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## In This Issue



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# THE MEASUREMENT OF MOISTURE IN LUMBER

IN THE manufacture of wood products—furniture, cabinet work, interior trim—the amount of free moisture in the wood itself is becoming recognized as a very important factor. In general, wood should be processed when at a moisture content representative of the mean value it will attain over the years of service of the manufactured item. If processed when at high moisture, it will later shrink and perhaps crack; if processed when too dry, it will swell. The optimum moisture content of the lumber is always desirable.

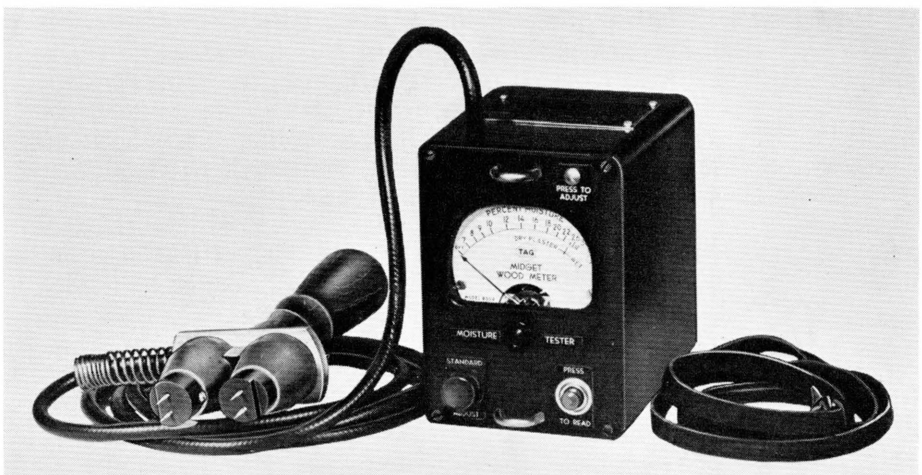



Figure 1—The new Model 8009 TAG Midget Moisture Meter for lumber.

Even kiln-dried lumber may vary from the preferred moisture content.

Classically, moisture in wood could only be determined by weighing a sample, drying it in a special oven and taking a second weight. This procedure is time consuming and requires laboratory facilities. Although it remains the basic standard to which other measurements are referred, there are today available direct reading moisture meters for lumber with which entirely adequate accuracy can be obtained instantly. They are portable and may be used on the lumber racks or in the yard.

Although several methods have been investigated for the quick measurement of moisture, no other system approaches in simplicity that of the conductive type. The essential principle here is simply measuring the electrical resistance between two spaced points in the lumber. The resistance to passage of electric current in a piece of lumber, or, putting it in another form, the carrier of the electric current is simply the moisture in the wood. The less moisture the less the ability to carry electric current and the higher the resistance.

If we establish the type of contact made and the distance between contacts and the voltage at which we make a measurement of the resistance, we can then associate the resistance values quite definitely with the moisture content of each wood species. It will be quite obvious that the resistance-moisture relation varies with the species when one compares the open grain of oak with the extremely fine grain of beech or maple. Organizations such as the Forest Products Laboratory, U. S. Department of Agriculture, at Madison, Wisconsin, have studied this relationship for many years and have developed a great deal of tabular data on moisture versus resistance. The resistance-moisture relationship is very consistent below the fiber saturation point of wood, which varies from about 25-30 per cent according to species. Of course, this must be converted to final values depending upon the form of contact. In the TAG-Heppenstall moisture meter, special pins somewhat similar to phonograph needles are set in a handle, Figure 2, a fixed distance apart and are pressed into the wood; a hammer type handle, Figure 3, is useful in hard woods and allows for driving pins into the wood.

Because the value of resistance for various woods covers such an enormous range, rather special electrical means are necessary. As an example, between the pins of the TAG-Heppenstall moisture meter we find a resistance of 600,000 ohms for 24 per cent moisture in Douglas Fir, whereas when the moisture drops down to 7 per cent, the resistance rises to 22,500,000,000 ohms. To compress this wide range of a single scale has required somewhat special arrangements as well as very high sensitivity. The conventional TAG-Heppenstall meter is a null type bridge in which the indicating instrument is set to a particular point through an adjustment, and then, with the electrodes in the sample, the dial switch is turned until the same meter reading is obtained. The position of the dial switch indicates the resistance value and the per cent moisture. The high sensitivity needed makes a vacuum tube necessary; batteries are self-contained in the case. Being of a balanced type, the condition of the batteries and the tube do not enter into the reading itself. Readings can be taken in a matter of seconds, with the result that moisture gradient across a board or in a shipment of lumber can be checked rapidly and with confidence.

With the advent of improved vacuum-tube circuits, a new approach has been made possible and the new Model 8009 TAG Midget Moisture Meter for Lumber, Figure 1, is announced. This is a direct-reading instrument, calibrated from 7 to 30 per cent, of small size and good accuracy. It weighs less than 4 pounds and the carrying strap makes it most desirable for measurements of this type. Calibrated directly in per cent moisture for common soft woods, the readings are modified according to tabular information given for hard woods and special types.

