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PRACTICAL DESIGN OF METER SHUNTS AND MULTIPLIERS

The basis of the multimeter employed in radio and electrical trouble shooting is the simple movable-coil (d'Arsonval) milliammeter or microammeter. Since this current meter has a characteristic resistance, which is the resistance of its internal movement, it essentially is a d. c. millivoltmeter, although its scales are graduated in current units. The voltage required for full-scale deflection is equal to the internal resistance (R_m) of the meter multiplied by the full-scale current value (I). Thus, the familiar 0-1 d. c. milliammeter employed in many radio circuits has an internal resistance (in most models) of 105 ohms and a full-scale current deflection of 0.001 ampere. It accordingly is a 105-millivolt meter, since $IR_m = 0.001(105) = 0.105$ v. $= 105$ mv. If the reader keeps in mind the fact that the basic current meter essentially is a d. c. millivoltmeter, he will be aided toward a clearer understanding of the behavior of multiplier and shunt resistors in multimeter circuits.

The basic current meter cannot safely handle an applied voltage which is higher than its full-scale millivoltage rating. 1 volt, for example, is 9.5 times the 105-millivolt full-scale deflection of the 0-1 d. c. milliammeter and will damage the meter if applied directly to its terminals. The meter can be adapted to give full-scale deflection at 1 volt, however, by connecting a properly proportioned multiplier resistor in series. The multiplier serves to introduce a voltage drop equal to the applied voltage minus the basic full-scale voltage deflection of the meter. In the case of the 0-1 milliammeter (0.105 volt full-scale deflection) used as a 0-1 voltmeter, the required voltage drop across the multiplier resistance would have to be equal to 1-0.105, or 0.895 v. This arrangement splits the applied 1 volt into 0.895 volt across the multiplier resistor and the remaining 0.105 v. across the meter. Similarly; if 100 volts were applied to the circuit, the multiplier resistor would have to introduce a voltage drop of 99.895 volts in order that the safe full-scale value of 0.105 volt would be applied to the meter. The basic d. c. voltmeter circuit, consisting of a current meter in series with a multiplier resistor, is shown in Figure 1.

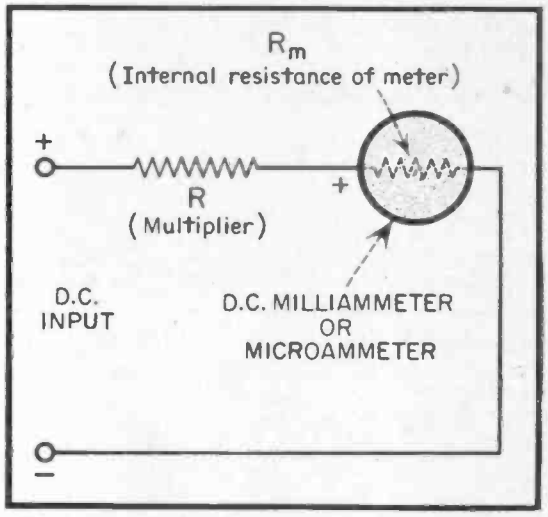

Fig. 1. Basic d. c. voltmeter circuit.

When current values higher than the full-scale deflection of the basic milliammeter or microammeter are to be measured, the meter again is used as a millivoltmeter. But this time the voltage drop across a resistor carrying the current of interest is measured. The resistance value is so selected that the maximum voltage drop produced will be equal to the full-scale millivoltage deflection of the basic meter. The range of the 0-1 milliammeter may be increased to 0-10 milliamperes, for example, by connecting the meter in

parallel with a resistor so chosen in value that 10 milliamperes flowing through the latter produce a voltage drop of 105 millivolts. Because of the connection of the current carrying resistor in parallel with the meter,

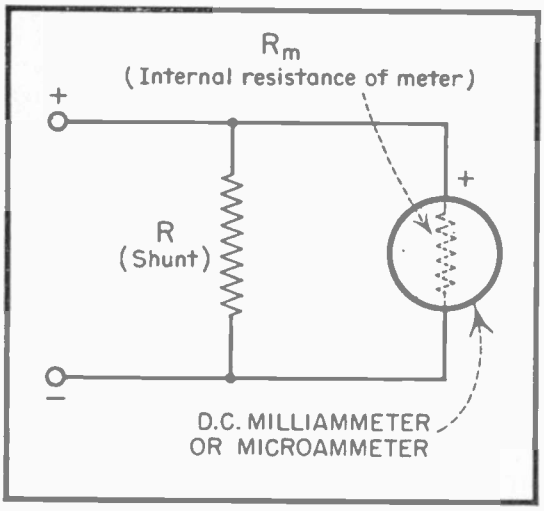

Fig. 2. Current meter with shunt to increase range.

this type of meter resistor is termed a shunt. The basic increased-range direct current meter circuit is shown in Figure 2.

The radio technician also has adopted the following practical concepts of meter resistor operation: That the voltmeter multiplier serves to reduce the maximum current set up by an applied voltage to the maximum full-scale current deflection of the indicating meter. And that the current meter shunt acts as a parallel bypass path to divert the extra milliamperes, microamperes, or amperes around the meter.

The three preceding paragraphs explain the basic functions of all meter multipliers and shunts. By proper choice of these resistors, a milliammeter or microammeter may be adapted to measure any desired current and voltage values in excess of the basic range of the indicating meter. By switching multiplier or shunt resistors of suitable values into the circuit, a multi-range instrument may be obtained. The calculation of the required resistance values for multipliers and shunts is a special application of Ohm's Law.

The experienced technician regards multiplier and shunt calculation and application as elementary. The less seasoned worker, however, finds scattered information on this subject, as located in several textbooks at his disposal, somewhat less direct and practical than he desires. Letters to the Editors indicate a present demand for a practical treatment in one article of meter resistor calculation.

Internal Meter Resistance

Before discussing the calculation of meter resistors, it is essential to point out the importance of internal meter resistance (R_m). This characteristic is of concern since it influences the value of any external resistor used to extend the meter range.

