Weston ENGINEERING NOTES

VOLUME 2 | AUGUST 1947 | NUMBER 4

In This Issue

John Parker, Editor
E. W. Hoyer, Technical Editor

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

A NEW HUMIDITY INDICATOR

RELATIVE Humidity, expressed in the form of a percentage, is the ratio of the actual quantity of water vapor in the air to the quantity that would saturate it under its actual conditions as to pressure and temperature. Complete saturation of the air is represented hygrometrically by 100 percent and partial saturation by a lesser percentage.

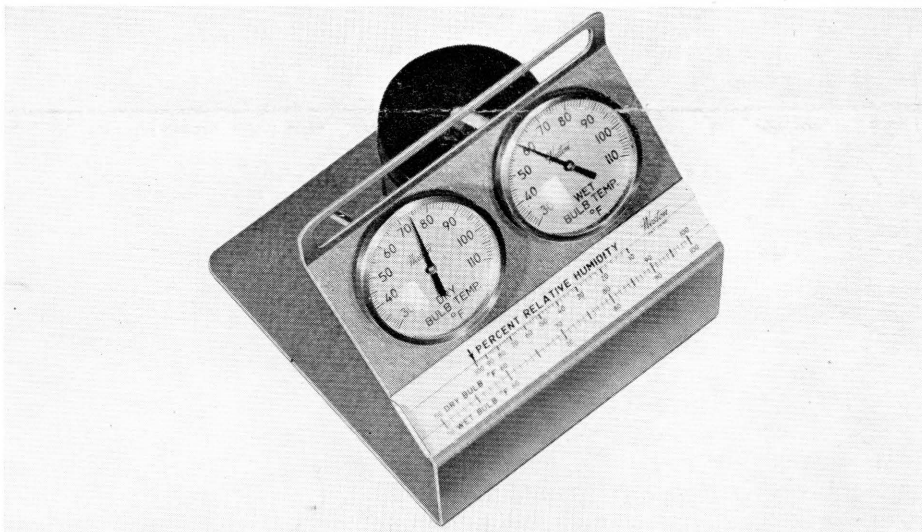


Figure 1—The New Weston All-Metal Humidity Indicator.

There are many methods of determining relative humidity. One method depends on the change in length of various substances such as hair, wood, plastic, and paper, due to the absorption of water vapor directly from the air in some proportion to the relative humidity. This method of relative humidity (hereafter referred to simply as R.H.) measurement is empirical only and the devices should be calibrated by an absolute method. These hygroscopic types of R.H. indicators are fairly satisfactory when used to indicate relatively constant values of R.H., but when subjected to rapid changes of the order of 20 percent to 30 percent R.H. or greater they exhibit a considerable time lag and small but cumulative changes in calibration. While the better types are guaranteed to be within ±3 percent R.H. in normal conditions of humidity, in actual use they are rarely this close and a group of different types and makes, tested under controlled conditions, may vary as much as 20 percent R.H.

Another common type of relative humidity indicator, and the more accurate of the two, is known as the Wet and Dry Bulb Hygrometer or Wet and Dry Bulb Humidity Indicator. Technically, the use of wet and dry bulb thermometers is considered as a semi-absolute method of determining R.H., since to obtain the percent R.H. it is necessary to resort to semi-empirical formula or to charts, tables, etc., derived from the formula.

Principle of Operation

The principle of the wet and dry bulb determination of percent R.H. is as follows: The dry bulb gives the free air temperature. The wet bulb is surrounded by a wick saturated with water. The evaporation of water from the wick into the air absorbs heat from the wet bulb, due to the change in state of the water as it evaporates from a liquid to a vapor. The absorption of the heat in the process of evaporation causes the water in the wick to drop in temperature, depending on the rate at which evaporation is progressing which in turn depends on the amount of water vapor already in the air. The smaller the proportion of moisture in the air, the greater will be the rate of evaporation and the lower the wet bulb temperature.

In still air, a condition which rarely exists, the vaporized water just leaving the wet bulb wick tends to form an invisible cloud surrounding the wick and inhibiting further free evaporation. This "clouding" adjacent to the wet bulb can cause an error of some few percent, since a high reading wet bulb causes an error in the high direction in the resulting determination of the R.H.

In actual practice, however, the air is always in motion though it may not be perceptible to casual observation. If the air is not at rest and its motion is uncontrolled, the wet bulb temperature will fluctuate slightly, as evaporation accelerates and slows down with variations in the blanketing cloud surrounding the wet bulb wick. However, if the air is forced past the wet bulb at a velocity sufficient to dispel the cloud and to bring evaporation to the maximum, the wet bulb will give a steady indication of the minimum temperature. A controlled air velocity may be obtained by a fan or blower, or by fanning by hand.