It might be stated here that per cent moisture is rather generally stated in terms of dry weight. That is, in the basic oven method, the difference in weight between the material as found and the final completely dry sample, divided by the weight of the dry sample and multiplied by 100, gives the moisture in per cent.

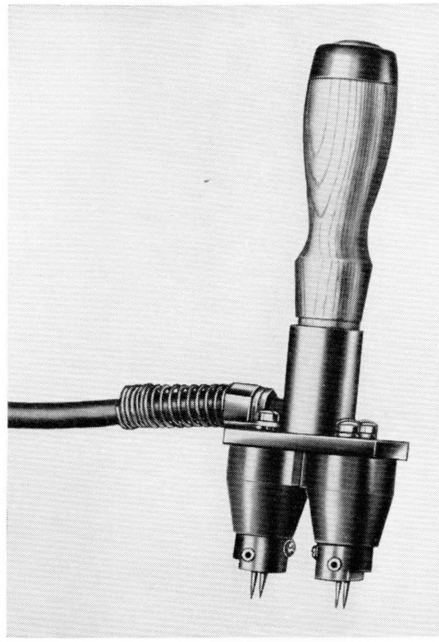


Figure 3—The hammer type handle holder used in hard woods.

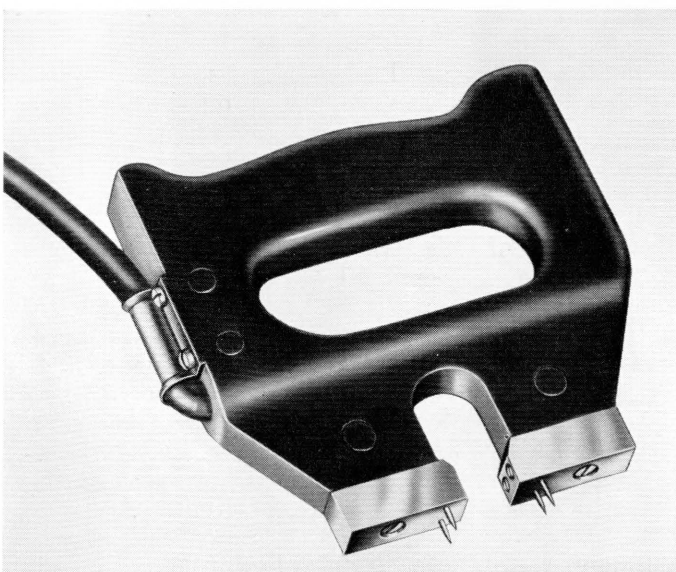


Figure 2—A handle of the type shown here is used when taking the moisture reading of common soft woods. The operator merely presses the special pins into the wood.

In the development of this latest moisture meter, particular attention has been paid to the basic requirements for such a device and these might be listed below.

1. The contact needles should be readily replaceable.
2. Current leakage in the needle-holding device, the cable, and the equipment must be at a minimum for accuracy. A very special high leakage cable is required and special attention must be paid to all parts of the equipment to minimize the leakage.
3. A guard ring circuit should be used on the external probe to minimize circuit leakage effects.

With all the above, construction and assembly must be kept simple and straightforward to the end that servicing can be readily performed.

The value given above for 7 per cent moisture in Douglas Fir might be noted and it amounts to 22,500 *megohms*. Wood with less than 7 per cent moisture is quite dry and very nearly a non-conductor. Values less than 7 per cent are most difficult to measure. However, values less than 7 per cent are rarely found except immediately after a drying cycle since most wood products balance in the climate of the United States around 10 to 11 per cent. Thus little need is found for measuring values less than 7 per cent.

In using the instrument, readings are generally taken with opposite electrodes along the grain. If it is suspected that the outer surface contains an excess of moisture, a check with the needles driven only part way in will develop this fact.

Another very interesting application of the moisture meter is in determining when a wood or plaster wall is dry enough to paint. Experience has shown that new plaster is safe to paint when the resistance across the probe is above 600,000 ohms. Since the resistance corresponds to a wood meter calibration point of 24 per cent, a plaster line has been added at this point on the scale.

Wood, in general, may be painted when its moisture does not exceed 20 per cent. It is important, however, that the painter be sure that the siding and insulation are not wet due to faulty plaster drying methods or entrance of water into the walls from some other source. If there is any question of this, a pair of nails, spaced 1¼ inches apart, should be driven through the weatherboard and into the rough siding. If the moisture reading across the nails is above 20 per cent, it is advisable to apply only the priming coat and wait until the interior of the wall dries before applying finish coats. In old buildings, the source of excess moisture should be found. Such moisture may come either from the outside or may be driven into the wall by a high humidity condition within the house.

Figure 4—Checking the moisture content of wood prior to painting.

