DEC. 1937

RADIO WORLD

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The Latest News

★ ★ ★ ★ ★

RECORD FOR TOP QUALITY AT MEDIUM PRICE MADE BY

MARION ULTRA FINE METERS

FIRST ANNOUNCEMENT OF NEW METER LINE

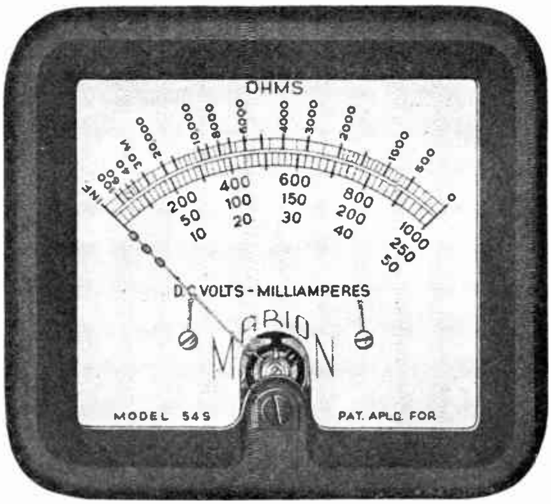
HERE is a new line of meters of vast importance to servicemen and experimenters because top quality is obtainable for the first time at medium cost.

Marion meters, made in all ranges in both medium and large-sized cases, are the result of the best engineering knowledge, the best tools, the best materials and the best workmanship. *Built Like a Fine Watch.*

Made in more than 86 standard ranges of d-c instruments, at sensitivity from 100 microamperes up, they meet the exacting needs of critical users.

Representative meters in the large (Model 54S) and medium-sized (Model 53S) in Bakelite cases, as illustrated.

A representative meter shown at right in the Model 54-S case, for volt-ohm-milliammeter service. Actual size is more than twice that shown.



A representative meter in the Model 54S case. With suitable shunts, multipliers and 4.5-volt battery (not supplied), this instrument is a volt-ohm-milliammeter of seven basic ranges: 0/50/250/1,000 volts-milliamperes; 0/100,000 ohms. Voltages at 1,000 ohms per volt. Actual size of meter is more than twice that shown above. Net price to dealers...................... **$4.86**

The above uses 0/1 Ma. It is obtainable with 0/1 scale, if preferred.

0/100 microampere movement, V-O-MA or standard scale for 54S, is priced to dealers @ $8.16

SPECIFICATIONS OF 54S

1. Accuracy 2%, maintained indefinitely.
2. Dead beat (pointer comes quickly to rest at deflection).
3. Dust-proof, Moulded Bakelite case.
4. Hairline pointer.
5. Same reading obtains at any and all positions of meter.
6. Extremely high overloads inflict no injury.
7. Readable even in a moderately dark room, due to large clear scales and high visibility pointer.
8. Magnets of best grade and fully aged.
9. Pivots run in genuine sapphire bearings.
10. Overall dimensions, 4⅝" x 4-3/16". Barrel diameter, 2 45/64". Barrel depth, 1".

Same specifications apply to the medium-sized instruments, case illustrated at left, except for the physical dimensions, as follows:

Model 53S, 3½" square overall; barrel depth, 1⅜".
Model 53R, 3-27/64" diameter overall; barrel depth, 1⅜".

Model 53S affords choice of same service and accuracy as the large-sized meters. 0-1 milliamperes, $3.90; 0-100 microamperes, $7.20.
Prices are Net to Dealers.

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MARION ELECTRICAL INSTRUMENT CO.

