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Instrument Testing Equipment for Military Requirements

Thermal Problems Relating to Measuring and Control Devices—Part IX

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INSTRUMENT TESTING EQUIPMENT FOR MILITARY REQUIREMENTS

THE amount of equipment required for the testing of electrical indicating instruments has constantly increased since the closing years of the last century. In the 1890's, instrument manufacture as we know it today was just beginning to get under way and almost the entire concern of the early manufacturer was to produce an instrument which truly indicated electrical quantities. The "refinements" and special characteristics as we know them today were to come later. During the last decade, an increasingly important segment of electrical indicating instrument production has been going to military use and the requirements to be met by such instruments have become more and more severe. In order to develop, design, test, and manufacture such instruments, the manufacturer finds it necessary to equip his laboratories and manufacturing departments with a new and wide variety of testing equipment, much of it far removed from the basic apparatus and standards long associated with measurement of purely electrical quantities.

The trend toward a wider range of testing equipment has been accelerated by other factors. For many years, the qualification or acceptance testing of instruments under such military specifications as 17-I-12, JAN-I-6 and others has been performed by the Armed Forces themselves and the manufacturer duly notified if shortcomings were present in his instruments. In contrast, there is now a trend toward in-plant qualification or acceptance testing wherein the manufacturer performs the actual tests required under the applicable specification and reports the results to the branch of the Armed Forces concerned. While the manufacturer is permitted to have his test work performed by testing organizations having the necessary specialized equipment, it makes for a far more satisfactory arrangement if the continuity of testing is maintained by having all tests performed at one location and by an experienced group of engineers alert to the particular problems involved. Another factor influencing the acquisition of in-plant facilities is the ability to meet specification requirements more completely if complete testing facilities are available during all stages of development, design, and manufacture. To this end, decision was made by the Weston Electrical Instrument Corporation to add to its already comprehensive test equipment such items as would further expedite the development of electrical indicating instruments to meet the requirements of the latest specifications of the Armed Forces.

Shock Testing

Much interest has been evinced in some of the rather specialized test equipment utilized in contemporary instrument development and testing programs and a description of some of this equipment is thought to be of general interest. Of the many aspects of specialized testing that are existent today, the equipment used for shock testing is among the most impressive. Quantitative evaluation of the ability of electrical indicating instruments to withstand severe shock was first undertaken to an appreciable de-

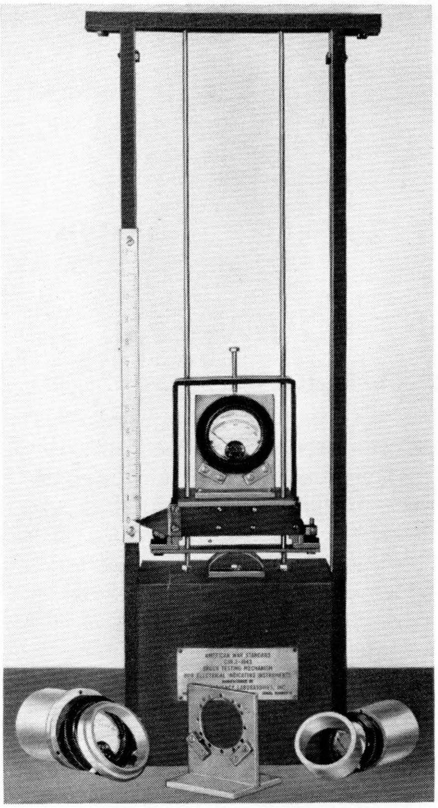

Figure 1—Panel instrument mounted on movable carriage of bench type shock tester.

gree during the early days of World War II. At this time, cooperative tests were run by the National Bureau of Standards and the Weston Electrical Instrument Corporation on a number of electrical indicating instruments using an impact testing device constructed at the Bureau. A similar type of tester was built at the Weston Laboratories and certain improvements were incorporated. Figure 1 shows such a shock tester, of which a complete description by A. T. Williams of the Weston Engineering Staff may be found in the February, 1946, issue of WESTON ENGINEERING NOTES (Vol. 1, No. 1). This tester is covered by Specification JAN-S-44 and is still widely used. As can be seen from Figure 1, the instrument to be subjected to shock is mounted on a movable carriage which is dropped a predetermined distance. When the calibrated spring fastened to the bottom of the carriage strikes the anvil at the base of the device, deceleration takes place and the nominal extent of this deceleration in G units can be readily determined. In the actual shock testing of instruments on this machine, the instrument is mounted in the several stated positions of the applicable specification and the carriage dropped in accordance with the specification. Thus, although the deceleration cannot be exactly calculated, through the use of a specified standard shock test machine and specified heights of drop, uniformity is obtained wherever the tests may be made.