As its name implies, meter resistance is the actual internal resistance of the basic current meter. In almost all cases, this is the resistance of the meter movement itself, although in some few instances a small series fixed resistor may be installed inside the meter for purposes of standardization.

The meter manufacturer specifies the R_m value for each type and range of d. c. microammeter, milliammeter, and ammeter catalogued. But if these figures are not available, the reader may measure the meter resistance by the method explained in the following paragraph. Never undertake to check a sensitive d. c. meter with an ohmmeter, since the meter under test is apt to be damaged by the ohmmeter battery.

The simple circuit for checking the internal resistance of a d. c. milliammeter or microammeter is shown in Figure 3. The meter under test is connected in series with a 1½-volt dry cell and a calibrated variable resistor, such as a decade box, which can be read to the nearest ohm. Starting with the highest resistance setting (to prevent damage to the meter), reduce the resistance carefully until

the meter is deflected exactly to one-half of its full-scale reading. Record this setting (in ohms) as R_2. Then, reduce the resistance setting further until the meter is deflected exactly to its full-scale reading. Record this resistance setting (in ohms) as R_1. The internal resistance of the meter may be calculated thus: $R_m = R_2 - 2R$. This system of measurement is based upon the fact that the external resistance would have to be doubled in order to halve the current indicated by the meter if the meter resistance were zero. But since the meter has an internal resistance which is in series with the external variable resistor, the resistance setting for half-scale deflection falls short of twice the full-scale value by a number of ohms equal to the internal resistance.

By using a decade box as the variable resistor, each resistance setting can be read closely. The calculated value accordingly may be determined to the nearest ohm. If a decade box

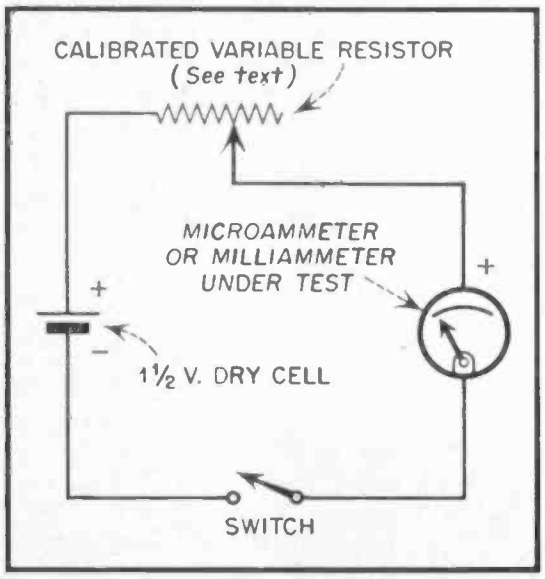

Fig. 3. Circuit for checking meter resistance.

is not available, somewhat less accuracy will be obtained by substituting a wirewound rheostat as the variable resistor. After each setting, one lead of the rheostat must be disconnected carefully from the calibration circuit and the resistance setting measured with a resistance bridge or good ohmmeter to obtain the R_1 and R_2 values for calculation.

If R_m values are obtained from manufacturer's tables, the reader must consult the literature of the builder of the particular meter in question. It must not be assumed that the instrument has the same resistance as one of the same current range described in some other manufacturer's data.

Voltmeter Multipliers

Referring to Figure 1, the required value of a multiplier resistor to convert a d. c. microammeter or milliammeter into a d. c. voltmeter of desired range may be determined by means of the equation:

$$(1) \quad R = (E/I) - R_m$$

Where R is the required multiplier resistance (ohms)

E, the desired full-scale voltage deflection (volts)

I, the present full-scale current deflection of the meter (amperes)

R_m, the internal resistance of the meter (ohms)

Example. What value of multiplier resistance will be required to convert a 0-1 d. c. milliammeter (internal resistance of 105 ohms) to a 0-2 d. c. voltmeter? Here; $E = 2$, $I = 0.001$, and $R_m = 105$. $R = (2/0.001) - 105 = 2000 - 105 = 1895$ ohms.

From Equation (1), it is seen that the value R_m determines the minimum full-scale voltage range of the meter. With the meter given in the illustrative example, the full-scale deflection (I multiplied by R_m) equals 0.105 volt when $R = 0$ (the condition when there is no external multiplier). It would be impossible, therefore, to provide a 0.05-volt range for this meter, since the internal resistance of the meter would have to be 50 ohms.

The internal resistance R_m may be neglected in Equation (1) without materially affecting the accuracy of the voltmeter whenever E/I is greater than

100 times R_m. **Example:** Determine the multiplier needed to convert a 0-100 d. c. microammeter (R_m = 2500 ohms) to a 0-1000 d. c. voltmeter. R = (1000/0.0001) — 2500 = 10,000,000 — 2500 = 9.997,500 ohms. This is a rather odd value of resistance to obtain, and since E/I in this case is 4000 times R_m, R_m may be neglected in the calculation and the even E/I value of 10 megohms taken as the required multiplier resistance. The 10-megohm value gives approx. ¼ volt increase in meter deflection at the 1000-volt full-scale reading, a difference much too small to be seen on this scale.

Voltmeter Input Characteristic

It is desirable to keep the total resistance of a voltmeter as high as possible, in order to reduce to a minimum the amount of current drawn by the instrument from a circuit under test. If the voltmeter resistance is not several times higher than that of the voltage source, indications of the instrument will be in considerable error.

The most satisfactory voltmeters employ low-range microammeters, so as to use the highest possible values of multiplier resistance. The standard method of specifying the input characteristic of a voltmeter is in terms of the amount of multiplier resistance for each 1 volt of deflection, or so many ohms per volt. This rating may be determined by dividing the multiplier resistance value (in ohms) by the full-scale voltage deflection provided by the multiplier. Thus; a 10,000-ohm multiplier with a 0-1 milliammeter provides a 0-10-volt range at 1000 ohms per volt, while a 200,000-ohm multiplier with a 0-50 microammeter provides the same 0-10-volt range at 20,000 ohms per volt. In the latter case, use of a sensitive microammeter results in a voltmeter 20 times more effective with respect to reduction of circuit loading and increase of accuracy of measurement than the milliammeter instrument. The ohms-per-volt rating remains constant throughout each voltage range, being the same for small voltage deflections as at full scale.