The wick covering the wet bulb is preferably of thin, closely woven unbleached cotton. The end should dip into a reservoir of water.

Basically, therefore, we may consider that a good humidity indicator may be made of a pair of good thermometers, one carrying a wetted wick surrounding the bulb, and psychrometric tables or their equivalent. Various attempts to simplify the device to make it easier to handle or read, or to better circulate the air or eliminate the need for a separate set of tables or charts, have naturally brought forth many different arrangements.

Features

The new Weston all-metal Humidity Indicator shown in Figure 1 is of the wet and dry bulb type, incorporating the following novel features:

Thermometers are all metal, range 30° F to 110° F, each line representing 1° Fahrenheit.

Wet Bulb has wick arranged to cover the thermal element in a self-supporting manner. No tieing, etc.

Reservoir is a heavy-walled, large-capacity jar. Entire jar slides out easily, is large mouthed for easy cleaning, and is covered to reduce undue evaporation.

Wick (on Wet Bulb) may be removed or renewed without removing jar, and jar may be removed without disturbing wick.

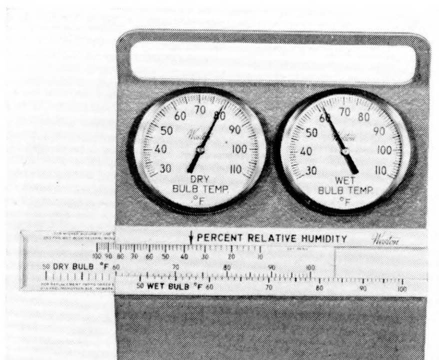


Figure 2—Front view of Humidity Indicator illustrating use of the slide rule calculator.

Slide Rule Calculator is a simplified type of slide rule fastened to stand directly under thermometer scales. The slide can be moved to the left only, thus preventing incorrect manipulation.

Supporting Stand is clean, open, and sturdy. It is well balanced and can be swung if desired to create air movement.

The slide rule indicates relative humidity from 10 percent to 100 percent. Figure 2 shows the device in operation. As indicated, the dry bulb temperature is 79° F and the wet bulb, 62° F. By positioning the slide properly with 79° F directly over 62° F, the percent R.H. arrow indicates 37 percent R.H.

When in use the wick must be wet when the reading is taken. The level of water, or the quality, makes no noticeable difference in the indication when the wick is new. Since dirt and minerals are carried up the wick along with the water, and since only the water evaporates from the wick, all other substances are left on the wick and they gradually fill or load the wick causing capillary action to decrease until finally the wick becomes stiff and totally dry. During this period of accumulation of foreign substances in the wick, the wet bulb readings will become progressively higher until finally the wet bulb temperature approaches that of the dry bulb. It is therefore good practice to use distilled water and minimize troubles due to wick stoppage. Very roughly, the wick should be changed every three months if distilled water is used, every two months where soft tap water is used and every month in places where the water used is hard tap water or bottled mineral water.

Other than changing the wick and replenishing the water, no servicing or maintenance or replacements are necessary, barring serious accidents and in that eventuality any part may be obtained from stock and replaced by even unskilled persons.

The inherent accuracy of determinations is approximately as shown below:

Thermometers.—Within ± ½° F near center of scale (around 65 to 75° F), tapering to within ± 1° F at 30° F and 110° F which are end scale values.

Slide Rule.—Within ± ½ of 1 percent R.H. when dry bulb thermometer reads near center of scale, tapering to within ± 1 percent R.H. for any temperature and value of R.H. down to 40 percent; to within ± 2 percent R.H. for any value down to 20 percent R.H., and within ± 4 percent for any value down to 10 percent R.H. *Over-all Accuracy in Percent R.H.* —Under extremes in temperature and at the lowest humidities in the driest atmospheres such as rarely exist in inhabited spaces, the accuracy is within ± 4 percent R.H.; under normal use in ordinary conditions of temperature and moisture the accuracy is within ± 1 percent R.H., which is considered quite satisfactory for ordinary industrial and laboratory uses.

W. E. N.—No. 30 —*Anthony H. Lamb*

ABSOLUTE UNITS REPLACE INTERNATIONAL UNITS NEXT YEAR

THE National Bureau of Standards has recently announced that the proposed change from international to absolute values of the electrical and photometric units will become effective January 1, 1948. The change was planned for 1940, but the outbreak of war in 1939 prevented execution of these plans. In October 1946, the International Committee on Weights and Measures met again and chose January 1, 1948 as the date for effecting the change to the new units.

