Weston
ENGINEERING NOTES

VOLUME 2 FEBRUARY 1947 NUMBER 1

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The Weston Industrial Circuit Tester

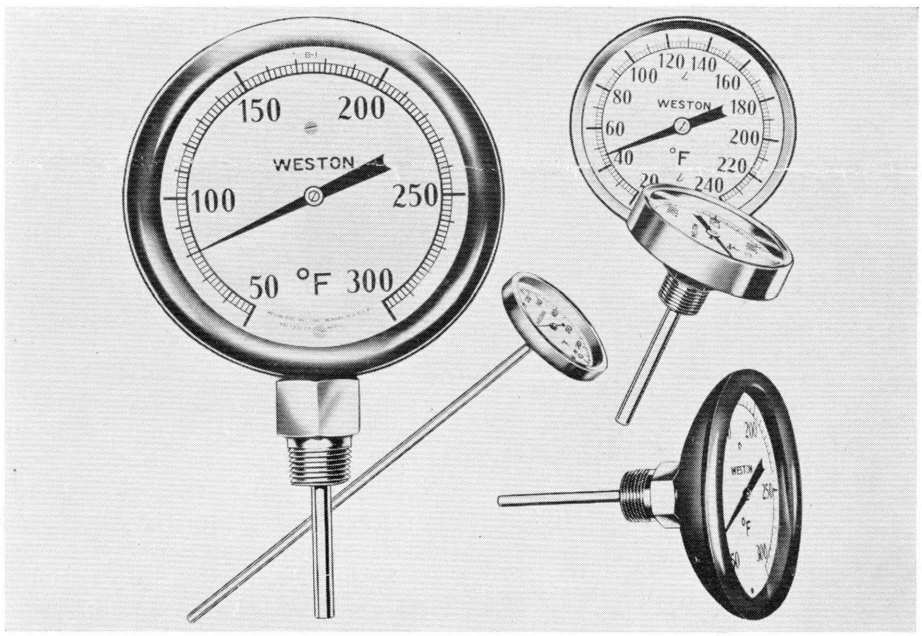
An Important Notice Regarding Future Issues of This Publication

John Parker, Editor

WESTON ELECTRICAL INSTRUMENT CORP.,
614 Frelinghuysen Avenue,
Newark 5, N. J., U. S. A.

MODERN THERMOMETRY

TEMPERATURE may be defined as the condition of a body which determines the transfer of heat to or from other bodies. In the science of temperature measurement, thermometry, the most important requirement is the ability of the measuring device to indicate always the same values at the same



Several Weston Bimetal Thermometers, including industrial and laboratory types, are shown above.

temperatures. Galileo's thermometer or "thermoscope" (16th Century), while probably the earliest scientific approach to the problem of temperature measurement, was inadequate in this respect primarily because it used the effect of the expansion of air in a bulb upon a column of liquid in a tube and the variations of atmospheric pressure on the open column introduced errors which could not be compensated or controlled.

The development of the liquid-in-glass thermometers by Grand Duke Ferdinand of Tuscany in the middle of the 17th Century eliminated the errors caused by atmospheric pressure changes but the temperature indications were difficult to interpret because the scale was simply marked to represent thousandths of the bulb volume.

In 1701 Sir Isaac Newton created a scale in which the freezing point of water was 0 and body temperature was 12. In 1714 Gabriel Fahrenheit marked a mercury thermometer scale with 0 at the point reached in an ice-salt bath and with 12 degrees as blood temperature. Later, to obtain finer indication and more divisions, the scale was changed to 0-96° in which 0 was the salt-ice bath, 32° was the freezing point of pure water and 96° was (erroneously) body temperature. Subsequently, the body temperature (or "blood heat") mark was corrected to 98.6°, and 212° was added at the boiling point of water. Newton's and Fahrenheit's contributions of fixed checking points of the freezing point of water, blood heat, and the boiling point of water thereafter replaced earlier "standards" such as "the temperature of a deep cave," the "coldest day," etc.

Still later in the 18th Century Reaumur laid out a scale of 0 to 80 R corresponding to 32 to 212 F and Celsius produced his centigrade scale in which 0 is the temperature of melting ice and 100 the temperature of boiling water.

In 1858 Lord Kelvin conceived a new scale starting at −273 C (absolute zero, at which it is assumed that all molecular motion ceases) and advancing in steps equal to the centigrade degree. Thus 0 K = −273 C, 273 K = 0 C and 373 K = 100 C.

Today the Fahrenheit scale is widely used in English speaking countries, with the centigrade scale used in the chemical and plastics industries and in scientific work. The Reaumur scale is used in the brewing industry. Some confusion occurs in certain complex industries where several types of thermometer scales are required or tables of formulas must be continuously referred to; however, in order to overcome this difficulty, thermometers may be obtained having two or more scales calibrated on the single thermometer dial.