Requirements have led to the development and adoption of another type of shock testing machine, the U. S. Navy Bureau of Ships Plan 10-T-2145-L. Such a high shock testing machine has been installed in the engine room of the Weston plant at Newark and is illustrated in Figure 2. The illustration clearly shows the size and heavy construction of this shock tester; note the size of the instrument in the illustration compared to the device itself. The instrument to be tested is mounted by means of its standard mounting hardware on the vertical test panel and is then subjected to a total of nine blows up to 2,000 foot-pounds. This blow is delivered by a hammer freely falling from heights up to five feet. The machine actually has two hammers, each of four hundred pounds weight. One, shown at the left of the illustration, swings at the end of a five-foot arm and either strikes an anvil on back of the test panel for a so-called "back blow," or an anvil at one edge of the test panel (with the panel rotated 90°) for a "side blow." The other hammer, at the left center of the illustration, drops like a pile driver to strike an anvil on top of the test panel to deliver a "top blow." A motor-driven hoist is necessary to raise the hammers to their dropping position. Adapters on the test panel permit its use for test of various types and sizes of instruments. Here again the mounting of the instrument, the height to which the hammer is raised, and the number of blows are all stated in the applicable instrument specifications so that all manufacturers use identical machines in an identical manner to apply the specified tests. The installation of a test device of such proportions involves some consideration. The location selected must allow for the

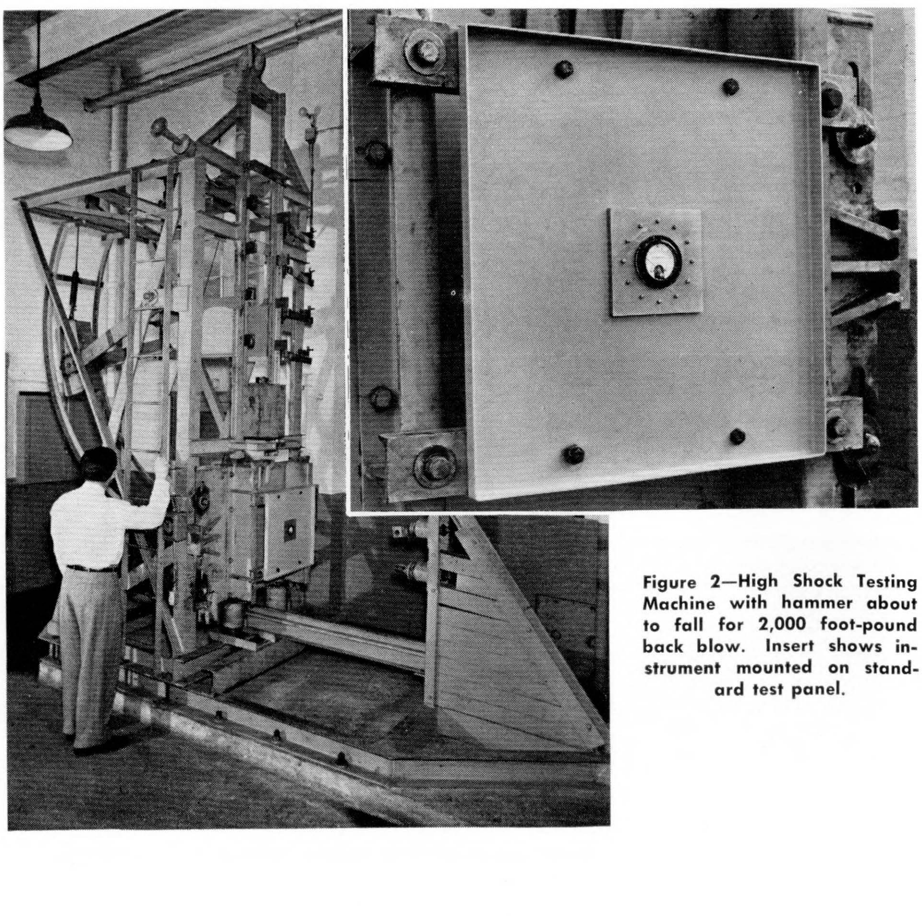

Figure 2—High Shock Testing Machine with hammer about to fall for 2,000 foot-pound back blow. Insert shows instrument mounted on standard test panel.