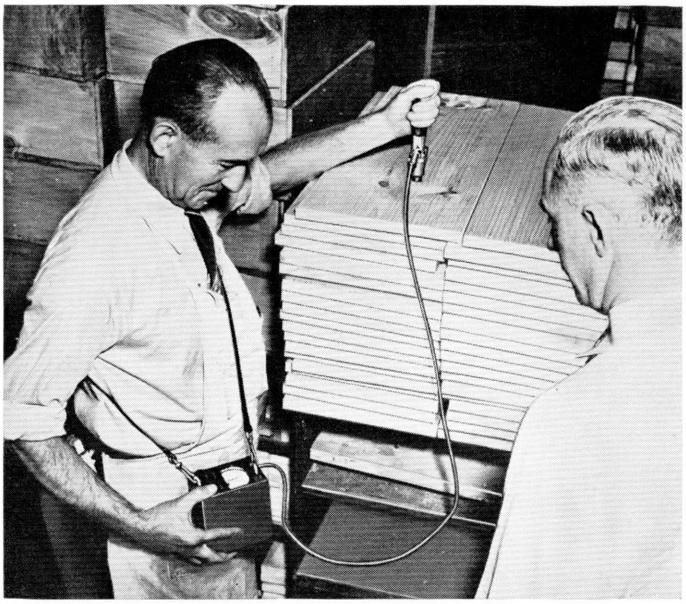


Figure 5—Here the carpenter very easily checks the moisture content of a piece of lumber.

A summary of important reasons for knowledge of the moisture content of wood follows:

1. A purchaser can quickly determine the moisture in lumber stated to be kiln dried. Obviously, if the moisture content is higher than acceptable for kiln-dried material, the drying has not been completed and the material is not kiln dried in the accepted sense.
2. By the same token the dry kiln operator can check the lumber when shipped to make certain that it is within specific limits and will not be rejected by the purchaser.
3. Each type of glue yields best results when applied to lumber or fabricated parts within specific ranges of moisture content. The glue manufacturers should be consulted for optimum performance as to moisture values.
4. If the moisture content of wood is too high, it may start wood rot or decay; the higher the moisture content the more rapidly the decay will progress.
5. The penetration of preservatives into wood is dependent upon the moisture content.
6. If any moisture gradients exist in lumber or wood products, consequent shrinkage and cracking will be increased.
7. Should two pieces of wood be glued together having different moisture contents, the assembly will most likely warp as both pieces come in equilibrium.
8. The strength of wood decreases as its moisture content approaches the fiber saturation point.
9. Wet lumber weighs more, increases shipping costs.
10. If lumber used in construction work has too high a moisture content, shrinkage will be abnormally high and the entire structure may distort to a point requiring extensive repairs.

To obtain the maximum benefit from the use of an electric moisture meter with its quick response, the user should study the instructions furnished with the device and become thoroughly familiar with its operation. Savings which can be realized over a reasonable period will usually be far higher than the cost of even the most elaborate moisture meter so that the original investment will be recovered rapidly. In numerous instances, it has been found that the original investment has been recovered many times over in even the first year of operation.

*—L. Van Blerkom,*
*O. J. Morelock*

E. N.—No. 79

# DIFFERENTIAL AND RATIO APPLICATIONS OF WESTON RELAYS

WESTON relays of the permanent-magnet movable-coil type, inherently of high sensitivity, are used in many interesting applications. Some of these uses occur in two closely related fields; one dependent upon a "differential" effect and the other dependent upon a "ratio" effect. These terms are described in later paragraphs. It is not always readily apparent that these two effects are identical at a single predetermined point and that a standard relay, differentially connected, will usually offer the desired relay control action.

The differential relay functions by virtue of the difference in voltage or current between two associated circuits. For example, two circuits may be so arranged that a relay contact is normally open when the voltages or the currents of these two circuits are equal and of any value within the rating of the relay, but closure of a contact will occur when one voltage or current differs from the other by a predetermined amount or differential. Note that, with a differential type of action, the device functions because of the difference between the two quantities being compared, regardless of the actual value or level of the quantities. A typical differential relay would be one designed to accommodate any voltage up to, for example, 20 volts on either or both of two circuits, and with contacts arranged to close whenever the voltage difference between circuits exceeded one volt. The relay would also possess the ability to discriminate as to which circuit possessed the higher voltage and make contact to the right or left side accordingly.

The ratio type of action is based on the ratio of one quantity to another rather than on the difference between the two quantities. For example, we might consider two circuits so arranged that a relay contact is normally open when the voltages or the currents of these two circuits are equal and of any value within the rating of the relay. Closure of a contact will occur when the ratio of one voltage or current to the other voltage or current attains a predetermined value or percentage. Note that, with a ratio type of action, the device functions because of the ratio of the two quantities being compared. Therefore, the actual difference between the two quantities at the point of contact closure is dependent upon the value or level of the quantities at the operating point. A numerical example might be that of a relay designed to accommodate any voltage up to, again say, 20 volts on either or both of its two circuits.