The glass thermometer has served man well and its worth can never be questioned, although it has long been known to possess many undesirable characteristics. The glass stem and bulb are easily broken; the chips and mercury or other liquid can be troublesome if they escape into food; the emergent stem error can be considerable. Mercury freezes below −40 F and alcohol or other liquids which wet the stem must be used for such low temperatures. The mercury and the glass are not stable at high temperatures, and the liquid column tends to separate in shipment and in certain usages. Coupled with the foregoing, the etched stem types especially are somewhat difficult to read as is well recognized by those who use them, or by anyone who has had occasion to read a clinical fever thermometer.

Principles of Operation

Liquid-in-glass thermometers operate fundamentally on the difference in rates of expansion of liquid and glass under temperature changes. Mercury and alcohol have high coefficients of expansion, glass has a relatively low coefficient, often considered as zero. The higher rate of expansion of the liquid forces it up the thermometer stem as the temperature is raised.

In similar manner the bimetal thermometer functions on the principle of the different rates of expansion of two materials, two metals in this type, usually nickel steel alloys which are certainly as good engineering materials as liquids and glass. If this premise is granted, we simply require a suitable mechanical system to cause this expansion rate difference to move a pointer or otherwise indicate the temperature applied to the bimetal.

The advantages of an all-metal thermometer, if well made, have long been self-evident. Many all-metal or bimetal types have appeared in the past several decades. However, because of inadequate knowledge of the materials or lack of thoroughness in the design and limited skill in manufacture, bimetal thermometers were properly regarded as inferior devices. The all-metal thermometer as now made by Weston demonstrated that bimetal thermometers properly designed and made were entitled to a position among reliable instruments possessing unique advantages in many applications.

Bimetal Material Proves Successful

The problem has been almost entirely one of developing a suitable bi-metallic thermal element. The case and housing, as such, presented no serious obstacle, although even there proper selection of materials and careful dimensioning are important details in the over-all result.

The thermally sensitive part of the all-metal thermometer consists

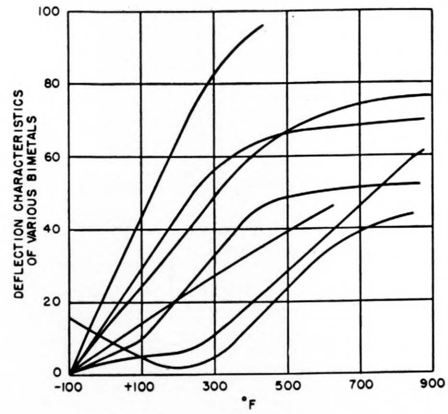


Figure 1—Temperature-deflection characteristics of various bimetals.

of a bimetal strip wound in the form of a helix or a series of helices, wound coaxially one within the other.

Early bi-material thermal elements consisted of very crude devices such as a strip of hard rubber, and even wood, riveted, cemented or screwed to a strip of brass or iron. The resultant errors were very large and the indications were not reproducible, in fact, early bi-material thermometers were almost as responsive to humidity and other variables as to thermal changes. It was soon realized that only material of a tough, resilient, and non-hygroscopic nature would offer any possibility of success; such material could only be a bimetal; and all work with bi-materials other than metallic was quickly discarded.

About this time remarkable developments were taking place in the nickel alloy field and one new alloy offered great hope for bi-metallic thermal elements. At normal atmospheric temperatures this alloy neither expanded nor contracted, its length was invariable, hence it received the name "Invar."

Other developments in this field produced a nickel alloy having just the opposite characteristic, that is, a high and consistent rate of expansion under increased temperature and of contraction when the temperature decreases. The effect was reproducible commercially, and constant cycling caused no appreciable "set" or aging. Here at last appeared to be a practical solution, an alloy of negligible expansion and one of large and constant expansion, which when welded together and rolled to the proper thickness would bend sufficiently under temperature changes to have a usable sensitivity as a thermometer.

Combining the Two Metal Strips

The riveting and other pressure type joining of the two strips was improved by a direct high-temperature, high-pressure welded lamination of the two materials in ingot form. Next a series of annealing and roll-down operations are performed until the desired thickness is achieved. By this method the two elements in the final strip of bimetal, no matter how thin, are perfectly bonded and mechanically inseparable and it has the strength of a single piece of similar alloy of equal cross section.

When a straight bi-metallic strip, fastened at one end, is heated it bends to form an arc of a circle with the high expansive, or "active" metal on the outside and the low expansive, or "dead" metal on the inside. This bending or curvature, by a suitable mechanical system and scale can be used to indicate temperature. Obviously, the greater the bending effect for a given temperature change, the more sensitive the temperature indication.

Alloys having widely differing coefficients of expansion are welded together for small thermal scale ranges such as 0 to 100 F and alloys of lesser difference of expansion are used for larger scale ranges, such as −100 to +1000 F.

Usual Thermal and Mechanical Precautions Must Be Considered

Proper selection of alloys must be made with a view to maintaining safe working stresses produced both mechanically and thermally, to provide resistance to vibration, shock, and corrosive conditions; safety against accidental overheating, and a multitude of other conditions met in practical use.

