



Designation: B389 – 81 (Reapproved 2020)

# Standard Test Method for Thermal Deflection Rate of Spiral and Helical Coils of Thermostat Metal<sup>1</sup>

This standard is issued under the fixed designation B389; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method covers the determination of the thermal deflection rate of spiral and helical coils of thermostat metal.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to become familiar with all hazards including those identified in the appropriate Safety Data Sheet (SDS) for this product/material as provided by the manufacturer, to establish appropriate safety, health, and environmental practices, and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 ASTM Standards:<sup>2</sup>

E77 Test Method for Inspection and Verification of Thermometers

## 3. Terminology

3.1 *thermostat metal, n*—a composite material, usually in the form of sheet or strip, comprising two or more materials of any appropriate nature, metallic or otherwise, that, by virtue of

differing expansivities of the components, tends to alter its curvature when its temperature is changed.

3.2 *thermal deflection rate, n*—the ratio of angular rotation to temperature change. It is a measure of the coil's thermal activity. It may have the units of angular degrees per degree Fahrenheit, or Celsius, and is expressed by the equation  $D = (A_2 - A_1)/(T_2 - T_1)$  where  $A_2$  and  $A_1$  are angular positions at temperature  $T_2$  and  $T_1$  respectively.

3.3 *spiral coil, n*—a part made by winding strip on itself. Fig. 1 and Fig. 2 show typical spiral coils, which can be wound with the low-expansive side inside or outside, mounted on the specimen holder.

3.4 *helical coil, n*—a part made by winding strip in a form wherein the plane of the width of the strip is parallel to the axial length. Fig. 3 shows a typical helical coil, which can be wound with the low-expansive side inside or outside, and right-hand or left-hand, mounted on the specimen holder.

## 4. Summary of Test Method

4.1 The test for thermal deflection rate of spiral and helical coils consists of measuring the angular rotation that a coil undergoes in response to a known temperature change.

## 5. Significance and Use

5.1 This test method simulates, to a practical degree, the operation of the thermostat metal coil.

5.2 The thermal deflection properties of a coil may vary from lot-to-lot of thermostat metal material. This method is useful for determining the optimum thickness and length of the material for a given deflection specification.

5.3 This method is useful as a quality test to determine acceptance or rejection of a lot of thermostat metal coils.

## 6. Apparatus

6.1 *Temperature Bath*—A stirred liquid bath or uniformly heated enclosure in which the specimen and mounting fixture can be placed shall be used. An adjustable heating source is desirable for maintaining the specimen at the desired temperatures with a variation in temperature throughout the specimen not to exceed 0.5°F (0.3°C).

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee B02 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.10 on Thermostat Metals and Electrical Resistance Heating Materials.

Current edition approved Oct. 1, 2020. Published October 2020. Originally approved in 1962. Last previous edition approved in 2016 as B389 – 81 (2016). DOI: 10.1520/B0389-81R20.

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.



