture; said crushed ceramic insulation having a liquid-absorbent character, whereby a rupture in the sheath allows bath liquid to penetrate and saturate the insulation for completing an electric circuit through the aforementioned conductor.

2. The thermocouple of claim 1 wherein the conductor extends substantially the entire length of the sheath whereby to detect a rupture at any point along the sheath wall.

3. The thermocouple of claim 1 wherein the sheath is electrically conductive, said sheath being ground-connected to furnish a current path from the ceramic when the ceramic is saturated with the bath liquid.

4. The thermocouple of claim 1 wherein the sheath-rupture detection means comprises a second current conductor extending into the sheath in spaced relation to the first current conductor, whereby saturation of the ceramic provides a current path bridging the two conductors.