Extending Range of Complete Voltmeter

It often is necessary to extend the range of a voltmeter already built up. The amount of additional multiplier resistance required may be determined by means of the equation:

$$(2) \quad R = (NCE) - CE$$

Where R is the required additional multiplier resistance (ohms) to be connected

C, the ohms-per-volt rating of the voltmeter

E, the full-scale reading (volts) of the meter range which is to be multiplied.

N, the number by which the present full-scale current reading of the meter is to be multiplied.

Example. There is available a 0-1000-volt d. c. voltmeter which is rated at 20,000 ohms per volt. This meter is to be converted into a 0-10,000-volt instrument for measurement of television receiver high potentials. What value of additional resistance will be needed? Here; N = 10, C = 20,000, and E = 1000. Using Equation (2), R = (10 x 20,000 x 1000) — (20,000 x 1000) = (200,000,000) — (20,000,-000) = 180,000,000 ohms = 180 megohms.

Current Meter Shunts

Referring to Figure 2, the required value of a shunt resistor to increase the range of a d. c. microammeter or milliammeter may be determined by means of the equation:

$$(3) \quad R = R_m/(N-1)$$

Where R is the required shunt resistance (ohms)

R_m, the internal resistance of the meter (ohms)

Example. What value of shunt resistance will be required to convert a 0-1 d. c. milliammeter (R_m of 105 ohms) to a 0-500 d. c. milliammeter? Here; the original 1-milliampere deflection of the meter is to be multi-

plied by 500, so N = 500, and R_m = 105. Using Equation (3), R = 105/(500-1) = 105/499 = 0.210 ohm.

Since shunt resistors have low resistance with respect to the internal

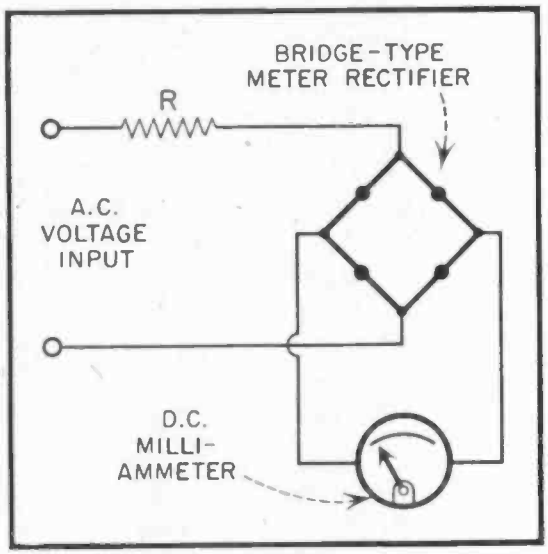

Fig. 4. Bridge-rectifier a. c. voltmeter.

resistance of the meter with which they are used, they must be mounted as close as practicable to the meter terminals and must be connected to the latter by means of heavy, short leads to avoid extraneous resistance. When shunts are switched into the circuit in a multirange instrument, the selector switch must have tight-engaging, heavy contacts, in order to reduce resistance from this source.

While it is desirable to keep the total input resistance of a voltmeter as high as possible, the opposite is true of the current meter. A microammeter, milliammeter, or ammeter must have as low input resistance as possible, otherwise the instrument will introduce an objectionable voltage drop in the circuit into which it is inserted.

The more sensitive (lower-range) current meters have the higher interval resistance values. Before undertaking measurements with such instruments the technician must determine if the instrument resistance may be inserted into the circuit under test without upsetting circuit operation.

The A. C. Voltmeter

Figures 4 and 5 show simple rectifier-type a. c. voltmeter circuits. It will be noted that the only point of difference between these circuits and those of d. c. voltmeters is the inclusion of a rectifier to drive the basic d. c. milliammeter.

In Figure 4, a full-wave rectifier is employed. While the common meter rectifier usually is of the copper oxide type, each of the four arms of the bridge might also be diode tube sections, germanium crystal diodes, or special subminiature selenium units.

In Figure 5, half-wave rectification is employed. When the upper a. c. input terminal goes positive; current flows in the direction of the solid arrows through multiplier resistor R, rectifier diode $RECT_1$, and the milliammeter which is deflected up-scale. When the lower a. c. input teminal is positive; a small current ordinarily would flow through the meter and $RECT_1$, causing a small down-scale deflection of the meter. This current would be small because rectifier $RECT_1$ now presents its cathode to the posi-

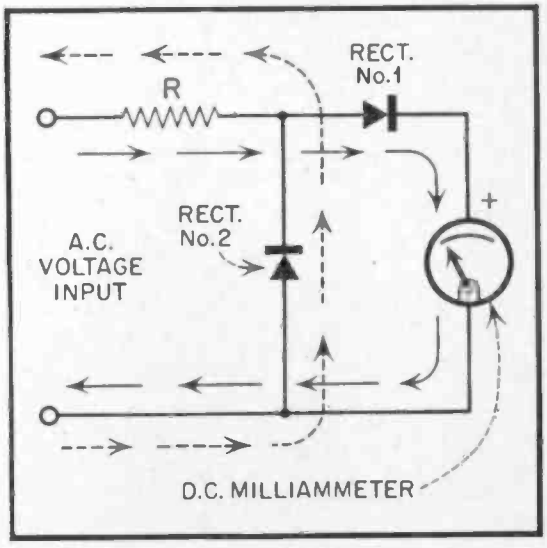

Fig. 5. Half-wave-rectifier a. c. voltmeter.

tive potential and accordingly is back-connected and appears as a high resistance. Passage of this reverse current through the meter is prevented by rectifier diode $RECT_2$ which is con-

nected so that its anode is presented to the positive potential. $RECT_2$ thus appears as a low resistance, and current is detoured around the meter circuit in the direction indicated by the dotted arrows.

