

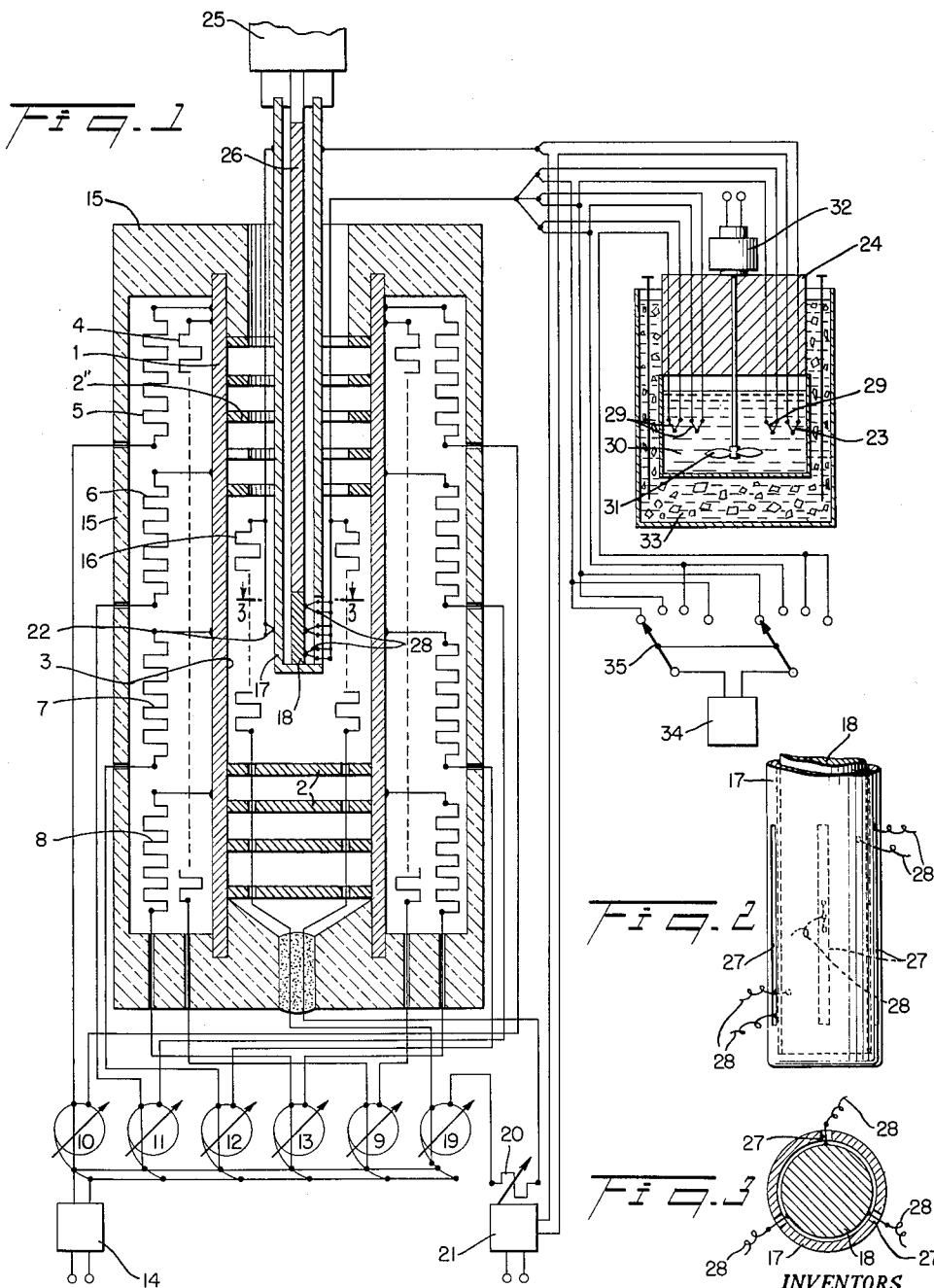
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FURNACE ADAPTED FOR USE IN DILATOMETRY

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FURNACE ADAPTED FOR USE IN DILATOMETRY
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It is necessary, in making precision dilatometry measurements, to have a furnace or heated enclosure in which the specimen being tested is introduced, which is maintained at a precise temperature. A typical temperature at which dilatometry measurements are made, for example, is 300° C. Such temperature must be maintained as uniform as possible, in order to decrease errors in measurement, particularly in the neighborhood of the critical temperatures of the material of which the specimen is made. Finally, in order to be successful in an industrial laboratory, it is necessary that the specimen be heated relatively rapidly to the desired temperature so that each measuring cycle, which includes alternate measurements on the heated and cooled specimen, may be relatively short.