MANCHESTER, NEW HAMPSHIRE

PRECISION SLIDE RULE *FREE*

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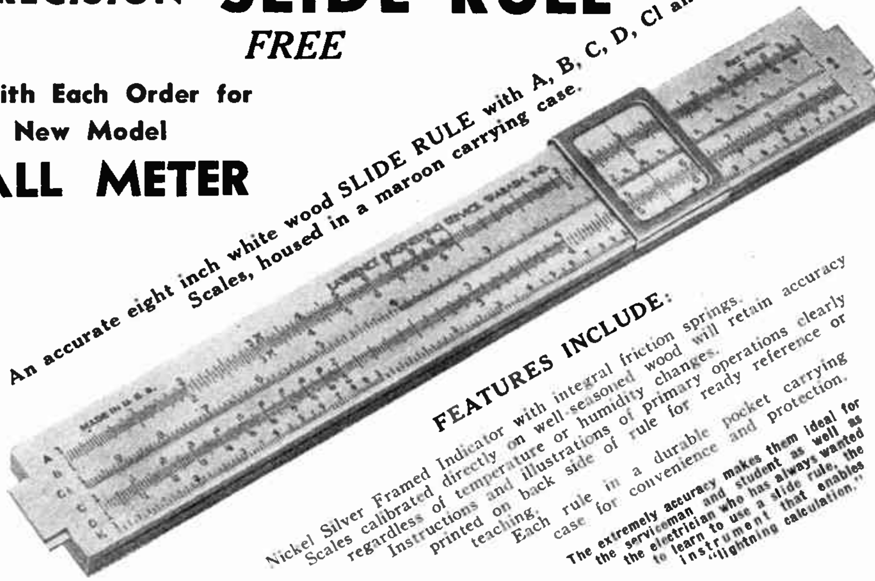
ALL METER



An accurate eight inch white wood SLIDE RULE with A, B, C, D, Cl and K Scales, housed in a maroon carrying case.

FEATURES INCLUDE:

Nickel Silver Framed Indicator with integral friction springs. Scales calibrated directly on well-seasoned wood will retain accuracy regardless of temperature or humidity changes. Instructions and illustrations of primary operations clearly printed on back side of rule for ready reference or teaching. Each rule in a durable pocket carrying case for convenience and protection.

The extremely accuracy makes them ideal for the serviceman and student as well as the electrician who has always wanted to learn to use a slide rule, the instrument that enables "lightning calculation."

NEW ALLMETER

Adds 6 Instruments, No Extra Cost to You, Bringing Total Services to... **27**

The Allmeter. 27 instruments in one. 1,000 ohms per volt, 90-120 v. AC-DC operation.

0-15 Volts A.C.
0-150 Volts A.C.
0-750 Volts A.C.
0-15 Volts D.C.
0-150 Volts D.C.
0-750 Volts D.C.
0-15 Milliamperes A.C.
0-150 Milliamperes A.C.
0-750 Milliamperes A.C.
0-1 Milliampere D.C.
0-15 Milliamperes D.C.
0-150 Milliamperes D.C.
0-750 Miliamperes D.C.
Continuity Tester
.01-50 Mfd.
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500-500,000 Ohms
—12 to +10 Decibels
+8 to +30 Decibels
By Interpolation
+28 to +50 Decibels
By Interpolation
Inductance,
5-1,000 Henries
V.T.V.M., 0-15 Volts A.C.
V.T.V.M., 0-150 Volts A.C.
V.T.V.M., 0-750 Volts A.C.
V.T.V.M., 0-15 Volts D.C.
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Table of Contents for DECEMBER, 1937

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KDKA'S 718-Ft. Antenna

New Structure Weighs 60 Tons—50 Miles of Buried Ground Wire Used

Steel riggers about to start their daily climb to the top of KDKA's vertical antenna during the course of its construction. Now completed, it is 710 feet high and weighs 60 tons.

KDKA's new antenna system will give primary broadcasting service over an area ten times greater than that previously provided, and with strong, clear radio signals from the world's pioneer station of the Westinghouse Electric and Manufacturing Company.

Principal elements of the improved radiating facilities are the main antenna, a steel spire towering 718 feet high, and a circle of eight 90 feet antennas designed to suppress interfering waves normally emitted in radio transmitting.

Vertical antennas of the type now installed at KDKA radiate both ground and sky waves. When these two waves meet in areas of varying distance from the station they interfere with each other to cause fading or mushy program reception. The ring of shorter towers also radiate sky waves but in opposite directions, to nullify the effect of the sky wave emitted from the main antenna. The fading zone is thus extended to great distances from the station and broadcast service vastly improved.

