June 24, 1930. P. CHEVENARD 1,766,775

DIFFERENTIAL RECORDING DILATOMETER

Filed April 23, 1926 4 Sheets-Sheet 1

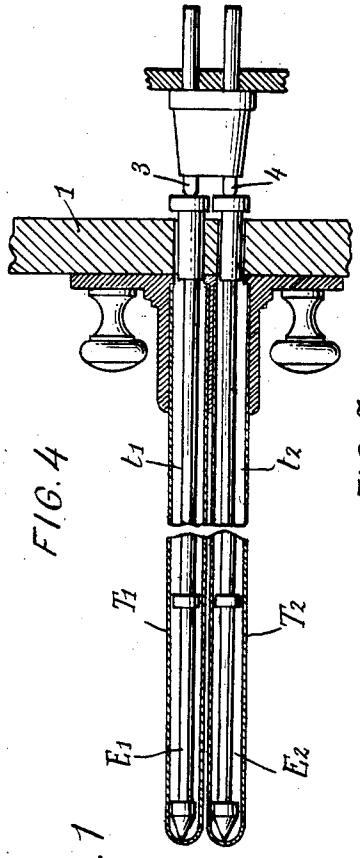


FIG. 1

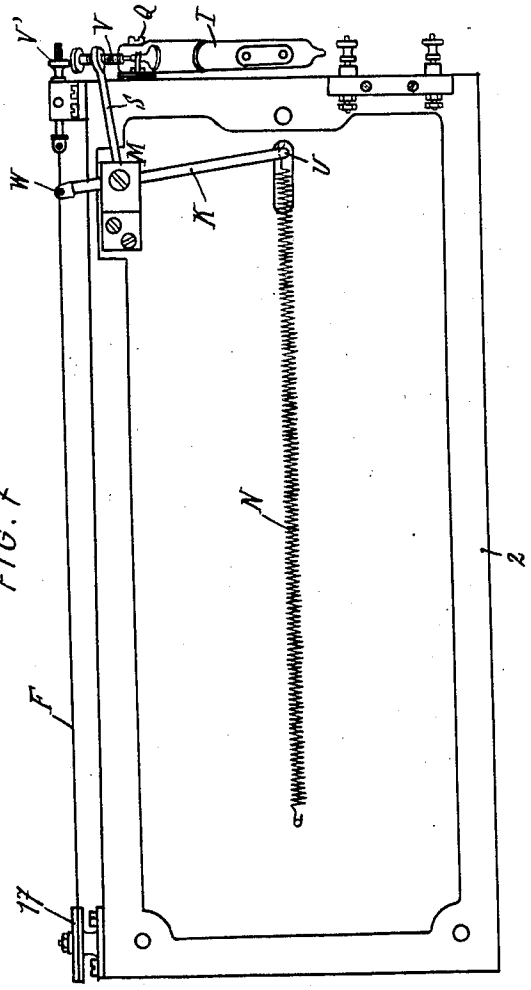


FIG. 7

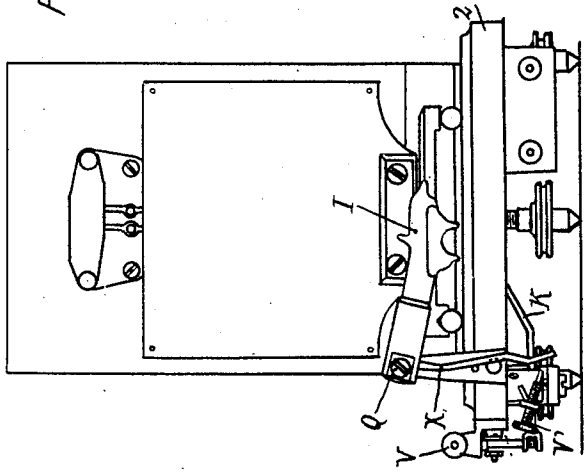
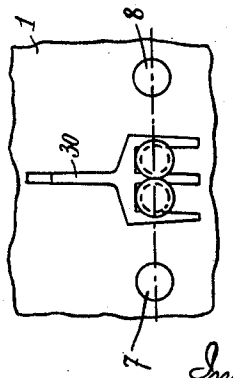


FIG. 6



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DIFFERENTIAL RECORDING DILATOMETER

