LABORATORY HINTS *

Extending the Range of a Signal Generator

A problem comes up at times in laboratories that are not equipped to measure signals in the ever-increasing higher frequency ranges: that is, measuring a frequency beyond the range of its signal generator. This signal can be applied to a mixing or a detector circuit of some kind, together with an adjustable signal of a lower frequency from a standard oscillator or the signal generator. The oscillator is set so that some undetermined harmonic of the latter is found to beat with the unknown signal. This will happen at more than one setting of the dial, assuming, as is generally the case, that harmonics exist in the oscillator. Carefully determine several of these frequencies that appear in successive order on the dial of the standard where beat notes occur, with emphasis on avoiding missing any one of them in order. Since the unknown frequency is higher than the standard it will be evident that the greater the difference the more numerous the points where these beats are heard.

A trial computation can be made using several successive frequencies determined in this way: \( f_1, f_3, f_5, f_7, \ldots \) applied to the relation \( f_x = \frac{f_1}{f_2-f_1} \)

\[ N = \frac{f_1}{f_2-f_1} = \frac{f_x}{f_2} \]

Harmonic orders in signal generator range.

* By courtesy of “Electronic Industries.”
If no intermediate beat has been missed this computation gives a rough value of the unknown. The precise value will be the value of either \( f_1 \) or \( f_2 \) multiplied by some integer which gives the value nearest \( f_3 \). Inasmuch as extra beat notes are frequently noted, the value should be checked using a third beat note setting, \( f_3 \), and then a fourth in the same succession, \( f_4 \), then

\[ f_x = \frac{f_1}{f_2} \cdot \frac{f_x}{f_2} \cdot \frac{f_1}{f_4} \cdot \frac{f_x}{f_4} \cdot \text{etc.} \]

Any of these relations that do not give the same value of \( f_x \) should be disregarded, as false harmonic tones were probably used.

In order to assist in making these computations the accompanying chart can be used to advantage.

**Speeding Up Inductance Measurements**

When making tests on a Q meter (or other type of instrument based on resonance measurements) inductance and capacitance values bear reciprocal relations with each other at the frequencies listed in the table. For greatest convenience these frequency points can be “spotted” on the oscillator dial direct and the capacitance scale can be provided with an auxiliary scale marked with values equal to the reciprocal of capacitance values.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Inductance</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.33 KC</td>
<td>( L = 10^4 \div C )</td>
</tr>
<tr>
<td>159.16 KC</td>
<td>( L = 10^2 \div C )</td>
</tr>
<tr>
<td>503.30 KC</td>
<td>( L = 10 \div C )</td>
</tr>
<tr>
<td>1,591.6 MC</td>
<td>( L = 1 \div C )</td>
</tr>
<tr>
<td>5.033 MC</td>
<td>( L = .1 \div C )</td>
</tr>
<tr>
<td>15.916 MC</td>
<td>( L = .01 \div C )</td>
</tr>
</tbody>
</table>

(Values are in m.m.f. and millihenries.)

For greatest accuracy the distributed capacitance of the inductance coil must be added to the capacitance value of the tuning capacitor at resonance.

The distributed capacitance of the coil can be quickly measured (if it has an inductance greater than a few microhenries) by connecting in another coil having an inductance of 1 per cent or less of the first, across the tuning capacitor. It will resonate at a frequency 10 times (or more) greater than the value selected for the test coil and used in Table 1. Having resonated the new coil to that frequency, connect the coil whose capacitance is to be determined across the tuning capacitor, and find out how much the setting of the latter has to be altered in retuning. The inductance change due to the two coils in parallel will be quite small and the shift can be considered to be that caused by the distributed capacitance of the coil alone.

When the inductance being checked is small to start with, it may not be possible to find a second coil sufficiently small to carry out this procedure. The usual method† in this case is to determine the capacitance \( C_1 \) needed to tune the coil to resonance with frequency \( A \) (select the latter so that practically full scale capacitance is needed) and then reduce this capacitance until it is approximately one-fourth of the first value, whereupon a deflection due to the second harmonic of the oscillator setting can usually be noted. Call this value \( C_2 \). Then

\[ C_n = C_1 - 4 \cdot C_2 \]

Since \( C_n \) is usually quite small it is necessary to use extreme care in making these settings. If the second harmonic of the oscillator is not evident, the oscillator must be carefully retuned to the doubled frequency.

† Reference Proc. IRE. Aug., 1921, p. 300.
WANTED: Signal Corps Equipment

You may have Radio-Amateur and Photographic equipment that is urgently needed by the Army Signal Corps. The Army will buy the following from private individuals.

Radio: Standard and commercial built short wave transmitters (such as Hallicrafters HT-1, etc.; Temco and Collins Model 32 and 30) and Standard and commercial built short wave receivers (such as Hallicrafter, National, RCA, RME, Hammarlund or Howard); AC and DC Voltmeters, Ammeters, Milliammeters, Radio Frequency Meters and Volt-ohm-milliammeters; Oscilloscopes, 2-3 inch; Audio sig. gen. 30-15,000 cycles; RF sig. gen. 15-215 megacycles; late model Tube Checkers, and other test equipment.