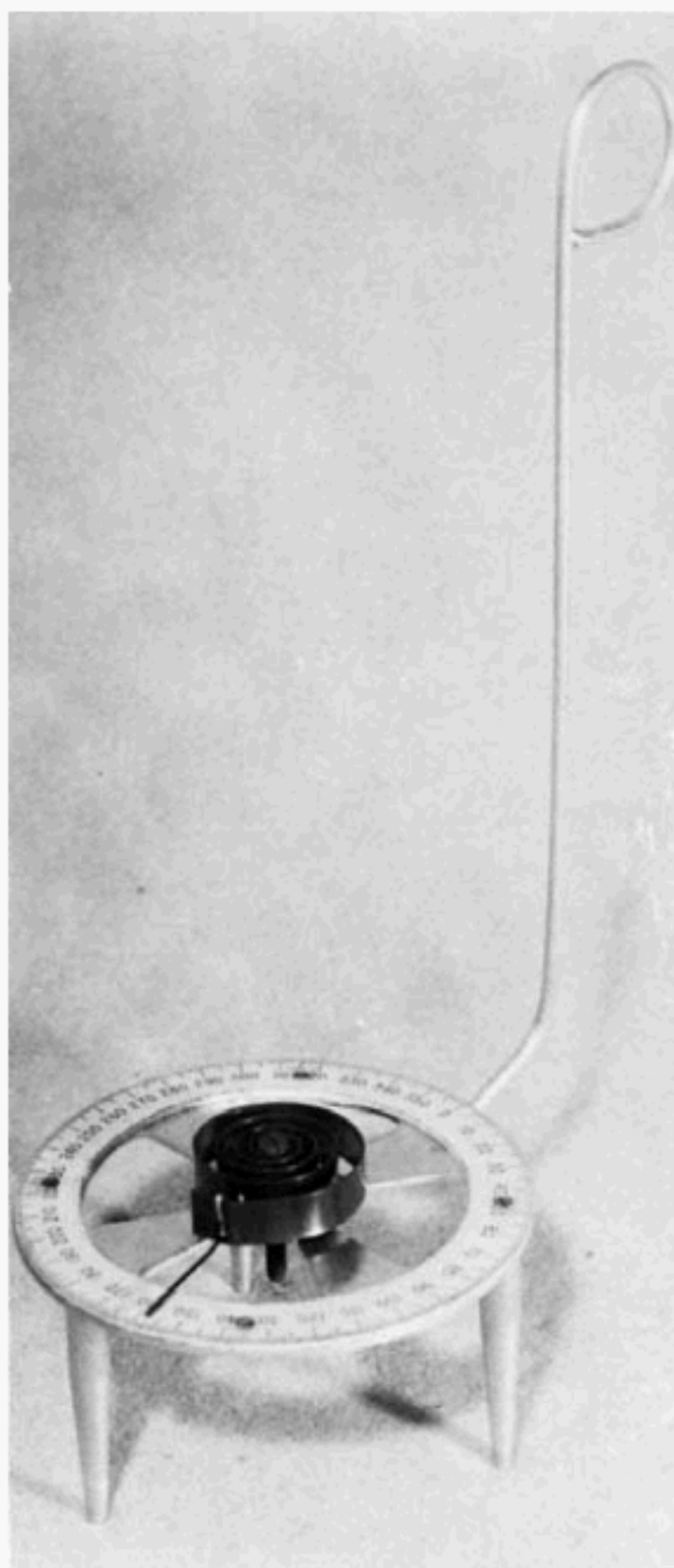


FIG. 1 Spiral Coil

6.2 *Protractor*—The angular position at each test temperature shall be measured by a protractor with a minimum division of  $0.5^\circ$ .

6.3 *Temperature-Measuring Apparatus*—The apparatus for making temperature measurements shall be of such accuracy that the individual temperatures shall be known to be within  $\pm 0.5^\circ\text{F}$  ( $\pm 0.3^\circ\text{C}$ ).

6.4 *Specimen Holder*—The preferred methods of holding spiral and helical coils are as follows:

6.4.1 *Spiral Coils*—The specimen holder for spiral coils shall provide means for securely holding the coil. Although other means of support are possible, the holder or mounting arbor shall be preferably circular cross section whose diameter shall be as large as possible without touching the inner turn of the coil under any conditions of test temperatures. The arbor shall be slotted across its diameter and to a depth greater than the width of the specimen. The width of the slot shall be slightly narrower than the thickness of the specimen so that the inner tab will be a push or snug fit in the slot. The edges of the slot shall be sharp where it intersects the circumference of the arbor. The slot shall be so positioned in the arbor that the center of rotation of the coil and the center of the arbor coincide.