The electrical units are based upon, and are intended to be exact multiples of the units of the centimeter-gram-second electromagnetic system, but because of the early difficulty in making the necessary fundamental measurements, this desirable result did not become possible until recent years, after the development of more precise methods.

International Units

In the year 1893, to provide for the practical use of these units, the International Electrical Congress at Chicago defined the ampere, the ohm, and the volt in terms of three physical standards, namely, the silver voltameter, a specified column of mercury, and the Clark Standard Cell, respectively.

It was later found that the units so defined were not sufficiently close to the absolute values, nor did they agree among themselves. In 1911, therefore, the International Technical Committee decided to retain the values of the ampere and ohm as defined by the silver voltameter and mercury ohm respectively and change the value of the volt to make it conform to the ampere and ohm according to Ohm's Law. Furthermore, the new value of the volt was defined as a definite fraction of the electromotive force of the Weston Normal Cell, which was found to be far superior to the Clark Cell in temperature coefficient, constancy and reproducibility, and the value of 1.018300 volts was assigned by definition as its emf. These units as defined are known as International Units.

Although, as stated previously, the original bases for the international ampere and the international ohm, as of 1911, were the silver voltameter and mercury ohm respectively, the ohm has actually been maintained at the Bureau of Standards by means of a number of manganin resistors, and the ampere derived by means of these resistors, and the Weston Normal Cell, in accordance with Ohm's Law.

It seems fitting here to note that electrical science and industry are greatly indebted to Dr. Edward Weston for his work in developing both the Weston cell, and the negligible temperature coefficient copper manganese alloy later known as manganin; by which the standard volt and standard ohm have been maintained with such unchanging precision throughout the years, and will continue to be so maintained in the future.

Absolute Units

In recent years, very precise methods have been developed for determining the values of the units directly from the fundamental mechanical standards of length, mass, and time, and when so developed, they are known as absolute units. These new units will become legal after January 1st, 1948.

To provide for the change at that time, the values of the present international units, used since 1911, have been measured at the National Laboratories of the various countries of the world in terms of the absolute units, and the most probable values adopted by international agreement.

The Bureau of Standards will continue to maintain the standard ohm by means of manganin wire resistors, and the value of the volt by the Weston Normal Cell as before, but these will be checked from time to time in terms of the fundamental mechanical standards of length, mass and time.

When stating values of the electrical units, where it is important to know which unit is referred to, the International Committee on Weights and Measures recommends that the name of the unit be preceded by the abbreviations abs or int, depending upon whether the absolute or international values are intended.

The following is a list of the values of the international units (U. S.) in terms of the absolute values, as agreed upon by the International Committee on Weights and Measures, and adopted by the National Bureau of Standards.

1 int. ohm	=1.000495 abs. ohms
1 int. volt	=1.000330 abs. volts
1 int. ampere	=0.999835 abs. ampere
1 int. coulomb	=0.999835 abs. coulomb
1 int. henry	=1.000495 abs. henrys
1 int. farad	=0.999505 abs. farad
1 int. watt	=1.000165 abs. watts
1 int. joule	=1.000165 abs. joules

Practical Effect of the Changes in Electrical Units

Indicating Instruments: The values given in the table show that the international volt differs from the absolute volt by about 1/30 of 1%, and the international ampere and watt differ from their respective absolute values by about 1/60 of 1%. These changes are so small relatively, that they need not be considered in the use of electrical indicating instruments, including the laboratory standard types having an accuracy of 0.1%.

Resistors: As resistance can be measured and compared to a very high precision, it may be found desirable to correct or at least allow for the changes in the value of the ohm, which amounts to about 1/20 of 1%.

Weston Standard Cells: The Weston Normal Cell, also known as the saturated form of Weston Cadmium Cell because its electrolyte is saturated at all room temperatures, has an electromotive force of 1.018300 international volts or 1.018636 absolute volts at 20C. This cell is used by national and other important standardizing laboratories because of its constancy and exact reproducibility when constructed from pure materials. It has, however, a small but appreciable temperature coefficient and in use its temperature must be maintained constant at a known value. For this reason it is not well adapted for commercial laboratory use.

The Weston Standard Cell, known also as the unsaturated form of Weston Cadmium Cell because its electrolyte is unsaturated at ambient temperatures above 4C, has a nominal electromotive force of about 1.018750 international volts or 1.019088 absolute volts. The value of the electromotive force of this form of cell is standardized by comparison with the Weston Normal Cell, either by the National Bureau of Standards, or by other standardizing laboratories equipped for this kind of work. Its temperature coefficient is practically negligible and for this reason it is the form of standard cell best adapted for commercial laboratory use.