Photographic: 35 MM Motion Picture Cameras (such as Mitchell (all models), Bell & Howell - Standard Professional, Akeley-Professional (all models) and Eyemo (all models) Bell & Howell Mfg.), etc., and 16 MM Motion Picture Cameras (such as Cine-Kodak Special Magazine Cine-Kodak, Filmo 70.D or Filmo Auto Master); Tripods; Lenses, all types for 35mm and 16mm equipment; Exposure Meters; and Cameras (such as Speed Graphic 4" x 5", and Speed Graphic 2⅜" x 3½" with or without flash synchronizers) and Leica Model III (F) or 11B (C), or equal; Range Finders; Pack Adaptors and Cut Film Holders.

If you have this type of equipment, you can assist the war effort materially by selling it to the Army. Write to:

EMERGENCY PURCHASE SECTION
PHILADELPHIA SIGNAL CORPS PROCUREMENT DISTRICT
5000 WISSAHICKON AVENUE, PHILADELPHIA, PA.

briefly describing the equipment you have and stating the price at which you can offer each item, FOB Philadelphia. Do not ship any material without specific directions from that office.

Price consideration is based upon your net cost less reasonable depreciation for use, age, and condition of equipment. Inasmuch as all equipment is being purchased FOB Philadelphia, cost of packing and shipping can be shown separately so that an allowance for the costs can be made when material is accepted.
SWAP—Jackson model 640 signal generator, just recalibrated. Want Argus C-3 or C-2, Kodak 35, Faith Derby 35mm or 1/2 V.P. or other photo equipment. Roy Powell, Box 422, Boynton Beach, Fla.

WANTED—Cash for pocket VOM, such as Triplet 666, 0-1 ma meters, precision resistors, copper oxide rectifier, test equipment. Answer made to all offers. Address D. F. Causey, P. O. Box 44b, University Station, Urbana, Illinois.


FOR SALE—Kolster K-20 and K-43 Kolster-Brandeis No. 15 chassis; Kolster-5 brand new amplifier with large dynamic speakers; Temple chassis and power pack; G. E. K-32 radio and dynamic speaker, A C. Utah dynamic speaker, Fada 8 tube chassis. All sets are in playing condition. Louis A. Goldstone, 1279 Sheridan Ave., Bronx 56, New York, N. Y.

FOR SALE—Rider’s Manuals, vols. 2, 3, 4 and 5, $20.00. Perfect condition. Will consider trade for late test oscillator or channel analyzer. Make offer. W. J. Closson, 295 8th St., Troy, N. Y.

WANTED—Thordarson high fidelity transformers No. T 15R05 power; T-90A04 audio; T90S13 output; Jensen JHP-52 speaker; some 1% high resistance Morrell resistors, any wattage, state what you have and price; need 1, 2, 5, 10 ma, and 1, 2, .5 meg in particular. Want 1916 QSTs, also Aug., 1917, Feb., 1919, June 1920. Murray J. Douglas, Concord, Calif.

FOR SALE OR TRADE—Large twin cylinder Milwaukee outboard motor, complete, in good shape, with hot shot battery. Sell for $40 or trade for radio tubes, parts or equipment. Tubes such as 3525, 35L6, 50L6, 12S47, 12SQ7, 12Q7, 12A8, 6A8, OZ4, 6X5, 1A5, 1C5, 1A7, 1HS preferred. McKinley’s Radio Service, Zebulon, Ga.

WILL TRADE—For 35 mm camera or? 1 30 watt class A Philco amplifier in portable case complete, mike, speakers and cable; 1 500 watt a.c. generator, puts out 110 v. a.c at 500 watts. for fan belt of car, both $150. 1 communication set, master station and 1 sub., value $25.00. Paint spray complete, value $100.00. No junk. John Arnold, Bluills, Illinois.

FOR SALE OR TRADE—2 Stanco M-30 mobile transmitters complete with tubes, dynamotor, handset, all cables and X1s for 30580 kc Billey MO2. H. B. Reynolds, Oneida, N. Y.

WANTED—Will pay full list price for either a Chanalyst or Supreme Audo-
yzer. Cripps Radio Service, Dunsmuir, Calif.

WANT—FM converter, will pay cash or swap a new 25X Bark telescope. Also need 500 ma smoothing choke. Will sell 16’’ transcription cable with rugged dual speed motor, a Swiss make. E. E. Matt Radio, 1950 Trowbridge St., Detroit, Mich.

FOR SALE—Supreme 89 deluxe tube and set tester. Can be modernized to test late tubes. As good as new. What is offered? Tone’s Radio Service, 125 Fourth Avenue. Paterson, N. J.
WANTED—Rider's Channalyst in good condition, also Rider's Manuals 6 to 13 inclusive with possible. Must be in good condition. Cash will be paid. Rural Radio Service, Clark Lake, Mich.

WANTED—Dry disc rectifier units with or without transformers, or any pack. A eliminator trickle charger, field supply, etc., using dry disc units, Sterling, Hoyt, etc., small 2½" or less; meters dc ma up to 500 ma. Wheel static eliminator springs similar to JPD. Mason- tie regular or tempered. Will buy or swap. June. 'Capacitor. Send details. Bob Eubank 1227 Windsor Ave. Richmond 22, Va.

FOR SALE OR SWAP—No. 6033A Western Electric hearing aid complete. Includes 388W transmitter, 550 BW ear insertion phone, 11A battery box, cables, etc. Uses only three standard D flashlight cells. No tubes or B battery needed. Excellent condition. Sold for well over $160.00 by National NC-100X or N 200 without tubes or speaker or complete, or make offer R. N. Eubank, 1227 Windsor Ave., Richmond 22, Va.

