Weston ENGINEERING NOTES

VOLUME 2 JUNE 1947 NUMBER 3

THE WESTON PHOTOGRAPHIC ANALYZER

THE Weston Model 877 Photographic Analyzer is an electrical device whereby transmission density and illumination can be read directly. By means of the analyzer, an exposure guide and a number of accessories, photographic equipment and technique can be accurately checked. To the black-and-white photographer and especially the color photographer, it offers a scientific means of checking each step leading to the finished print. Definite tones and tone ranges can be predicted with accuracy. The characteristics of photographic films and papers can be determined in the photographer's own dark room and in terms of his own equipment and technique. Diligent use of the analyzer will give the photographer an entirely new conception of factors which are now used rather thoughtlessly. Instead of using such terms as "flat negative," or "a contrasty negative," the negative can be numerically rated as "a negative density range of 0.6," or "a negative density range of 1.5." Photographic papers can be similarly rated and the proper paper can thus be readily selected to match the negative.

Color photography requires precise control in all of the steps leading to the ultimate color print. By means of the analyzer the effective filter factors and film speeds can be determined, time-gamma curves drawn, color-separation negatives balanced, and so on.

Figure 1—The Weston Model 877 Photographic Analyzer.

In This Issue

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

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Newark 5, N. J., U. S. A.

Description

The analyzer shown in Figure 1 consists essentially of a barrier layer type of photoelectric cell associated with a sensitive electrical measuring instrument, an optical system comprising two condenser lenses, a heat filter, a light source whose intensity can be varied by means of a rheostat and an aperture plate to restrict the area of the photographic negative being measured, toggle switches to operate the lamp in the optical system and the lamp which illuminates the scale in the electrical indicating instrument. All of the above are mounted within a case which is 12¼ x 8½ x 4 inches.

The top panel has been designed so that the toggle switches, rheostat knob and meter are recessed, thus leaving a flat surface on which film and glass plates can be placed, minimizing the danger of scratching or breaking. The case is made of pressed steel which is provided with a perforated bottom plate, side and front louvres and a space between the top of the steel case and bakelite panel in order to allow sufficient flow of air to dissipate the heat from the lamps and rheostat.

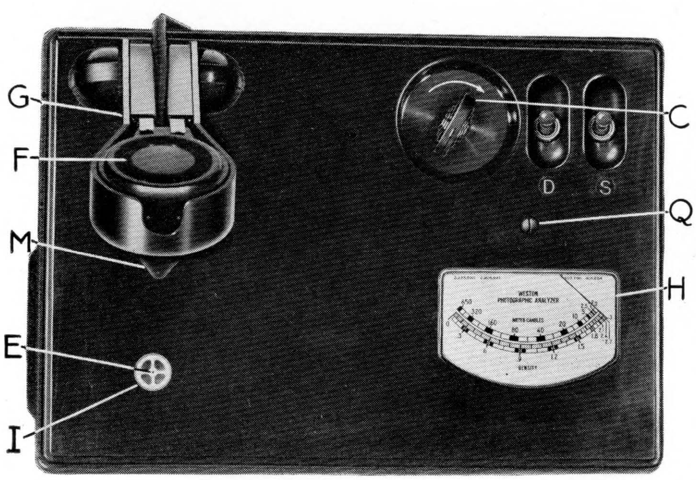


Figure 2—Top view of Analyzer showing panel arrangement. Recessing of toggle switches and rheostat knob provides clear, flat surface to minimize danger of scratching negatives and plates.

Figure 2 shows the top view of the analyzer. In this figure, "G" is a movable arm which contains a removable photoelectric cell "F" and an integrating cone "M." "I" is an aperture plate which contains an aperture "E." "C" is a rheostat knob, "D" and "S" are toggle switches, "Q" is a zero corrector screw for the meter "H."

The arm "G" which contains the removable photoelectric cell "F" and the integrating cone "M" is mounted on trunnions having sufficient friction so that the arm will remain where placed except for the last one-half inch or so above the aperture plate "I." At this point, on the downward motion, a vertical pin on the trunnion end of the arm engages with a horizontal pin on the arm which holds the diffusing glass "O" shown in Figure 3 and this causes the diffusing glass to retreat from the optical system as will be explained later. As the diffusing glass retreats, it is opposed by a helical tension spring so that when the arm "G" is manually released the tension spring automatically lifts the arm free of the aperture plate. This is a convenient feature when measuring the density of negatives as it facilitates examining the negative without visual obstruction.