Furnaces or ovens which are satisfactory for other purposes are not satisfactory for the present purposes since they do not fulfill the above requirements. As a matter of fact the introduction of a cold specimen into the furnace at an elevated temperature causes large thermal perturbations which cause a relatively large gradient in temperature precisely in the region of the furnace where the temperature should be most uniform. As a result, the temperature of the specimen cannot be brought to a value accurate enough to permit a correct measurement of the dilation or expansion of the specimen without an undue delay to achieve temperature equilibrium.

The present invention relates to an oven or furnace of the double chamber type, which is characterized by the use of a first or outer heated chamber, and by a second heated chamber located interiorly of the first chamber and receiving the specimen to be heated. The external chamber assures the maintenance of a chosen uniform temperature on its inner surface, and the internal chamber, which is completely enveloped by the external chamber, has for its function the transmission of said temperature to the specimen to be heated.

Preferably both of the chambers, and in any event the external chamber, include a plurality of heating elements so constructed and arranged as to yield perfect uniformity in the temperature and the necessary heat insulations. Such temperature is held accurately by control and regulating apparatus employed in conjunction with the furnace.

The specimen to be heated is supplied with heat from the system for heating the inner chamber, which is preferably placed in operation at the moment of the introduction of the specimen into the apparatus. According to another manner of operation of the device of the invention and to gain time said heating of the interior chamber may be started before the introduction of the specimen, in such manner as to accumulate in advance a quantity of heat sufficient to produce all or a part of the rise in temperature of the specimen which is required.

The present invention will be described in a detailed manner by reference to a preferred, non-limiting embodiment, of apparatus for making precision dilatometric measurements. Such embodiment incorporates a double-chamber furnace made in accordance with the present invention. It is clear that the furnace of the invention may be applied to other applications such as, for example, the determination of magnetic permeability as a function of temperature, or of Curie points. Those skilled in the art will, without difficulty, immediately comprehend a

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number of other uses to which the furnace may be put. In the accompanying drawings, forming a part of the specification:

FIG. 1 is a somewhat schematic view in vertical cross section through the aforesaid apparatus which makes precision dilatometric measurements;

FIG. 2 is a fragmentary view in said elevation on an enlarged scale of the lower end of the specimen holder; and

FIG. 3 is a view in transverse section through the specimen holder, the section being taken along the line 3—3 of FIGS. 1 and 2.

Turning now to the drawings, the illustrated precision industrial dilatometer is of the vertical type, and has a microscopic head. The apparatus includes a cold chamber, maintained at 0° C., and the double-chamber furnace of the present invention. The specimen being tested is placed successively in the cold chamber and in the double-chamber furnace, and the measurement of the elongation of the specimen when heated to the temperature allows the determination of the linear coefficient of dilation or expansion of the specimen.

In FIG. 1 the external chamber has its inner wall formed of an elongated metal tube 1 of great thickness which is preferably made of copper. Tube 1 is provided with a number of discs or diaphragms 2, 2', preferably also made of copper, suitably distributed on both sides of central part 3 that comprises no disc. At the upper end of tube 1 the discs 2' have a central opening through which the specimen and its holder may be introduced into the furnace. The bottom discs 2 and the upper pierced discs 2', taken two by two, form closed or partially closed spaces which contribute to the thermal equilibrium of the furnace. The discs 2 and 2' are made vertically adjustable with respect to tube 1, so that it is possible to adjust the volume of the spaces between successive discs, whereby to obtain better thermal equilibrium of the furnace in certain cases.