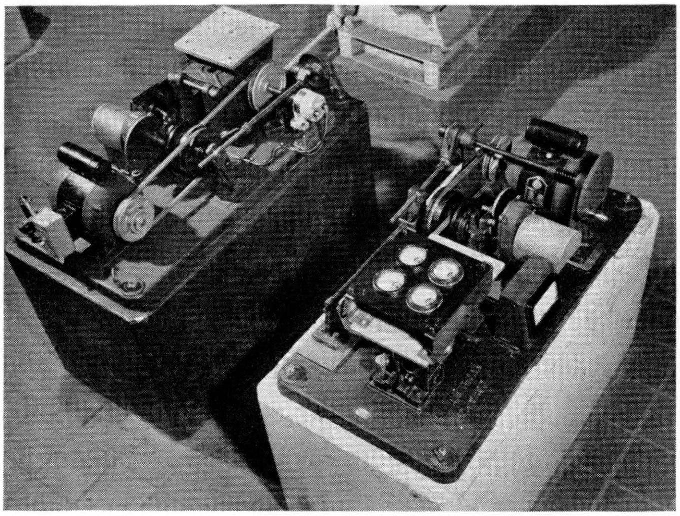

Figure 3—Vibration Test Machines: foreground—for vibration in horizontal plane, shown with instruments mounted; background—for vibration in vertical plane.

considerable head room required by the device, its mass and tendency to "walk" necessitates a heavy foundation, and the noise resulting from the impact of the hammer against the anvil requires a location somewhat isolated from laboratories and assembly departments.

Vibration Testing

From the earliest days of application of electrical indicating instruments to locomotives, automotive vehicles, and aircraft, vibration has been an important factor. Early aircraft applications resulted in the development of a standard of vibration wherein the instrument under test is mounted at a 45° angle from a panel describing a circular motion at speeds from 500 to 2,500 revolutions per minute. The diameter of the circle of motion is adjustable up to 0.062 inch.

Subsequent specifications have called for other types of tests in which simple harmonic vibration is applied in either a horizontal or a vertical plane with a frequency varying continuously between selected limits during the entire period of the test. Two such machines in use in the Weston Engineering Building are shown in Figure 3, the machine in the foreground having a work table which vibrates horizontally while the machine in the background has a table which vibrates vertically. These machines permit vibration of an amplitude up to 0.1″ and at frequencies from 10 to 55 cycles per second. A motor-driven cam automatically changes the frequency over this range, 10 to 55 and back to 10 cycles per second or 10 to 33 and back to 10 cycles per second, once a minute. Manual control is also available if other frequency combinations are desired. As in the case of the high shock test device, a massive mounting base is required and the illustration shows the solid blocks of concrete upon which these machines are mounted.

Tumbling Test

The two types of tests described above subject the instrument to more or less predetermined forces, but certain branches of the Armed Forces have evolved another type of test for instruments intended for certain applications. This is a test wherein the instrument is subjected to the random jouncing, falling, bouncing and tumbling action it might receive in some types of severe usage. Figure 4 shows such a testing machine, called a tumbling machine. The instrument to be tested is fastened in a cylindrical steel sleeve which is then placed in one of the compartments of the tumbling machine. Within the compartments are steel shelves from which the cylinder and instrument drop in a random fashion as the compartments rotate. The machine pictured rotates at a rate of five revolutions per minute and the usual test is forty-five minutes, with a drop within the compartment of twelve inches. This means the instrument, in effect, tumbles down a flight of 450 steps, each one foot high. Instruments must be ruggedly built to take such punishment.

Temperature Test

For many years, instruments were expected to operate satisfactorily over a reasonable span of temperature, such as might be encountered in industry, perhaps somewhere between the freezing and blood-heat points. Then the military began applying electrical indicating instruments in greater and greater numbers and at the same time spread their operations over much of the face of the earth. As a result, instruments for military use are now often expected to operate

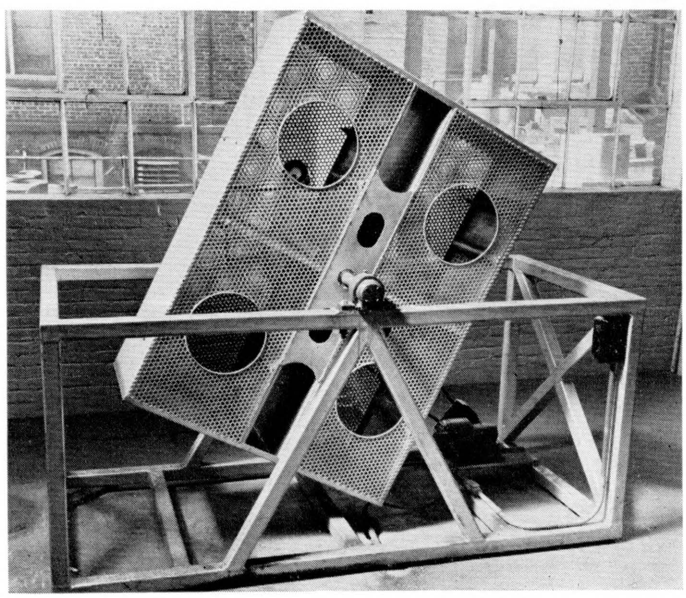

Figure 4—Tumbling Machine. Instrument is falling from shelf in upper compartment.