FOR SALE—Portable Jackson dynamic output radio analyzer, 535A $25. F. Combs, 344 Peach Orchard Road, Dayton Ohio.

FOR SALE OR TRADE—1 Webber oscillator, battery operated, 90 kc to 25 mc range. See ad. Selling condition with battery $15.00. 1 No 171 RCA station allocator, ac/dc or battery operation, less battery, new condition $17.50. 40 new and 20 used tubes. Want Rider's 1 to 5 incl. Glendaford Radio, Williamsburg Iowa.

WANTED—In good condition a McMurdo Silver Model 6 late or early model receiver. With National. Must be reasonable. Send details. Paul Capito 637 W, 21st St. Erie, Pa.

WANTED—A Precision tube tester model 912P, 912CP or 912C, new preferred but will accept one in new condition. Quote price and condition. Anthony Vital 317 Linden St Camden, N J.

FOR SALE—A K. "B" eliminator with Ri7 rectifier tube, 7 short wave 4 prong plug-in coils. Bud 2½ m h v 1 chokes, new in original case. 50 radio chassis with half parts still mounted, many later models. 100 used tubes, plenty of hearing aid parts; instrument cases, midget condensers, crystal mike, Astatic crystal ear piece, low impedance maganet ear piece. Edwin T Larson, Box 46 Martinsburg, Ohio.

WANTED—Weston 772 multimeter or similar 20,000 ohm per volt multimeter. State Price. Maurice Rushworth 531 South Lonawood St., Baltimore 23, Md.

WILL TRADE—SX-25, Super Deliant Halkerifiers communications receiver almost new, factory seal never broken for Hickok oscillograph model RFO-5 or Supreme Model 560A vedolyzer or RCA Rider channalyst. Robert Wendt, K2R Willow Village, Ypsilanti, Mich.


WANTED—Old type Dodge 12 v. motor-generator, prefer North East model, or 6 v. or 12 v. dc electric motor ¼ horse or larger, to power wheel chair. Pay cash or have used radio parts and tubes and stamp collection to trade. Dean A. Lovell, Waukomis, Okla., P. O. Box 21.


WANTED—1931, 1932, 1933-5-7-8, 1940, 1941, 1942 bound vols. RCA service notes. Also GE bound volume. State cash price one or all. The Radio Hospital, 420 N. Hudson, Oklahoma City, No. 3 Okla.

FOR SALE—1 Supreme model 505 tube test set up to date, $40.00 cash. Ramm's Radio Laboratory, 218 South Bronough St Tallahassee Fla.

WANT—2, 3 or 4 mid 600 v. oil filled condensers, plate relay, slide rule, horn engine. Other Radio transmitting parts, meters, photographic accessories, or? Gommo', 46 Northwest 94, Miami, 38, Florida.

FOR SALE OR TRADE—Radio transmitting parts meters for fast wide angle lens cover 4x5 127 mm Ektar lens in supernormal or other photographic equipment or Hantam Special. Gommo', 46 Northwest 94 St Miami Shores, 38, Florida.

FOR SALE—6 RCA ET05022 mobile transmitters (high parts value only, limited parts lists available). 6 Electric Specialty Go SL4 dc generators, 550 v. at 250amps 12 volts at 6amps at 1500 rpm. 11 RCA dynamotor units 6 vdc input 250 vdc at .050 amps 1 0-1 Triple- lott model 346 thermocouple ammeter. 2 Bilsley HF2 crystals 29950 and 29987 kc. 11 RCA 841 tubes. City of Racine Police Radio Dept., 1400 Tenth Street, Racine, Wisconsin.

(Continued on page 13)
POWER OUTPUT METERS *

EASY-TO-BUILD AND SIMPLE TO CALIBRATE POWER OUTPUT METER—MEASURES AUDIO FREQUENCY WATTAGE OF RADIONIC EQUIPMENT

Radio, radionic, and amplifier technicians readily concede that an audio-frequency wattmeter which presents little or no load to the power source under test and which indicates power levels directly in watts (even if scale factors need be applied mentally to some of the readings) is an adjunct to the test bench. In trouble shooting and in experimentation alike, this instrument pays large dividends by eliminating much guess work.

P. A. men particularly feel the need for this type of meter when they put amplifiers through their paces. With it, they are freed from burdensome computations of power output and the errors attendant to such figuring. But available instruments have long been in the laboratory class and have been priced accordingly, and the amplifier technician with an average clientele has been forced to get along without direct-reading wattmeters.

A satisfactory audio wattmeter may be constructed of spare parts by any radio or amplifier man. Several well known circuit arrangements are available. The layout chosen will be a matter of availability of the required equipment and access to calibration equipment. We have looked over the various circuits and systems and finally selected a design which lends itself to easy duplication. For calibration, all that is needed is a source of variable a.c. voltage and a reliable voltmeter.

Standard audio wattmeters for radio and amplifier use are either a.c. voltmeters or a.c. ammeters connected to deflect on either the voltage drop across a known load resistor or the current flowing through this resistor. Since these deflections are proportional to the power dissipation in the load, the meter scale may be marked off directly in watts.

Obviously, the power calibration will hold for only one value of load resistance. And since a number of load values are generally encountered in amplifier output circuits, some provisions must be made to convert all impedances to the value associated with the indicating meter or to convert wattage readings in accordance with various impedance values.