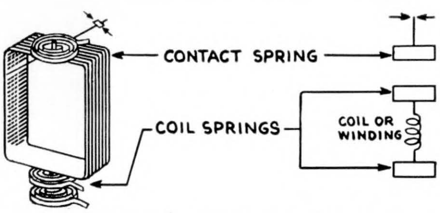



**Figure 1—Diagram showing Standard Single Coil Three-Spring Relay.**

The contacts would be adjusted to close whenever one quantity differed from the other quantity by a ratio of say 0.1 or 10 per cent. This means that if, for example, the voltage of one circuit was 10 volts, a contact would close when the other circuit differed by a value of 10 per cent of the first circuit, or 1 volt. Or, if the voltage of one circuit of this same relay was 15 volts, the contact would close when the other circuit differed by a value of 10 per cent of the first circuit, or 1.5 volts, and so on.

The ratio type of relay is seldom made and many ratio control problems lend themselves to a differential type of relay. Standard permanent-magnet movable-coil relays may be set up with a differential connection for this use, and a comprehensive discussion of such differential relays may be found in the August, 1946, WESTON ENGINEERING NOTES, Volume 1, Number 4. The use of the differential connection for a ratio application is not as serious a limitation as might first seem in relay control problems and at a single point, which may be predetermined, the differential action is identical with the ratio action. At the null or balanced condition, there is no deflection of the contact arm with either the differential or the ratio method. As process control or alarm features are usually desired for a predetermined differential or ratio change and at a predetermined level, or for synchronizing purposes, the differential connection will meet nearly all requirements.

There are many circuit variations which may be used with a Weston relay of conventional design to obtain differential action. Differential relays with two separate actuating windings can be made but usually the standard single coil relay shown in Figure 1 can be differentially connected to achieve the desired result with consequent savings in cost and delivery time. Figure 2 represents what is probably the simplest of such circuits and is a so-called "bucking" circuit. This circuit is adapted to comparing potentials or the potential drop across shunts if currents are to be compared. This is a null method in that no current flows through the relay when the input voltages are balanced or equal. $E_1$ and $E_2$ represent the potentials to be compared, and $R_1$ and $R_2$ represent the resistances of the sources and wiring of $E_1$ and $E_2$ respectively. Sometimes $R_1$ or $R_2$ includes a calibrated rheostat to permit changes in the differential required to operate the relay. $R_R$ represents the resistance of the movable coil of the relay. The relay current $I_R$ for a given potential differential of $E_D$ volts would be:

$$I_R = \frac{E_D}{R_1 + R_2 + R_R}$$

The relay is subjected to an overload whenever $E_D$, the difference between $E_1$ and $E_2$, exceeds the value at which the contacts are designed to operate. The maximum overload would occur if either $E_1$ or $E_2$ were reduced to zero while the other was at its maximum value. These relays are capable of withstanding appreciable overloads, but overload conditions must be considered when designing such a differential system.

Figure 3 depicts a commonly used variation of the basic "bucking" circuit of Figure 2. This variation permits the comparison of voltages or currents of dissimilar magnitude at the null or balance point. For example, Circuit No. 1 might represent a potential of 20 volts and Circuit No. 2 a potential of 5 volts for the null condition. The resistors $R_1$ to $R_4$ can be readily proportioned to achieve such a result. A similar arrangement, omitting $R_1$ and $R_2$, will permit comparison of currents of dissimilar value. It is even possible to compare a potential across one circuit with a current passing through the other circuit.

Figure 4 shows the so-called "boosting circuit" wherein a current common to both sources flows at all times, even when the net current through the relay is zero. The resistances $R_1$ and $R_2$ may well include portions of a single wire-wound potentiometer, with the movable contact arm connected to one terminal of the relay. This enables the relay to be electrically balanced to its mid-position between the contact, or to effect a change in the ratio of $E_1$ to $E_2$ for operation of the contacts. Generally, the values of $R_1$ and $R_2$ are determined by the allowable current drain from the sources $E_1$ and $E_2$ when they are at their maximum voltage.

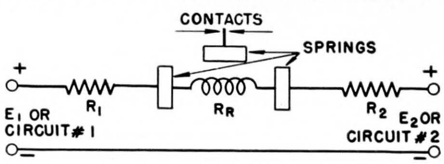



Figure 2—"Bucking" Differential Circuit.

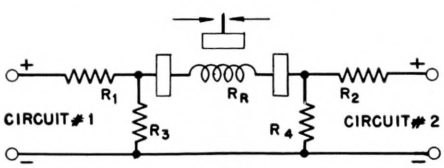



Figure 3—A variation of the "Bucking" Differential Circuit.

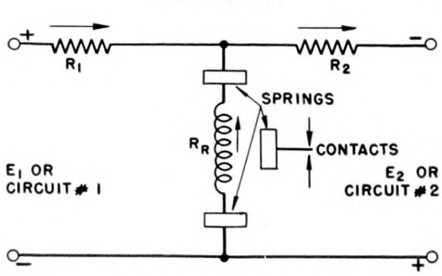



Figure 4—"Boosting" Differential Circuit.