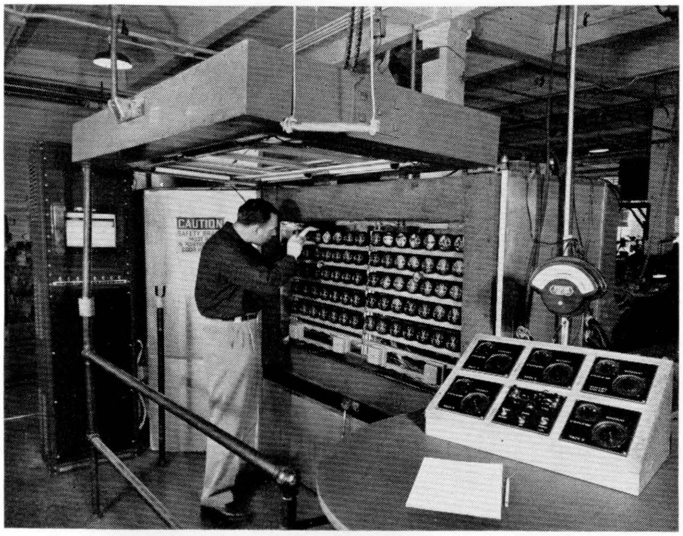

Figure 5—Extreme Temperature Test Cabinet. Temperature range: −75 C to +85 C (−103 F to +185 F).

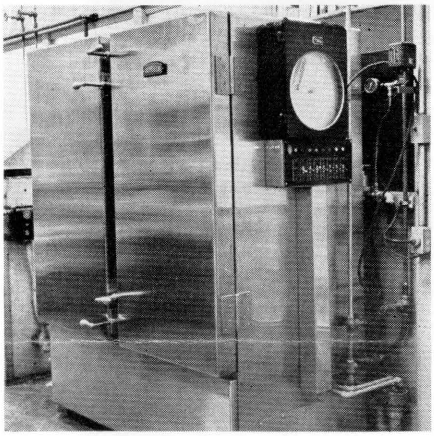

Figure 6—Test cabinet for moisture-resistance test cycling, automatically controlled over cycle. Temperatures range from 2 C to +80 C with relative humidity up to 95 per cent.

over the extreme temperature range of −55C to +85C, the frigid arctic to the torrid equator. Weston has available a wide selection of test cabinets capable of reaching these temperature extremes. These cabinets are heated electrically to obtain the high temperatures, and for the lower temperatures, either mechanical refrigeration or dry ice is used. Figure 5 pictures a test cabinet at Weston with a temperature range of −75C to +85C. It is interesting to note that this cabinet requires 50 hp of motor capacity for attaining the −75C temperature. CELECTRAY Temperature Recorder Controllers, as manufactured by the TAGliabue Division of the Weston Corporation, provide automatic control to assure maintenance of the desired temperature within close limits. Note that windows are provided to permit observation of the instruments during test.

Figure 6 shows a test cabinet in which instruments or their component parts are subjected to a moisture-resistance test. Automatic control is provided to give a predetermined cycle of specified temperature and relative humidity, and portions of a typical cycle closely approximate the atmosphere of a steaming jungle. A recorder-controller chart gives both dry and wet bulb temperatures, enabling determination of both temperature and relative humidity at any time during the test. Another test applied in particular to sealed instruments is a thermal shock by immersion test during which the instruments are alternately immersed in water at 85C and at 0C. A thermostatically controlled test tank for the 85C bath is pictured by Figure 7. Other test cabinets are available for salt spray tests to determine corrosion resistances of materials and finishes.

Sealed instruments are quite naturally expected to be water tight and a test has been set up to insure conformance to this requirement. The instruments are placed in water in a test chamber and the pressure is reduced to 2.5 inches mercury, absolute, by means of a motor-driven vacuum pump. As this test lasts as long as four hours in some instances, some method is desirable to maintain accurately the correct degree of vacuum, and Figure 8 shows a Tagliabue Absolute Pressure Controller used in the Weston Laboratory to maintain the required vacuum automatically.

In addition to the testing equipment discussed above, the instrument manufacturer must maintain a wide range of electrical equipment to accomplish calibration, checking, and testing of the electrical characteristics of instruments. This equipment includes precision potentiom-

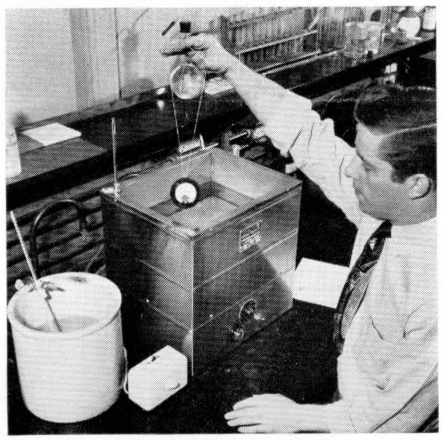

Figure 7—Compact Thermostatically Controlled 85 C Test Tank for thermal shock by immersion test. Instrument has just been removed from 85 C bath and will be immersed in adjacent ice water bath.