Exteriorly of tube 1 there are placed heating coils for the external chamber; in the embodiment shown such coils consist of a principal winding 4, shown placed closer to tube 1, and four auxiliary heating coils designated 5, 6, 7, and 8, and shown disposed further from tube 1. It will be understood that the relative disposition of the principal and auxiliary heating coils may be varied as desired. The principal heating coil provides the major part of the necessary heat, and the four auxiliary heating coils at their respective positions then provide local heat necessary to eliminate any gradient of temperature along the length of tube 1. The principal heating coil 4 is supplied with heating current through its individual control means 9, which may be in the nature of an auto-Variac. The auxiliary heating coils 5, 6, 7, and 8 are likewise under the control of their individual controlling elements 10, 11, 12 and 13, which may be similar to element 9. Heating current for each of the heating elements is supplied from a suitable source 14 which provides a stabilized voltage. The tube 1 and the principal and auxiliary heating elements are enclosed within a heating insulating chamber 15 which has a closed bottom and, closed side-walls enveloping the heating coils and tube 1, and a top having a central opening aligned with the axis of tube 1.

By suitable adjustment of control means 9—13, inclusive, the furnace may be heated to the desired temperature, and each temperature may be made uniform throughout the total extent of the surfaces of the central cavity 3 of the external chamber.

The interior chamber encloses a heating coil 16 which is disposed within cavity 3 extending about the axis thereof. Heating means 16 is so disposed as to receive within it a specimen carrier 17 which extends downwardly into the furnace coaxial of tube 1. The speci-

men being measured, designated 13, is disposed coaxial of specimen carrier 17, and thus lies coaxial of heating coil 16. The electric current necessary to heat coil 16 is furnished by an arrangement including an auto-Variac 19, which may be similar to devices 9-13, inclusive, and a rheostat 20 which is controlled by a regulator 21. Preferably regulator 21 is of the so-called proportional action type, operated by a thermocouple having a large variation of voltage with temperature change. The hot junction 22 of such thermocouple is supported in the immediate neighborhood of the specimen 18; the cold junction 23 of such thermocouple is maintained very accurately at 0° C. in an auxiliary enclosure designated 24.

Heating coil 16 furnishes all or the major part of the heat necessary to raise the specimen 18 and the specimen holder 17 to the desired temperature. The heating of coil 16 decreases or ceases when the specimen attains the desired predetermined elevated temperature at which the measurement is to be made. Heating coil 16 functions to regulate the temperature of the furnace during such measurement so that it is not necessary, during such measurement, to vary the heating of coils 4, 5, 6, 7 and 8 of the external chamber. Thus the current supplied to such latter coils may be initially determined, and need not be further varied throughout a series of measurements.

The specimen 18 is positioned at the bottom of the tubular specimen holder 17, the latter being closed at its lower end. The upper end of the specimen holder is supported, by means not shown, under a microscopic head 25 of apparatus which measures changes in length. The specimen 18 is in contact with a longitudinally-extending rod 26 which is of very accurate length and diameter and which slides freely in the specimen holder 17. The upper end of rod 26 engages the feeler of the microscopic head 25. In order to minimize the values of residual corrections, the specimen holder 17 and the rod 26 are made of the same material, and preferably are made of material having a low coefficient of expansion such as, for example, transparent silica.

The construction of the specimen holder 17 is shown more fully in FIGS. 2 and 3. The side wall of the specimen holder is provided with three vertical slots or windows 27 equally spaced 120° apart. Slots 27 allow the three hot junctions 28 of three thermocouples to be placed directly in contact with the surface of the specimen 18. Preferably one of such junctions engages the top of the specimen, the second engages generally the midst of the specimen, and the third engages the bottom of the specimen.

The cold junctions 29 of such three thermocouples are immersed in a bath contained in the auxiliary enclosure 24 and accurately held at 0° C. Such three thermocouples are preferably of the platinum-platinum rhodium alloy type (10% rhodium, 90% platinum). The auxiliary enclosure 24 contains a liquid 30 in which are immersed the cold junctions 23 and 29 which is a good conductor of heat and has good dielectric or electrically insulating properties. The bath is maintained at uniform 0° temperature and is stirred by an agitator or propeller 31 driven by a motor 32. The auxiliary container 24 is immersed throughout a substantial part of its depth in melting ice and water bath 33 wherein the temperature is maintained substantially constant by manual agitators as shown.

Measurement of temperature by means of the three thermocouples is carried out very accurately by means of a potentiometer 34, sensitive to the microvolt, which may be connected sequentially to the respective thermocouples by the switch 35. When an accurate instrument 34 is employed the temperature of each point on the sample may be obtained with an accuracy of $\pm 0.1^\circ$ C. The fourth position of switch 35, which is that shown in FIG. 1, allows the three thermocouples to be connected in series, the series connected thermocouples being then con-

nected to the potentiometer 34. This gives a reading on potentiometer 34 which is the sum of the three thermoelectric forces, and determines the mean temperature of the specimen 18 with a high degree of precision. The apparatus thus insures that the error difference between each of the local temperatures and the mean temperature of the specimen shall not exceed a predetermined value.