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FIG. 11

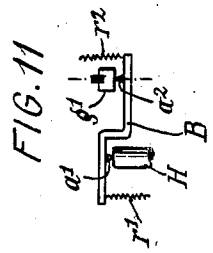


FIG. 2

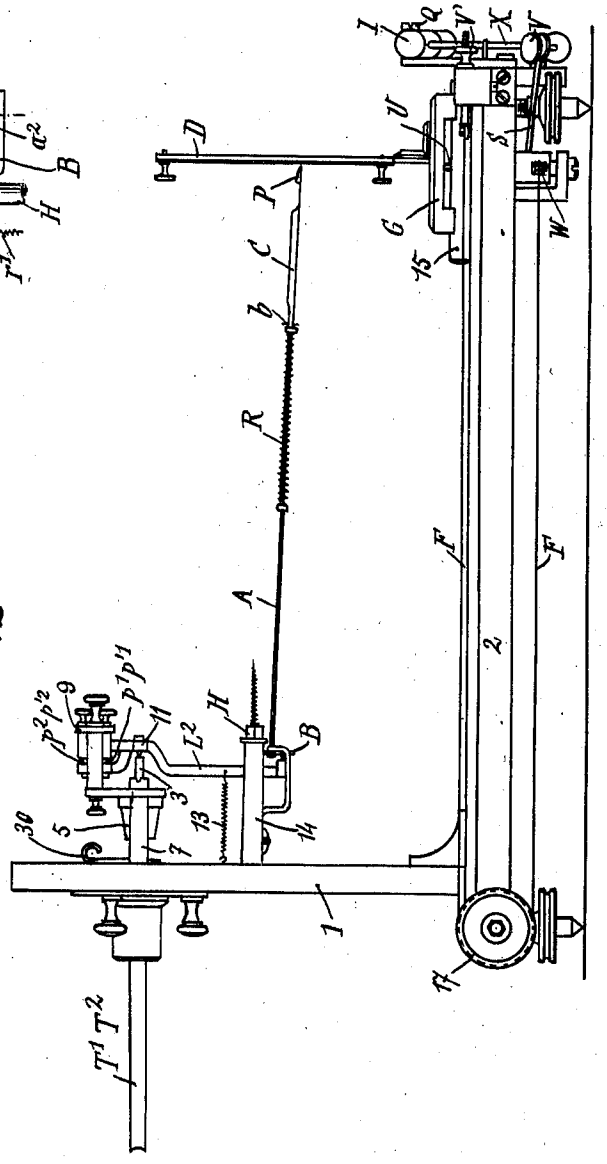
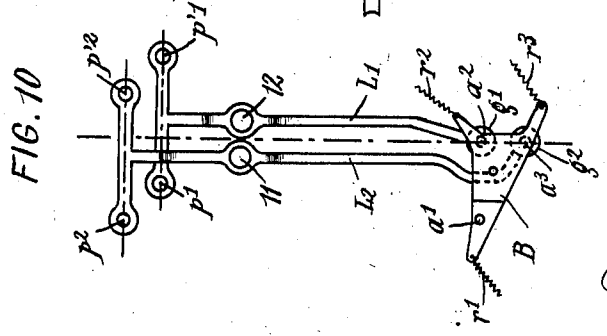


FIG. 10



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DIFFERENTIAL RECORDING DILATOMETER