In rectifier circuits of the type shown here, the milliammeter deflection is proportional to the average value of the applied alternating voltage. The deflection therefore is somewhat less (usually about 10 per cent lower) than it would be for the same value of applied direct current. For this reason, multiplier R must be higher than would be required in a d. c. voltmeter circuit. The actual value of the multiplier depends upon individual characteristics of both the rectifier and milliammeter. There is no simple and foolproof method which we can recommend for calculating the required value of a multiplier for the rectifier-type a. c. voltmeter. The best practical scheme is to connect a calibrated variable resistor, such as a decade box, in the multiplier position, apply the desired full-scale a. c. input voltage to the a. c. input terminals, and adjust the resistor for full-scale deflection of the milliammeter. A multiplier then may be made up, using fixed resistors having a total resistance corresponding to the setting of the test resistor. If a decade box is not available, a wirewound rheostat may be used. After the proper setting has been made, the rheostat must be removed from the circuit and its resistance setting measured with a good resistance bridge or ohmmeter.

A special a. c. voltage scale must be provided for the milliammeter, since response of the circuit is not linear. The non-linearity of the rectifier increases at low voltages, requiring that a separate scale be prepared for full-scale deflections such as 1, 2, 2.5, and 5 volts. A 10-volt scale will serve also for 100 and 1000 volts, a 20-volt scale for 250 and 2500 volts, etc., etc.

Specifications of Meter Resistors

Voltmeter Multipliers. Highest accuracy and best long-term stability will be obtained with wirewound resistors. When odd multiplier resistor values are required, they may be made up by connecting in series several resistors having values which total the required multiplier value.

Precision wirewound resistors, designed for instrument applications, are available with accuracies of 1, ½, and 1/10 per cent. These components are non-inductive, possess a good temperature - resistance coefficient, and should be used whenever possible.

Current Meter Shunts. The low-resistance units required as current shunts ordinarily are not as readily available as manufactured items as are multiplier resistors. We refer, of course, to the shunts required for milliammeters in radio-electronic test gear. In general, shunts must be made by the technician.

Manganin wire should be employed, since this material has an excellent temperature-resistance coefficient not possessed by some of the other resistance wire alloys.

The wire may be cut to the proper length to give a desired resistance value, as determined by measurements with a d. c. resistance bridge. The shunt is completed by winding the wire on an insulating bobbin or card or, if the wire is short enough, simply coiling it without a supporting form and soldering its ends to terminals.

Final adjustment of the shunt must be made with this resistor connected to the meter. A standard current meter, of known accuracy, may be used for calibration. For this reason, it is advisable to make the shunt with a little more than the calculated value of resistance. The excess resistance, as determined by calibration of the completed instrument, then may be pruned away by clipping off a fraction of an inch of the resistance wire at a time.

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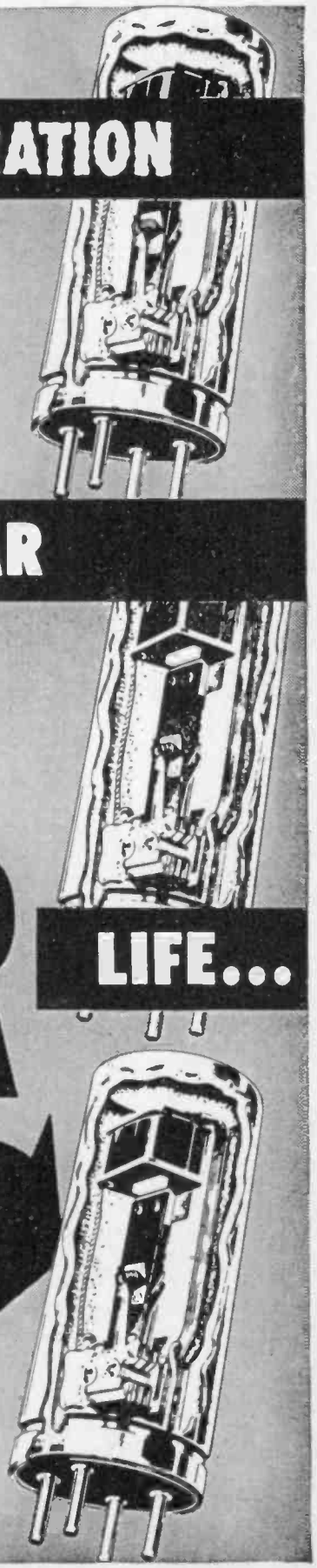

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All ads are published in the order received, but those held over two issues are discarded. Every effort will be made to include your ad either in the issue being prepared or the succeeding number, but will be automatically dropped thereafter.

"MANY" THANKS

Both our organization and myself take this opportunity to thank our many friends and readers for the nice Christmas greetings with messages of appreciation of the helpfulness and service our little publication, The C-D Capacitor, has been to them. Cards of all varieties from servicemen, radio amateurs, engineers, students and radio tradesmen came from those in Brooklyn to Bombay extending greetings this holiday season. Many, many thanks.

Cordially yours,
William G. Many, Editor,
The C-D Capacitor.

FOR SALE—General Industries recorder-playback, single play, complete with 12 watt amplifier in carrying case, $30. Tuck Radio Service, Point of Rocks, Md.

FOR SALE—Riders Vols 14 and 15; ATR 6 volt Adjust-A-Volt. Best offer. Joe Hopkins, Osage, Ia.

FOR SALE—Vomax 900 multimeter; Weston 777 tube checker; Precision 200 sig. tracer; Crystaliner sig. gen., all A-1. Also tubes and load of misc. parts. All for $125 cash. J. Dougherty, 38 Chestnut St., Hicksville, N. Y.