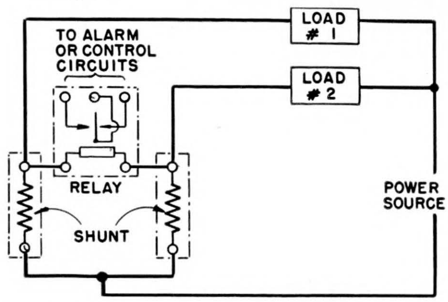



Figure 5—Arrangement to maintain approximately equal current through two varying loads.

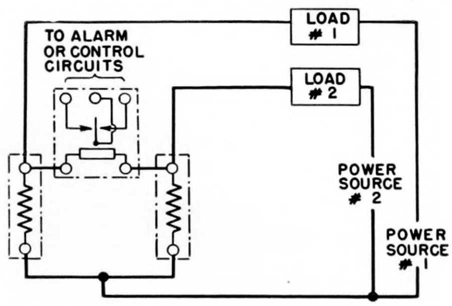



Figure 6—Two varying loads with separate power sources.

If $E_1 = E_2$ at balance, $R_1$ will equal $R_2$ and the relay current $I_R$ for a given potential differential of $E_D$ volts would be:

$$I_R = \frac{E_D \, R_1}{2R_1 \, R_R + R_1^2}$$

For other conditions where $R_1$ is not equal to $R_2$, the relay current $I_R$ would be:

$$I_R = \frac{E_2 \, R_1 - E_1 \, R_2}{R_1 \, R_R + R_2 \, R_R + R_1 \, R_2}$$

The arrows shown on Figure 4 indicate the direction of current flow for the above equation. If the difference $E_2 \, R_1 - E_1 \, R_2$ is a negative value, the direction of current through the relay is opposite to that indicated by the arrow at $R_R$ of Figure 4.

There are many other circuit variations which may be used to achieve ratio or differential effects with the conventional three-spring relay, but no general rule or circuit can be given that will represent optimum design for any and all applications. A few examples of applications will serve to illustrate some of the possible uses of differentially connected relays.

Figure 5 shows an application wherein it is desired to initiate an alarm or control action whenever the current difference between Load No. 1 and Load No. 2 exceeds a given value. In this particular application the maximum current might be 100 amperes and the maximum differential might be 2 amperes. This application is basically similar to that of Figure 2 if the millivolt drop of the shunts is likened to $E_1$ and $E_2$. $R_1$ and $R_2$ are negligible in this instance and it can be seen directly that the range of the Model 534 Relay may be expressed in millivolts. As 2 millivolts represents the desired differential of 2 amperes in 100 ampere 100 mv shunts, the relay range would be 2-0-2 millivolts, the relay contact arm resting midway between contacts when the shunt currents are equal. Figures 6 and 7 show other variations of this same basic circuit. The circuit of Figure 6 is essentially the same as that of Figure 5 except for the use of two separate power sources instead of a single source.

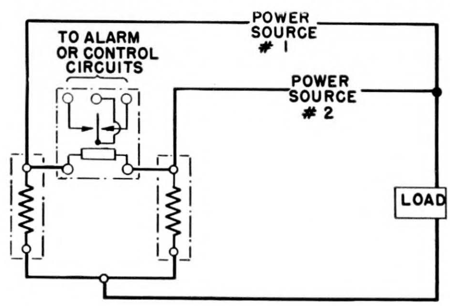



Figure 7—One varying load with two power sources.

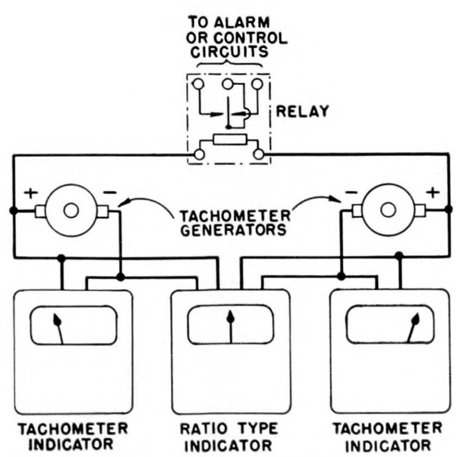



Figure 8—Relay arranged to signal synchronization of input and output shafts—or of shafts of two machines.

Likewise, Figure 7 illustrates the case where a predetermined division of a single load from two power sources might be desired. It is important in Figures 5, 6 and 7 that the common lead between the two shunts be of low resistance and that the connection to it be at its midpoint.