Photometric Unit

The value of the International Candle Power has been maintained by a number of carbon filament incandescent lamps kept at the National Bureau of Standards for that purpose, which have a color temperature of about 2100K.

The new value of the candle, to be designated "new candle," is derived from the brightness of a black body radiating at the temperature of freezing platinum, which is 2046K. Careful measurements have shown that the brightness of such a radiator is 58.9 international candles per sq cm. By international agreement this brightness is assigned a value of 60 "new candles" per sq cm, in order to give a round number, and not to differ greatly from the present international value.

At a color temperature of about 2100K, therefore, the "new candle" will be about 1.9% smaller than the international candle. As a result of the effect upon the eye of color temperature, however, the luminous intensity of vacuum incandescent lamps, operating at about 2500K will have the same value for all practical purposes, whether expressed in the "new" or the international unit.

For gas-filled lamps operating at 3000K and higher the "new candle" will be effectively somewhat larger than the international candle, not exceeding about 1%. This shows that for practical purposes there will be no material change in the candle power ratings of present-day illuminants.

E. N.—No. 31 —*W. N. Goodwin, Jr.*

ORGANIZING AN ELECTRICAL INSTRUMENT STANDARDIZING LABORATORY*

ELECTRICAL STANDARDS FOR DIRECT CURRENT INSTRUMENTS—POTENTIOMETER AND STANDARD CELL

BASIC electrical standards are maintained for reference by recognized national laboratories such as our National Bureau of Standards and the British National Physical Laboratory. The National Bureau of Standards serves industry and science by comparing industrial standards when submitted to them with the basic electrical standards in their possession. The National Bureau of Standards continually check and recheck their basic standards to maintain their accuracy in order that they may be relied upon as precise standards.

Since 1911 the International units have been used, but as of January 1, 1948, revised values of the volt, the ohm, and other electrical quantities will be made standard, these being the so-called absolute units. The changes are minor, but are indicated throughout this discussion where pertinent. The changes are being made to bring the electrical values into agreement with the absolute values of the fundamental mechanical units in the centimeter-gram-second system.

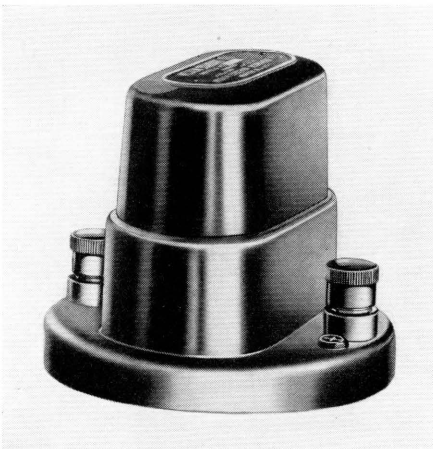


Figure 1—The Weston Model 4 Standard Cell.

Voltage Standard

The standard volt is maintained as the average of a number of Weston Saturated Cadmium Cells, sometimes known as the Weston Normal Cell. The average value of this bank of cells is defined as 1.018300 international volts (1.018636 absolute volts, an increase of 1/30 of 1%).

The Weston Standard Cadmium Cells, both the saturated and unsaturated types, were invented and developed by Dr. Edward Weston prior to 1891. The unsaturated type shown in Figure 1 is the most widely used form. This type is practically free from temperature influence, and when made with chemicals of the highest purity it is stable over long periods of time.

Standard Cells, like all precision measuring instruments, should be used with great care in order to

This is the second of a series of articles on this subject. The previous article appeared in the June 1947 issue of ENGINEERING NOTES.

prevent even slight damage or change. A good laboratory should have a bank of at least three standard cells so that they may be used for inter-comparison and any damaged cell located. Such a bank of cells also permits one of them to be used on the potentiometer, one to be held in reserve and one of them to be sent to a reputable standardizing laboratory or to the Bureau of Standards for re-standardization. The schedule shown in Table I may well be followed in maintaining the group of standard cells. Note that one cell is sent to the Bureau every four months; that every cell is re-standardized yearly. One cell is kept in use, one is kept as a check cell, and one presumably has been sent to the Bureau. On the dates given the cell in use is sent to the Bureau for its certification, the check cell is put in use, and the latest cell from the Bureau becomes the check cell. As soon as the cell is returned from the Bureau with a new value (it may have changed a few microvolts or parts per million), the check cell and the cell in use are compared with it on a potentiometer and new values assigned if deemed advisable.