Since a bimetal is simply another method of transforming the energy of heat into mechanical movement, the usual thermal and mechanical precautions must be considered. The bending of the bimetal strip is used to move a pointer tip so that it describes an arc. This work combined with the bending and movement of the strip itself constitutes a mechanical load which must not stress the joined metals beyond their elastic limit. If the elastic limit were exceeded it would cause a loss of accuracy, a permanent set, and general unreliability. Maintaining safe stress limits simply requires a sufficient length of bimetal which, however, presents mechanical problems of winding, support, and spacing, about which more will be mentioned.

TABLE NO. 1

Safe Working Stress Values for Typical Bimetals

Temp. °F.	*Lbs./Sq. In.*
−100	25,000
+100	25,000
200	23,000
400	20,000
800	12,000
1,000	7,000
1,200	3,000

There have been developed many different types of bimetals for various temperature ranges and to produce various scale characteristics, usually uniform but on occasion purposely non-uniform and congested over one section of the scale. Imperfectly designed or wrongly used bimetals exhibit surprising characteristics. Even Invar which shows no tendency to expand at normal atmospheric or room temperatures will, at elevated temperatures, expand appreciably and in fact while intended as the "dead" half may become more active than the "live" half thus causing a pointer which is progressing in a clockwise direction as the temperature rises, to slow down and then actually reverse and deflect counterclockwise with still increasing temperature. The temperature-deflection characteristics of various types of bimetals are shown in Figure 1.

A general rule applying to the selection of a proper bimetal is to use the type which exhibits the greatest uniform activity within the desired temperature range and other requirements which must be met. Most bimetals offer a constant and uniform mechanical deflection over a limited thermal range only.

The thermal activity of bimetal has been named *Flexivity* and the American Society for Testing Materials proposed the following method of determining flexivity (F).

The method of test considers the bimetal in an approximately straight strip form, supported near the ends on two knife edges, as shown in Figure 2. The flexivity is the change in curvature of the center line of the specimen per unit change in temperature per unit thickness.

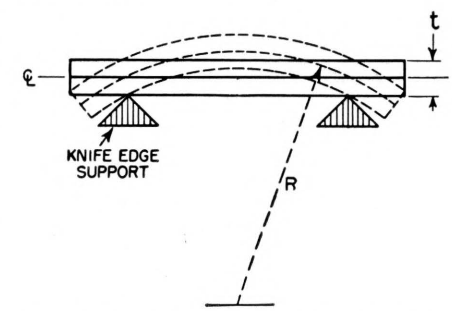


Figure 2—ASTM test procedure for determining flexivity of bimetals.

The formula is as follows:

$$F = \frac{\left(\frac{1}{R_1} - \frac{1}{R_0}\right)t}{T_1 - T_0}$$

where F = flexivity

R_1 and R_0 = radius of curvature in inches, as shown in Figure 2

t = thickness in inches

$T_1 - T_0$ = temperature change in ° F.

The deflection or actual movement or activity of a strip of bimetal is proportional to the flexivity. With one end fixed, the end of a straight strip moves or deflects as the square of the length, inversely with the thickness, and in direct proportion to the temperature change, if operating on the straight section of the thermal response or deflection characteristic curve. Thus if the length is doubled the end will deflect four times the distance, and if the thickness is halved the deflection will double.

The angular deflection of a pointer on the end of a helix or spiral changes directly with the length of the strip, inversely as the thickness of the material and again in direct proportion to the temperature change, if operating on the proper section of the thermal curve.

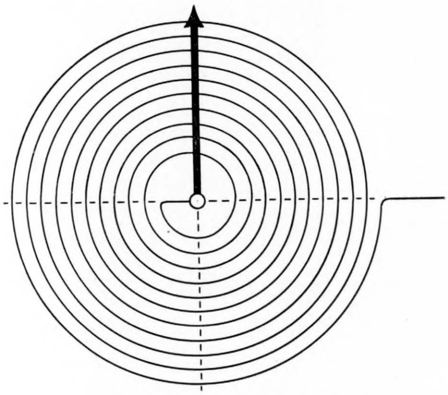


Figure 3a—Bimetal wound in a spiral form with normal adjustment. Notice position of pointer axis.

The Bimetal Is Heated and Rolled

After determining the characteristics and selecting the proper bimetal material and calculating the required thickness, width, and length, the large bar of bimetal is repeatedly heated and rolled until the last rolling produces the correct size and hardness. The strip is then wound into the final helical or spiral form and lastly subjected to various stabilizing thermal treatments in suitable atmospheres. This last series of treatments is at least as important as any other phase in the production of uniform and permanent bimetal elements.

Let us assume we now know which bimetal to use, how to heat treat it and how it will perform thermally over the desired range. We must still decide on the stem or housing into which the bimetal element is to be placed and the size and shape of the wound coil which the strip must take to fit into the stem.