Figure 8 illustrates the application of a differentially connected relay together with Weston speed-ratio and tachometer indicators. The two tachometer generators are connected directly or through gear boxes to rotating parts of the machine or machines with which they are to be associated. These rotating parts may be the input and output rolls of some sheet-rolling process or other process where the working material passes over rolls, such as textile, steel or pulp and paper processes, or may be rotating shafts of separate machines whose speed is to be compared. Weston Circular A-17-D describes such indicators in detail. Three things can be accomplished by such an arrangement:

1. The speed of the input and output tachometer generators is shown by the tachometer indicators, calibrated in terms of whatever quantity is being measured, such as "Yards per Minute," "Operations per Hour," "R.P.M.," etc.
2. The speed ratio of the two tachometer generators is indicated directly in per cent by the ratio meter.
3. The relay may be used for a control or alarm function to maintain synchronization between the two tachometer generators or to operate when a predetermined difference exists between the speeds of the tachometer generators.

There are many more possibilities and combinations for the successful application of differentially connected relays and the preceding discussion is intended to point out some of the functions that might be accomplished by these relays. Detail design of such relays should be considered in the light of the entire problem and it is urged that all details of such applications be submitted, rather than the request for a specific relay, so as to benefit from the background of experience available at Weston.

E. N.—No. 80 —*E. G. DeMott*

# AN ALTERNATOR FIELD TEMPERATURE INDICATOR

A DIRECT indication of the temperature of the rotating field of a large alternator is usually considered desirable in the power plant control room. Indication of the temperature of the stator and other fixed items in the power plant is common practice either through the use of thermocouples or embedded resistance elements. In a rotating member, however, it is obviously difficult to use such elements because of the necessity of bringing out connection leads, in turn necessitating slip rings and contact arrangements, and a somewhat different approach is required.

The development of the ratio meter for the measurement of resistance has broadened in recent years, and several installations have been made of a rather special type of ratio meter actually reading the ratio of the voltage to the current in the rotating field. Of course, this amounts to the resistance, which, in turn, is related to temperature. In operation, the instrument provides a continuous temperature indication that can be co-ordinated with the load, reactive power and other factors affecting the efficient operation of the equipment.

In practice, the energy from the current circuit is picked up from a suitable shunt and the voltage is

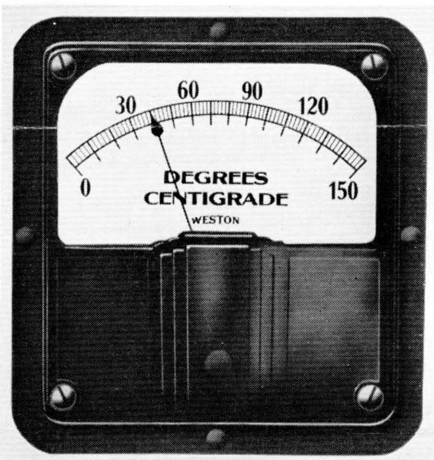



Figure 1—The Weston Model 918 Ratio Meter.

taken across the brushes to the main slip rings of the alternator field. A somewhat special version of the Weston Model 918 Ratio Meter has been used for this purpose with one coil wound to best match a shunt and the other coil to be best suited for potential connection.

More broadly, the Model 918 mechanism is of the twin-coil type with ratio indicated by the mechanical balance of the two opposing torques produced by the currents of the two coils.

The moving coil, shown in Figure 2, has two separate windings with the axis of rotation running lengthwise through the adjacent sides of the two coils. The ends of each winding are brought out to either two top connecting filaments or two lower filaments. These are extremely low torque springs, their function being purely electrical except for the very small torque required to move the pointer off scale when the instrument is not energized.

The magnetic system is arranged with conventional circular pole pieces and a high coercive magnet. The soft iron core is mounted eccentric to the bore to produce a non-uniform magnetic field. It is quite obvious that the flux density will be greater at the upper end of pole pieces due to the shorter air gap and will be roughly proportional to the actual length of the

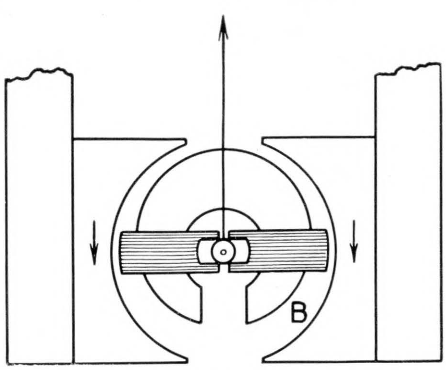



Figure 2—Diagram showing the Ratio Meter Moving Element, Core and Pole Piece Structure.

gap. The core is recessed at the center to accommodate the twin moving coil.

The operation of the assembled mechanism is dependent upon the balancing of two opposing torques resulting from the currents in the two windings. The torque, as in a direct current moving coil type instrument, is proportional to turns, current, and field strength. The current in one coil produces a torque opposing that of the second coil, both attempting to rotate into the weaker field. With one current larger than the other, the moving element will come to rest when the products of flux density and current balance for the two coils.