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TRADE—HQ129-X, matching speaker, manual, and set spare tubes, perfect condition. Want 12" TV set same condition. Also need 10 meter mobile converter and PE103, will trade or buy. Paul Vick, Bradford, Illinois.

FOR SALE—BC412 oscilloscope, completely converted from standard conversion blueprint, print included. Scope will not be shipped. Without tubes, $25 — with tubes, $30. Also Dumont No. 168 5" scope, $25. William Henshaw, 46 Front St., Tarrytown, N. Y.

FOR SALE—Beam rotator, consisting of gear box, motor and selsyn indicators, $10; 1,000 volt plate power supply, $10. Must be picked up, will not ship. P. J. Faulkner, 136-05 Sanford Avenue, Flushing, L. I., N. Y.

FOR SALE OR TRADE—4 x 5 enlarger; electronic timer; Weston photo analyzer (densitometer); other photo equipment. Want outboard motor or communications receiver. J. R. Floyd, 4300 Rusk, Houston 3, Texas.

FOR SALE—Model 05 Heath-Kit scope with Superior five-way binding posts, $60. All radio and test equip. kits assembled reasonabe. Custom knobs, binding posts, etc., available. Jack Lisowski, 213 South Tenth, Virginia, Minnesota.

FOR SALE—Feiler TS-3 sig. tracer, $25; Knight a.c.-d.c. ivory table model radio, 6D-225, $15. Want cabinet for Globe model 454 three-way portable radio. Henry J. Richards, 6716 So. Parnell Ave., Chicago 21, Ill.

SELL OR TRADE—Hickok model 610 universal television alignment sig. gen., excellent, $100 cash. Or trade for RCA 630TS TV receiver. Mellott's Radio Sales-Service, 6419 Cherry Ave., Long Beach 5, Calif.

WANTED—An AM-FM crystal controlled sig. gen., Simpson, Triplett, or Hickok. Give model number, length of time used, exact condition, and lowest cash price. Mercury Radio Service, 439 South Wabash Ave., Chicago 16, Ill.

FOR SALE—Television cabinet (for table model 10" Fada TTV30 or 799 chassis) fits RCA 630 type chassis. Excellent, walnut, make offer. Raymond Conover, Stone Ridge, N. Y.

FOR SALE—Television for Radiomen by Edward M. Noll, $4. Les Hague, 2804 - 33rd Ave., Astoria, L. I. C. 6, N. Y.

WANTED—7.0 to 7.3 mc crystals and holders for cash. State manufacturer, pin spacing, price, etc. Frank Michaelson, 32 Washington Ave., Coxsackie, N. Y.

FOR SALE—Hickok model 203 volt, ohm, capacity milleammeter, $75; 2 Vomax model 900, $25. In excellent condition. Phil Maggio, 718 Eagle St., Utica, N. Y.

FOR SALE—10" television set built from a Telekit, with all tubes but less cabinet, in good working condition. Oil-filled magnifier for above set, in good condition. Best Offer. P. A. Uricchio, 116 Franklin Ave., Hartford 6, Conn.

WANTED—General Radio, Boonton, Ferris, other top-quality equipment, particularly for 100-6,000 mc. region; also 707B, 703A tubes, other special-purpose types, maggies, klystrons. Cash or trade. Describe, price, in first letter. Littell, Farhills Box 26, Dayton 9, Ohio.

SALE OR SWAP—All nine transformers from BC-610-E and three chokes L1, all in good condition. Will sell or swap for Lysco model 600, Hunter Band-It 20B, or newer model Meissner signal shifter. R. O. Schramm, Route 2, Portland, Ind.

FOR SALE—Instructograph code practice machine, spring motor, complete set of (wire) tapes, instruction book, and Signal-Electric telegraph set M-110. In excellent condition, $25. George Luellman, 300 Milledge Circle, Athens, Georgia.

FOR SALE—Gardiner automatic code tape sender with 20 code practice lessons. 3 months old. A $24 value for $15. $3 down, balance C.O.D. D. Ridgley, 1345 Porlier St., Green Bay, Wis.

WANTED—Technical Manual (not diagram) on BC-788 and I-152 altimeter and indicator, and APN-4 Loran. Very urgently needed. Will pay cash. S. Balsera, Jr., 25 - 1004 Vedado, Havana, Cuba.

FOR SALE—Eico 5" Oscilloscope, model 425K, and sweep generator, in original packing, good condition, $85 for both. A. Sersam, 222 E. 27 St., New York 16, N. Y.

FOR SALE—Hammarlund HQ 129-X, $140; Meissner signal shifter, $50; original Vibroplex Bug, $10. All perfect cond., f.o.b. Bob Childress, 1205 Chamberlain Ave., Chattanooga, Tennessee.

FOR SALE—Riders Vols. abridged 1 and 5 and 9 through 17. $163.50 worth of books for $125 if sold together. M. W. Nelson, Co. Q (Queen) STR, Ft. Monmouth, N. J.

FOR SALE—Precision multitester No. 830, and 6 volt "A" bat. eliminator, $12 ea.; vac. tube V.M. with 500 microammeter, a.c.-d.c., $8; Supreme Autom. Lab., No. 385, good cond., $35. Will trade all for Supreme 504B. W. F. Onder, R 1, Box 330, Arnold, Mo.

WANTED—Rider's Manuals, vol. 1 to date. Advise on volumes you have and price. James E. Kilroy, 924 Stock St., Pittsburgh 7, Pa.

FOR SALE—RCA 5TP4 projection tube in good condition. A bargain, $9. H. Bergh, 1583 E. 96th St., Brooklyn 36, N. Y.

FOR SALE—Hickok signal generator, model 288X; Rider Manuals vols. 8, 10, 11, 12, 13. Both excellent cond., Best offer. Herbert Dregalla, 915 Spring Rd., Cleveland 9, Ohio.

FOR SALE—Back copies QST, excellent condition. 1943 - 44 - 46 complete, 45 except April, also 42 June and Dec. only, 47 Jan. and Feb. E. E. Ross, 446 Ross Ave., Pittsburgh 21, Pa.