In the standard laboratory-type audio wattmeter, the indicating voltmeter is shunted across a fixed resistance in which the power to be read is dissipated. And by means of a tapped input transformer, numerous common impedance values are converted to the value of this resistance. Thus, the meter is always actuated by the voltage drop across the standard load resistor. In the impedance-switching operation, various losses in the transformer, as well as the varying voltage ratio attendant to the changing impedance ratio, are compensated for by auxiliary resistors which are automatically cut in and out by the impedance range switch.

This type of instrument, while of the best design, does not lend itself easily to duplication at this time chiefly because of the special transformer required. None of the common multi-match amplifier-type transformers are suitable for this application, since they do not provide the proper primary and

* By Guy Dexter in "Radio News."
secondary taps for wide-range amplifier testing. The special transformer is not immediately available because of the present shortage of materials, and it may not easily be built unless the constructor has had considerable experience in the manufacture of high-quality a.f. transformers. Accordingly, the design we have chosen to present measures the voltage drop across the actual amplifier load or across an auxiliary load resistor and interprets this voltage in terms of watts.

It is essential that the wattmeter function independently of the frequency of the measured power. For this reason, we have employed a simple vacuum-tube voltmeter rather than an oxide-type a.c. voltmeter.

Operating Principle

The operating principle of the simple wattmeter is illustrated by the block diagram in Figure 1. The power source, which is shown here as an a.f. amplifier, is connected in the normal manner to its load device. While the latter is shown simply as a pure resistance (R), it might easily be an impedance instead. In practice, such a load device might be the speaker into which the amplifier operates, or it might be a transmission line.

The v.t. voltmeter, which might be of any convenient type possessing high input impedance, is shunted across the load to indicate the voltage developed across the latter. Its reading is proportional to the power developed in the load by the amplifier and may be used to find the actual power level from the relationship:

\[ P = \frac{E^2}{R} = \frac{E^2}{Z}. \]

It is apparent that the meter scale might be graduated directly in watts on the basis of the above relationship. However, it is easily seen that the value of load resistance or impedance must be known, otherwise the calibration would be meaningless. For example: a reading of 10 volts might indicate either 25 watts in 4 ohms, 10 watts in 10 ohms, 20 watts in 5 ohms, 1 watt in 100 ohms, etc., etc. Moreover, the calibration would hold only for the particular value of load with which it was made.

These discrepancies may be offset by making the calibration for some
value of load resistance which will facilitate mental multiplications or divisions of wattage readings when other impedance values are employed.

Figure 2 shows a convenient arrangement of the functional equipment. Here the load resistance has been included in the instrument itself to take the place of the missing amplifier load device. Power measurements are frequently made in this manner in order to permit removal of the speaker which would give rise, during the measurement, to considerable disturbance. The resistor R must have the same ohmic value as the normal load device and must have a wattage rating sufficient to enable it to dissipate safely the maximum amplifier output power. A load resistor so employed should preferably be of the non-inductive power type in order to eliminate the errors introduced by the impedance of inductive, wire-wound power resistors, unless the L/R ratio of the wire-wound unit is extremely low.

Fig. 2. VTVM used to measure output load.

Most audio power measurements will be made directly across the load device, coupling transformer, or line, and the arrangement of Figure 1 will be applicable. However, it is frequently desirable to have the wattmeter terminate the power source in lieu of the normal load device, so provision has been made in the complete instrument for the insertion by binding post connection of a load resistor of suitable resistance and wattage. Since at least forty load values are commonly encountered in audio-frequency work, no attempt was made to build a high-powered, bulky switched resistance load into the wattmeter. When the operator desires to employ the wattmeter as the amplifier load, he will need only to insert the one resistor connection into the binding posts provided for the purpose. When employing the instrument in the manner indicated in Figure 1, the resistor is removed.

In order to obtain complete isolation of the wattmeter, battery operation of the v.t. voltmeter unit has been adopted. This prevents return paths ordinarily encountered through the power line when both the power source under test and the v.t. voltmeter are operated from the a.c. line. The meter circuit has been made as simple as possible, and low-voltage batteries are employed.

The complete circuit diagram is shown in Figure 3. This schematic reveals the wattmeter to be a specially calibrated electronic voltmeter with high input resistance. The circuit has three voltage (power) ranges: 0-2 volts, corresponding to 0-4 watts: 0-6.32 volts, corresponding to 0-40 watts; and 0-20 volts, corresponding to 0-400 watts. These ranges are afforded by the input voltage divider comprised by resistors R1, R2, and R3, totaling 1 megohm, and the rotary selector switch S1.

The indicating instrument M is a Simpson 0-500 d.c. microammeter. This is the most desirable current range for this instrument, although larger or smaller instruments might be employed with corresponding changes in the power ranges. Thus, a 0.1-milliammeter would afford a full-scale power deflection of approximately 16 watts on the lowest range.

The "B" battery B2 is a midget flat 7 1/2-volt "C" type battery (Eveready 775). The small size of this component (4" x 2 3/4" x 1 1/2") makes it possible to keep the dimensions of the complete instrument small. The filament battery B1 and meter-bucking battery B3 are regular 1 1/2-volt flashlight cells (Eveready No. 950).