Naturally, the stem should have the necessary rigidity and strength but be light in weight, small in diameter and thin walled. The material must have the proper thermal properties and should not be prohibitively complicated or costly. For laboratory use in checking the temperature of liquids in beakers, test tubes, and other small containers a stem diameter near 1/8 inch is ideal. Within this 1/8 inch outside diameter of the stem we must place the walls of the stem, the bimetal element, and associated

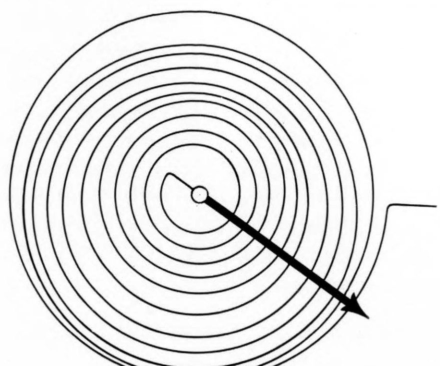


Figure 3b—Note pointer position and shape of coils after a change in temperature. Friction occurs in the turns of the coil and at pointer bearing.

supports, staff, etc. Thus the coil must be considerably less than 1/8 inch in diameter and it should be as compact as possible in order that correct temperatures can be measured in shallow vessels and at the depth levels desired.

In selecting the bimetal, one was chosen which would not be stressed unduly even under accidental excess temperatures and which for a certain range, turns out to be some 20 inches long, and approximately .050 inch wide and .005 inch thick. No other combination of dimensions is optimum or will produce exactly the desired results.

To wind the 20 inch strip into a flat spiral coil is the easiest by far but this would produce a flat pancake shape about 1/4 inch in diameter, obviously too large. Also, a spiral, when subjected to a change in temperature, not only rotates the pointer but tends to shift it out of position as the coil changes shape. See Figure 3. This varying side thrust causes considerable pressure against the pointer bearing with resulting errors. The spiral, therefore, is bad from the size standpoint and tends to create variable friction errors. Caution indicates that it would be unsafe to use a bimetal at a higher stress or with a reduced safety factor, as the 20 inch strip was chosen as being the optimum. So let us consider the remaining possibility, a helix. See Figure 4.

Development of the Multi-Helix

A helical coil overcomes the disadvantage of large diameter as it can readily be wound within the 1/8 inch requirement but now other unfavorable conditions arise. The wound helix becomes quite long and tends to sag in the center and when the helical coil expands and rotates the pointer it also tends to thrust it out away from the scale plate toward the glass and to pull the pointer down when it contracts.

Since best structural rigidity and best mechanical and thermal action can be expected from a coil wherein the necessary length of strip is formed into the smallest over-all size, steps were taken to develop a multi-helix arranged so that two or more helical coils are wound coaxially one within the other. This results in the desired compactness and reduces the end thrust since this effect in the outer coil is cancelled by that in the inner coil. See Figure 5.

The multiple helices, or "coils within coils," are wound in one continuous piece but do not touch each other along the sides despite the compactness of this arrangement. Since the pitch, or direction, of the winding runs in opposite directions, the tendency for the pointer to be shifted axially and laterally is counterbalanced within the coils. Especially in the instance of greatest sensitivity in shallower depths, this very compact result affords the best over-all temperature measuring arrangement.

This coil-within-coil arrangement is used in most Weston thermometers, and the patent rights in the United States are owned exclusively by Weston. Regular production

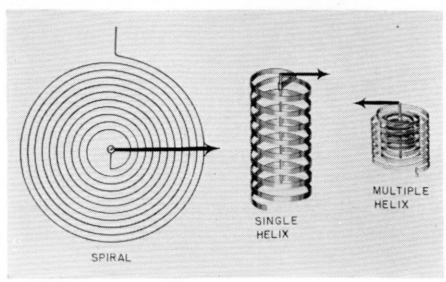


Figure 4—Relative size of three types of bimetal elements having the same torque and deflection.

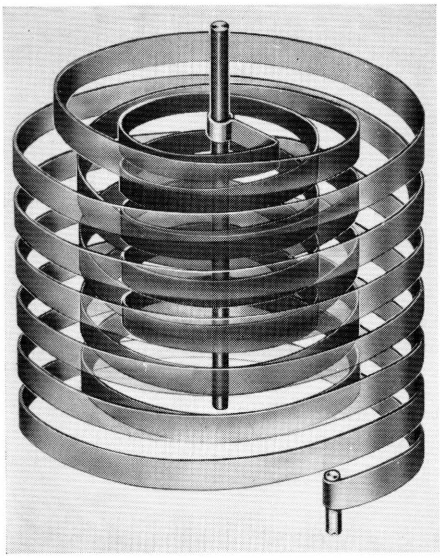


Figure 5—Enlarged view of a multiple helix showing coil arrangement.

design is therefore dictated only by the best technical practice as to whether a short strip of bimetal wound into a short, single helix or a very long strip wound into four coils-within-coils is used.