The new system vindicates an original antenna design by Dr. Frank Conrad, first tried in 1929, but considered unsatisfactory then because severe fading was experienced close to the station. By using the Conrad system as a suppressor ring for a standard antenna, the efficiencies he originally sought have been obtained and an interference problem solved.

RESTS ON BALL-SOCKET JOINT

So high that its top half is often obscured by clouds, KDKA's spire is composed of thirty-two three-cornered welded steel sections. Only five feet wide, these sections are bolted together. Two sets of long guy wires hold the antenna upright. The 60-ton structure rests in the ball-and-socket joint of a single large porcelain insulator, strong enough to support the weight of the steel plus about 20 tons additional load added by the pull of the guys. The main insulator, though only three feet high, has been tested to withstand loads of more than 100 tons. About half-way up the spire, three smaller sectionalizing insulators have been inserted to break the antenna, electrically, at a height of 336 feet. Insulators are also inserted in the guy wires to eliminate radiations from this source or the conducting of current to the ground.

Completely insulated from the ground, the steel spire becomes charged with static during storms, then crackles and sparks continuously. Such electrical phenomena has no effect on its broadcasting efficiency.

To improve the conductivity of the ground

Front Cover Illustration

Searchlights illuminate KDKA's new 718-foot antenna and the building housing the transmitting equipment for KDKA, station of the Westinghouse Electric & Manufacturing Company at Saxonburg, Pa.

Fifty miles of wire were buried around KDKA's new antenna to improve its radiating efficiency. The wire, laid in 700-foot lengths, radiates out, one degree apart, from the base of the tall antenna spire erected by Westinghouse engineers at Saxonburg, Pa., 20 miles from Pittsburgh. Pulled by a tractor, a plow dug shallow trenches into which the lengths of wire were laid about a foot below the surface.

around the antenna 50 miles of copper wire have been buried a foot under the surface, radiating out, one degree apart, for 700 feet. The vast efficient ground system so formed aids in reducing the effect of sky wave emissions.

An eight-wire radio frequency line sends the output of the transmitting station to a tuning house near the base of the antenna. From this point four power lines run up inside the spire carrying radio frequency and current for a brilliant aviation beacon at the tip as well as four riding lights installed along its sides.

In last month's issue an article described a noise-reducing system based on use of a long buried wire, whereby two grounds were used in effect, one the sual cold-water pipe ground, the other the buried wire. Antenna coil was returned to the conventional ground, buried-wire around to set chassis.

An Unusual Trouble Solved by Serviceman

A resident of a small rural community in the Middle West reported trouble with his battery-operated Philco. He bought a new battery and within ten days it ceased to function. Again he replaced the battery, but again the battery went dead.

A serviceman sent by the dealer to the man's home, tested the radio and found it up to standard. The new battery was produced and the serviceman told the owner to make the connections, as he had hooked up the other two batteries.

When the man started to attach a red cable where a green one should be placed, the mystery was cleared. The customer was colorblind and had been short-circuiting his batteries.

Third Edition Issued of "Experimental Radio"

The third edition of "Experimental Radio" by R. R. Ramsey, Professor of Physics, Indiana University, presents logically and coherently a manual of radio, composed of 128 experiments covering radio from "Testing Dry Cells" to "Television," and the more complex problems of radio.

For the beginner this is a valuable handbook on every phase of radio, written simply and accurately. The average experimenter finds in this book as much information as he requires, besides original experiments and helpful information on the construction of apparatus. To advanced engineers, "Experimental Radio" offers a valuable means of brushing up on some forgotten points.

Professor Ramsey has interestingly included material for those readers who have not had college physics, or who lack regular physical apparatus.

RIGHT OR WRONG?

PROPOSITIONS

1 The sensitivity of a vacuum-tube voltmeter depends on the lowness of the full-scale voltage, i.e., if the lowest range is 5 volts full-scale, then the meter is five times as sensitive as one having 25 volts as the lowest full-scale deflection.

2 When the mismatch of impedance consists of a high impedance working into a low one, assuming they should be equal for best results, the loss is less for the same ratio of mismatch than when a low impedance is working into a high one, where again they should be equal.