TABLE I
SCHEDULE FOR STANDARDIZING THREE STANDARD CELLS

Date	*Cell A*	*Cell B*	*Cell C*
Jan. 15, '47	Send to Bu. of Stds	In use	Check cell
May 15, '47	Check cell	Send to Bu. of Stds.	In use
Sept. 15, '47	In use	Check cell	Send to Bu. of Stds.
Jan. 15, '48	Send to Bu. of Stds.	In use	Check cell

The Weston Standard Cell has an internal resistance of about 100 to 200 ohms. In normal use no current is drawn from the cell when the galvanometer in its circuit is balanced but it is permissible to draw as much as 50 microamperes from the cell without damaging it. Greater currents may result in polarization and the cell may be affected permanently although not necessarily damaged beyond use. In general, atmospheric heat and cold do not permanently affect standard cells, as they are shipped within the United States throughout the year without any special precautions. It is recommended, however, that the standard cells not be subjected deliberately to extreme temperatures.

The voltage of a standard cell may be temporarily affected if one of the legs of the "H" tube has a temperature different from the other leg. Therefore, it is advisable not to permit unequal temperatures on the case of the standard cell such as might be caused by setting the cell in the sun or having a lamp or a soldering iron too close to the cell. When a standard cell is shipped or moved around the laboratory without due care, the elements may be shaken up so that the voltage is unsteady for a short period. If the cell is not moved carefully in an upright position it should be allowed to stand in one place and settle for 24 to 48 hours before making a precision comparison. Standard cells may show a voltage drift over a period of time which in general does not exceed 50 microvolts per year. This drift in addition to wear from use makes it necessary to standardize the cells periodically.

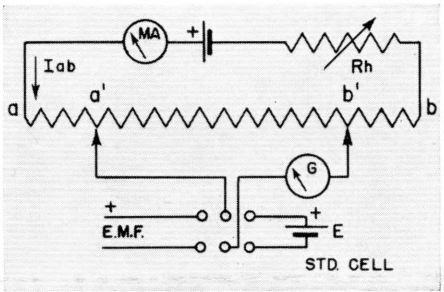


Figure 2—Diagram of a simplified potentiometer circuit.

Resistance Standard

The standard ohm is maintained as the average of a group of one-ohm manganin resistors that have shown a change of less than one part per million from the mean of the group over many years. These resistance values were derived from the mercury ohm (14.4521 grams of mercury, of uniform cross section, about one square millimeter, of a length of 106.3 centimeters and at 0° C). As of January 1, 1948, the absolute ohm will be legal, and will be 0.999505 international ohm as now used. One international ohm equals 1.00495 absolute ohms.

Manganin is an alloy of copper, nickel and manganese which was invented by Dr. Edward Weston. It has, when properly treated, a very stable resistance and its thermal emf against copper is negligible when properly used. It is ideally suited for standards of resistance because of its form and electrical characteristics.

Potentiometers

The potentiometer is a means of establishing known potentials by comparison in order to use the single potential value of the standard cell. A potentiometer consists of a series of known resistances or a calibrated slide wire. See Figure 2. One portion of these resistances is adjusted so that the potential difference across it is the same as the known potential of a Weston Standard Cell. Then, by proportion, the potential across all other portions of the group of resistors is known. Resistance values and adjustments

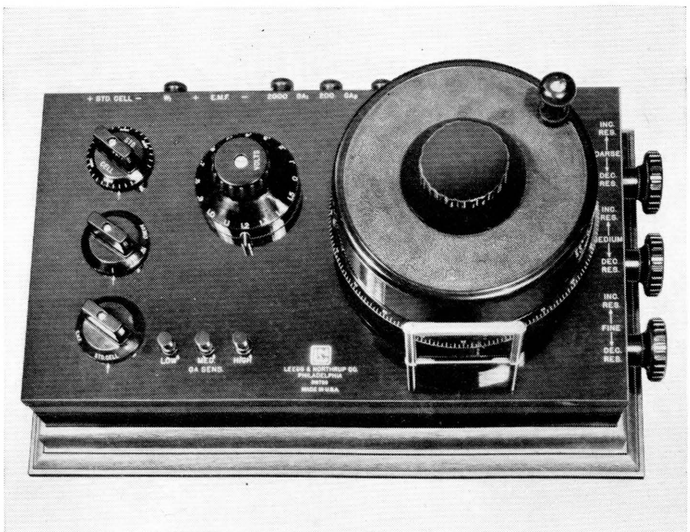


Figure 3—Leeds and Northrup Type K-2 Precision Potentiometer.

are made so that even values of potential can be read directly. Figure 3 shows a Leeds and Northrup Type K-2 precision potentiometer.

Figure 4—Leeds and Northrup Model 7 Brooks Deflection Potentiometer.