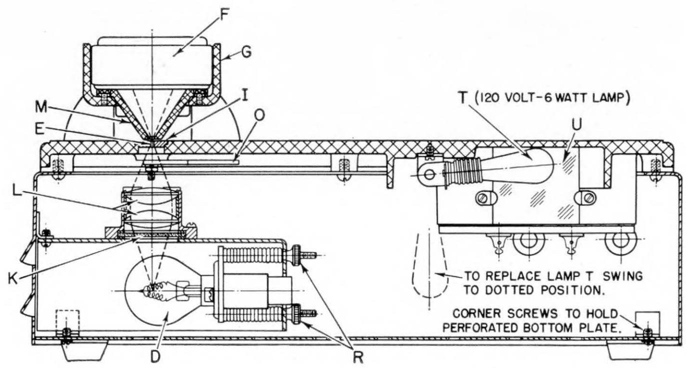


Figure 3 — Cross-sectional view of Analyzer showing arrangement of optical system.

Transmission Densitometer

The various components of the transmission densitometer are shown in Figure 3 and the operation is as follows: Light from the lamp "D" passes upward through the heat-absorbing glass "K," the double condensers "L," diffusing glass "O," and emerges as a cone-shaped beam from aperture "E" in the viewing plate "I." When the outside arm "G" is lowered to take a density reading, the diffusing glass "O" automatically slides out of place, and the light beam from aperture "E" passes through a corresponding aperture on cone "M" and impinges on the photoelectric cell "F." The diffusing glass "O" is used to cut down and diffuse the light when examining and placing the photographic negative over the aperture "E" prior to measuring the density.

The cone "M" is really an integrating cone, as it is finished on the inside in white so as to gather and integrate all of the light transmitted through the negative being measured. By reflections and re-reflections all of the light has an effect on the photoelectric cell. The diameter of the aperture "E" is one millimeter and the normal light flux is about one-half lumen. The light intensity is about 60,000 foot-candles or about 6 times the illumination produced by mean noon sun in summertime. It is because of this high illumination that a heat filter must be used to protect the film from being scorched when density measurements are made and why a diffusing glass must be used when examining negatives.

Referring to the scale of the densitometer shown in Figure 4, it will be seen that the scale is substantially uniform from 0 to 1.8 density and becomes increasingly congested to a density of 3. For a direct-reading densitometer the accomplishment of these scale characteristics is quite an achievement since every 0.3 increase in density cuts the photoelectric current in half, thus the current available for the 1.8 density point is only 1.6% of the available current at 0 density. It will be noted that the meter contains two density scales, one divided into blocks which facilitates coordinating the scale readings with the exposure guide dial and the other scale which is calibrated in divisions to facilitate easy readings in absolute values.

The density calibration is in terms of diffuse density as this has been generally accepted as standard. Mathematically, the density of a photographic negative may be expressed as follows:

$$D = log\ O\text{, or } D = log\ \frac{1}{T}$$

where D = density, O = opacity, and T = transmission.
For example, a negative having an opacity of 100 would have a density of 2 and a transmission of 0.01 or 1%.

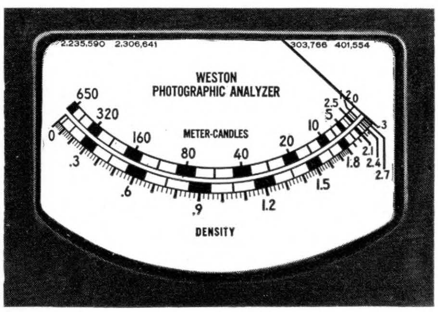


Figure 4—View showing scale of the illumination meter calibrated to read meter candles and density.

The above formulas are quite simple but they do not consider the scattering of the light by the negative. The density value obtained depends upon the method of measurement. If only the light which passes straight through the negative is collected and used as a criterion of the transmission, the result is called Specular Density. If all of the light which passes through the negative is collected and used as a criterion of the transmission, the result is called Diffuse Density. The usual method of collecting all of the light, both straight and scattered, is by means of an integrating sphere. Instead of using an integrating sphere on the analyzer, the Integrating Cone was developed and it does an excellent job of collecting the transmitted light and is more practical than the use of a 6- or 8-inch diameter sphere.