The tube employed is a 1Q5-GT with screen and plate connections tied together. The total no-signal plate cur-
rent is quite low at the low value of plate voltage employed, being approximately the full-scale deflection of the microammeter. The meter is therefore not endangered by this current when the zero-adjustment resistor R4 is off adjustment.

No-signal plate current is bucked out of the meter by the rheostat R4 and the 1½-volt cell B3 which make a smooth and efficient zero adjusting combination. Both the filament circuit and the meter-bucking circuit are closed simultaneously by the double-pole, single-throw toggle switch (the two sections of which are shown as S2 and S3) thus both batteries are removed from drain circuits when the instrument is switched off. The negative terminal of the filament battery and the circuit returns are connected to the No. 7 pin of the tube, this being the side of the filament to which the beam element is connected within the tube.

The 0.1-μfd., 200-volt tubular by-pass condenser C provides a low-impedance path for any a.c. passed by the interelectrode capacitance of the tube.

The input voltage divider (R1-R2-R3) is made up of three sections—684,000, 216,000, and 100,000 ohms respectively. The two former sections are of odd resistance value and must each be made up of several lower values connected in series. Resistors employed are ½-watt. R1 may thus be made up by connecting in series one each 600,000 ohms, 70,000 ohms, and 14,000 ohms. Likewise, R2 is made by connecting in series one each 200,000 ohms, 15,000 ohms, and 1,000 ohms. The accuracy of the two higher-wattage ranges will be dependent entirely upon the accuracy of these resistors. R1 could be a 1-megohm volume control, R2 a 250,000-ohm control, and R3 a 250,000-ohm control. During the calibration process, to be described presently, these controls may be set exactly, as they might also be during recalibration when the tube is subsequently replaced.

The voltage calibration of this v.t.v.m. circuit is given in Chart I and the corresponding power (watt) values in Chart II.

The binding-post terminals T1 and T2 accommodate the test leads or other

---

**Fig. 3. Schematic diagram of the VTVM output tester.**

R1, R2, R3—See text
R1—100,000-ohm midget rheostat
C—0.1-μfd., 200-volt tubular condenser
S1—Three-position, single-pole rotary switch
S2, S3—D. P. D. T. toggle switch
M—0-500 d.c. microammeter
B1, B2—1½-volt flashlight cells
B3—Midget, flat 7½-volt battery
T1, T2, T3, T4—Bakelite binding posts
Tube—IQ5-GT
connections made to the power source under test, while the posts T3 and T4 are for the external load resistor when this type of unit is employed.

The voltmeter circuit possesses extremely low zero drift. In fact, we have been unable to detect any drift upon the microammeter scale.

The wattage readings given in Chart II are based upon 1 ohm load impedance, this being a convenient value to which other load impedance ratings may be quickly referred when reading the meter. The constructor will find that the voltage calibration given in Chart I will correspond within a fraction of a dial division to the individual calibration he will make.

Mechanical Construction

The wattmeter, as shown in the photograph, was built of materials that happened to be available. The instrument case is a coated steel chassis, 5½"x10"x3" in size. The front panel is a sheet of thin metal stock originally cut to serve as a base plate for the chassis. The panel is held to the chassis by four self-tapping screws seen along the top and bottom edges. There is ample "breathing space" inside this case, since its overall size is somewhat in excess of that actually required as a minimum. The reader is free to exercise considerable latitude in dimensioning his own unit, since the placement of parts is not at all critical, and the components of the instrument do not occupy a great deal of volume.

The binding post terminals for meter input and for the external load resis-
tor (when the latter is employed) are arranged along the top left edge of the panel. These posts are mounted with shoulder-type fiber washers so that their terminal screws are insulated from the panel through which they pass. The tube socket is mounted on the panel by means of 1½" long 6-32 screws which support the socket away from the panel. Batteries are held to the case (chassis) by means of spring-brass clips which the writer formed from scrap stock. Here again, the reader may exercise his own ingenuity in mounting these components. Leads were soldered directly to the battery terminals, since the low current drain of the instrument makes it possible to operate for long periods of time without changing batteries and any quick-change scheme was deemed unnecessary.

The on-off toggle switch is mounted directly below the two controls, seen along the center line of the front panel in the photograph. The left-hand control is the meter zero adjustment rheostat R4. The right-hand control is the single-pole, three-position rotary wattage range switch S1.

If carbon resistors are used in the R1, R2, and R3 positions, they may

<table>
<thead>
<tr>
<th>Chart I</th>
<th>Voltage Calibration (S1 in 2-volt position)</th>
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</thead>
<tbody>
<tr>
<td>Microamperes</td>
<td>Volts (RMS)</td>
</tr>
<tr>
<td>500</td>
<td>2.0</td>
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<td>465</td>
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<td>130</td>
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<td>100</td>
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<tr>
<td>50</td>
<td>0.35</td>
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<td>22</td>
<td>0.20</td>
</tr>
<tr>
<td>10</td>
<td>0.10</td>
</tr>
</tbody>
</table>
be connected directly between the terminals of S1. If volume control type rheostats are employed, they may be mounted on a narrow subpanel which may be supported from the front panel by means of long screws. All wiring is cabled, since no trouble with circuit interaction, feedback, etc., is experienced at the frequencies at which the instrument is operated.

