April 1, 1924. 1,489,115

P. CHEVENARD

DIFFERENTIAL RECORDING INSTRUMENT FOR EXPANSION MEASUREMENTS

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Fig. 1

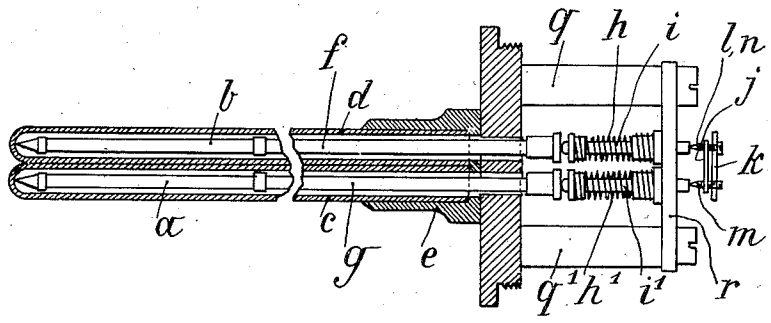
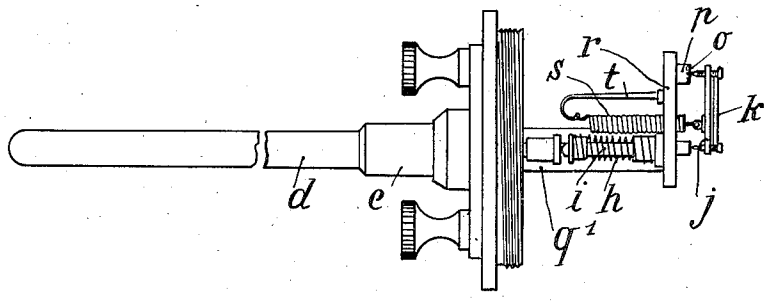


Fig. 3



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Fig. 2

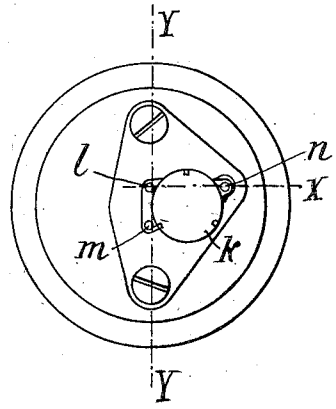
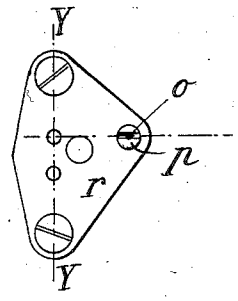


Fig. 4



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UNITED STATES PATENT OFFICE.

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DIFFERENTIAL RECORDING INSTRUMENT FOR EXPANSION MEASUREMENTS.

Application filed August 16, 1921. Serial No. 492,785.

To all whom it may concern:

Be it known that I, PIERRE CHEVENARD, a citizen of the Republic of France, residing in Imphy, Nievre, France, have invented new and useful Improvements in Differential Recording Instruments for Expansion Measurements (for which I have applied for patent in France August 9, 1917), which is fully set forth in the following specification.

This invention relates to an apparatus for observing the expansion of alloys throughout a wide range of temperature, in view of the thermic analysis of such alloys. The measurement of the expansion is carried out in differential form, that is, the relation is observed between the expansion of metal under examination and that of a suitably selected standard which is entirely exempt from anomalous expansion effects.

The said apparatus is automatic in its operation and produces a photographic record of a curve whose ordinates are the differences between the expansion of a specimen piece of the metal under test and that of a standard specimen. The abscissæ of the said curve are the temperatures which are checked by the expansion of the standard specimen.

The following description, together with the accompanying drawing which is given by way of example, shows constructional forms of this invention.

Fig. 1 is a section through the vertical plane of symmetry of the apparatus. Fig. 2 is a side view of Fig. 1. Fig. 3 is a plan view of Fig. 1. Fig. 4 is a side view of Fig. 1 with the optical lever removed.

In the apparatus herein represented, the test pieces a of the steel under examination and the standard piece b are disposed within the tubes c, d formed of melted silica and cemented to a socket e of invar metal which is secured to the base of the instrument. The said test pieces are terminated at one end by a rounded point bearing against the hemispherical end of the tubes c, d. Upon the other ends thereof, which is terminated by a plane surface are caused to bear the rods f, g, preferably formed of melted silica which are submitted to the action of the springs h, h^1. The closed end of the said tubes is inserted in the chamber of an electric furnace of the resistance type which is provided in the interior with a metal muffle and is adapted to bring the test pieces to a high temperature attaining 1100° C., which is exactly uniform.

The expansion of the test pieces which is communicated to the members in melted silica is transmitted to the exterior of the said furnace by the silica rods f, g, and are finally communicated by the tempered steel rods i, i^1 to the optical lever j which serves to amplify the expansion effects. The said lever which is constructed of invar metal is provided with a concave mirror k and is pivoted upon three points of chrome steel l, m, n which are disposed at the angles of a right-angled triangle. The point l situated at the right angle corresponds to the standard piece b, and it bears within a very small recess formed at the end of the steel rod i. The point m bears upon the highly polished end surface of the rod i^1. The point n which maintains an invariable level with reference to the base of the instrument is movable within a groove o formed according to the straight line l, n in a block of tempered steel p which serves to prevent any rotation of the optical lever in the plane thereof. The extension of the straight line l, n encounters the axis of the rod i. In the construction, the straight line l, n will be horizontal when the apparatus is in the level position.