When balanced, potentiometers do not draw any current from the measured circuit or the standard cell—the only current is drawn from the auxiliary battery. In general, the galvanometer does not carry any current when the circuit is balanced. An exception, however, is the Brooks deflection potentiometer, shown in Figure 4, which is an ingenious measuring instrument using a network of resistances so that the major part of the potential is balanced and only a minor part is indicated on the galvanometer, which is an accurately calibrated measuring instrument. This deflection potentiometer thus has some of the operating advantages of an indicating instrument although it has greater precision. Fundamentally, however, it is not as flexible as the null-type potentiometers, as it has a basic range of 150 millivolts as compared with the multi-range type K-2 potentiometer wherein self-contained ranges of 1.6, 0.16 and 0.016 volts are available.

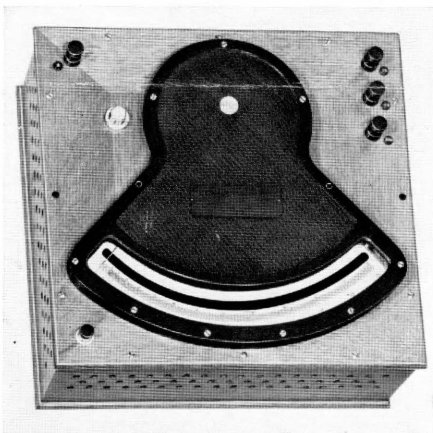


Figure 5—The Weston Model 326 Voltmeter.

A volt box is used with the potentiometer for measuring potentials which are higher than the fundamental range of the potentiometer. It consists of a number of accurately standardized resistors connected in series. The potentiometer measuring circuit is connected across one of these resistors and measures its potential drop. The known ratio of the resistors in the volt box is then used as a multiplying factor to obtain the potential applied to the volt box. It is pointed out that the volt box does draw current from the circuit.

The electrical standards of current and potential discussed above are purely direct current standards. To use their values on alternating current it is necessary to resort to transfer instruments. Such instruments are those which are equally accurate on direct current or alternating current such as electrodynamometer instruments and thermocouple instruments. These transfer instruments, see Figure 5, may be accurately standardized against the d-c standards and then used with equal accuracy for measuring alternating current. Resistances can be made for use on either direct current or alternating current up to some definite frequency by designing them so that the values of inductance, capacity and skin-effect are negligible in their effect when used on alternating current.

E. N.—No. 32 —*J. B. Dowden*

METHODS FOR DETERMINATION OF RESISTANCE OF POWER SOURCES

PERIODICALLY it becomes necessary to obtain the value of the effective resistance of a power source, be it a battery, a generator with its associated line, a high-frequency oscillator, or an audio-frequency system feeding a load. A number of methods are available for making such measurement from the classical Mance's* method for batteries to the simpler so-called voltage-doubling methods. Perhaps the latter can best be called a resistance-doubling method, and is very generally applicable. The method may be either at constant current or constant voltage, depending upon the problem at hand.

The power source may be considered as a fixed voltage, E, in series with a resistance, R_s, whose value is to be determined. Connect a decade box, R, and a suitable milliammeter in series with the source as shown in Figure 1. The decade box is then adjusted to a value, R_1, so that a substantial indication is obtained on the milliammeter. Then readjust this resistance to a value, R_2, to give a second current reading of exactly

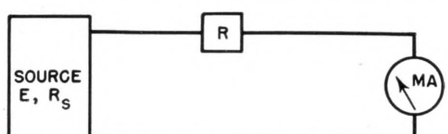


Figure 1—Circuit for determining the resistance of a power source by resistance-doubling method.

*ABSOLUTE MEASUREMENTS IN ELECTRICITY AND MAGNETISM, Andrew Gray, Second Edition, MacMillan & Co., Ltd., pp. 376-379.

one-half the previous reading. Then the source resistance, $R_s = R_2 - 2R_1$. Actually the resistance of the milliammeter is a part of R_1 and R_2, but may be neglected if small in comparison as is usually the case. If the circuit constants and parameters are such that R_1 can be zero and the meter resistance is negligible, obviously $R_s = R_2$. Where the source resistance is low and short circuit currents cannot be drawn, R_1 values will be found to be necessary but should be maintained at the lowest possible value and also, in these cases, it may be advisable to consider the instrument resistance R_m, in which case $R_s = R_2 - 2R_1 - R_m$. The method is rigorous provided that the circuit constants are linear and, further, for a-c circuits, provided that the impedance does not differ from the resistance by an appreciable amount.

Where non-linear circuits are used, as in rectifier networks, instead of halving the current the voltage can be doubled to maintain the current in the second condition to the same value, whereupon the same equations apply. This arrangement is suitable where an audio-frequency power source is available with an attenuation system or some other voltage control and will give directly the source resistance which can usually be interpreted as impedance at audio frequencies.