After the instrument has been completely assembled and wired and the wiring has been checked, the calibration may be carried out in the following manner:

1. Turn on the on-off switch S2. The meter M will immediately be deflected and will read somewhere along its scale. It is not likely that it will be found standing at zero with the current switched on. However, if there is no movement of the pointer, slowly rotate R4, watching the pointer which should be moved up or down the scale depending upon the direction in which R4 is rotated. Allow the instrument to heat up for two minutes before proceeding with the rest of the operations.

2. Bring the meter pointer to zero by adjusting the zero-set control R4 either to the right or left.

3. Provide a variable source of a.c. voltage at any convenient frequency. This will generally be a 60-cycle voltage obtained by means of a potentiometer or variac.

4. Connect the range switch S1 to the 2-volt position, adjust the variable-voltage source to zero and connect the latter to the input binding posts T1 and T2.

5. Connect a reliable a.c. voltmeter (with several ranges) also to the input terminals designated on the diagram as T1 and T2.

6. Adjust the voltage source, bringing the voltage up until the monitoring a.c. voltmeter shows that a voltage of 2 is applied to the input terminals. This voltage will cause a full-scale deflection of the microammeter.

7. Drop the input voltage successively to voltages lower than 2 v., obtaining numerous calibration points along the meter scale. Compare the readings obtained with the sample values given in Chart I. The two should not show a great difference.

8. After the 2-volt scale calibration is completed, turn range switch S1 to the 6.32-v. position and bring up the input voltage to 6.32.

9. This voltage should produce a full-scale meter deflection. If it does not, the resistors must be adjusted until the deflection is exactly full-scale.

10. Next, set S1 to the 20-volt tap and bring up the input voltage to 20. If full-scale deflection is not obtained in this case, it is likely that only R3 need be adjusted slightly until full-scale deflection is obtained.

<table>
<thead>
<tr>
<th>Chart II</th>
<th>Wattage Levels Corresponding to Voltage Calibration (Assuming 1-ohm Load)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMS Volts</td>
<td>RMS Watts</td>
</tr>
<tr>
<td>0.1</td>
<td>0.01</td>
</tr>
<tr>
<td>0.2</td>
<td>0.04</td>
</tr>
<tr>
<td>0.3</td>
<td>0.09</td>
</tr>
<tr>
<td>0.4</td>
<td>0.16</td>
</tr>
<tr>
<td>0.5</td>
<td>0.25</td>
</tr>
<tr>
<td>0.6</td>
<td>0.36</td>
</tr>
<tr>
<td>0.7</td>
<td>0.49</td>
</tr>
<tr>
<td>0.707</td>
<td>0.50</td>
</tr>
<tr>
<td>0.8</td>
<td>0.64</td>
</tr>
<tr>
<td>0.86</td>
<td>0.75</td>
</tr>
<tr>
<td>0.9</td>
<td>0.81</td>
</tr>
<tr>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>1.1</td>
<td>1.21</td>
</tr>
<tr>
<td>1.11</td>
<td>1.25</td>
</tr>
<tr>
<td>1.2</td>
<td>1.44</td>
</tr>
<tr>
<td>1.22</td>
<td>1.50</td>
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<tr>
<td>1.3</td>
<td>1.69</td>
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<tr>
<td>1.32</td>
<td>1.75</td>
</tr>
<tr>
<td>1.4</td>
<td>1.96</td>
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<tr>
<td>1.41</td>
<td>2.00</td>
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<tr>
<td>1.5</td>
<td>2.25</td>
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<tr>
<td>1.58</td>
<td>2.50</td>
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<tr>
<td>1.6</td>
<td>2.56</td>
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<td>1.65</td>
<td>2.75</td>
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<td>1.73</td>
<td>3.00</td>
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<td>1.8</td>
<td>3.24</td>
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<tr>
<td>1.87</td>
<td>3.50</td>
</tr>
<tr>
<td>1.9</td>
<td>3.61</td>
</tr>
<tr>
<td>2.0</td>
<td>4.00</td>
</tr>
</tbody>
</table>
11. Remove the indicating meter from the panel and remove the meter carefully from its case. Remove the microampere dial from the meter and make a new dial by tracing around the old one on thin white Bristol board with a sharp pencil. Mark off a new scale on the card and transfer the various voltage positions corresponding to wattage values (see Chart 11) to this new scale.

12. When a sufficient number of wattage points have been inked-in and marked, replace the meter in its case and re-install on the front panel.

**Application**

The wattmeter described in the foregoing is intended for measuring power levels across known values of impedance or resistance. When the power source under test is not equipped with a normal load device, however, a load resistor of the proper ohmage and wattage is connected to the special terminals designated as T3 and T4.

When measuring power across a known load, connect heavy leads from the two ends of the load device (such as a transformer, voice coil, or line) to the input terminals T1 and T2. Energize the power source (such as an amplifier) either by switching it on to produce power output or (as with an amplifier) exciting it with a signal from an oscillator. The wattmeter will be deflected. If the deflection is greater than full-scale, set the range switch S1 to the next highest position. (Standard practice is to start measurements at the highest range and to progress to the lower ones for greater readability, in order to prevent damage to the indicating meter.) Read the power level directly on the scale of the wattmeter.

The direct-reading scale applies only to power levels developed in a 1-ohm load. For all other load values, the meter readings must be divided by a suitable factor. If, for example, the load resistance is 1,000 ohms, mentally divide the meter readings by one-thousand (or multiply by 0.001). If the load impedance is 100, divide by one hundred (or multiply by 0.01). If the load impedance is 30 ohms, divide by thirty (or multiply by 0.3), etc., etc.