## Application of the Ratio Mechanism

The desired range of a rotor temperature indicator is generally 0-150C. This means the basic ratio from bottom scale to top scale must equal the ratio of field resistance between these temperatures. Basing this on the known resistance at 25C gives the following ratio:

$$\frac{R_{t_1}}{R_{t_o}} = \frac{R_t[1+.00385\ (t_1-t)]}{R_t[1+.00385\ (t_o-t)]}$$

and

$$\frac{R_{150}}{R_o} =$$

$$\frac{R_{25}[1+.00385\ (150-25)]}{R_{25}[1+.00385\ (0-25)]} = 1.64$$

By altering the eccentricity of the mechanism core in the pole pieces, the ratio meter can be adjusted for this exact ratio.

The two individual moving element coils are adjusted by means of series resistances to the nominal field voltage and to the millivolt drop of the field circuit ammeter shunt. This is shown in Figure 3. It is obvious that the 25C scale position must be based on the current and voltage with the 25C field resistance. End scale values of 0 and 150C will be correct by virtue of the over-all instrument ratio of 1.64, as previously explained. The voltage circuit series resistance consists of manganin wire, and the current circuit a combination of manganin and a negative temperature coefficient composition resistor to give comparable temperature coefficients to each circuit. The use of two isolated circuits eliminates the possibility of error that might occur if a common lead for the two circuits was used. Sensitivity may vary over a range of from about 5 to 15 milliamperes or more, depending upon the value of field voltage and current.

There are several practical considerations involved in specifying an instrument of this type and can be listed as follows:

1. Field Resistance. A value is generally supplied by the manufacturer or can be measured at a stabilized temperature by the voltmeter-ammeter method.
2. Brush Drop. The voltage drop in the brushes can be estimated by the manufacturer with sufficient accuracy based on the type of brush used. An assumption of two volts over the working range is usually satisfactory.
3. Ammeter Shunt Leads. It is sometimes necessary to run leads several hundred feet to the control room. A maximum lead allowance of 1.5 ohms is possible with the Model 918.
4. Ammeter Shunt. The shunt selection depends entirely upon the total possible variation in current. Generally a 100-millivolt drop shunt based on the maximum current is satisfactory.
5. Scale Range. A range of 0-150C is optimum for the ratio mechanism, and also adequately covers the temperature range of alternator rotors. Generators are rated for a maximum temperature rise of about 90C by the resistance method and with a cooling air temperature of 40C; this gives a maximum actual temperature of the order of 130C.

There is no question as to the desirability of rotor temperature measurements and this is reflected in the growing requirements for suitable devices in power plant specifications. While the more readily obtained stator or armature temperature serves as a guide to alternator heating, the knowledge of all factors affecting maximum permissible loading is desirable for best over-all power plant efficiency and utility. Varying duration of overloads, conditions of power factor, and ambient and coolant temperatures all have marked influences on both rotor and stator temperatures. In the power field, any additional safeguard against shutdown or damage to equipment is of vital importance. The use of indicating instruments to show the temperatures of both stator and rotor temperatures is a step in this direction.

E. N.—No. 81 —*L. W. Pignolet*

*Reference: American Standard Association, Standard Rotating Machinery, C50-1943.*

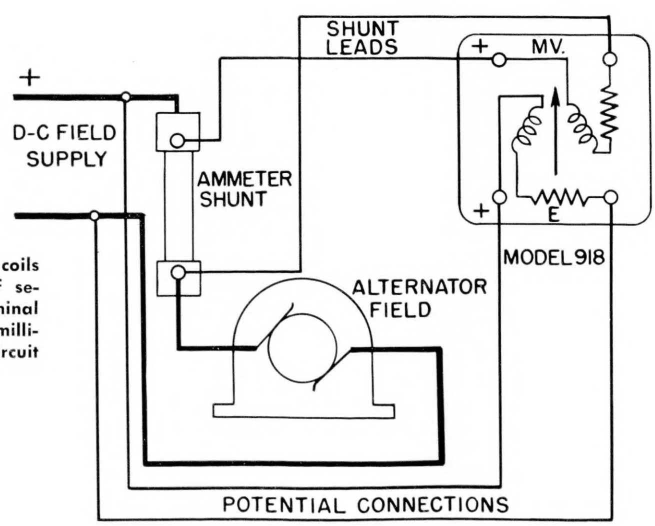


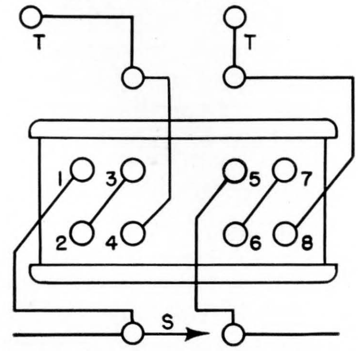

Figure 3—The two moving coils are adjusted by means of series resistances to the nominal field voltage and to the millivolt drop of the field circuit ammeter shunt.