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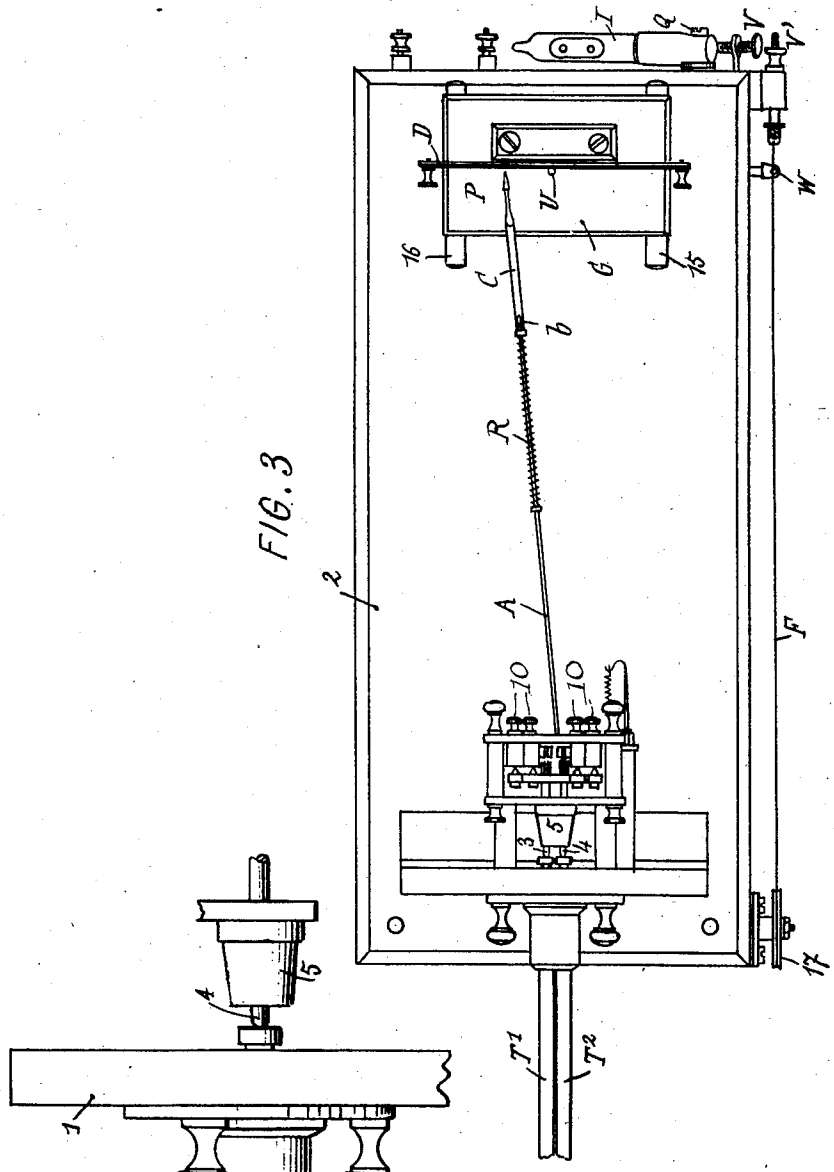


FIG. 3

FIG. 5

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FIG. 9

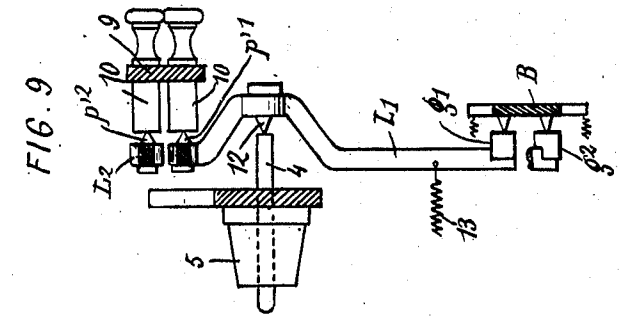


FIG. 8

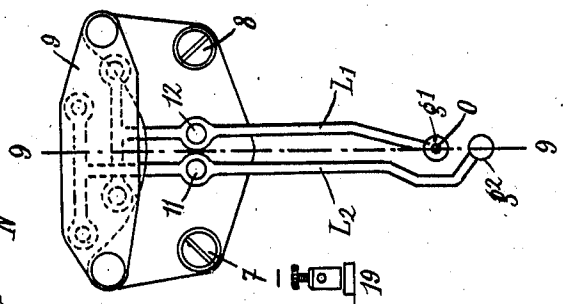


FIG. 12

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Patented June 24, 1930 1,766,775

UNITED STATES PATENT OFFICE

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DIFFERENTIAL RECORDING DILATOMETER

Application filed April 23, 1926, Serial No. 104,130, and in France May 8, 1925.

The dilatometer, the object of the present invention, which comprises a device ensuring the mechanical registering of the expansions, is derived from the registering differential dilatometer the object of a U. S. Patent in the applicant's name No. 1,489,115. It combines the sensitiveness and accuracy of this apparatus with the substantial construction and the convenience of a mechanical registering device. The apparatus, which offers very little encumbrance, may be installed without any special precautions. Photographic manipulations are obviated, and the particular features of the dilatometer curve can be observed during the registering. In this manner the experiment can be stopped as soon as the desired phenomenon has been produced, and this will offer a great economy of time.

As in the differential dilatometer with photographic recording, the new dilatometer automatically inscribes a curve whose co-ordinates are:

1.—The difference between the expansion of the sample to be studied and of a standard consisting of Pyros alloy, for example of the alloy described in U. S. Patent No. 1,489,116 raised to the same temperature.

2.—The expansion of the standard, which covers the axis of the abscissæ and shows the common temperature of the two test bars.