Illumination Meter

The illumination meter is calibrated to indicate meter candles on the scale shown in Figure 4. When the illumination meter is used, the photoelectric cell "F" is removed from the bakelite arm "G" and placed on the surface upon which it is desired to measure the illumination. The photoelectric cell is furnished with a six-foot cord so that the cell can be located over quite a large radius from the analyzer. The usual application is to measure the illumination on the enlarger easel or printer platen and since these are in the dark room it would be difficult to read the meter scale unless it is illuminated. To do this, and at the same time prevent the fogging of photographic papers, the meter is equipped with a six-watt lamp and a red filter to light the scale. It will be seen that the scale is divided into blocks, the object being to facilitate easy coordination with the calculator. Each of these blocks corresponds to an increment equivalent to a cube-root-of-two step, hence every three steps represents a change of 100% in illumination or exposure. The intermediate values, if desired, can be ascertained readily from the calculator on which all of the step values are marked. By means of a multiplier the scale range of 650 meter-candles can be extended to 6500 meter-candles.

Exposure Guide

The exposure guide shown in Figure 5 is 6 x 9 inches and can be read easily in subdued light. It is used to correlate the transmission density of the negative and the sensitivity of the photographic paper to the exposure time and illumination necessary to produce a satisfactory picture by instrumentation.

The exposure guide has been designed to have mathematically uniform steps except for a slight amount of rounding off in order to obtain whole numbers. It will be noted that the increments are equivalent to photographic steps corresponding to one-third of an f/stop and since it is always possible to select the step nearest to the desired value, the calculator actually can be set to an accuracy of one-sixth of an f/stop which is sufficiently close even for accurate color work.

Figure 5—The Weston Model 877 Exposure Guide.

It will be noted that the exposure guide has two arrows, one marked "MIN" and one marked "MAX." For black-and-white work the minimum negative density has been found to be the best criterion for photographic exposure, hence the "MIN" arrow is used. For color work the maximum density has been found to be the best criterion, hence the "MAX" arrow is used.

Photographic Paper Speeds or Analyzer Numbers

Paper speeds do not have the same significance as film speeds, due to the fact that the density of a photographic negative depends upon the optical system used to illuminate it. The same negative which may have a density of 1.0 in a diffusion enlarger may have a density of 1.2 in a condenser type of enlarger, hence if the same photographic paper with the same negative was printed in each enlarger it would appear that the paper speed is different in each enlarger. Because of this we may, for convenience, say that the effective speed of a paper depends upon the type of enlarger used. It is for this reason that we merely issue a tentative value as a guide so the photographer can ascertain the correct Analyzer Number to suit his equipment and technique.

Step Wedges and Gray Scale

These accessories are required when paper characteristics are to be determined for either black-and-white or color photography. Two negative step wedges are supplied, one for use in 35 mm enlargers and the other for use in standard enlargers and for contact printers. The calibrated gray scale is necessary when doing color work in order to establish time-gamma curves and when making the final print to determine if the color balance is correct. Other uses are explained in the instruction book which accompanies each analyzer.

Electrical Characteristics

The lamps used are both designed for 120 volts and since they are the only load, the analyzer can be used on any 120 volt a-c or d-c circuit. The total power input is approximately 40 watts. The design is adequate to stand a 1250-volt breakdown test between the line and all external parts.

Applications

Due to the fact that the analyzer is calibrated in fundamental units, density and illumination, the photographer has basic tools with which to carry on accurate research and development work in the field of photography. The following are a few of the more important phases which are thoroughly explained in the instruction book and which can readily be performed.

1. Determine characteristics of contact and enlarging photographic papers.
2. Check film speeds.
3. Check filter factors.
4. Construct time-gamma curves.
5. Balance color-separation negatives.
6. Mask transparencies to reduce their contrast ranges.
7. Measure uniformity of light on the easel or printer platen.
8. Control the various steps in wash-off relief, carbro, dye transfer, Printon, and other color processes.

Instruction Book

The instruction book, furnished with each analyzer, has been written not as a textbook on photography but rather to supplement accepted photographic practice and manufacturers' instructions and reduce them to a systematic procedure using instrumentation as a guide and check on each progressive step. By means of the analyzer and the instruction book, the photographer for the first time has a means of checking his equipment and doing practical Sensitometry and Densitometry in his own dark room.