The same general method is used for taking the resistance of a rectifier meter such as a VU meter. Figure 2 shows a variable power

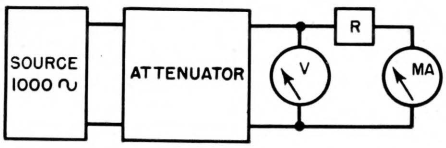


Figure 2—Voltage-doubling method for determining the resistance of non-linear circuits.

source, usually 1000 cycles, with voltage control and an accurate voltmeter, V. With a decade box, R, set initially at zero, the rectifier-type instrument, M, is adjusted to read the point at which the equivalent resistance value is to be taken. The voltage is then doubled and the decade box adjusted to give the same reading on the instrument. By definition, then, the resistance of the instrument including its non-linear rectifier is equal to the resistance of the decade box. Through the use of this method the effective resistance of the instrument can be taken at any scale point.

It must be noted that a single figure representing the resistance of a non-linear resistive element is an anomaly and the single value of resistance can be given only if suitably defined. In the case of rectifier-type instruments the definition is simply that the resistance value be taken as described, using the voltage-doubling method. In the practical sense, these resistance values are quite useful in analyzing rectifier meters and, in general, the values obtained by this method probably represent a preferred mean value for any type of non-linear resistive network.

E. N.—No. 33 —*John H. Miller*

THE NEW WESTON ENGINEERING-ADMINISTRATION BUILDING

SINCE June of last year when the project was announced, we have been asked many questions about our new headquarters building. Now that it is in use, it seems fitting that the special details of the laboratory and engineering facilities be described and placed on the record.

The engineering department of the Weston organization has been quite crowded in recent years. New materials, new methods, electronic circuits, and fundamental research have all caused an expansion to the point where space became the most limiting factor. Perhaps we should say space and facilities since space alone is of limited utility unless provided with the necessary facilities, such as electrical energy in its many forms, as well as instrumentation.

Over the years a philosophy of the requirements for an ideal engineering structure has developed and these viewpoints have, to some degree, been clarified and sometimes modified by new structures aimed to solve similar problems. For example, the new Murray Hill buildings of the Bell Telephone Laboratories have caused much envy among our engineers.

In the fall of 1944 a detailed study was instituted as to what would be an ideal structure for the purpose and committees of engineers were formed to review in greater detail what had been accomplished by other organizations. Study trips were made to the laboratories of the International Business Machines Corporation at Binghamton, New York, the Bell Telephone Laboratories at Murray Hill, New Jersey, the Engineering Laboratory of the Public Service Electric and Gas Company in Newark, the Princeton Laboratories of the Radio Corporation of America, and the new laboratory building of the Federal Telephone and Radio Corporation. Gradually our viewpoint became clarified and a few important viewpoints emerged.

(1) Complete flexibility is a basic requirement. It is utterly impossible to decide when a building is erected that a certain group will require a fixed amount of space and fixed facilities for all time. We have seen group assignments, as in the measurement of light, grow from practically nothing to an important segment of our engineering group.

Steel partitioning is available today in standardized form which allows for the changing of office and laboratory arrangements in a relatively few hours. Such partitioning seems to be the answer to the requirement for flexibility.

(2) Services such as various kinds of electrical energy, as well as gas, air, water, steam and drainage facilities may be required in any area; the answer appears to be to place these facilities, or space for them, in a series of ducts along the wall under the windows in a so-called wall chase. Telephone wires and, indeed, steam radiators can

also be placed in the wall chase. The general idea is to have a place to run wires or pipes from any location to any other location with a minimum of effort. For example, one laboratory may have a standard frequency oscillator, the output of which is needed for a few days in another area. It is very simple to feed this on a pair of wires back to a switchboard in the main laboratory and cross-connect on a plug board or even to run a special twisted pair from one space to the other, the wires being out of the way and, indeed, in a trough for just this sort of thing.

(3) If standard partitioning and services are arranged, a degree of uniformity is necessary in the building proper and a so-called module was selected of 6 feet between window centers which would be continued completely around all areas. The 6-foot module consists of a 3-foot window and a 3-foot wall space. Office and laboratory partitions can then be run to a wall always within 1½ feet of any desired location and without splitting a window. This arrangement also allows for wall mounting of charts, bookcases, or even a wall galvanometer about as required.