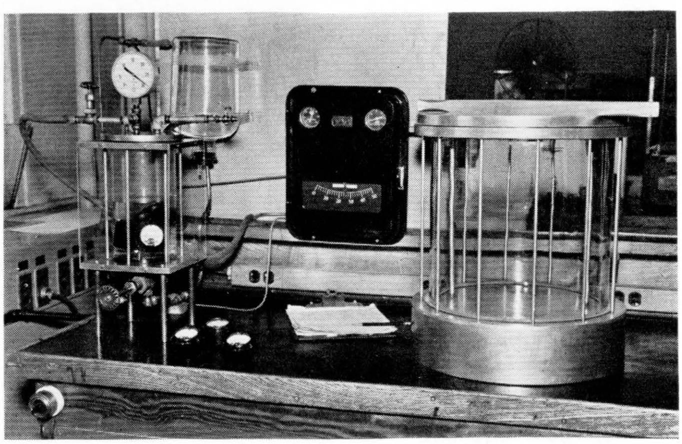

Figure 8—Absolute Pressure Controller and Vacuum Chambers for water-tightness test.

eters, standard cells, standard resistances, transfer standards, instrument potential and current transformers, bridges, and regulated power supplies of various a-c and d-c voltages. Also available is equipment for dielectric strength and insulation resistance tests, oscillators for frequency error testing, and large current-carrying coils or loops for magnetic influence or external field influence tests.

From the foregoing it can be seen that the complete engineering laboratory must have many pieces of equipment which in years past would not have been considered as being tools for the development of better electrical indicating instruments.

E. N.—No. 89 —*E. G. De Mott.*

THERMAL PROBLEMS RELATING TO MEASURING AND CONTROL DEVICES—PART IX

Steady State Distribution of Temperature on Various Shapes of Conductors Connected to Terminals

Introduction

IN THIS section, a study will be made of the distribution of temperature, after it has reached a steady state, along bars or strips having a uniform cross section and connected to terminals, such as shunts, bus bars, and similar conductors; and some practical examples will be given.

25. STEADY STATE DISTRIBUTION OF TEMPERATURE ALONG A CONDUCTOR OF UNIFORM CROSS SECTION, CONNECTED TO TERMINALS, WHEN HEATED OR COOLED AT A CONSTANT RATE, AND WHICH EXCHANGES HEAT WITH THE SURROUNDING MEDIUM.

Let the conductor, illustrated in Figure 24, be connected between two terminals T_1 and T_2. For greater generality, and for most useful practical purposes, let the terminals have different temperatures above ambient, T_1 and T_2.

One form of temperature distribution curve is shown diagrammatically above the conductor. The terminal temperatures as shown are higher than ambient, but they may equally well be lower in which case they would simply become negative.

The conductor may be heated by an electric current as in a shunt or bus bar, or be heated or cooled by radiant energy depending upon whether the source of radiation is warmer or cooler than the conductor. Furthermore, if no heat is added or removed by an external source, then the temperature distribution results from the exchange of heat with the terminals and the surrounding medium.

Let A = area of cross section of the conductor; cm.^{2}

h = rate of exchange of heat between the conductor and the surrounding medium per unit length, per degree centigrade difference in temperature; watts per cm. per degree centigrade.

k = thermal conductivity of conductor material; watts, cm., degree centigrade.

L = length of conductor between terminals; cm.

x = distance from terminal T_1 to any part of conductor; cm.

T_1 and T_2 = temperatures of terminals above ambient.

θ = temperature above ambient of conductor at any distance x from terminal T_1.

$\theta_o = w/h$ = the increase in temperature of the conductor which would result if all the heat added were dissipated by convection to the medium, and none conducted to the terminals.

θ_c = temperature at mid-point of conductor above ambient.

ρ = resistivity of the conductor; ohms/cm.^{3}

$u = \sqrt{h/(Ak)}$ = thermal length of conductor per cm. length; hyperbolic radians/cm.

w = rate at which heat is generated in conductor per unit length; watts/cm.

25(a). Temperature Distribution Along the Conductor When It Is Heated or Cooled Uniformly by Any Means at a Constant Rate.

As developed in a previous paper by the author,[1] and as will be shown later in this chapter, the temperature of the conductor above ambient at any distance x from the terminal T_1 when it is heated at a constant rate of w watts per cm. length, is

$$\theta = \theta_o - \left(\frac{(\theta_o - T_1)\ sinh\ (L-x)u + (\theta_o - T_2)\ sinh\ xu}{sinh\ Lu} \right) \quad (185)$$

If the conductor is cooled at a rate of $-w$ watts per unit length, then θ_o is negative.

