March 15, 1932. E. HERZOG ET AL 1,849,832

THERMOCOUPLE

Filed April 20, 1927

Fig. 1.

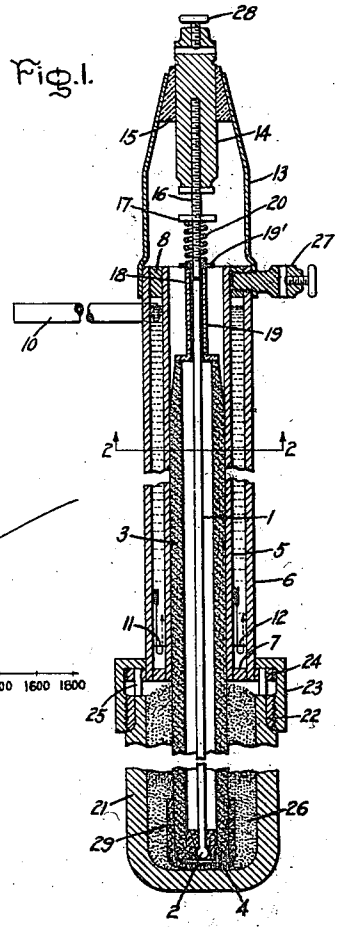


Fig. 3.

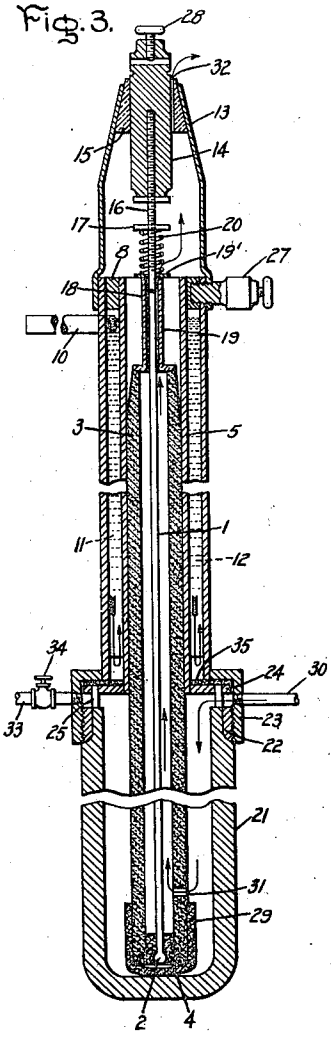


Fig. 4.

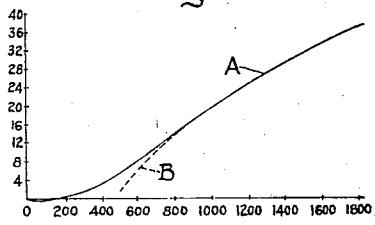
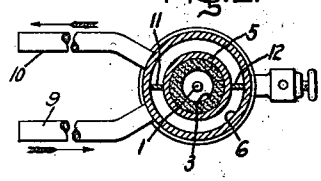


Fig. 2.



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Patented Mar. 15, 1932

1,849,832

UNITED STATES PATENT OFFICE

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THERMOCOUPLE

Application filed April 20, 1927. Serial No. 185,324.

The present invention relates to thermocouples, and comprises particularly thermocouples adapted accurately to measure very high temperatures for prolonged periods of time.

Heretofore in the use of high temperature measuring devices it has been possible only by delicate laboratory methods to accurately measure temperatures as high as 1400° C. Thermoelectric pyrometers when employed above this temperature are usually contaminated or quickly destroyed by the intense heat, while optical pyrometers are generally unsatisfactory, owing to the effects of vapors or gases which are usually given off by materials when heated to high temperatures.

We have discovered that a thermoelectric couple comprising tungsten and graphite has thermoelectric and other physical properties peculiarly adapted for the determination of such high temperatures. Thermocouples embodying the invention have proved to be adapted for continuously indicating and accurately measuring high temperatures between about 1000 to 2300° C. for prolonged periods of time. One of the novel features of our invention comprises the combination with such a couple of means for protecting the couple from the effect of deleterious gases. Other novel features which we believe to be characteristic of our invention are set forth in the appended claims.