**THE RADIO TRADING POST**

*(Continued from page 6)*

**SERVICEMEN—TUBE DEALERS** — Tubes available. Many odd types can be used as alternates for hard to get types. Example—20 types will replace 12SA7, 12SQ7, 12SK7, 35L6, 35Z5. No set, socket wiring changes. List of nearly 100 alternate types used in our shop and how to use them sent postpaid for 75c. C. E.anniger, Gowrie, Iowa.


**FOR SALE OR SWAP**—1 WE output trans. for PP 211Es, tubes 1 WE 282B, 5 WE 231D, 3 WE 275A, 2 WE 211E. 4 Centralab PA Delta T pads 50 ohm; 3 RCA magnetic phono heads; 1 6v to 180 30 ma genemotor, 1 6v to 225v 50 ma genemotor, various Weston and Jewell meters, 6v pot units for trumpets. H. H. Harrison, 300 37th St., Sacramento, Calif.

**TRADE**—5 vol. ICS Reference Library in Industrial Management, in very good condition, for Radio Course, radio books or testing equipment or what? R. A. Lorani, Sr., RFD 1, New Kensington, Pa.

**WANTED**—RCA Radiola Model 17 condenser block, test equipment VOM and oscillator, will consider any make. State price and make, all mail answered. John J. Puzio, Radio Service, 1250 Franklin St., Taylor, Pa.

**WANTED**—Tube tester, signal generator, or comb. tube and set tester. For sale or trade. 15 in. jig saw, very good, earphones, tubes new and used, used vol. controls, speakers, chokes. Philco 5 tube and 47 Majestic radios. Joyce Saxton's Radio Shop, Rt. 1, Pontiac, Illinois.

**WANTED**—Rider's manuals 7 to 13, Rider chanalyst; Jr. voltohmist meter, Precision E 200 series 900 tester, state price. Joseph Trahan, 45 Dyer St., Danielson, Conn.
WANTED — Univex Mercury camera 35mm, 3.5 lens, 1500 sec. speed and flash gun unit, leather carrying case, exposure indicator, red filter, 5 flash bulbs, like new. $35 or good radio instrument. George Lang, 32 W. Garrison St., Bethlehem, Pa.

FOR SALE — 2 used power trans. for 5V, 24V, 1/2V tubes, $1.00 each; 2 used 6V generator, good cond., $1.00 each; 4 prs. 6 in. longnose pliers (new) $2.25 each; 3 1/2 in. heavy duty dynamic speakers, no trans., $10 to $15 each. Any of above shipped FOB on receipt of price. M. A. Porter, 1713 Larrabee St., Chicago, Ill.

WILL SWAP — Five 5.5x17 tires and tubes four almost new, for a good two or 3 in. oscilloscope, or a good short wave commercial receiver, or what have you. Joseph Bucca, 1371 W. 13th St., Brooklyn, N. Y.

WANTED — Hallicrafters S-22R or similar for cash or will trade Hallicrafters S-20 as part payment. M. J. Dodge, New Windsor, Md.

SOLD OR SWAP — A good supply of bakelite local sockets which take 4-prong UX base tubes. Will swap for any standard bakelite or wafer sockets, or other radio parts. Norbert Rulde, Holdingford, Minn.

TRADE — For late tube tester and oscillator. Speckers ac-dc dynamic and magnetic-dry, disc; rectifiers, headphones, elec. phono motor and pickup, transformers, radio generators, many used parts. All letters answered. D. Ingersoll, 1741 Lysander, Detroit, Mich.

FOR SALE OR TRADE — 1 Confidence tube tester with modernization panel; 1 Triplett Lab. complete (175 kc osc.); 1 Briggs-Stratton 1 hp motor, model FH.; 1 Remington repeating rifle, model 12A, with special Marble front sight (like new). Will trade rifle for multimeter or condenser tester. Clifford D. Lessig, Frenchtown, New Jersey.

WANTED — Illuminated window sign, either RADIO or RADIO SERVICE. Will pay cash or what do you want in trade. Also want new or used tubes in good condition. Byron Radio Shop, Byron, Illinois.

SELL OR TRADE — 140 pairs Chicago roller skates, perfect condition. Have complete outfit ready to roll. Excellent opportunity for right party. Want radio equipment and parts. Need Channelist or Voltamist, also good microphone. W. S. Frank, Route 3, Box 2, Chippewa Falls, Wis.

WANTED — Stancor power pack model 131 or 132 for cash, also signal generator. Robey's Radio Service, Waldorf, Md.

WANTED — General Electric house radio, Model A-82, A-87 or E-126, state price and condition. P. J. Rumbol, 46 N. High St., Greenville, Penna.

FOR SALE — Presto Recorder, new, complete with cutter, headfed screw mechanism, playback amplifier and pickup. $475.00. H. S. Walker, 5433 Victoria Ave., Montreal, Que.

SOLD OR SWAP — Weston 547 analyzer, RCA code course with code machine, Wilcox Gay phono record player, National SW-3 complete, 4 sets B.S. coils. WANTED — All wave osc. output meter. William Quigley, 102 Ave. S. Brooklyn, N. Y.

SOLD OR SWAP — Emerson electric fn. 12 inch, oscillating, 110 volt direct current. Want small radios, tubes, or what have you to offer? Byron Radio Shop, Byron, Illinois.