6.4.2 *Helical Coils*—The specimen holder for helical coils shall provide means for securely holding the coil. Although other means of support are possible, the coil shall be held with its axis in a vertical position, the bottom end of the coil secured

and the top end allowed to rotate freely with a temperature change. Preferably the end of the coil with the center tab shall be considered the bottom and secured by clamping or press-fitting the tab into a slotted arbor similar to that described in 6.4.1 for spiral coils. The depth of the slot shall be such that the full height of the tab shall be held. If the coils do not have a center tab, the arbor shall contain provisions for attaching the coil with screws, rivets, or by welding. A transmission pointer can be affixed to the top end. The center line of the coil, the transmission pointer, and the protractor shall coincide.

6.4.3 Deviations from these procedures of holding may be necessary when simulating the mounting used in the device for which the coil was designed, or in cases where coils are press fitted on arbors. In these cases, the details of mounting should be mutually agreed upon between the manufacturer and the purchaser.

#### 6.5 *Transmission Pointer:*

6.5.1 *Spiral Coils*—To the outer end of the spiral coil shall be attached a pointer that will transmit the rotation of the coil so that it can be read on the protractor. The pointer shall be of lightweight construction and attached to the coil by suitable means so that the movement of these portions of the coil that do not normally contribute to the movement of the coil with a temperature change shall not influence the rotation of the pointer. The pointer, when using the fixture shown in Fig. 1, shall be so positioned that its tip shall ride slightly above the divisions of the protractor, but shall not touch the protractor at any time during the test. The pointer, when using the fixture shown in Fig. 2, shall be of sufficient length so that the top may protrude from the bath when the coil is submerged. The pointer for either method, shall be so positioned that it will be in line with the radius of the protractor and the specimen.

6.5.2 *Helical Coils*—To the free end of the helical coils shall be attached a shaft that will transmit the rotation of the coil so that it can be read on the protractor. The shaft can consist of a wire or rod and shall be of lightweight construction. It shall be attached to the coil by a suitable means so that the movement of those portions of the coil that does not normally contribute to the movement of the coil with a temperature change shall not influence the rotation of the shaft. The transmission shaft shall be so located that its main axis coincides with the center line of the coil. It shall be at right angles to the plane of the protractor and shall pass through its center. The end of the transmission shaft shall be so bent or an extension pointer so attached at right angles to the main body of the transmission shaft that its tip shall ride slightly above the divisions on the protractor, but shall not touch the protractor at any time during the test.

6.5.3 The angular position of the pointer shall be known to an accuracy of  $0.25^\circ$  at each test temperature.

## 7. Sampling

7.1 Test for thermal deflection rate shall be taken in a manner to assure representative sampling of the test lot. A lot, for quality control purposes, comprises of the finished yield of one bonded coil of material. Sampling shall consist of parts made from each cut of material across the bonded width. Frequency of sampling shall be mutually agreed upon between the manufacturer and the purchaser.