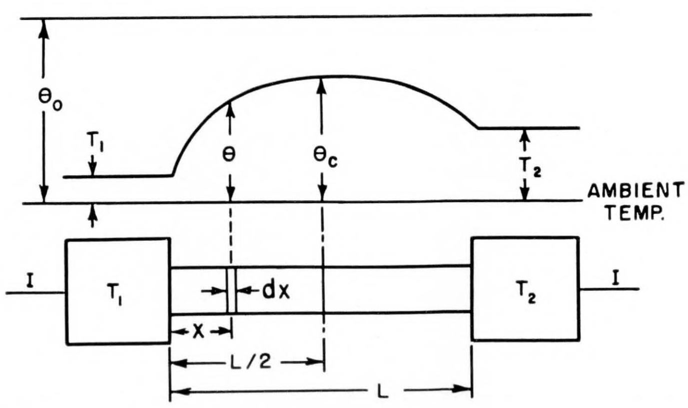

Figure 24—A conductor connected to terminals, heated uniformly at a constant rate, and dissipating heat by conduction to the terminals, and by convection to the surrounding medium. The diagram above the conductor illustrates one form of temperature distribution.

Temperature at Mid-Point of Conductor

By making $x = L/2$ in Equation (185), and separating the effect produced by the heat added from that exchanged with the terminals, we have the temperature at the mid-point above ambient,

$$\theta_c = \theta_o\left(1 - \frac{2 \sinh Lu/2}{\sinh Lu}\right) + (T_1 + T_2)\frac{\sinh Lu/2}{\sinh Lu}$$

and since $\sinh Lu = 2 \sinh Lu/2 \cosh Lu/2$, the equation reduces to

$$\theta_c = \theta_o\left(1 - \frac{1}{\cosh Lu/2}\right) + \frac{T_1 + T_2}{2 \cosh Lu/2} \quad (186)$$

25(b). Distribution of Temperature When the Conductor Is Heated by an Electric Current, as a Function of the Difference of Potential Between the Terminals.

When a conductor is heated by the passage of an electric current through it, it is convenient to state temperatures in terms of the difference of potential, V, between the terminals.

Then the rate, w, at which heat is generated per unit length is

$$w = V^2A/(L^2\rho)$$

from which

$$\theta_o = \frac{w}{h} = \frac{V^2A}{L^2\rho h} = \frac{V^2}{k\rho L^2u^2}$$

When the value of θ_o as a function of V is inserted in Equation (185), and the heating and terminal effects separated, it is found that the temperature above ambient at any position x is

$$\theta = \frac{V^2}{k\rho}\left[\frac{\sinh Lu - \sinh (L-x)u - \sinh xu}{L^2u^2 \sinh Lu}\right] + \frac{T_1 \sinh (L-x)u + T_2 \sinh xu}{\sinh Lu} \quad (187)$$

Temperature at the Mid-Point of the Conductor Heated by Current

By substituting for θ_o in Equation (186), its value in terms of V, we have the temperature at the mid-point above ambient,

$$\theta_c = \frac{V^2}{8k\rho}\left[\frac{2\left(1 - \frac{1}{\cosh Lu/2}\right)}{(Lu/2)^2}\right] + \frac{T_1 + T_2}{2 \cosh (Lu/2)} \quad (188)$$

It was shown previously by Equation (102) that if the conductor is cooled only by conduction to the terminals, where the heat dissipated by convection to the surrounding medium is negligible, the temperature at the mid-point above the terminal temperature, if they are equal, or above their mean value if they differ, is

$$\theta_c = V^2/(8k\rho)$$

Equation (188) then shows that the temperature above the effective temperature of the terminals at the mid-point of a conductor subject to both convection and conduction losses is equal to the temperature at the mid-point of a conductor from which all of the heat is dissipated by conduction to the terminals, multiplied by the factor $2\,[1 - (1/\cosh Lu/2)]/(Lu/2)^2$. The curve in Figure 25 gives this factor for various values of the thermal length of the conductor, Lu, which is useful in solving practical problems.

26. TEMPERATURE DISTRIBUTION IN A CONDUCTOR OF UNIFORM CROSS SECTION HEATED BY CURRENT AT A CONSTANT RATE, WHEN THE HEAT DISSIPATED BY CONVECTION IS NEGLIGIBLE RELATIVE TO THAT CONDUCTED TO THE TERMINALS.

When the heat dissipated to the surrounding medium by convection is negligible, as for example in a conductor which has a very short thermal length Lu, approaching zero, the temperature distribution is obtained by substituting $Lu = 0$ in Equation (188). This results in the indeterminate form, $0/0$, which, however, can be evaluated in the simple manner used for Equation (158) by changing the hyperbolic functions into their series forms and letting Lu approach zero. We then obtain the following relations.

Temperature Distribution Along the Conductor

The temperature above ambient at any position x of the conductor is then

$$\theta\Big]_{Lu=0} = \frac{V^2}{8k\rho}\left[\frac{4x(L-x)}{L^2}\right] + \frac{T_1(L-x) + T_2x}{L} \quad (189)$$

This is the same as Equation (105) except that in Equation (189), temperatures are based upon the ambient temperature rather than upon the terminal temperature T_1 as in (105).