We now have progressed from the optimum bimetal to the best form and size of winding. To proceed with the housing; the stem and all of the metal parts, both internal and external, are fabricated of stainless steel which while costly has been found best for general usage. It is little affected by the acids and alkalies with which it comes in contact and it does not contaminate or change the taste of milk and other foods into which it is immersed. Its heat-conducting properties are almost ideal in that the thin wall section transfers the heat quickly to the bimetal measuring element whereas the relatively longer stem section tends to prevent heat loss by transmission along the stem.

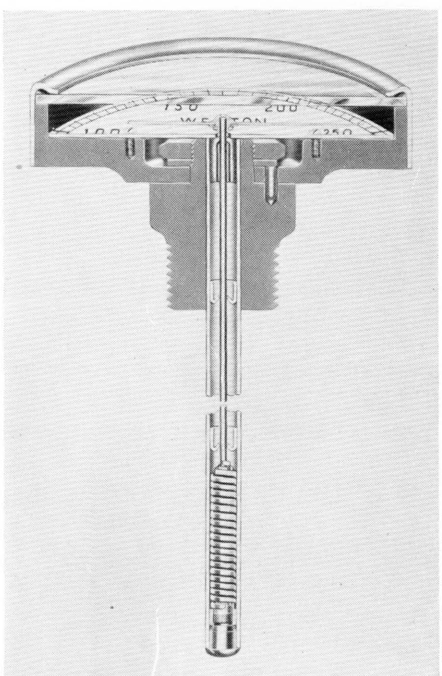


Figure 6—Sectional view of the Weston Model 221-D Industrial Thermometer.

The bimetal element is normally anchored at the bottom of the stem and transmits its rotary motion up to the pointer in the head by a straight one-piece stainless steel staff. No gears or levers or other amplifying linkages are required or used. See Figure 6.

Easy-to-Read Scale

We now have a complete all-metal thermometer with the exception of the glass window which naturally can be transparent plastic when desired. On seeing such an all-metal thermometer one instantly recognizes its virtual unbreakability and that it has a large, open, easily read and easily understood scale.

Other than the fact that the smallest size can be read at arm's length and the largest quickly read across the room even through smoke or steam or in poor light, and that the stems are of stainless steel instead of glass, what else has the all-metal thermometer contributed to modern thermometry?

1. Errors eliminated—Certain errors inherent in the mercurial and other liquid-in-glass thermometers are non-existent in the all-metal type.

   As an example, consider the emergent stem error to be contended with in a glass stemmed thermometer. Figure 7 shows the temperature gradient in the immediate vicinity of the thermometer stem.

   The mercury column is not only the indicator or "pointer" by which readings are accomplished but it is also part of the thermally responsive element and when the bulb is immersed, part of the mercury contained therein moves up the stem out of the thermal bath and into room air. This condition can cause an error of several per cent although the readings are sometimes corrected by applying the glass stem correction formula.

   $$\text{Correction} = K \times N(T\text{-}t)$$

   where $K = .00016$ for centigrade thermometers
   or $K = .00009$ for Fahrenheit thermometers
   N = length of mercury column, in degrees exposed to room air
   T = temp. being measured
   t = temp. of room air.

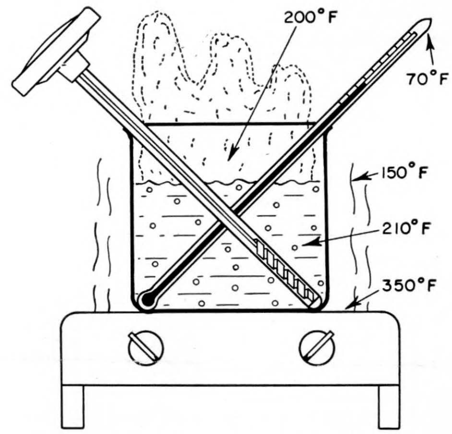
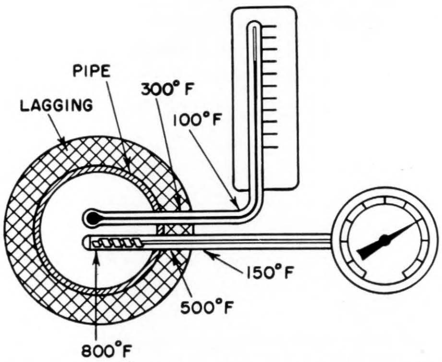


Figure 7a—Emergent stem errors in boiling temperature range.

2. Accidental over temperature causes no damage—On ranges below 250 F accidental overshooting up to 100% will spin the pointer around and around but will not damage the all-metal thermometer in the least; 50% over temperature is permissible up to 500 F and 10% up to 750 F.

   Liquid-in-glass thermometers cannot and are not expected to withstand such ruinous excess temperatures; over temperature beyond the small safety space at the top of the stem might cause an immediate explosion, or other serious damage.
3. Direct drive-through—In the all-metal type the bimetal element is bonded directly to the staff on which the pointer is mounted. No separation can

take place. In glass stemmed types the liquid column sometimes separates and the error is



TEMPERATURE GRADIENTS SUCH AS SHOWN MAY CAUSE VARIABLE AND LARGE ERRORS IN GLASS STEM AND OTHER LIQUID OR GAS EXPANSION TYPE THERMOMETERS.