The invention itself, however, will best be understood from the following specification when considered in connection with the accompanying drawings in which Fig. 1 is a vertical cross-section of our improved form of thermocouple; Fig. 2 is a cross-sectional view taken on the line 2—2 of Fig. 1; Fig. 3 is a modified form of our invention; and Fig. 4 is a curve which shows the voltage difference between the elements of the couple for a temperature range.

In carrying the invention into effect, we employ a thermocouple consisting of graphite and tungsten members which are given a suitable heat treatment prior to assembly, in order to provide a thermocouple the elements of which will be stabilized or in other words will have substantially constant electrical characteristics. The heat treatment comprises heating the tungsten member, for example to a temperature of about 2000° C. and aging it at that temperature for approximately two hours. The heating and aging of the tungsten produce a structure having substantially constant electrical characteristics. It is probable that this process results in the production of large tungsten crystals, thereby preventing a slow crystal growth of the tungsten member when subjected to heat which would cause variations in the electrical characteristics of the tungsten and, therefore, in readings obtained on an indicating device connected to the thermocouple. The graphite member is heated and aged in the same manner and at the same temperature as the tungsten, the heating and aging of the graphite preventing substantially any subsequent graphitization of carbon in the graphite member.

The thermocouple, when assembled, is protected by means of a layer of suitable carbon, such as charcoal, which surrounds that part of the couple exposed to high temperatures. A portion of the charcoal combines at high temperatures with oxygen from the air which is mixed with the charcoal and forms a layer of carbon monoxide which is inactive with respect to the tungsten and graphite and, therefore, effectively protects from oxidation the hot junction of the thermocouple as well as any portion of the couple which is subjected to the high temperature.

Referring more particularly to Fig. 1 of the drawings, there is indicated at 1 a tungsten rod or wire having a bead 2 at one end thereof and cooperating with a hollow graphite tube or shell 3 to provide a thermocouple. A tapered graphite plug 4, bored centrally to accommodate rod 1, engages and closes the lower end of the graphite tube 3 and provides, with rod 1, the hot junction of the thermocouple.

The upper end of the thermocouple remote from the hot junction is cooled and maintained at a desired temperature by means of a water jacket consisting of an inner metallic member 5 in contact with the graphite tube and an outer metallic member 6. The lower and

upper ends of the jacket are closed by plugs 7 and 8, respectively. Water is supplied to the jacket through a pipe 9, the outlet being indicated at 10 (see Fig. 2). To provide for the proper circulation of the cooling water in the jacket 2, vertical or longitudinal partitions 11 and 12 are inserted between members 5 and 6 at opposite sides of the water jacket.

A tapered metal cap 13 is mounted on the upper end of the water jacket and is provided with a closure member or plug 14 of conducting material mounted in an insulating bushing 15. The plug 14 is provided at its lower end with screw threads adapted to engage a conducting rod 16. This rod is provided with an adjustable plate 17 and is welded at at its lower end to the upper end of the tungsten rod 1, as indicated at 18. An insulating bushing 19 is mounted within the tube 5 to surround the welded joint between the tungsten member and the rod 16 and carries at its upper end an insulating washer 19′. A spring 20 bears against the washer 19′ and plate 17 and serves to maintain the graphite plug 4 in good electrical contact with the graphite sleeve 3, and the tungsten rod 1 in good contact with plug 4.

A sheath 21, the character of which depends on the conditions under which the couple is to be used, surrounds the lower end of the thermocouple. The sheath is provided with a screw threaded ring 22 adapted to engage a second ring 23 mounted on an annular member 24 secured to the lower end of the water jacket. Movement of ring 23 adjusts the position of the sheath 21 with respect to the thermocouple. The sheath is provided with pins 25 movable in openings in the member 24, and is substantially filled with suitable carbon, such as finely divided charcoal, as indicated at 26, which completely surrounds the lower portion of the thermocouple. If desired, a graphite cap 29 may be applied at the lower end of the thermocouple to prevent the couple from sticking to the sheath 21.

Electrical connections may be made from the thermocouple to any suitable indicating device by means of a metal screw threaded binding post 27 electrically connected to the graphite element of the thermocouple through the water jacket, and by means of a screw threaded member 28 provided in plug 14.