3 A single transmitter in a carrier call system may serve five different receivers, operating on different reception frequencies, without any molestation or adjustment of the transmitter, and five different messages may be sent and received on the five different sets, without crosstalk.

4 Meters are rated as to percentage accuracy, and this means that the percentage applies to each of the bars of the graduated scale, so that at any setting that causes the needle to indicate such a bar, the accuracy is as guaranteed.

5 High inductance may be measured by passing a.c. through it, and it is permissible to accept the current reading, which is a reflection of the impedance, as indicating the inductance, without regard to the d-c resistance of the coil.

6 A single-pole, double-throw switch is the same as a one-circuit, two-position switch, and a three-pole, three-position switch is the same as a triple-throw, triple-circuit switch.

7 D.c. may be measured more accurately than it may be computed, while a.c. may be computed more accurately than it may be measured.

ANSWERS

1 Wrong. While the term sensitivity has been loosely applied to tube voltmeters in terms of the lowest voltage for full-scale deflection, the proper viewpoint is that the sensitivity of the instrument, as of any other meter, depends on how small, if any, amount of current it draws, and is independent of the voltage readings on any scale. Thus for no-current-draw meters, the sensitivity is infinite.

2 Wrong. The example of the low impedance working into the high one illustrates the lesser loss, other considerations being as stated in the proposition.

3 Right. This is accomplished as follows: the transmitter operates on a fundamental, but being an oscillator, it generates harmonics, and if four harmonics are used, besides the fundamental, each of the five frequencies may be taken off separately, each separately modulated, and separately transmitted, along th same wire, and five receivers tuned to the fundamental and the four harmonics, respectively, will pick up the five different messages without crosstalk.

4 Wrong. The percentage accuracy applies to full-scale deflections only, and to no other setting. The accuracy at about four-fifths full-scale may be greater than that at full scale, while at low readings on the scale the accuracy may be much less than the full-scale accuracy.

5 Right. The d-c resistance, for inductances of 10 henries or more, using 60 cycles, enters only slightly into the determination of the impedance, which is the total opposition to current flow, and therefore the impedance may be permissibly construed as comprised wholly of the inductive reactance.

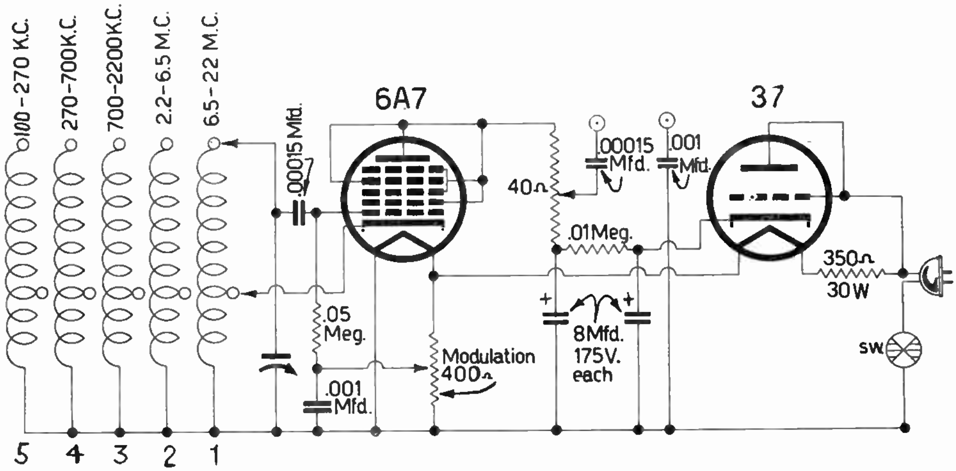
6 Right. The word "pole" is synonymous with "circuit" in the sense, and the word "throw" is synonymous with "position."

7 Right. The topic has debatable points, however. With a.c. so many factors may enter that accuracy of measurement is more difficult to attain than the results by computation.

Very High Accuracy

In a Very Simple Generator

By H. J. Bernard



About the simplest modulated-unmodulated generator that a fellow can build. Factors concerning accuracy, and adjustments for attaining frequency precision, are fully discussed in the text.