E. N.—No. 27 —*A. T. Williams*

WESTON VACUUM THERMOELEMENTS

CHARACTERISTICS AND APPLICATIONS

THE manufacture of vacuum thermoelements was described in WESTON ENGINEERING NOTES for June, 1946, Vol. 1, No. 3. While manufactured primarily for use in Weston thermo instruments, they are now being made available and will shortly be listed by our Parts Department. The general characteristics of the several ranges are listed below, along with some suggestions for their proper use.

The vacuum thermoelement consists of the heater, a straight piece of non-magnetic resistance wire, to which is attached a thermocouple of two dissimilar metals, all assembled in an evacuated glass bulb with suitable terminals.

The current to be measured raises the temperature of the heater wire and the thermo junction generates a d-c voltage which is proportional to the temperature rise. The voltage output, as measured on a suitable

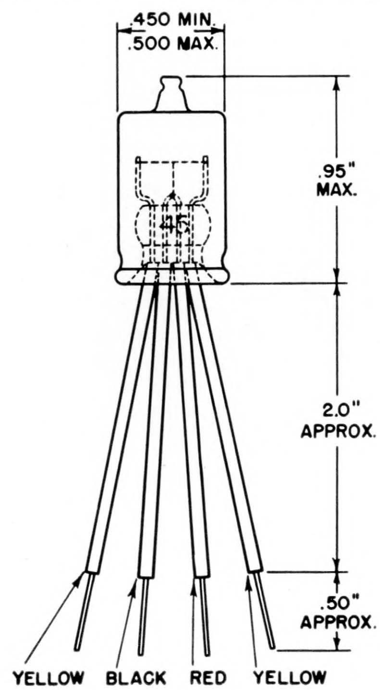


Figure 1—Dimensions of Weston Vacuum Thermoelement.

d-c instrument, varies approximately as the square of the current. Since the temperature depends upon the effective value of the current, the indicators are true rms values.

The thermoelement is inherently adapted to the measurement of currents at frequencies in the hundred megacycle region. With a suitable series impedance, potential measurements also can be made.

Vacuum thermoelements do not require any special handling and are really quite rugged. The over-all size is shown in Figure 1, and is sufficiently small to permit its placement in small confined spaces such as panel instruments, or the plug-in thermoelement shown in Figure 2, used with Weston Model 622.

Table I lists the approximate constants for these vacuum thermoelements. The range is defined as that current which will produce not less than 5 millivolts output on open circuit; in practical manufacture a tolerance is, of course, required and the current to produce that output may be 20% less than the rating. The maximum safe heater current is listed, and, while materially less than the current used in aging the element, it is the highest current that can be applied continuously without effect on the output. The "burn-out" values listed are, of course, only approximate, but represent minimum values found on test as the various ranges have been put through their paces in our laboratories.

Metallic heaters are used on the higher ranges and carbon heaters on the very low ranges. Since metallic elements have a positive temperature coefficient of resistance and carbon has a negative temperature coefficient of resistance, the heater resistance will rise with the metallic element and become less with the carbon element resulting in variations from the square law scale, but will still indicate rms values. Figure 3 shows the relation between input or heater current and output millivolt values, along with a pure square law curve. It will be noted that the deviations are of a relatively small order. In actual use it is necessary to calibrate each thermoelement; however, if assembled with an instrument in which the scale is to be drawn, the over-all characteristic can be calibrated into the final scale.

Figure 2—Plug-in vacuum thermoelement as used with the Model 622.

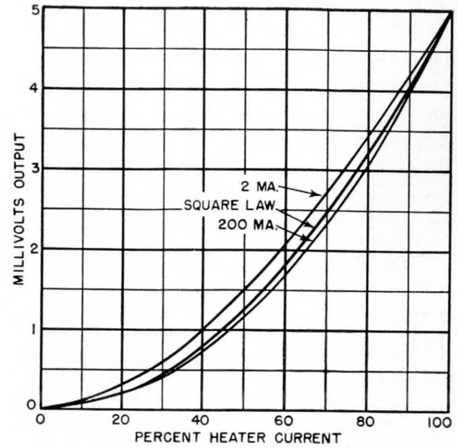


Figure 3—Curves showing close approximation of thermoelement output to square law.

Applications

The thermoelements are rated in terms of open circuit output. In the last analysis the output energy is very small. Maximum energy transfer is obtained when the instrument resistance approximately matches the couple resistance which, in turn, means that the millivoltage of the instrument mechanism is approximately half that available from the element on open circuit. In portable instruments a standard type frequently used has a resistance of 10 ohms, a current sensitivity of 200 microamperes and, thus, a millivolt drop of 2 millivolts.

