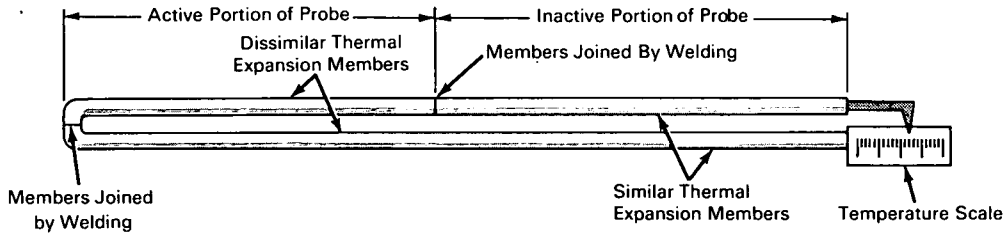
NASA TECH BRIEF

Bimetal Sensor Averages Temperature of Nonuniform Profile



TEMPERATURE PROBE DESIGN PRINCIPLE

The problem:

The usual method to determine an average temperature for a span of nonuniform temperatures consists of averaging a series of point temperature measurements. If the span is long or contains large temperature gradients, the number and distribution of point temperature measurements affect the accuracy of the calculated average temperature. Although bimetal differential elongation probes have been used as steady-state temperature indicators, no study or analysis of bimetal probe performance in a nonuniform temperature field could be found.

The solution:

An instrument that measures an average temperature across a nonuniform temperature profile under steady-state conditions. The principle of operation is an application of the expansion of a solid material caused by a change in temperature.

How it's done:

The temperature probe consists of two parallel members of dissimilar materials joined together at one end so that a change in temperature along the probe length produces a difference in elongation at the free ends of the two materials. When the temperature along the probe length is nonuniform, the total difference in elongation at the free ends is a summation of local differences as generated by local temperatures along the probe. Thus, the total difference in elongation becomes a measurement of the average temperature along the length of the probe.

Notes:

1. The linear motion produced by the probe may be indicated on a meter attached directly to the probe assembly, or the motion may be converted, by a transducer, to a signal for actuating a remote meter.
2. A prototype instrument had an active probe length of 35.6 centimeters consisting of 0.157 centimeter diameter rods of tungsten and stainless steel. A probe extension consisting of 55.8 centimeter long rods of stainless steel was used to locate the transducer at a safe distance from the heated active portion of the probe.

   The transducer was a commercially available linear variable differential transformer which generated an output voltage proportional to the axial displacement of the core within the transformer. The body of the transducer was attached to the stainless steel probe members, while the movable tranformer core was attached to the extension of the tungsten member.

   Probe calibration and performance tests were conducted in a 20-kilowatt controlled-temperature

(continued overleaf)

furnace. The active portion of the probe was inserted to four different lengths through a hole in the furnace door. Uniform probe temperature profiles, which were used for calibration checks, were obtained with full insertion of the probe in the furnace, while nonuniform temperature profiles were obtained by inserting three-fourths, one-half, or one-fourth of the active probe length in the furnace; the remainder of the probe and the transducer were exposed to room temperature.

The temperatures indicated by the probe were compared with the arithmetic average of temperatures obtained from the eight reference thermocouples spaced equally along the probe at test conditions which indicated temperature profiles that varied as much as 750°C. For the nonuniform temperature profiles, the bimetal probe averaged as much as 13°C lower than the arithmetic average temperature obtained from the eight reference thermocouples. An analysis indicated that for steep temperature gradients the bimetal probe measured temperature is more accurate than the average temperature obtained from eight thermocouples.

3. This device can be used to indicate the average temperature over a nonuniform temperature profile in jet engine ducts, heat exchangers, ovens and furnaces, and other environments.
4. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B68-10007

Patent status:

No patent action is contemplated by NASA.

Source: R. T. Dittrich
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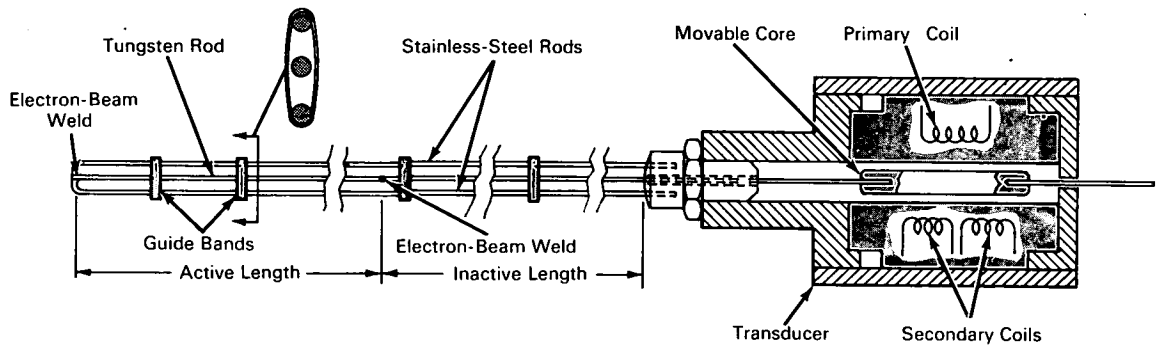

PROTOTYPE TEMPERATURE-MEASURING PROBE AND TRANSDUCER