FOR SALE OR SWAP—Photoelectric light sensitive cells, high output, sealed in plastic housing. Want soldering gun, radio servicing diagrams, books, multitester, equipment, tubes. R. Howard, 410 Central Park West, N. Y. C. 25, N. Y.

WANTED—A 5" or 7" TV set. Willing to pay a reasonable price. Phil Kantrowitz, 203 East 174 St., Bronx 57, N. Y. C.

FOR SALE—Hammarlund 4-20 transmitter and modulator 80, 40, 20 and 10 meter coils with built in VFO. Will ship prepaid. Price, $90. Edward A. Spacek, 311 East 70 St., New York 21, N. Y.

FOR SALE OR TRADE—ART-13 (very good); BC779-B (beat up shape); K.W. power supply and final parts; TCS-11 and dynamotor; BC344-D (excellent). Will trade for garden tractor. B. Armstrong, 18425 4th S. W., Seattle, Wash.

FOR SALE—Vomax VTVM, excellent cond., only $35. William Harsh, 2001 Parker St., Berkeley 4, California.

FOR SALE—Sylvania tube tester; Meissner Anaylst; Jackson sig. gen.; Sprage Tel-O-Mike. All complete, in excellent cond., $190, or will sell separate. John Allen, 2820 Louisiana, Longview, Wash.

WANTED—BC222 heterodyne freq. meter in perfect order, complete with calibration book. Must be reasonably priced. William H. Smith, 115 Eastern Ave., Bellmore, L. I., N. Y.

FOR SALE—Simpson 479 TV-FM sweep generator, very good cond.; vol 14 and vol. 2 Riders TV. Best offer, cash only. C. Osiecki, 65 Vine St., Ansonia, Conn.

WANTED—Rider's Manuals, 11, 16, 17, 19, and 20. State vol. No., price, and cond. J. O. Basham, Altamont, Covington, Va.

FOR SALE—S40A Hallicrafters, perfect condition, with or without panel mounted S meter, phono input jack, and external speaker jack. Best offer over $60 f.o.b. R. E. Franklin, 239 East Fourth Ave., Roselle, N. J.

FOR SALE—HT-17 transmitter (Hallicrafter) with all coils, never been used, $35; S41-G receiver, good condition, $22. Louis De Meo, 113 University Pl., N. Y.

FOR SALE—Rider Manuals, vols. 8 to 17 inclusive, in excellent condition, about one year old, used very little. Will take considerably less than cost, make offer. H. F. Albee, 377 Ingleside Ave., Dayton 4, Ohio.

WANTED—Gonset 3-30 converter. Good VOM. G. Thompson, 830 Kains Ave., San Bruno, Calif.

FOR SALE—Fourteen volumes Riders Manuals, 1 to 14 inclusive, with index. Condition good to excellent. $90 f.o.b. Chauncey Coston, Rt. 3, Box 25, Hoquiam, Wash.

FOR SALE OR TRADE—Cameras for new condition television service equipment. Also have radios, transmitters, scopes, etc. K. H. Stelle, 3619 W. 102nd St., Inglewood, Calif.

TRADE OR SELL—Japanese voltmeter, very sensitive, 6" meter, in well constructed case. Want used television set or S-38 receiver. Paul M. Jenks, Jr., 317 N. Nelson, Pampa, Texas.

WANTED—Code practice machine, with or without tapes. Will pay cash. State type, condition, price. L. H. Kephart, 214 W. Lincoln St., Tucson, Arizona.

FOR SALE—Eico scope, 5", model 400, perfect condition, $35. Evancich Radio and TV, 9528 Commercial Ave., Chicago 17, Ill.

WANTED—300 or 500 watt gas generator. Vernon Blaine, Gary, S. D.

FOR SALE—Wilcox Gay portable professional recorder, used less than 2 hours. Sacrificing for $100 for a quick sale. Perfect condition. Howard R. Klauer, 639 N. Central Park Ave., Chicago 24, Illinois.

WANTED—Portable a.c. and d.c. radio. Also target gun. A. E. Levriett, Box 3542, Sta. F, Jacksonville, Fla.

WANTED—Rider vols. 15 and 18. State price. Southend Radio Service, 2346 South Washington, Wichita 9, Kansas.

FOR SALE—General Industries single play recorder play-back, complete with 12 watt amplifier, carrying case, used little, excellent condition, $30. Tuck Radio Service, Point of Rocks, Md.

FOR SALE OR TRADE—8mm projector and camera, imported Jap and German field glasses, tubes, and other assorted radio stuff. Want used TV receiver in good condition. D. B. Hoffman, 960 E. 12th St., Brooklyn 30, N. Y.

FOR SALE—NRI tester (VTVM) batt. operated, manual included. Needs 45V batt., $5 plus express or postage. H. G. Cooling, 428 Formwalt S. W., Atlanta, Ga.

SELL OR TRADE—7" TV set (works poorly), and Mark II set converted to a.c. (excellent condition). Want cash or firearms. P. H. Trautwein, 40-25 206 St., Bayside, N. Y.

FOR SALE—Presto K-8 professional type recorder, crystal mike, several blanks, $200, or best offer. Gerard J. Ward, 12608 Watterson Ave., Cleveland 5, Ohio.

FOR SALE OR TRADE—American made 32 cal. revolver, includes ammunition and holster, perfect condition. Want tube checker with roll chart or AM sig. gen. L. D. Wilder, 826 St. Charles, New Orleans, La.

FOR SALE—Precision 844-P volt-ohm-milliammeter, 34 ranges a.c.-d.c., in hardwood portable case with instructions, batteries, standard test leads and HV test leads, excellent, $24. Seymour Sinuk, 1366 Clay Ave., New York 56, N. Y.

WANTED—RCA battery VoltOhmyst, model WX-65A, in complete operating condition, with test leads. Will pay reasonable cash, or have Hickok 1000 ohm/volt multimeter with 4½" face as partial trade. George F. Steeg, 118 Saratoga Ave., Waterford, N. Y.