When the test pieces expand, the complex movement of the optical lever may be reduced to two rotations, whereof one takes place about the axis l, x and the other about the axis y, y perpendicular thereto. The image of a fixed spot of light in the mirror k will describe a plane curve, whose abscissa according to l is proportional to the expansion of the standard piece and the ordinate according to l, m to the difference between the expansions of the pieces. All the essential parts of the instrument are constructed of invar metal, with the exception of the columns q, q^1 which are of a 44% nickel steel and whose expansion is such that it will compensate the expansion of the tempered steel rods i, i^1. The said columns are connected by a disk r of invar metal.

The test pieces usually have the same length, but pieces of unequal length may also be used, in such manner as to render a

given region of a curve parallel to the axis of temperatures for the purpose of better exhibiting a small anomalous action. The spot of light whose image in the mirror serves to trace the curve upon a photographic plate, not shown, may be obtained in any suitable manner. For the purpose of recording the time or any other variable, means may be taken to act upon the light beam either by periodically interrupting the same by a suitable mechanism, or by causing to appear in proximity to the curve a suitable standard position mark, such as a short line, cross or the like.

In order that the indications of the expansion pyrometer shall be quite correct, it is necessary that the standard metal should be suitably selected and should correspond to certain conditions. It should particularly possess a mean calorific capacity and a mean expansion which are very near that of the metals under test. Its curve of expansion should be of a perfectly reversible nature and exempt from all abnormal features. Certain metals or alloys of the current types may be used in some cases and within a more or less extended interval of temperature. Such metals are, in the order of increasing expansion, tungsten, platinum-iridium, palladium, copper, silver, etc. But for the greater number of cases, and more particularly for the investigation of steels and iron alloys, the best standards will be found in the two following groups of the series of alloys of iron, nickel and chromium.

First group: Nickel 15 to 25%, chromium 20 to 10%, iron complement.

Second group: Nickel 80 to 90%, chromium 20 to 10%, iron complement.

The above-mentioned alloys which are non-magnetic by reason of the addition of chromium and are therefore exempt from all anomalous expansion effects, will fulfill all the required conditions. By the addition of chromium, they are almost entirely free from oxidation.

Fig. 3 represents a plan view of Fig. 1 wherein the column q^1 is removed, and a spring s carried by the arm t is used to maintain the said optical lever j upon the points l m n. Fig. 4 shows a front view of the plate r, with the optical lever removed.

The device as a whole possesses the following advantages:

The mechanism is of a very simple character and is not affected by shocks, vibrations, or outside electric or magnetic disturbances.

It possesses a high degree of sensitiveness which is obtained by the use of the differential method and the suitable choice of the expansion value of the standard.

A great precision is obtained by reason of the special expansion properties of the standard metal; the precautions taken to obtain equal temperatures for the two test pieces; the use of special alloys to compensate the effects of variations of outside temperature; and the sharpness of the record resulting from the lack of sensitiveness to jarring and the reliable operation of the amplifying mechanism.

What I claim is:—

1. A device for thermic analysis, based upon the measurement of expansion effects by the differential method, comprising two tubes adapted to be heated in an electric furnace, two tests pieces disposed respectively in the said tubes, one of said pieces being formed of the metal under examination, and the other of a standard metal possessing a reversible expansion exempt from anomalous effects and of a value substantially the same as the first piece, means for communicating the expansion of the test pieces to the exterior of said tubes, and light directing means actuated by said first-named means.

2. A device for thermic analysis as set forth in claim 1, which includes means for optically amplifying the expansion effects.

3. A device for thermic analysis as set forth in claim 1, which includes an optical lever of amplification by which the expansion effects are transmitted, three points located according to a right-angled disposition serving as a support for said lever, means for connecting one of said points to the standard test piece, means for connecting the second of said points to the test piece formed of the metal to be examined, means for preventing rotation of said lever in the plane of said three points, a concave mirror supported by said lever and reflecting a fixed point of light for producing a luminous image which is adapted to describe a plane curve, and record, upon a recording device, its movements, the abcissæ of said curve being proportional to the expansion of the standard, and the ordinates to the differences between the expansion of the standard and the metal under examination.

4. A device for thermic analysis as set forth in claim 1 in which the tubes to be heated by the electric furnace are formed of melted silica.

5. A device for thermic analysis as set forth in claim 1, in which the expansion effects of said test pieces are transmitted to the exterior of said tubes by means of silica rods prolonged by tempered steel rods subjected to the return action of springs, the two systems of rods being disposed in the prolongation of the pieces to be studied.

6. A recording device for thermic analysis as set forth in claim 3, including a member provided with a groove in which said

third point moves, in a manner to prevent all rotation of the optical lever in the plane thereof.

7. A recording device for thermic analysis as set forth in claim 6, including a support on which is fixed said grooved member, and suitable columns of nickel-steel for maintaining said support and whose expansion compensates and eliminates that of the tempered steel rods.

8. A device of the class described, comprising, in combination, a pair of test tubes for receiving two test pieces of metal, a pair of rods respectively abutting one end of each of said pieces interiorly of said tubes, means operatively engaging one end of each of said rods exteriorly of said tubes, and a light-reflecting member having engagement with said means and mounted for movement about two axes disposed at right angles, one with the other.

In testimony whereof I have signed this specification.

PIERRE CHEVENARD.