Where used in a small panel instrument it is considered permissible to overload the thermoelements from 50 to 100% simply because more energy is required for such panel instruments. Thermoelements so used have a smaller overload capacity in terms of the over-all instrument range but have been found quite useful.

If the thermoelement is to be mounted inside an instrument or other device, it is best arranged in a well cushioned holder with cotton batting around the glass bulb which offers good protection against mechanical damage and, at the same time, adds some thermal insulation against sudden ambient temperature changes.

Ambient temperature changes affect the thermocouple by changing the temperature base above which the heater temperature is raised, and at the same time the resistance of the couple proper is changed slightly. Somewhat elaborate circuit means are used in the more precise portable instruments to at least partially compensate for these effects.

For voltage measurements, there is quite a problem in obtaining a satisfactory series impedance as the frequency is increased. Wire wound units are satisfactory up to perhaps 15 kc. Resistors wound on mica sheets may be used up to several

TABLE I
APPROXIMATE CHARACTERISTICS OF WESTON VACUUM THERMOELEMENTS

Range, Ma.†	Resistance ±10%		Maximum Safe Heater Current Ma.	Burn Out Current Ma.	Weston Part Number
	Heater Ohms*	Couple Ohms			
1.5	1365	6	3.2	20	117441
2.0	750	6	5.0	30	117442
5.0	82	6	10.0	20	117445
7.5	36.2	6	16	35	117446
10	23.4	6	25	50	117447
15	13.0	6	40	85	117448
20	8.4	6	50	120	117449
25	7.0	6	62	150	117450
30	5.8	3	75	180	117451
37.5	4.6	3	85	210	117452
50	3.3	3	115	260	117453
75	1.36	3	170	330	117454
100	1.03	3	220	380	117455
150	0.66	3	320	540	117456
200	0.46	3	420	700	117457
250	0.39	3	510	900	117458
300	0.33	3	610	1050	117459
400	0.25	3	800	1300	117460
500	0.20	3	1000	1900	117461

* Resistance of heater at rated current.
† Heater current for 5.0 millivolt open circuit may be 20% less than rated current.

hundred kilocycles. For still higher frequencies the problem is considerable although in the laboratory series condensers are sometimes used, their impedance being calculated in terms of the frequency of the applied voltage.

The assembled plug-in element shown in Figure 2 is arranged in rather special form for use with the Weston Model 622, Figure 4, and these elements are arranged to be interchangeable by individual adjustments of the heater resistance and the output through the use of series resistors self-contained in the small bakelite housing. The particular Model 622 shown uses a vacuum thermoelement in a shunted circuit with a switch for the selection of any one of 4 ranges. In this instance the shunt network imposes a frequency limit of 15 kc, high enough for most audio work. For higher frequencies single ranges only are available, except through the use of a group of calibrated couples as occasionally furnished.

The thermoelement terminals are wire leads, two of which have yellow sleeving over them and are connected to the heater. The couple terminals are red and black respectively, the red covered wire being positive.

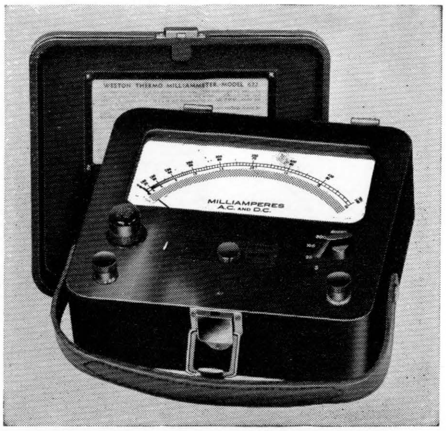


Figure 4—Weston Model 622 Multi-Range Milliammeter equipped with plug-in element.

Vacuum thermoelements are first placed in small plastic boxes and each unit carries with it a complete rating sheet giving both its nominal values, as well as the exact value of current for 5 millivolts open circuit, 10 millivolts open circuit, and the heater resistance, cold, and the couple resistance. The plastic case is then further contained in a cradle in a cardboard box for stocking, making it possible to handle these elements in as simple a manner as a rheostat, condenser, or any other prime element used in electronic art.

Over the past few years of manufacture we have been agreeably surprised at the very small number of rejects, but believe that the rigorous testing of all welded joints in special bridge circuits, the use of full annealing techniques on all of the glass parts, and the very high vacuum obtained has resulted in a thermoelement which is a marked advance over those previously available. Our own tests show higher overloads are possible before detrimental changes occur than was ever before thought reasonable. Stability of output has made calibration somewhat easier than in the past. Random burnouts have become practically non-existent.