WANTED — Used 16mm sound projector, with or without amplifier and speakers. Have good used tubes, 35Z5, 35L6, 12SK7 80, 6K7, 6F6, etc., all set tested, to trade or will pay cash. Have odd type new tubes, 2A5, 2A7, 2A7, 12A5, 37, 38, 2A4, 6B7 to sell or swap, what have you? Boulevard Radio Shop, 3120 Taylor Blvd., Louisville, Ky.

WANTED — AC-DC B.C. and short-wave table-model radios; also test oscillator or signal generator, radio parts, used Rider Manuals. Adolph C. Roncallo, 253 West 45th St., Seattle, Washington.

WANTED — Rider's manuals 1, 2, 3, 4, must be in good condition. State price. Sullivan's Radio Service, 930 West 1st St., Duluth, Minnesota.

FOR SALE OR TRADE — Radio and electrical course. Will sell for $20. Must pay own shipping charges. Sullivan's Radio Service, 930 West 1st St., Duluth, Minn.

WANTED — AC-dc multimeter similar to Model 446A of Radio City Products Co. make in A-1 condition (no junk). State make, condition and lowest cash price. Fred Prince, Box 305, Normandy, Tenn.

FOR SALE — RME-69 communication receiver, condition new, in original carton, including Lamb noise silencer, i.f. crystal filter, ear tuned i.f. with 8 in. P.M. speaker in metal cabinet to match RME-69. $189.50 complete. L. J. Schneider, 610 Monroe Ave., River Forest, Illinois.

WANTED — Weight wind clock works for grandfather clock. Wyckoff Radio Shop, Lincoln, N. C.

SELL — Airport traffic control frequency crystal, 278 kc Biley BC3A in holder, never used, cost $20. make offer. W9ARN, Bartonville, Ill.

WANTED — Superior dynamometer or any ac operated VOM, also need condenser analyzer such as Jackson, also power supply, converter from 110 ac to 32 volt dc. Dearth Radio Service, Augusta, Ohio.


WANTED — Cash or trade, RME, DM30XA or DM36A, Abbott TR 4 or Mrt 3, National One Ten, Browning Converter, S29 Sky Traveller.

FOR SALE — 2 Biley Xials new sealed in type B5, frequency 7212 and 7224. Also 150 and 75 mtr xials and holders. V. Howerdell, 102 Hancock Ave., Jersey City, N. J.

WANTED — A Model 95 Aerovox LC checker, a Precision signal generator or other make of a good VTM condenser tester for cash. Roger E. Keon, Union St., P. O. Box 317, Mantua, N. J.

WANTED — Precision E-200 signal generator, must be in A-1 condition. Will pay cash. Describe condition, serial number, date of purchase and price desired in first letter. J. Lipiner, 1032 Rutland Road, Brooklyn, New York.

SWAP — For a 2 1/4 x 3 1/4 speed Graflex and equipment or Leica, etc., for my Howard 435A receiver, A-1 condition and brand new 1943 Motor Repair Library, armature winding clearly detailed. Also Winchester 24-12 gauge shot gun, like new. Kates, Woodridge, N. Y.


WANTED — Signal generator, Hickok. 188x, 188, 177x, oscillograph RFO 4 or 5, electronic multimeter RCP 662 or other. The Radio Mtn., 1724 Central Ave., Middletown, Ohio.

WANTED — Latest tube tester, Hickok, Weston, Supreme, or Precision, also signal generator of same make in A-1 shape. Have For Sale 7 tubes and 1800 Gernsback (comb.) $3; very good 15 in. jig saw $8; Superior tube tester 1240, $8; new and used tubes, new and used parts, 4 t. Majestic radio. $6. Royce Saxton's Radio Shop, R. I., Pontiac, Illinois.

FOR SALE — One Readrite Model 432-A tube tester, like new, $15. New self-vulcanizing tire reiners, 600x16, 5.50x 17, $2.95 or will trade for radios. Auto and Appliance Supply, Main at Newton Sts., Granby, Mo.

FOR SALE — Give Offer — All these radios are clean and in playing condition 1 Majestic 70 chassis power pack and speaker; 3 Majestic 90 chassis power packs and speakers; 2 Majestic 90B and speakers; 1 Majestic 130 and speaker, 1 Majestic 160 super and speaker; 2 Majestic 300 chassis only; 2 Brunswick 9 tube supers and speakers. Catalog no. 17; 1 AC-DC 5 tube sup, no speaker; 1 Temple chassis and power pack; 1 Kolster Brandes chassis, model no. B15. L. A. Goldstone, 1279 Sheridan Ave., Bronx, 56, New York.

WANTED — Solar capacitor exameter. Sprague el-o-mike, Solar capacitor bridge model CB, CC, QBK, QBC, Cornell-Dubilier BF-50 or BN, Aerovox LC checker. Any of these for cash or trade. State condition and lowest price wanted. Anthony, Pusateri, 1101 Fleming St., Coraopolis, Pa.


WANTED — Used oscillator in real good condition. State make, model, serial number and price. George Cannova, 41-15 Union St., Flushing, N. Y.

FOR SALE — Best offer. Several radios in good playing condition, such as Brunswick, Temple, Fada, Kolster, etc. Write for list. L. A. Goldstone, 1279 Sheridan Ave., Bronx, 56, New York.


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