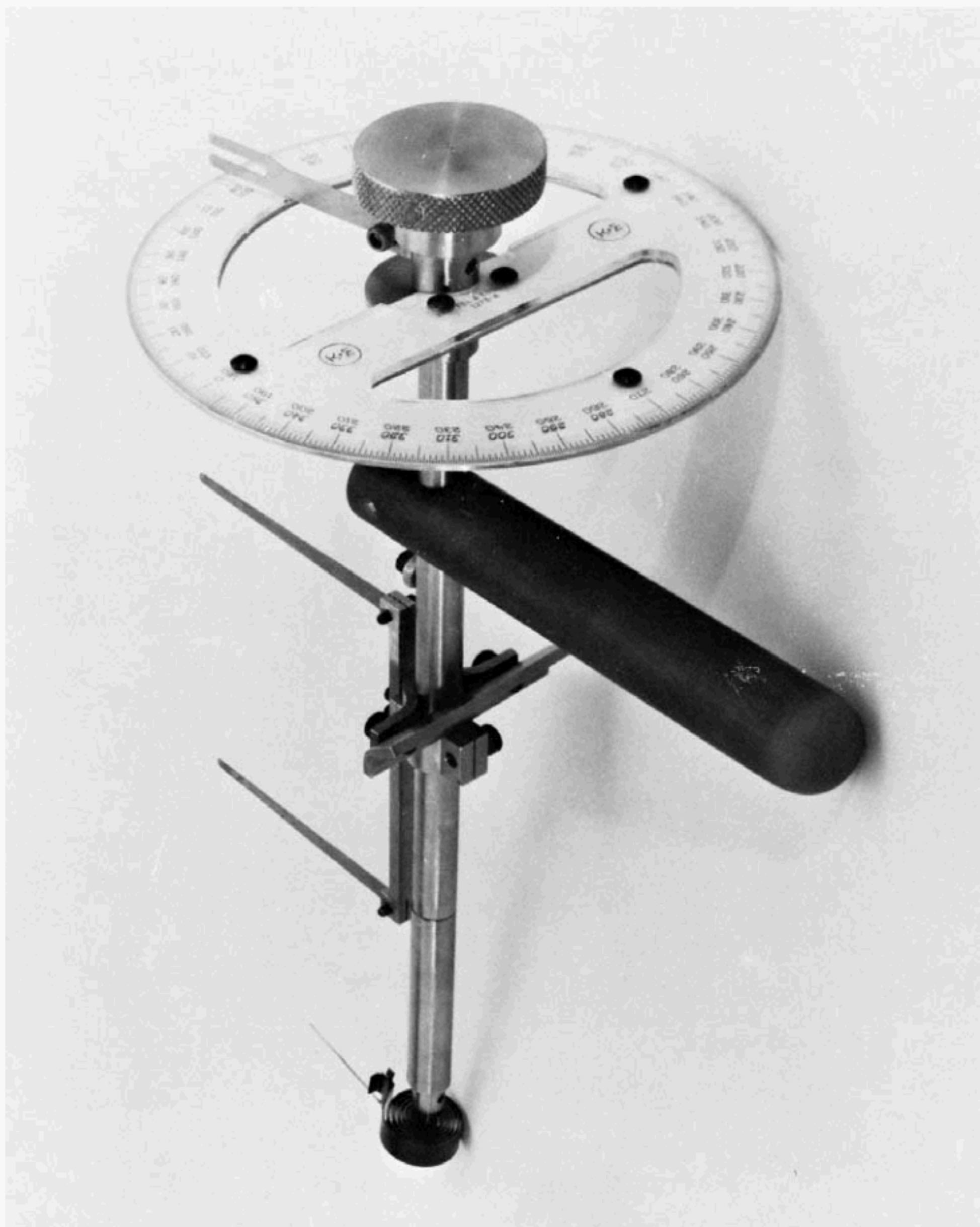


FIG. 2 Spiral Coil

## 8. Procedure

8.1 After all forming operations and before testing, subject the specimen to a stabilizing heat treatment to relieve internal stresses. This treatment shall consist of heating the specimen, while free to rotate, for a prescribed time and temperature. The details of the stabilizing procedure will depend upon the characteristics of the thermostat metal being tested and shall be mutually agreed upon between the manufacturer and the purchaser.

8.2 Mount the specimen with the pointer attached on the specimen holder. Place the specimen holder with the specimen

in the first bath of the desired temperature. When temperature of the specimen has reached the bath temperature, measure and record the angular position of the transmission pointer and the bath temperature.