The following description, with reference to the appended drawings which are given by way of example, clearly sets forth the manner in which the invention is carried into effect.

Figs. 1, 2 and 3 are respectively views in profile, in elevation and in plan, of the dilatometer, the object of the invention.

Fig. 4 is a sectional view of the tubes containing the test bars.

Fig. 5 is an elevational view of Fig. 4.

Fig. 6 is a front detail view of the silica rods traversing the plate.

Fig. 7 is a view of the base from below.

Fig. 8 is a front view of the levers transmitting the expansions.

Fig. 9 is a section on the line 9—9 of Fig. 8.

Fig. 10 is a front view of the levers and of the tripod compounding their movements.

Fig. 11 is a section of the tripod.

Fig. 12 is a diagrammatic view of the electric mechanism ensuring the alternating motion of the board carrying the record paper.

The sample bar E_2 and the standard bar E_1 are enclosed in silica tubes T_1 T_2 (Fig. 4); said tubes are heated at the same time in an electric furnace, and the expansion of the bars is imparted to the amplifying elements by the silica rods t_1 t_2. The silica tubes T_1 T_2 are mounted on a vertical plate 1 which is disposed upon the horizontal base 2 of the dilatometer, and the silica rods t_1 t_2 traverse the plate 1, as shown in Fig. 5. The ends or heads of the said rods are in contact with the push-pieces 3 and 4 (Figs. 3 and 5) which are mounted in the sleeve 5. Upon the plate 1 is mounted by means of the rods 7 and 8 (Figs. 2, 6 and 8) the cage 9 which is shown in front view in Fig. 8 and in section in Fig. 9. The said cage comprises four adjustable stop-pieces 10 which are disposed according to two parallel lines and are in contact with the pointed portions p_1 p_1' and p_2 p_2' of the levers L_1 L_2 (Figs. 8 and 10); said levers which are terminated by the said pointed members comprise at the middle part the pointed portions 11 and 12 which are in contact with the push-pieces 3 and 4 (Figs. 2 and 9). Finally the levers L_1 L_2 are terminated by tempered steel contact pieces g_1 g_2. Springs such as 13 (Fig. 2) maintain each of the levers L_1, L_2 in position.

The levers L_1 L_2 which are thus pivoted about the lines of the pointed portions p_1 p_1', p_2, p_2', forming lines of stationary points, will thus afford the first amplification, so that the contact pieces g_1 g_2 at the end of said levers will be displaced by a quantity which is respectively proportional to the expansion of each test bar E_1 E_2.

These expansions are compounded by means of a tripod B (Figs. 9 to 11) provided with the three sharp points a_1, a_2, a_3 which are disposed at the vertices of a right-angled triangle (Fig. 10). The point a_2 corresponding to the right angle is placed in a small recess O which is formed at the centre of the contact piece g_1 (Fig. 8); the point a_3 is in contact with the highly polished flat face

of the contact piece g_2; lastly the point a_1 is engaged in a horizontal slot, not shown, provided at the end of a steel block H (Fig. 11) secure to the support 14 which is mounted on the plate 1 (Fig. 2). The said slot and the recess O which are disposed in line with the slot, will prevent all rotation of the tripod in its own plane. The springs r_1, r_2, r_3 (Figs. 9 and 11) ensure the contact of these various parts. A needle A, terminated by a pen P carrying glycerine ink, is secured to the tripod B and is perpendicular to the plane of the three points a_1 a_2 a_3 (Figs. 2 and 3).

The fork 30 having three branches, shown in Fig. 6, serves as a spacing member, and is inserted below the heads of the rods t_1, t_2 during the assembling of the apparatus; said member limits the displacement of the sliding member to the left, and prevents the tripod from assuming angular displacements of an excessive amplitude.

When the test rods expand, the tripod B is subjected to a complex movement about the stationary point a_1. This movement may be decomposed into two rotations whereof the first, which takes place about a horizontal axis a_1 a_2 is proportional to the difference in the expansion of the two test bars, and the second, about a vertical axis passing through a_1, is proportional to the expansion of the standard bar. The end of the pen P will thus describe, upon a sphere whose centre is a_1, the curve of the differential expansion.

It is now required to register this spherical curve upon a sheet of ordinary paper, while entirely eliminating the friction which would be prejudicial to the delicacy of the curve. The solution of the problem consists in placing the sheet of paper upon a board D which is carried by a sliding element G, movable on the rails 15 and 16 (Figs. 2 and 3) on the base 2 and is given an alternating motion perpendicular to the mean direction of the needle A.