THE simple diagram of a signal generator may be used as the basis of an examination of the factors affecting the accuracy of the instrument.

First, a brief discussion of the circuit itself will pave the way to an understanding of the other considerations.

A 6A7 tube is used as the radio-frequency oscillator. Here r.f. refers to both the intermediate and higher frequencies.

An audio frequency is introduced for modulation, and consists of the frequency of the a-c line, usually 60 cycles. The advantage of introducing that audio frequency is that it affords the simplest method of obtaining a modulating source, and also the form is sine wave within the requirements of service practice.

APPLICATION OF SCALE

As for the radio frequencies, these are generated in the circuit consisting of the 6A7, the d-c supply voltage, and the coil-condenser system. The coils are commercial products, and consist of five to cover the bands of 100-270 kc, 270-700 kc, 700-2,200 kc, 2.2-6.5 mc and 6.5-22 mc. Moreover, the precalibrated scale applies only to a particular condenser. The assumption made by some not very well versed in radio that if the coils are "right" almost any condenser may be used, is entirely erroneous.

The outside of each winding of a universal (semi-honeycomb) coil goes to grid, the tap to cathode, and the remaining terminal to the line. For solenoids, larger winding is between grid and tap, with tap to cathode. Also, the tuning condenser rotor goes to the line, so if a metal chassis and box are used, insulating bushings must prevent d-c continuity between the chassis and the condenser rotor, coil returns, etc. This usually requires only that the condenser mounting be fully insulated from the chassis, because condenser frame goes to line, and chassis and metal cabinet are thus protected from the line. The object is to avoid shorting the line by external connections, e.g., grounding the cabinet. The two fixed condensers at the output binding posts are also preventives of short circuits in two directions.

The r-f oscillator is a Hartley, and the circuit is so arranged that there is automatic volume control. This is due to the grid-leak-condenser combination of .00015 mfd. and .05 meg (150 mmfd. and 50,000 ohms). The values are relatively small, and must be so, to avoid self-squealing and loss of selectivity, particularly at the high frequencies (6.5-22 mc).

THE OUTPUT CIRCUIT

All five coils are tuned by the variable denser, and thus the frequencies are produced. A switch, consisting of two circuits,

(Continued on following page)

(*Continued from preceding page*)
five positions, enables selection of the desired coil, while the tuning condenser remains unaltered, except for change of capacity by rotation of the moving plates, for all bands. That is, different coils are used, but the same condenser. This condenser, if of two sections in commercial practice, is used only for the larger section, from which the trimmer condenser must be removed, as the dial was calibrated that way. The scale, also, is a commercial product.

The output is in the plate circuit proper, from plate to B plus, through a low resistance, say 40 ohms. If this is a potentiometer, as in the diagram, and the connections are made as shown, you have provision for attenuation. That is, there is volume control of the output. So you have both automatic and manual volume control.

A word about the a.v.c. It has been said the leak-condenser in the oscillator provides this. The action arises from the charge put on the condenser during the peak of the positive cycle, and the discharge through the leak. This charge causes the grid to become positive, hence attract electrons from the cathode, at the instantaneous existence of the peak of the oscillation wave.

Immediately direct current flows through the grid leak, through which the electrons find their way back to cathode. However, the flow of the direct-current electrons is necessarily in one direction only, and the polarity is opposite to that which obtained when the a-c peak was present, i.e., the grid, after the peak has spent itself, is maintained negative, and while the grid condenser is discharging through the leak there is no current drawn from the oscillation voltage source.

HOW A.V.C. ARISES

Since the d.c. endures during the positive cycle at the value established by the peak, and is much slower in coming to rest, because the leak and condenser are chosen to establish the circuit that way, the d.c., after the peak, bucks the a.c. During the negative cycle the oscillator is inactive, or not functioning, because to the enduring d-c negative grid is added the negative value of a.c., and hardly enough plate current flows to permit oscillation. So the tube also behaves as a half-wave rectifier.

The higher the wave amplitude the more negative the grid, the relationship is nearly linear, and so we have a.v.c.

Only the a.c. is taken off at the plate circuit, however, and this is of sufficient magnitude to make the signal generator, simple though it is, practical for all ordinary service work.