Figure 7b—Emergent stem errors at high temperature.

in direct proportion to the separation. This is particularly troublesome and difficult to detect if it occurs in a section of the tube covered by a protective sheath or by lagging.

4. Operation in any position—All-metal thermometers indicate accurately in any position, even face down, there being no liquid to be affected by gravity. In like manner centrifugal force in any direction has no detrimental effect and all-metal thermometers are frequently mounted on rotating kilns, paddle blades, rolls, pistons, etc., where they are read by ordinary light or stroboscopically, as required.
5. Can be read in the dark—Radium dials and pointers can be supplied and any luminescent or other special material may be applied as desired. In one particular application a toothpick-like tube of radioactive luminous material was bonded to the pointer and small button-like glass containers of luminous material were placed at various points on the scale.
6. Monograms and instructions imprinted on dial—The dial is large and roomy and it is frequently desirable to print safe and danger lines, or words, or flags, on the scale. Dials are printed in as many as four colors and carry much information in addition to the temperature scale.
7. Mechanical versatility—Since the all-metal thermometer is really mechanical by nature, rather than liquid, it offers wide mechanical flexibility. Thus the pointer can carry contacts, or a max-min hand, or drive small telemetering transmitters.

   The pointer may be touched not only by other pointers but also by human hands as is done in the Braille Thermometer which is used by the blind.
8. Pointed and gimlet ended stems — The stems may be pointed and carry various screw threads, gimlets, etc., for direct, easy entry into hard substances such as turnips, hams, cartons, and frozen food, all of which are checked at various times to determine their internal temperature.

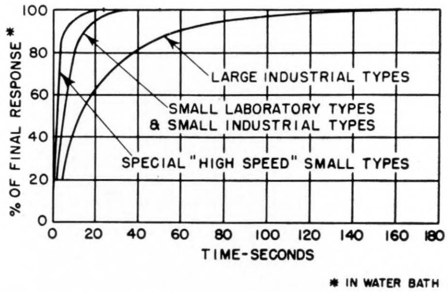


Figure 8—Response time characteristics of various types of Weston thermometers when immersed in liquid.

These ends are actually a part of the regular stem and in metallic contact with the bimetal thermal element permitting quick heat transfer; the ends are not extra sheaths or adapters such as used in connection with glass stemmed thermometers and which cut down the thermal response. The curves shown in Figure 8 illustrate the response time characteristics of various types of Weston Bimetal Thermometers when immersed in liquid.

Thus, we find that the all-metal thermometer offers many possibilities which may pass unnoticed until we think in terms not heretofore associated with the art and science of thermometry.

E. N.—No. 22 —*A. H. Lamb*

THE WESTON INDUSTRIAL CIRCUIT TESTER

THIS multi-range instrument known as the Model 785 shown in Figure 1 has been in production for several years in commercial as well as Navy types. Recently the new Type 6 was announced replacing the commercial Type 3. This model has several interesting features some of which are new in the Type 6.

The industrial circuit tester was designed to provide in one complete portable instrument the means for making d-c and a-c voltage and current measurements as well as resistance readings on all types of control equipment and electronic

Figure 1—The Weston Model 785, Type 3 Industrial Circuit Tester.

apparatus. After some study of the general field and laboratory service requirements it was decided in the original design that two different range complements were advisable for the d-c and a-c voltmeter sections. Independent switch positions were provided for the 12 voltmeter ranges, 6 of these for d-c voltages and 6 for a-c voltages. Thus it was possible to select the most useful a-c voltage ranges without having to compromise in favor of d-c voltage requirements. The a-c voltage ranges are 5/15/30/150/300/750 volts full scale. The lower ranges are suitable for measuring potential on a-c relays, low voltage transformers, vacuum tube heaters and the like. The higher ranges were selected for measurements on power lines of 120, 240 and 440 volts. All a-c voltage ranges operate at a 1,000 ohms per volt sensitivity, a figure adequate for electronic applications as well as power line testing.

A sensitivity of 20,000 ohms per volt was selected for all d-c voltage ranges. It seemed advisable to include a 1 volt and a 1,000 volt range with suitable coverage in between for all types of electronic, relay control and general d-c testing. Hence ranges of 1/10/50/200/500/1000 volts full scale are available. A 100 line d-c arc is used on the 4½ inch meter scale for all d-c voltage and current readings.