8.3 Establish the next chosen temperature and measure and record the position of the pointer and the bath temperature.

## 9. Calculation

9.1 Calculate the thermal deflection rate as follows:

$$D = (A_2 - A_1)/(T_2 - T_1)$$

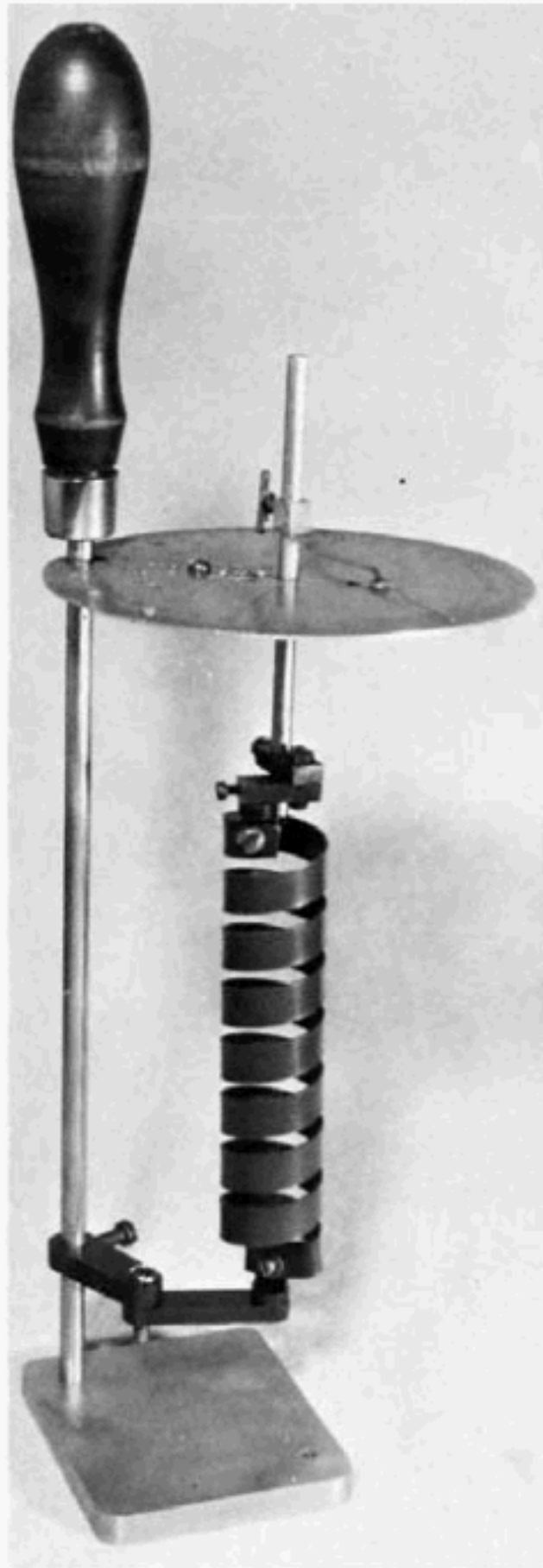


FIG. 3 Helical Coil

where:

- $D$  = thermal deflection rate,
- $A_2$  = final angular position of pointer,
- $A_1$  = initial angular position of pointer,
- $T_2$  = final temperature corresponding to position  $A_2$ , and
- $T_1$  = initial temperature corresponding to position  $A_1$ .

## 10. Report

- 10.1 The report shall include the following:
  - 10.1.1 Type of thermostat metal,
  - 10.1.2 Dimensions of material,
  - 10.1.3 Dimensions of coil,
  - 10.1.4 Temperature and time of stabilizing heat treatment,
  - 10.1.5 Dimensions of arbor,
  - 10.1.6 Temperature range of test, and

10.1.7 Thermal deflection rate.

## 11. Precision and Bias

11.1 The reliability of the results of the thermal deflection rate depends on the method and apparatus. The most common sources of variations in test results are (1) bath temperature nonuniformity, (2) unverified temperature measuring apparatus, and (3) parallax when reading the angle.

11.2 The bias of test is that prescribed in Section 6 for the quality of apparatus.

## 12. Keywords

12.1 helical coil; spiral coil; thermal deflection rate; thermostat metal



*ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.*

*This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or [service@astm.org](mailto:service@astm.org) (e-mail); or through the ASTM website ([www.astm.org](http://www.astm.org)). Permission rights to photocopy the standard may also be secured from the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, Tel: (978) 646-2600; <http://www.copyright.com/>*