FOR SALE—Well stocked radio shop. Rent $40 per month with heat, mgr. passed away, sell for $1,500 cash. Harry's Radio Shop, 7019 Indiana Ave., Cleveland 5, Ohio.

WANTED—Rider Manuals vols. 15-19 inclusive, in good condition. State price. Black Radio Service, 1000 So. 10th, Burlington, Iowa.

FOR SALE—Copy of Nilson and Hornung "Practical Radio Communication," perfect condition, $5. Leon Medler, 2109 Daly Ave., Bronx 60, N. Y.

WANTED—BC624 (SCR 522) converted for 2 meters or otherwise. State price and details. Have excellent Webster 78 rpm changer if exchange is wanted. George W. Harrold, 1907 So. Park Ave., Haddon Heights, N. J.

WANTED—Precision E-400 TV sig. gen. Also Sams Photo-facts 51 to 90 State condition and price. Elmer E. Ash, 431 N. Milwaukee St., Port Washington, Wis.

FOR SALE—McMurdo - Silver receiver 802 in good condition, all tubes, all coils, 80 to 6 meters, $22. H. I. Griffiths, 39-82 65 Place, Woodside, L. I., N. Y.

WANTED—Sig. gen., tube tester, VOM, at reasonable price. John Beechan, Box 97, Cairnbrook, Pa.

FOR SALE—Amplifier, 18 watt output, Stancor transformers, highest quality parts throughout, $22.50 prepaid. V. R. Hein, 418 Gregory, Rockford, Ill.

FOR SALE—Meissner FM receptor, model 9-1047A, 8 tubes, 41.2 - 50.4 MC, perfect condition. Also Weller dual heat soldering gun, 135 watt-100 watt, very good. J. Lipiner, 1032 Rutland Road, Brooklyn 12, N. Y.

FOR SALE—NC-173, excellent cond. with matching speaker, $130. Will deliver in Boston and vicinity. S. Swetzoff, 149 Intervale St., Boston 21, Mass.

SWAP—Deluxe Blue Racer Vibroplex bug in carrying case for used Pilot FM tuner in good condition. R. T. Beck, 1305 Jefferson, Racine, Wis.

FOR SALE OR TRADE—Hallicrafters S20R in very good condition. Make an offer, or what have you to trade? Carl F. Pietschner, 1045 Mary's Dr., Wichita 12, Kansas.

FOR SALE—RCA Rider Chanalyst, excellent condition, $85. Also Rider Manuals in A-1 condition at $10 ea. Carrs TV Center, 15-17 Kelley Square, Worcester 4, Mass.

FOR SALE—Brush BK-401 tape recorder, top condition, new motor, 5 new tubes, $100. Brush and Scotch brand tapes with operas, etc., $2 ea. H. Heller, 12326 Fairport Ave., Cleveland 8, Ohio.

WANTED—Set of instructions for Hickok signal generator model No. 15 and Hickok volt - ohm - milliammeter model 202B. Jennings Radio Service, 230 Washington Ave., Covington, Va.

FOR SALE—R.C.P. model 450A portable mult. meter, $20; Astatic JT-30 crystal mike, $6; Kingston battery charger 6V, $6; Burgess electric sprayer, $5. All in excellent condition. Lewis Mascara, 197 McKay Ave., Huntington Station, L. I., N. Y.

WANTED—2 meter transmitter and receiver complete, prefer SCR522. State condition, description, and price. Edmund Bedat, 1601 E. Cheltenham Ave., Phila. 24, Pa.

WANTED—Amateur mobile equip. Trans. and receiver converters. Also vibrator or Dynamotor power supply. Interested in good equipment. E. Harris, 5815 N. Wayne Ave., Chicago 40, Illinois.

WANTED—Two walkie talkies, used or new, or similar equipment. Specify freq. Ryan's Radio and TV, 15 Lincoln Ave., Havertown, Pa.

FOR SALE—Meissner 8C FM tuner and cabinet, excellent, $25; Webster 56 changer with base, $10; RCA 20W hi. fi. amplifier, $25. R. C. Spangler, Marietta, Pa.

WANTED—Will buy transmitting, special-purpose and receiving type tubes. Will swap. B. N. Gensler, 136 Iiberty St., New York 6, N. Y.

FOR SALE—Hallicrafter 36A, $100; SCR 522 rec. and trans. with tubes, $20. Peter Dal Corobbo, 10441 Corliss Ave., Pullman 8836, Chicago 28, Ill.

TRADE—BC-348-Q, converted tq a.c. Want press type camera, Graphic preferred. Elvin L. Holley, Box 336, Vaughn, New Mexico.

FOR SALE—Very good National "57," with new separate "S" unit. Also G. E. electric unimeter radio clock. Frank E. Wooley, Apt. 22G, 415 Union Ave., Irvington, New Jersey.

FOR SALE—RME-45 receiver and BC-375-E Transmitter with units and dynamotor. Equipment in good condition. H. Straccio, 569 N. Main St., Mansfield, Mass.

TRADE—G.E. 110V d.c. input rotary converter to two phase 80v or single phase 115V a.c. Want condenser analyzer or what have you? Richard Schneider, 192 Willoughby Ave., Brooklyn 5, N. Y.

TRADE—Excellent Heath signal tracer for Pilot FM tuner in very good condition. J. W. Landon, Wayne, W. Va.

FOR SALE OR TRADE—Kodak 35, RF, f3.5 coated lens, Weston Master II, flash unit, carrying cases, etc. Want high grade test equipment. Al B. Werhan, Box 142, Manlius, N. Y.

WANTED—7EP4 C.R. tube. Must be in good condition. Brace Radio, 32-09 44 St., L. I. C. 3, N. Y.

SELL OR TRADE—Silver condenser tester model 904, $35; Philco Junior scope model 7019, $35. Or will trade one instrument for a solar Exam-Eter CF-1-60. Arthur Wood, 93 Ralph Ave., Brooklyn 21, N. Y.