The pen is mounted at the end of a tube C which is slidable upon the needle A; said tube is urged outwardly by a spring R, but its movement is limited by a pin b (Fig. 2).

The amplitude of the alternating motion imparted to the sliding element G is such that the pen ceases to bear upon the board D when the sliding element is at the end of its stroke; but when the board is displaced to the left of Fig. 2, it meets with the pen P and drives back the tube C upon the needle A, whilst a point is registered upon the paper. The curve is thus formed of a series of points which are sufficiently close together to form a continuous curve. Since after each recording of a point, all contact between the pen and the paper ceases, the friction is entirely eliminated and the curve will show the smallest anomalies in the expansion of the sample bar.

To impart the alternative motion to the board, one may employ a mechanical device of any kind, and for example an eccentric controlled by clockwork or by an electric motor. But the motor operating by expansion which will be described hereinafter will afford very satisfactory results.

The board D is actuated by means of an arm U, formed in one with a lever K which is disposed below the instrument base 2 (Figs. 7 and 12) and is pivoted about a vertical axis M M'. To the end W of the lever K is attached a wire F whose outer end is secured to a regulating screw V'. To diminish the space occupied, the wire F is disposed on a pulley 17, so that the operative length of the wire is substantially double the length of the base 2.

The wire F is of an alloy of iron, nickel and chromium which is very expansible and very tenacious when hot; it may be heated by a electric current for which the make and break is controlled by a mercury drop switch I. The said switch is pivoted on a horizontal axis Q. The pivoting movement is controlled by an arm M S which is rigidly secured to the lever K; the regulating screw V which is disposed at the end of the lever M S is in contact with the arm Q X mounted on the switch I. The spring N, whose outer end is attached to the arm U, keeps the wire F suitably stretched at all times. The switch I and the screw V' are connected with the terminals 18, 19 of a suitable source of current (Fig. 12).

When the current passes, the wire F is heated by the Joule effect and thus expands. The change in length, amplified by the lever K, is transmitted by the arm U, and the board D which is urged by the spring N, will make contact with the pen P.

But this movement will cause the pivoting of the mercury switch I, due to the action of the screw V upon the arm X, so that the circuit will be broken. The said wire will be cooled and will thus contract, and the board will be brought to the rear, to a point at which the switch I is again closed, and the above-mentioned actions will proceed as before.

The screws V and V' permit of regulating the amplitude of the alternating motion and the position of the middle of the stroke, relatively to the point of the pen P.

The movement is perfectly noiseless and regular. On the other hand, the device hereinbefore described will allow of marking the time upon the curves for the differential expansion. In fact, by means of a time switch, the current which supplies the expansion motor is cut off, for instance for one minute in every five minutes, and the curve is thus formed of isochronous dashes whose length represents a duration of four minutes, whilst the white space between the same will correspond to a duration of one minute.

Obviously, without departing from the spirit of the invention, it is susceptible of modifications in detail.

What I claim is:

1. A differential dilatometer comprising a device containing a standard piece and a test piece, amplifying levers adapted to be acted upon by the said pieces, during expansion thereof, a tripod adapted to be displaced by said amplifying levers about two rectangular axes, the movement on one axis corresponding to the expansion of the test piece, and the movement on the other axis corresponding to the difference between the expansion of the test piece and the standard piece, a rod mounted on said tripod, a pen secured to said rod, and means for recording the successive positions of the pen.

2. A differential dilatometer, comprising a device containing a standard piece and a test piece, amplifying levers which are acted upon by the said pieces during their expansion, a tripod which is displaced by the amplifying levers in such manner that the said tripod is moved according to two rectangular axes, the movement on one axis corresponding to the expansion of the test piece, whilst the movement on the other axis corresponds to the difference between the expansion of the test piece and the standard piece, a pen which is secured to a rod mounted on the said tripod, a recording board which is brought into contact with the said pen at regular intervals, and means imparting an alternating movement to the said recording board.

3. A differential dilatometer comprising means adapted to contain a standard piece and a test piece, a plurality of sets of amplifying levers which are separately acted upon by the respective pieces, means whereby the compound action of the sets of amplifying levers may be affected, the said means being adapted for the displacement of an element according to two axes, a rod which carries a tracing member and is secured to the said element, and mechanical devices for rcording the movements of the said tracing member.

In testimony that I claim the foregoing as my invention, I have signed my name hereto.

PIERRE CHEVENARD.