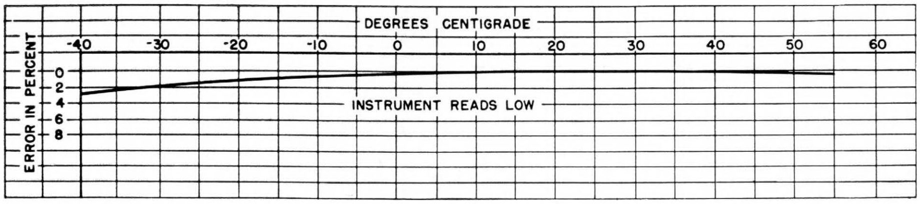


Figure 2—Curve showing temperature compensation of d-c current and voltage ranges.

Current Ranges

The a-c current ranges function through an internal current transformer with the tapped primary section entirely insulated from the instrument circuit. A-c current ranges of .5/1/5/10 amperes were selected as adequate for an internal transformer design. The 1, 5 and 10 ampere ranges may be used with external high range current transformers such as the Model 604, wherein current readings up to and including 500 amperes are available.

The d-c current ranges are 50 microamperes, 1/10/100 milliamperes and 1 and 10 amperes. Binding posts which are always preferable for ammeters and milliammeters are used for all current ranges from 1 ma to 10 amperes. The 50 microampere or basic instrument range is brought out through a separate pair of pin jacks for low microampere readings. These same jacks are used for external shunt connections where ranges above 10 amperes are required. The potential across these jacks for full scale meter deflection is 100 millivolts in the Type 6, as differentiated from 200 millivolts in the earlier types. Improved instrument design made it practical to include the 100 millivolt range and at the same time increase the torque-weight ratio or merit factor of the instrument. Weston cataloged 100 millivolt shunts with ranges up to a recommended maximum of 500 amperes can be used with the Type 6 circuit tester. Provision is made for storing the shunts in the accessory compartment in the case.

Five series type ohmmeter ranges provide resistance readings from 1 ohm to 30 megohms. Ohmmeter energy is supplied from two internal batteries mounted inside the device.

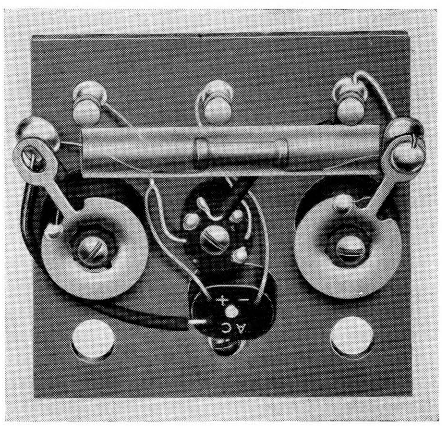


Figure 3—A-c adjustment plate for Model 785.

Temperature Compensation

The accuracy of the Type 6 has been improved over a wide range of temperature. Additional compensation has been included on the d-c current ranges and on the a-c voltage and current ranges. The ring shunt network for the d-c current ranges includes a negative temperature coefficient resistor to balance the positive copper temperature coefficient of the instrument moving coil. Since manganin is used for the shunts, practically all temperature errors are caused by variation in resistance of the microammeter movement. This arrangement provides adequate compensation on all d-c current ranges as shown in the average curve of Figure 2. This does not apply on the 100 millivolt 50 microampere range where larger errors will be encountered at temperatures substantially above or below 25 C when the instrument is used as a millivoltmeter.

Wide range temperature compensation of rectifier type instruments is not a simple problem since several parameters are involved, and this is particularly true in the case of multi-range instruments. In the Model 785, the 50 microampere d-c instrument required for the 20,000 ohms per volt d-c ranges is also used for the 1,000 ohms per volt a-c ranges wherein a mechanism is available that is considerably more sensitive than would normally be required. Since ample energy is available, compensating networks with very considerable loss factors can be introduced while still maintaining a 1,000 ohm per volt or 1 milliampere a-c sensitivity.

A so-called half bridge circuit is used wherein two single rectifier discs make up two arms of the bridge, and wire wound resistors are used for the other two bridge arms. Since the instrument moving coil resistance is high, the bridge arm resistance determines the current density in the rectifier discs. This is selected for a high-current density with a resultant reduction in sensitivity. While the d-c output from a half bridge circuit is somewhat less than half the output from a full

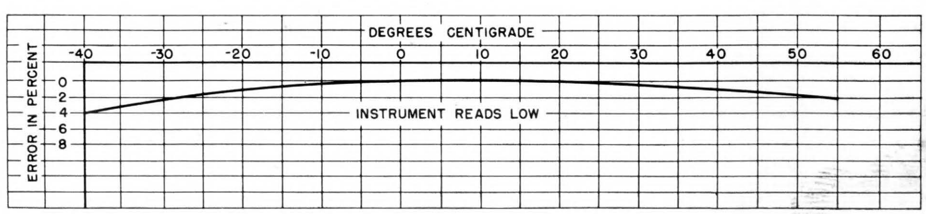


Figure 4—Curve showing temperature compensation of a-c current and voltage ranges.

bridge circuit, there are several advantages in the use of the half bridge circuit for a temperature compensated a-c instrument. A shunt compensator circuit connected across the a-c input to the bridge controls the a-c sensitivity

Figure 5—The Weston Model 792 Insulation Tester.

at 1 milliampere, and provides effective temperature compensation on all a-c voltmeter and ammeter ranges. The rectifier along with its several associated resistors is mounted on a small plate shown in Figure 3 which is assembled on the two back connection studs of the Model 801 instrument. The complete rectifier assemblies are interchangeable and may be replaced as a unit in case of failure.