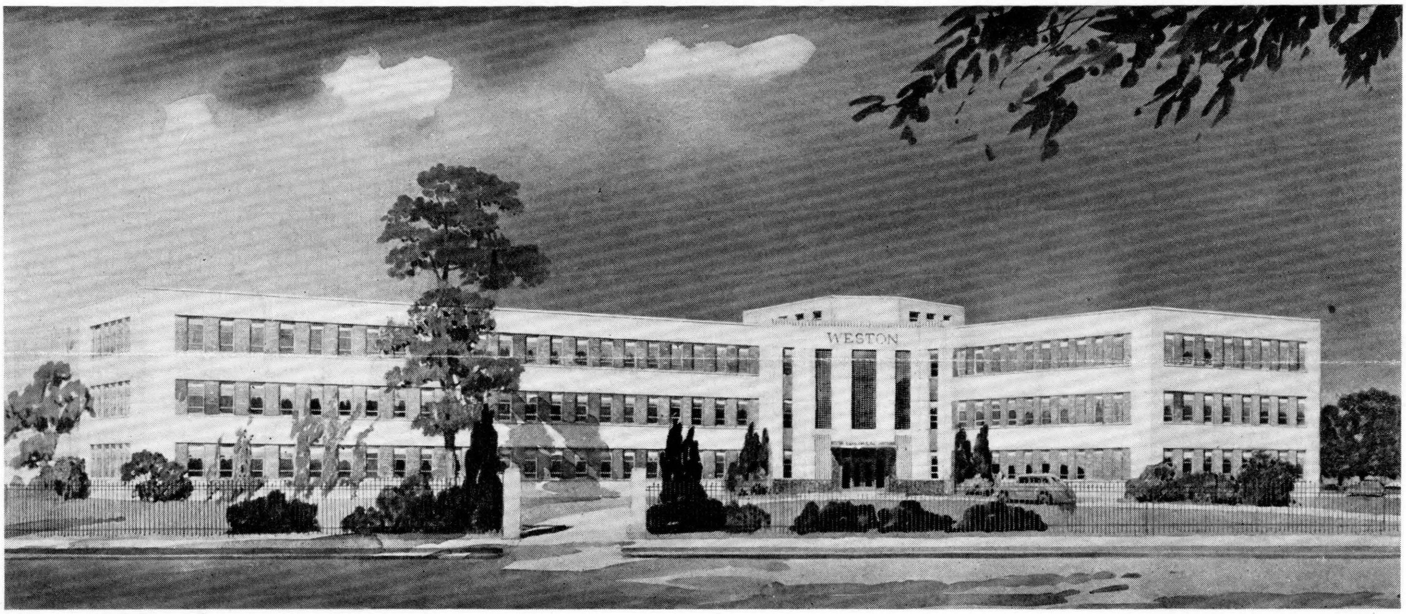
(4) To bring services to a desk or a laboratory bench anywhere in the area, underfloor ducts would be required every 6 feet from which the facilities could conveniently be brought to the surface as required.

With these thoughts in mind and Management approval for further consideration of a new building, along with a Management request for new and larger space for an executive area, a commercial division and a factory planning division, it seemed time to make some real plans.

The Walter Kidde Construction Company was retained for the purpose. Since considerable land was available adjacent to the present buildings, a rather specific study was instituted leading to the layout of the new building. It is T-shaped, set at an angle to the street and in line with the older structures. The main entrance was located in the center to give relatively short runs to each of the three wings. A building with long rows of single windows, uniformly spaced, can be monotonous and unattractive. The solution was to use two tones of brick to obtain long horizontal color bands, tied in with vertical lines in the limestone trim and glass brick around the entrance. The long side on the south is also broken up by vertical bands of darker brick near its center.

To maintain the 6-foot module, it was decided that we should have a clear 24-foot space on one side of each wing with an 18-foot space on the other side; the 18-foot space could be on the side with a hallway 6 feet wide and we would then have a uniform structure with 24 feet clear each side of the center columns. With center columns 18 inches square the wide, clear space then becomes 49½ feet and the structure was designed of reinforced concrete on this basis.

The layout of the concrete work was interesting because the requirement for the wall chase to some degree eliminated the possibility of wall columns coming into the room. Columns were worked out of full width between the windows and while this arrangement required more material than a square column, it was economical in securing the result wanted. Floors and roof are concrete slab cast in place. The building was erected with no basement except for a small area in the center for a heating plant, transformer vault, and facilities of this sort. In constructing the building this boiler room area was thoroughly water-proofed since some water flow was encountered in the excavation. The boiler room is entered from outside staircases on each side of the building, thus isolating it from the building proper.



Further descriptive data on such important items as the distribution facilities in the wall chase, the standardized laboratory benches, the use of metal partitions, the bus duct and the like will be published in these pages in the near future.

E. N.—No. 34 —*John H. Miller*