Sometimes the question is asked as to the top frequency with which these thermoelements may be used. As long as the output limit is not exceeded, there appears to be no top frequency limit of operation. By this we simply mean that no burnout will occur as long as the output millivolts are held within acceptable values at low frequency. After all, a current at any frequency can merely raise the temperature of the heater and the practical limit of top frequency appears to be only that which can be introduced into the unit through the connecting leads.

E. N.—No. 28 —*M. C. Kunz*

ORGANIZING AN ELECTRICAL INSTRUMENT STANDARDIZING LABORATORY

With the further growth of the electrical industry and the founding of new research laboratories, we have had a number of requests for a series of articles on the formation of a standardization laboratory for the checking and maintenance of electrical measuring instruments.

A series of articles covering both the broad phases of standardization work, as well as the more practical details of standardizing and associated equipment is in preparation.

The first article, below, has been written by Mr. J. B. Dowden who has supervised the standardization work in the Weston laboratories for the past two decades.

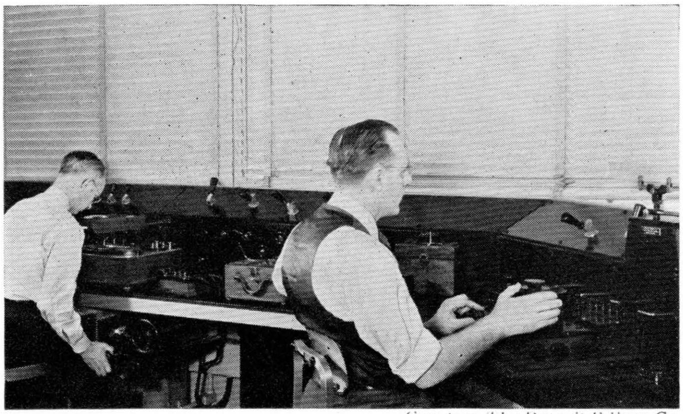
THE EDITOR.

MANY research laboratories and industrial concerns whose products are electrical have found the facilities of an electrical testing laboratory of prime importance in insuring the quality of the product, the accuracy of research data or the efficient operation of electrical equipment, depending on the primary activity of the organization.

A decision regarding the establishment of such a laboratory must evaluate the advantages to be obtained, giving consideration to the number of electrical instruments in use—the importance of accurate electrical measurements—and the desirability of securing prompt service in the maintenance and testing of instruments.

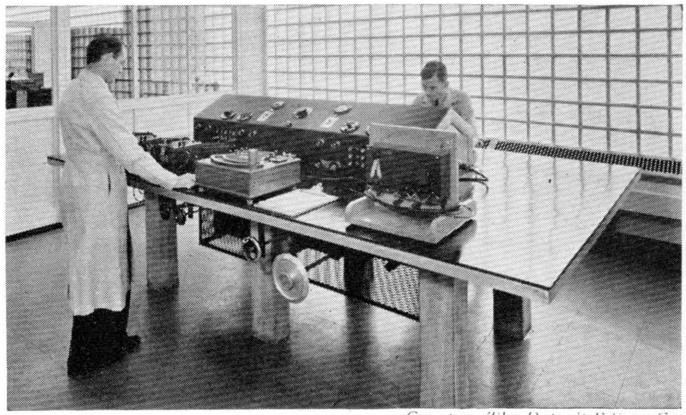
Other factors which should be taken into consideration when deciding upon the establishment of an instrument laboratory follow.

1. The character of the product or activity which would indicate the desirability of close control and maintenance of the electrical instruments. If the company, for instance, manufactures an electrical product, no doubt many electrical instruments are used which are subject to considerable wear and tear and hence must be kept in accurate and good operating condition in order to insure the quality of the



Courtesy The Detroit-Edison Co.

Standardizing a Weston Model 326 Ammeter using an L. & N. Type K Potentiometer.



Courtesy The Detroit-Edison Co.

Alternating Current Standardizing Table. Note the heavy, well-insulated supports used to minimize leakage currents and vibration.

product. On the other hand, if the company is a large user of electricity and the electrical instruments are used only for control and testing, it might be desirable to depend upon outside laboratory facilities such as are provided by instrument manufacturers or local instrument laboratories for maintenance and repair.