As mentioned previously, the determination of the constants for effective wide range compensation is relatively complex, involving the copper in the instrument moving coil, the current density in the rectifier discs, the instrument sensitivity, the type of bridge circuit used, the ratio of shunted a-c current to bridge current and other factors. Figure 4 shows the average temperature error in per cent from −40 C to +55 C as taken on production instruments. It will be noted that the curve is relatively flat over a wide operating temperature range, where the Model 785 Type 6 will indicate values approximately 2% below nominal at +55 C and 4% below nominal at −40 C. Due credit should be given to Mr. R. L. Anthony for his valuable assistance in the development of this rectifier circuit.

Accessory Models

The Model 792 shown in Figure 5 is a small 500 volt d-c supply designed for use with the Model 785 in measuring insulation resistance at higher potentials. This unit is powered from a 120 volt a-c line, and is equipped with a tap switch for line voltage coverage from 100 to 130 volts. This combination provides resistance readings up to 900 megohms, extending the highest internal ohmmeter range of the Model 785 by a factor of 30. As in most insulation resistance measuring devices, the potential across the unknown is a function of the ratio of unknown to instrument resistance. However, at the high resistance end of the scale where most insulation resistance readings fall, the potential is 500 volts d-c. This conforms to accepted practice as recommended by the A.I.E.E. The Model 792 has been designed to fit in the accessory compartment of the Model 785.

The Model 604 current transformer shown in Figure 6 may be

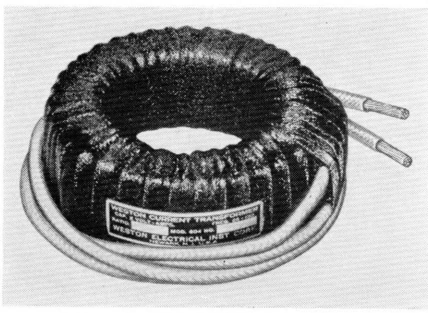


Figure 6—The Weston Model 604 Current Transformer.

used as an external accessory to extend the Model 785 a-c current ranges up to 500 amperes. This transformer is an inserted primary type, where the current carrying conductor is fed through the open core. It is available in ranges of 200/5, 300/5, 400/5 and 500/5 amperes. Since the instrument scale is figured in multiples of 3 and 5, ratios of 300/5 or 500/5 are suggested. The transformer leads connect directly to the 5 ampere and ± binding posts on the Model 785. If lower ranges are required, the primary conductor may be passed through the open core two or more times. The rated accuracy is 1% on frequencies from 60 to 125 cycles, and 2% on frequencies from 25 to 1,000 cycles.

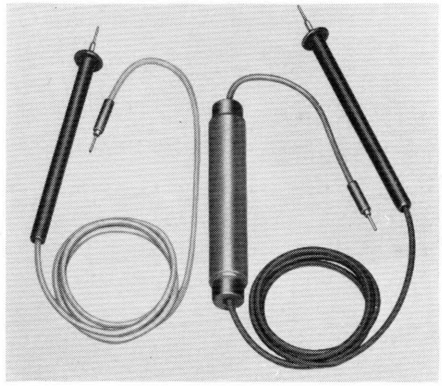


Figure 7—The Weston Model 766 Televerter for 5,000 or 10,000 volts.

For d-c potential readings of 5,000 or 10,000 volts, at 20,000 ohms per volt sensitivity, the Model 766 Televerter multipliers are available for use with the Model 785, see Figure 7. The Type 1 unit is used for potentials up to 5,000 volts, and the Type 2 for potentials up to 10,000 volts. Both units have been designed to pass A.I.E.E. breakdown tests and are equipped with well insulated test leads and special test prods. The multipliers are doubly sealed against humidity effects and the ends are protected with molded bakelite caps. The total multiplier resistance is included in the unit so that the Model 785 may be operated at chassis potential regardless of polarity. The rated accuracy of each multiplier is 5%.

The Model 785 may be purchased with or without the quartered oak carrying case. Many thousands of the earlier type instruments are in service today and it is expected that the new Type 6 will have an even wider field of activity.

E. N.—No. 23 —*O. J. Morelock*

To All Owners of Weston Model 798 Tubecheckers

New instruction books and data cards containing revised and additional tube data are now available and will be furnished free on request. Address requests to Weston Electrical Instrument Corporation, Newark 5, New Jersey, Attention 364. Please give serial number of tubechecker.

IMPORTANT

The revision of the *Weston Engineering Notes* Mailing List is about completed. If you did not return the address card included in the mailing of the last edition, do so now.

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