When the lower end of the thermocouple is placed in a furnace, the temperature of which is to be measured, the heat from the furnace causes a portion of the charcoal to unite with whatever oxygen may be present in the sheath, and form carbon monoxide. This gas forms a layer completely surrounding the lower portion of the thermocouple, and since the gas thus formed is inactive with respect to the elements of the thermocouple, it effectively prevents any deleterious action on the thermocouple due to the high temperatures employed. The charcoal may be renewed from time to time as found necessary.

Sheath 21 may be made of various materials and its composition depends upon the circumstances under which it is intended to employ the thermocouple. In a gaseous oxidizing flame, it will be found advantageous to employ a carborundum sheath, while if the temperature of molten iron is to be measured by immersion, this sheath will usually be composed of graphite bonded with clay.

In the modified form of the invention indicated in Fig. 3, means are provided whereby gases, such as nitrogen, argon, water gas or hydrogen, which are inactive with respect to the thermocouple for a temperature range depending on the gas employed, may be circulated around the lower portion of the couple. If desired, an inert or inactive gas may be produced by dropping wood alcohol into the hot zone. The particular gas employed, however, will, of course, depend upon the temperatures to be measured.

In carrying this form of the invention into effect, the ring 23 is provided with a supply pipe 30 which may be connected to a suitable source of gas supply, such as an ordinary commercial tank containing, for example, hydrogen. The gas may be supplied very slowly from the tank to the space between the sheath 21 and thermocouple. To provide for the circulation of the gas, a small opening 31 is made in the lower end of the graphite member 3. The heated gas enters opening 31, passes upwardly through members 3 and 19 and then through a small opening 32 in the insulator 15 and out into the atmosphere.

Before starting operation, it may be found desirable to flush out sheath 21 and remove any air which may have accumulated therein. To promote such action, an outlet pipe 33 having a valve 34 is provided in the ring 23. This arrangement allows a large volume of gas to be passed through the sheath, thereby effectively removing any accumulated air. Valve 34 is then closed, and a quantity of gas, only sufficient to ensure exclusion of air, permitted to flow through the sheath. An asbestos gasket 35 renders sheath 21 substantially gas-tight.

A thermocouple consisting of tungsten and graphite members and constructed in the manner above disclosed is particularly advantageous since it will give a relatively high and substantially constant electromotive force for any given temperature and will operate at temperatures up to 2300° C., and even higher temperatures, depending on the conditions of use.

A thermocouple consisting of the above elements has a further advantage due to the low temperature at which reversal of its electromotive force takes place. In the operation of thermocouples, there is a tempera-

ture at which the electromotive force passes through zero and reverses. This reversal takes place with many couples at relatively high or extremely low temperatures. With the present type of thermocouple, this reversal takes place at about 100° C., so that the couple is not affected by this action throughout any portion of its operating range.

This particular feature of the invention is clearly illustrated in Fig. 4, in which the abscissæ represent temperatures in degrees centigrade, and the ordinates millivolts. Curve A was actually determined in practice, while the lower dotted portion B represents points which were calculated but not observed, and indicate the direction which the curve A would normally be expected to take. The reversal of electromotive force of the couple takes place at a point slightly above 100° C., thereby providing an unusually long working range for the thermocouple. It will be noted from the curve shown in Fig. 4 that if the cold junction of the couple were varied in temperature from zero to 130° C., the error introduced in the temperature determination would be quite small; in fact, the maximum error introduced would be approximately 15° C., which obviously would be negligible in high temperature determinations.

What we claim as new, and desire to secure by Letters Patent of the United States, is:

1. The method of treating the elements of a thermocouple consisting of a carbon member and a tungsten member, which comprises heating said elements prior to assembly at a temperature of about 2000° C. for about two hours to thereby produce substantially constant electrical characteristics in said elements.

2. The method of treating the elements of a thermocouple which consist of tungsten and carbon, which comprises aging the elements prior to assembly at a temperature of about 2000° C. to thereby produce substantially constant electrical characteristics in said elements.

In witness whereof, we have hereunto set our hands this 16th day of April, 1927.

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HAROLD L. WATSON.