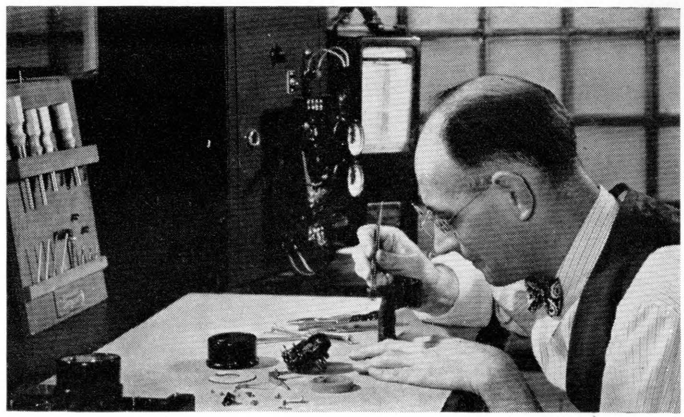
2. The quality of the product is highly important to any manufacturer and inspection departments should be provided with the highest quality of testing instruments which adequate control of the product demands. Routine checking of the testing instruments is required so that the accuracy of the equipment may be properly maintained.

3. The maintenance of electrical equipment is very important in order that it may be operated efficiently without damage or alternatively, without paying for excess capacity in underloaded equipment.

The uses to which electrical measuring instruments may be put can be summarized as follows.

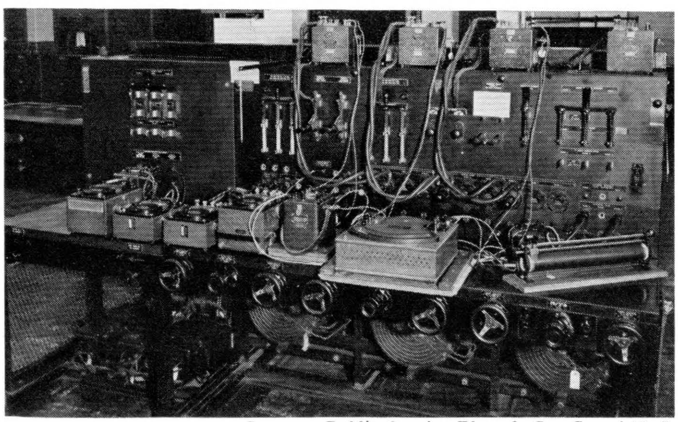
Typical scene of checking procedure using a Weston Model 326 Laboratory Standard Voltmeter to check a Weston Model 433 Voltmeter.

Courtesy Public Service Elec. & Gas Co. of N. J.



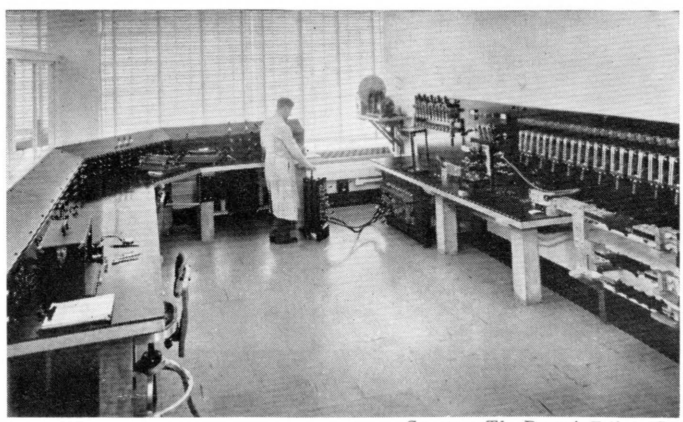
Typical instrument repair bench. Neatness and cleanliness are essential in repairing electrical instruments.

Courtesy The Detroit-Edison Co.



Courtesy Public Service Elec. & Gas Co. of N. J.

Scene at Public Service Laboratories, Maplewood, N. J., showing sine wave test table for calibrating rotating standards.



Courtesy The Detroit-Edison Co.

General scene of Direct Current Standards Laboratory.