The dilatometer includes, in addition to the heated chamber or furnace and its accessories which have been described above, a cold chamber of the type used in the International Bureau of Weights and Measures, such cold chamber being maintained very accurately at a temperature of 0° C. In accordance with one particularly advantageous embodiment, the cold chamber and the heated chamber may be placed upon a support which rotates in such manner that the axis of each of the enclosures may be moved to coincide with the axis of the specimen holder. Such support may also be adjusted to the desired height, as for instance by an oil press. With such arrangement, the axis of the specimen holder with its contained specimen may be placed in alignment with the axis of the considered chamber and may be successively introduced into the cold chamber and then into the heated chamber by progressively raising the support. In making measurements with the apparatus above described and shown in the drawings, the temperature of the furnace or oven is first regulated by proper adjustment of the voltages to which the heating coils 4-8, inclusive, are subjected. The principal heating element is energized to give a temperature below that desired. The inevitable gradient in temperature at the interior of the external chamber is then corrected by placing in service the four auxiliary heating elements 5-8, inclusive. Such auxiliary heating elements are energized in such manner as to obtain a uniform temperature longitudinally of the cavity 3. Such adjustment of the auxiliary heating elements may be made with the aid of suitable thermocouples (not shown) disposed temporarily into such cavity 3.

The specimen 18, whose length is measured by the microscopic head 25, is successively cooled to 0° C. by the cold bath and is then heated to the desired temperature in the furnace. At the moment when the specimen holder is thrust into the interior of the furnace the regulating thermocouple affixed to the specimen holder will be placed in the furnace at the same time and will operate the regulating heating element 16 which is thus placed in operation and compensates for the cooling of cavity 3 caused by the introduction of the cold specimen. At the same time the final temperature of the specimen is attained, and is maintained uniform throughout the time necessary for the dilation measurement.

According to an alternative embodiment, in order to shorten the time required for making such measurement the regulating heating element 16 may be energized before the introduction of the specimen into cavity 3, and may thus participate in the initial heating of the furnace, causing the temperature of cavity 3 to rise above the final predetermined temperature desired. The introduction of the cold specimen holder and the cold specimen will then decrease the temperature of the furnace to the desired temperature, and the regulating thermocouple and heat coil 16 will assure the stabilization of such temperature.

The above described dilatometer permits the determination of the coefficient of linear dilation or expansion for a large number of solid substances and in a variety of forms.

By way of example the described apparatus permits the obtaining of a temperature gradient less than 0.3° C. from one extremity to the other of a specimen having a length of 100 mm., and to determine the mean temperature of the specimen with an accuracy better than $\pm 0.2^\circ$ C. When a microscopic head sensitive to the tenth of a micron is employed, the accuracy of such ap-

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paratus is at least comparable or equal to that of existing interferential dilatometers. With specimens of standard known lengths, the coefficients of dilation may be obtained in absolute values. Measurements may be made with the apparatus with great rapidity; for example, in one hour with an apparatus provided with one microscopic head a complete measurement may be carried out. Alternatively, 12 determinations of coefficients of dilation may be made in 8 hours with an apparatus embodying two heads so as to permit simultaneous measurements on two specimens at one time with the same equipment, in the manner outlined above wherein cold and heating chambers are disposed on the same rotatable support.

Although only a limited number of embodiments of the invention have been illustrated in the accompanying drawings and described in the foregoing specification, it is to be expressly understood that various changes, such as in the relative dimensions in the parts, materials used, and the like as well as the suggested manner of use of the apparatus of the invention, may be made therein without departing from the spirit and scope of the invention as will now be apparent to those skilled in the art.

What is claimed is:

1. A furnace comprising a first, internal heating chamber adapted to receive an object to be heated, heating means for said first chamber, a second, external heating chamber containing the first chamber, heating means within said second chamber and outside said first chamber of the electrical resistance type comprising a principal heating coil extending throughout substantially the entire length of the second chamber and supplying the major part of the necessary heat energy, and auxiliary windings located at different localized zones within the second chamber supplying additional heat at said various localized zones, said second chamber heating means maintaining the internal surface of the second chamber at a predetermined desired temperature, the first chamber transmitting the necessary heat to said object to heat the same to a predetermined temperature.