Temperature of the Conductor at Its Mid-Point

When $L/2$ is substituted for x in Equation (189) we obtain as the temperature above ambient at the mid-point of the conductor

$$\theta_c\Big]_{Lu=0} = \frac{V^2}{8k\rho} + \frac{T_1 + T_2}{2} \quad (190)$$

27. EXAMPLES.

Problem 1

Let us examine an ordinary commercial form of 50 millivolt shunt to determine the effectiveness of the conductor to cool itself by its direct surface contact with the surrounding air.

Assume that it consists of a single sheet of manganin, one inch wide, two inches long, and one millimeter thick, connected between terminals.

Then the thermal length is $Lu = L\sqrt{h/Ak}$, from Equation (185)

Wherein $L = 2$ inches $\times 2.54 = 5.08$ cm.

h = rate of heat convection from the two sides of the strip per cm. length per degree centigrade.

Then $h = 2 \times 1$ inch $\times 2.54 \times 0.00139 = 0.00706$ watt per degree centigrade per cm. length in which 0.00139 is the convection coefficient in watts per square cm. per degree centigrade as deduced from experimental data given previously.[2]

The cross sectional area $A = 1$ inch $\times 2.54 \times 0.1 = 0.254$ cm.[2] The thermal conductivity of manganin is $k = 0.26$ watt-cm.-deg. C. Then $Lu = 5.08[(0.00706)/(0.254 \times 0.26)]^{1/2} = 1.66$ hyperbolic radians. Referring to the curve in Figure 25, we find that for a thermal length of 1.66 hyperbolic radians, the difference in temperature between the mid-point of the manganin strip and the terminal has been reduced only to 77.6 per cent of that which would result if the strip itself had no cooling effect whatever. When more than one strip is used, their cooling effectiveness is still less, since the small spaces between the strips as usually designed are practically useless for ventilation. Even if they were spaced farther apart, the maximum reduction in temperature could not exceed that for the single strip, namely 22.4 per cent.

This analysis shows that the multiple strip conductors used in commercial forms of 50-millivolt shunts are practically useless for cooling purposes. They are provided, however, for the purpose of producing a more positive and permanent junction between the manganin conductor and the terminals. Furthermore, it shows the necessity for carefully made connections between the shunt terminals and the bus bars, and properly designed bus bars, since practically all of the heat generated must be dissipated by conduction to the bus bars.

Problem 2

Sometimes as a matter of economy or of space limitations, shunts of the size and type designed for 50 millivolts are operated on a basis of double current capacity corresponding to 100 millivolts under the assumption that currents in excess of normal will be intermittent and of short duration. This practice is not recommended in general, for if the full double load current were maintained too long, the manganin conductor might be damaged by oxidation resulting from the prolonged high temperature.

As an example, let us compute the temperature of the 50-millivolt shunt of the preceding problem when it is operated at 100 millivolts.

From Equation (102) or (190), the temperature at the mid-point of the conductor above that of the terminals, if no heat is dissipated directly from the conductor to the surrounding air, is

$$\theta_o = V^2/(8k\rho)$$

The thermal conductivity of manganin $k = 0.26$ watt-cm.-deg. centigrade. The electrical resistivity of manganin $= 38.2 \times 10^{-6}$ ohms/cm.[3] Then $\theta_c = (0.1)^2/(8 \times 0.26 \times 38.2 \times 10^{-6}) = 125$ deg. centigrade. As in the previous problem, the direct cooling effect of the conductor strip reduces the temperature difference to $125 \times 0.776 = 97$ degrees centigrade.

In practice the temperature of the terminals may be 40 degrees centigrade above ambient which itself may be at 40 degrees centigrade. Therefore, the actual temperature of the conductor at its mid-point may reach $97 + 80 = 177$ degrees centigrade. This temperature will be still further increased, approaching 205 degrees centigrade if a multiple strip conductor is used where direct cooling becomes relatively less.

28. DERIVATION OF EQUATION (185).

Figure 24 illustrates a conductor connected between heat absorbing terminals at temperatures T_1 and T_2 above ambient. Above the conductor, a temperature diagram is shown illustrating ambient, terminal, and conductor temperatures.

Let the positive direction of heat flow be in the direction of increasing values of x. Then at any distance x from the terminal T_1 the heat generated in dx per unit time is $w dx$, and the heat dissipated by convection in dx to the surrounding medium is $h\theta dx$ per unit time.

Therefore, the net change in the heat rate across dx is $(w - h\theta)dx$.