# THE USE OF WESTON TYPE 30 VOLUME LEVEL INDICATORS ON 150 OHM LINES

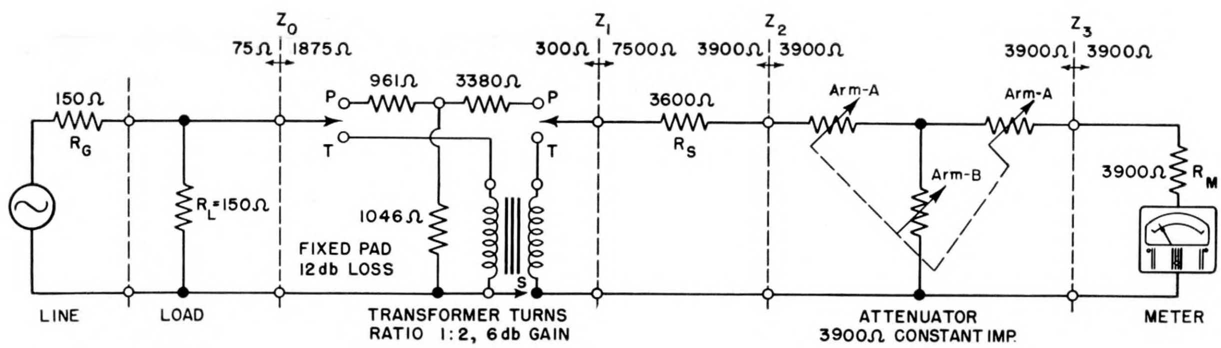
THE Weston Type 30 VU meter which has become so universally standard on broadcast systems of all kinds was originally designed for use on 600 ohm lines. Quite a number of 150 ohm lines are coming into use, however, and in most instances it is desirable to use a volume level indicator of some kind so that a study has been made of the possibility of using the VU meter as it now stands in such installations.

One arrangement which is now recommended is through the use of a transformer such as the General Radio Type 941A and as shown in the diagram below. The transformer may be used directly, with switches "T" closed, up to any level for which the transformer is suitable. Switch "S" may be open for a fully insulated system, or omitted entirely and this circuit closed if a grounded system is deemed satisfactory.

However, since any transformer has some power limitations, and since a 12 DB pad can be arranged to serve as a match between the line and load, the diagram shows an arrangement where the transformer is switched out of the circuit and a fixed pad switched in at the 12 DB or 16 VU point; the two line switches are transferred to "P," and switch "S" must be closed if left open previously. It is convenient to associate these transfer switches with the 12 DB position on the attenuator and it might be noted that it is possible to use the resistor elements for the first 11 steps over again for the higher steps shown in the tabulation of resistance values below. Connections to the Type 941A transformer are shown in the small diagram with reference to particular terminal numbers; these numbers should be used exactly as shown in order to maintain the high and low potential points.




Any other type of attenuator, such as a balanced H, may be used with the matching transformer ahead of the attenuator throughout, or transferred to a fixed pad at the higher levels as may best suit the requirement of any particular level and circuit.




| Attenuator Loss — DB | Level VU | Switch Position | Arm A Ohms | Arm B Ohms | Attenuator Loss — DB | Level VU | Switch Position | Arm A Ohms | Arm B Ohms |
|---|---|---|---|---|---|---|---|---|---|
| 0 | +4 | T, T. | 0 | Open | 15 | +19 | P, P. | 666.9 | 11070 |
| 1 | +5 | T, T. | 224.3 | 33801 | 16 | +20 | P, P. | 882.5 | 8177 |
| 2 | +6 | T, T. | 447.1 | 16788 | 17 | +21 | P, P. | 1093 | 6415 |
| 3 | +7 | T, T. | 666.9 | 11070 | 18 | +22 | P, P. | 1296 | 5221 |
| 4 | +8 | T, T. | 882.5 | 8177 | 19 | +23 | P, P. | 1492 | 4352 |
| 5 | +9 | T, T. | 1093 | 6415 | 20 | +24 | P, P. | 1679 | 3690 |
| 6 | +10 | T, T. | 1296 | 5221 | 21 | +25 | P, P. | 1857 | 3166 |
| 7 | +11 | T, T. | 1492 | 4352 | 22 | +26 | P, P. | 2026 | 2741 |
| 8 | +12 | T, T. | 1679 | 3690 | 23 | +27 | P, P. | 2185 | 2388 |
| 9 | +13 | T, T. | 1857 | 3166 | 24 | +28 | P, P. | 2334 | 2091 |
| 10 | +14 | T, T. | 2026 | 2741 | 25 | +29 | P, P. | 2473 | 1838 |
| 11 | +15 | T, T. | 2185 | 2388 | 26 | +30 | P, P. | 2603 | 1621 |
| 12 | +16 | P, P. | 0 | Open | 27 | +31 | P, P. | 2722 | 1432 |
| 13 | +17 | P, P. | 224.3 | 33801 | 28 | +32 | P, P. | 2833 | 1268 |
| 14 | +18 | P, P. | 447.1 | 16788 | | | | | |



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