FOR SALE—Tubes and ballasts from 1.4V to 117V, list $44.95, entire lot prepaid, $12.50; 6 tube underdash auto set, $12.50; Astatic xtal mike, $6.50; Everything plus odd lot parts prepaid, $30. Ellis Radio Service, 421 Grand St.; Vermilion, Ohio.

FOR SALE—Excellent Revere tape recorder, $125. Also excellent Gonset 10-11 meter converter, $27.50. Milton Kalashian, 2 Congress St., Newburyport, Mass.

FOR SALE OR TRADE—Wilcox Gay home recorder, has phono, radio PA system, plus mike, originally $175, case shop-worn. Also 16mm movie camera, $10, and projector, $25. J. Madden, 412 Columbus Ave., Tuckahoe 7, N. Y.

FOR SALE—Precision E-200 C sig. gen., $55; Rider Manual 15, $12; Ghirardi Radio Servicing, Audels Radioman's Guide, Supreme Radio Diagrams 1926-38, three books, $8. All items near perfect. John H. Schaeppner, 615 East 7th St., Brooklyn 18, N. Y.

FOR SALE—NC-57 in A-1 condition, $65. James L. Tift, 577 So. Beech St., Manchester, N. H.

FOR SALE OR TRADE—Good disc recording and playback unit; Remington typewriter; sig. gen.; CREI radio engineering course; tube tester; many other items. E. G. Bartlett, Box 86, Atlanta, Missouri.

FOR SALE—Model 576 Supreme sig. gen.; Triplett model 2413 tube tester; 45 asst. condensers, 35 asst. tubes; other small articles; going out of business, $85 James H. Barker, Mt. Holly, N. C.

WANTED—TV set in working condition. Have NRI tracer, Heath VTVM, Basic Scope kit, CRT Voltage supply, and draftsmen's tools. Carl Moore, Jr., 432 Lookout St., Warren, Pa.

WANTED TO BUY—BC348, BC312, BC788, BC794, CW-3, SCR522, F-3, APS13, Super-Pro receiver, ARC-3. Please state quantity, condition and price. Alfred Livingstone, 12-01 Ellis Ave., Fair Lawn, N. J.

FOR SALE—National short wave three with three sets of coils and power pack. Also have radio parts, books on drawing, painting, record changer with motor, jig saw, etc. John Haynes, Doe Run, Mo.

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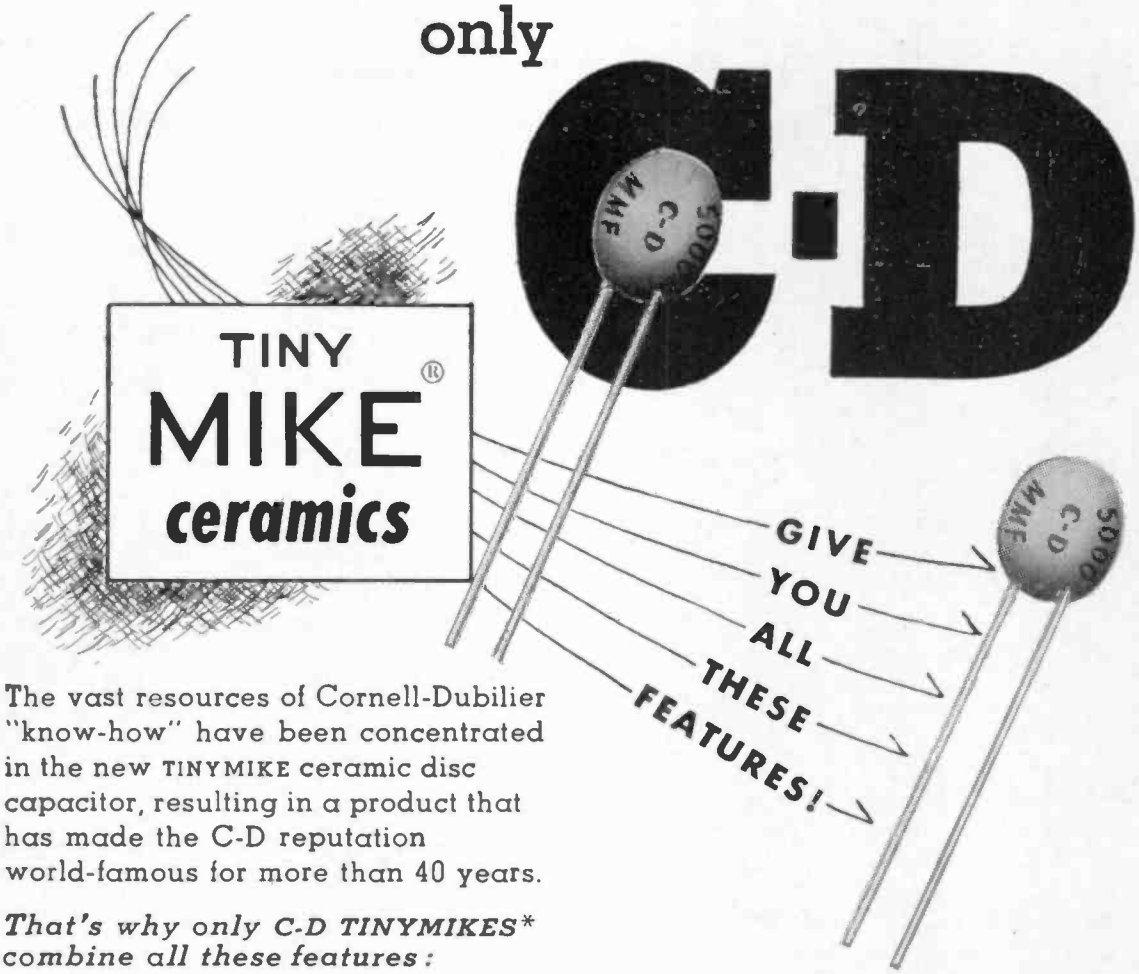

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