Now, the rate at which the heat conducted through the conductor at x per unit time varies across dx is

$$-Ak\left(\frac{d^2\theta}{dx^2}\right)dx$$

Equating these quantities we have

$$Ak\left(\frac{d^2\theta}{dx^2}\right) = -(w - h\theta) \qquad (191)$$

The sign is negative for the reason that the sign of the direction of heat flow is opposite to that of the temperature gradient producing the flow.

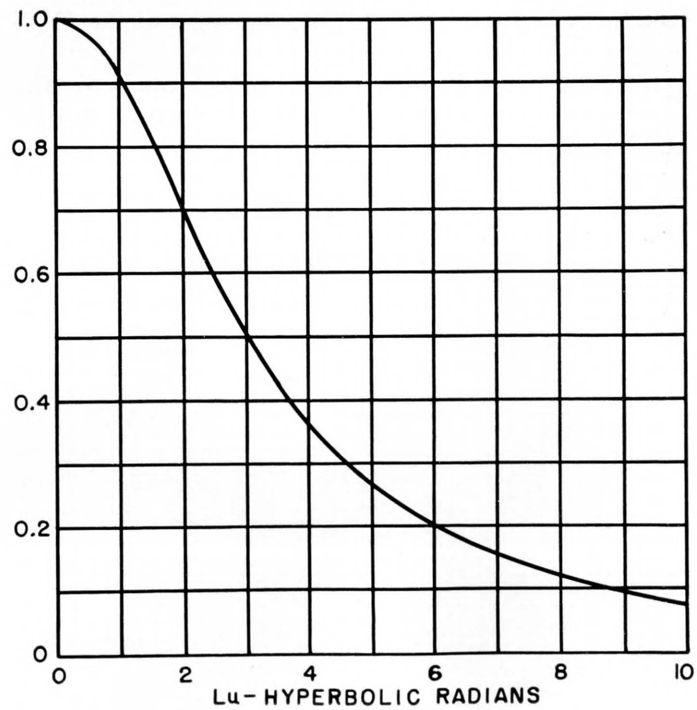

Figure 25—The factor $2[1-(1/\cosh Lu/2)]/(Lu/2)^2$ as a function of the thermal length Lu. This is the ratio of the difference in temperature between the mid-point of the conductor and the terminals when heat is dissipated both by conduction and convection, to that which would result if the heat were dissipated solely by conduction to the terminals.

Integrating this equation once by multiplying both sides by $2(d\theta/dx)dx$, we have

$$\left(\frac{d\theta}{dx}\right)^2 = \frac{h\theta^2}{Ak} - \frac{2w\theta}{Ak} + B_o \qquad (192)$$

To simplify let $h/(Ak) = u^2$, and $w/h = \theta_o$

Substituting these values in Equation (192), and after adding and subtracting θ_o^2, substituting B^2 for the constant $\left(\theta_o^2 - \frac{B_o}{u^2}\right)$, and reducing, we have,

$$dx = \frac{d\theta}{uB\left[\left(\frac{\theta_o - \theta}{B}\right)^2 - 1\right]^{1/2}} \qquad (193)$$

Integrating this equation, there results after reducing

$$\frac{\theta_o - \theta}{B} = -\cosh\,(x+c)\,u \qquad (194)$$

Where B and C are constants of integration, which are determined from the known conditions that when $x=0$, $\theta = T_1$, and when $x=L$, $\theta = T_2$.

Expanding $(x+c)u$, applying the boundary conditions, and reducing, we have

$$\theta = \theta_o - \left[\frac{(\theta_o - T_1)\sinh\,(L-x)u + (\theta_o - T_2)\sinh\,xu}{\sinh\,Lu}\right]$$

which is Equation (185).

References:

[1] *W. N. Goodwin, Jr.* The Compensated Thermocouple Ammeter, Trans. A.I.E.E., Page 25, Vol. 55, 1936.

[2] *W. N. Goodwin, Jr.* Thermal Problems, Part III, WESTON ENGINEERING NOTES, Vol. 3, No. 4, Page 8, August, 1948.

E. N.—No. 85 Cont. —*W. N. Goodwin, Jr.*

EDITOR'S NOTE: *The second installment of Part IX will be continued in a future issue of the* WESTON ENGINEERING NOTES. *It will continue the analysis of the steady state temperature distribution and heat conduction in conductors and will consider some practical applications.*

NEW MANUFACTURING AREA SOON TO BE OCCUPIED

A new air-conditioned building, adding 25% production area to the Weston plant, will be fully occupied by June 1. This expansion, a necessary requirement to meet the increased demand for instruments primarily for the Armed Forces, will provide employment for over 1,000 new workers.

The new building, illustrated in the insert, is the nineteenth constructed since the establishment of the Company in 1888.

It is constructed of poured reinforced concrete. The two upper floors will be occupied by assembly departments. Receiving, shipping and stock departments occupy the first and basement floors.

For over 64 years, Weston has kept pace with the measurement requirements of industry and is today the world's largest organization devoted exclusively to the art of instrumentation.