INSTRUMENT LABORATORY RECORD

CLASS	Voltmeter-D.C. CODE NO. VD 23
DESCRIPTION	Weston Model 1 Vm. Sr No 25648 Ranges 150/15/3 V. Sensitivity 1.0 Ma.
CHECKING DATA	Check calibration every 3 mos. Use Weston Model 5 Laboratory Standard or equivalent. Full calibration checked on 150 V. range with full scale check on other ranges. Accuracy. ¼% of full scale value.
USE	General Laboratory Testing

(Front)

CALIBRATION RECORD

DATE	1-2-47	4-2-47	4-3-47
READING			*
0	✓	✓	✓
10	✓	Pointer Bent	✓
20	✓		✓
30			
140		1.0	✓
150	✓	-1.0	✓
15V.	✓	-1.0	✓
3V.	+.1	-.9	✓

REMARKS:— 1-2-47 Calibration check O.K.—Condition Good
4-2-47 Calibration error 1%—Severe treatment
4-3-47 Pointer bent; straightened and rechecked *

(Back)

The record card should contain sufficient data to maintain a reasonably complete history of the instrument's use and condition.

(a) Inspection tests of product.
(b) Acceptance tests of incoming material.
(c) Compliance tests of product for customers.
(d) Maintenance tests of electrical manufacturing equipment.
(e) Standardization of the company's testing and research instruments.

The selection of equipment necessary for establishing an electrical instrument laboratory requires a careful analysis of the functions of such a laboratory, the quantity of instruments involved and their types, and the class of accuracy required. For instance, research laboratories generally require that their instruments be maintained to operate at the highest precision of which they are capable. Production testing on the other hand requires only a nominal accuracy, depending upon normal production tolerances. This subject has been broken down into the equipment necessary to test and service the various types of electrical testing instruments, power supplies, etc., and a discussion of each phase of the subject will appear in subsequent articles.

Primary requirements may indicate that the laboratory only be equipped to test electrical measuring instruments of certain types and to make correction curves and possibly minor adjustments. Later, it may be found desirable to service and repair instruments in order to keep the instruments on hand in active use, thus securing the maximum service.

Records of the accuracy of the laboratory standards and the instruments presented for test should be kept in order to know their history fully. These reports may be very elaborate but such records are not recommended because too much time will be spent on paper work. Printed forms similar to those shown above contain a sufficiently detailed record for general purposes and if printed on a suitable card can be conveniently filed for ready reference.

The operating personnel can vary quite widely, depending upon the service provided by the laboratory. An electrical engineer in charge of the instrument laboratory is highly desirable in order to secure the advantage of his education with respect to the instruments and their use. The intelligent use of electrical measuring instruments, in general, requires some knowledge of the product and equipment and its ultimate use. An experienced instrument man with some technical education should be secured for the laboratory work. Such a man has an instrument experience and a "touch" which are quite invaluable. He will usually be found so adept that he can solve many special problems as well as operate the equipment intelligently and make minor adjustments and repairs. The number of employees will, of course, depend upon the volume of work to be done and its precision.

An electrical instrument laboratory may be combined with other types of laboratories such as a mechanical laboratory or a chemical control laboratory and the same personnel used for any of the laboratory work for which they may be suited. Such a combination will depend very much upon the type of organization and the man in charge.

The convenience of having an electrical instrument laboratory available frequently more than justifies its expense because of the time saved in securing service and instruments which may be available in such a laboratory for immediate use.

A reference library covering electrical instruments and electrical measurements is generally considered a valuable part of the well-equipped instrument laboratory. For convenience, a number of engineering texts on this subject are listed below.

E. N.—No. 29 —*J. B. Dowden*

List of References:

1. ELECTRICAL METERS—*C. M. Jansky—McGraw-Hill, New York.*

2. MAINTENANCE AND SERVICING OF ELECTRICAL INSTRUMENTS—*J. Spencer—The Instruments Publishing Co., Pittsburgh, Pa.*

3. ELECTRICAL MEASUREMENTS—*F. A. Laws—McGraw-Hill, New York.*

4. ELECTRICAL MEASUREMENTS AND MEASURING INSTRUMENTS—*E. W. Golding—Pitman and Sons, Ltd., London.*

5. INDUSTRIAL ELECTRICAL MEASURING INSTRUMENTS—*Edgcumbe & Ockenden—Pitman and Sons, Ltd., London.*

Correction Notice

In the April issue of WESTON ENGINEERING NOTES an error was made in the article, "The Measurement of Reactive Power." On page 3, the word VARS which appeared in the caption of Figure 5 is incorrect. The caption for Figure 5 should read as follows: "Diagram of connections for a two-element electrodynamometer for measuring watts in a two phase, three-wire circuit."

Printed in U.S.A.