2. A furnace as defined in claim 1 wherein said internal chamber has positioned at each end thereof a plurality of temperature stabilizing zones formed by a plurality of spaced-apart partitions supported by the exterior wall of said chamber, and wherein the internal chamber heating means is positioned in the central part of said chamber.

3. A furnace as defined in claim 2 wherein said partitions are movable toward and away from each other along the axis of said internal chamber whereby the volume included between successive partitions may be varied.

4. A furnace according to claim 1 in which the heating means inside the internal chamber is of the electrical resistance type and comprises a heating coil positioned for surrounding the object to be heated and control means for regulating the temperature of the object to keep the same constant during the whole time it is maintained in the furnace.

5. A furnace according to claim 4 in which the control means for the heating coil of the internal chamber is actuated before the introduction of the object and its action is suppressed when the object is brought to the desired temperature.

6. A furnace according to claim 4 in which the control means for the heating coil of the internal chamber is actuated when the object is introduced in said chamber and its action is suppressed when the object is brought to the desired temperature.

7. A furnace according to claim 6 wherein the control means for the heating coil of the internal chamber comprises a regulator operated by a thermocouple having its hot junction placed in the immediate neighborhood of the object.

8. A furnace according to claim 4 in which the heat-

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ing coil is placed in the central part of the internal chamber between an upper and a lower zone provided with parallel transverse partitions supported by the exterior wall of said chamber, the partitions of the upper zone leaving a central opening for the reception of the object to be heated.

9. A furnace according to claim 8 in which the distance between the partitions is adjustable.

10. A furnace adapted for use in a precision dilatometer comprising a first, internal heating chamber having an opening therein adapted to receive a specimen holder, a second, external heating chamber containing the first chamber, and heating means within the second chamber and outside the first chamber, said heating means maintaining the internal surface of the second chamber at a predetermined temperature, the first chamber transmitting said predetermined desired temperature to the object to be heated, said heating means comprising a first heating resistance coil surrounding substantially the entire partition separating the internal chamber from the external chamber and a plurality of auxiliary heating coils acting on localized parts of the height of the external chamber and being separately regulated for compensating the temperature differences which may be established along the height of the external chamber.

11. A precision dilatometer comprising a specimen holder, a microscopic head for the specimen holder, and a furnace for heating the specimen holder and the contained specimen to the predetermined desired temperature, said furnace comprising a first, internal heating chamber having an opening therein adapted to receive the specimen holder, a second, external heating chamber containing the first chamber, and heating means within the second chamber and outside the first chamber, said heating means maintaining the internal surface of the second chamber at a predetermined temperature, the first chamber transmitting said predetermined desired temperature to the object to be heated, said heating means comprising a first heating resistance coil surrounding substantially the entire partition separating the internal chamber from the external chamber and a plurality of auxiliary heating coils acting on localized parts of the height of the external chamber and being separately regulated for compensating the temperature differences which may be established along the height of the external chamber.

12. A precision dilatometer as defined in claim 11 in which the specimen is contained in a specimen holder whose side walls is provided with three slots equally spaced of 120° permitting the direct contact of the hot junctions of thermocouples with the surface of the specimen.

13. A precision dilatometer as defined in claim 11 in which means are provided for placing the axis of the specimen holder in alignment with the axis of the heated chamber.

14. A precision dilatometer as defined in claim 13 in which the specimen holder is raised by a support so that it may be successively introduced in the heated and into a cold chamber.

15. A furnace adapted for use in a precision dilatometer comprising a first heating chamber having an opening therein adapted to receive a specimen, a second heating chamber surrounding said first chamber, heating means within said second chamber whereby the internal surface of the second chamber is maintained at a predetermined temperature and comprising a first heating resistance coil surrounding substantially the entire partition separating the first chamber from the second chamber and a plurality of auxiliary heating coils acting on localized parts of the height of the second chamber and being separately regulated for compensating the temperature differences which may be established along the height of the external chamber, heating means for said first chamber, control means for said first chamber heating means comprising a regulator operated by a thermocouple which has its hot junction

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tion placed at spaced apart positions adjacent the specimens to be heated.

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