AVOIDING OVERMODULATION

The 37 tube is used as a diode, because of grid connected to plate, to half-wave rectify the line a.c., while the .01 meg. resistor (10,000 ohms) and the two bypass filter condensers of 8 mfd. smooth out the hum from the pulsating d.c. in the rectifier output.

A line cord, 350 ohms, 30 watts, is used for reducing the line voltage, assumed at 117 volts, to the required voltage for the heaters, 6.3 volts each, evenly divided. Only tubes drawing .3 ampere heater current may be used, in conjunction with the specified line cord.

The line is switched on and off by SW.

Now there remains need for discussing only that part of the circuit theory applying to the modulation. By modulation is meant another frequency superimposed on the radio frequency. As already stated, that other frequency is the line frequency. Hence if the house line is d.c. there will be no modulation. If, instead of returning the .05 meg. grid leak directly to one side of the line, a resistor is placed across the 6A7 heater, and the leak return made to an arm sliding over this resistor, by moving the arm downward we introduce less and less of the 6.3 volts of the 6A7 heater into the grid circuit, until with arm at the line itself, we introduce none of the 60 cycle frequency. By moving the arm all the way up we introduce the full 6.3 volts. This may be too much, but if so, the arm is moved downward a bit. If too much there will be distortion, described as overmodulation, or modulation distortion, and anyway we desire only enough modulation to render the note plainly audible. That it will be even at a low setting of the 400-ohm control.

If for any reason it is desired to bring out the line frequency itself, this may be done by introducing two fixed Cornell-Dubilier paper condensers of .1 mfd. from one and the other sides of the same 6A7 heater. This conection is not shown and would normally require two extra binding posts. The 60-cycle supply then may be used as 60-cycle sweep alone for an oscillioscope, or for the timing axis (horizontal deflection) when the modulated r.f. is used for the amplitude input (vertical deflection). In either instance, the 60 cycle supply goes to the horizontal deflecting plates of the oscilloscope. Another feature is that the 60 cycles could be used for external synchronization of an oscilloscope.

MUST USE 6A7 OSCILLATOR

The foregoing describes the circuit theory. Questions that may arise concern the tube choices particularly. The 6A7 must be used as shown, with all elements except Grid No. 1, cathode and heater interconnected as effective plate, because the scale under discussion was prepared when the tube was connected that way, and any change in tube or its connections would defeat the accurate application of the scale.

The rectifier may be any heater tube of the 6.3-volt, .3 ampere type, even another 6A7, where cathode is positive of the B feed, and the interconnected other elements, save heater, form the effective anode, or plate.

Now, there is nothing very difficult about the circuit theory. But the performance has to be analyzed on the same basis as that of a much more complicated signal generator. Although this is one of the simplest ac-dc generators, with pure wave modulation, constructable at low cost, it has to subscribe to the laws of nature just as well as the most intricate oscillator.

WHAT ABOUT R-F LEAKAGE?

The output potentiometer is of low ohmage so that no setting of that control will have any appreciable effect on frequency. The output voltage is not as high as it would be, at least for output at the intermediate and broadcast frequencies, but that is a secondary consideration, as sufficient output is obtained, anyway. On short waves the oscillation is favored by this low resistance, so that the detouring effect of the tube output capacitance is not serious. However, it is always a problem in any very simple instrument to have the output control completely effective on high frequencies, and some loss of such control must be expected on 6.5-22 mc particularly.

Another consideration worthy of note is that there will be some energy fed through the line, as the expression is. That means really that the a-c cable acts as an antenna, and some radiation takes place for that reason not only into space, but along there is conduction along the wire, and into the lighting line. So oscillation voltage could be conceivably picked up by a receiver in some other part of the building, or farther away, provided the line is common to generator and receiver. In this instrument that trouble is not totally eliminated but it is not of the usual large magnitude.

FREQUENCY ACCURACY

There is a field of experimentation open along this line, so that the radiation resulting from antenna effect of the a-c cord, whether line limiting resistor is included or ballast tube, may be minimized still further, or prevented entirely. About the only solution applied in commercial products is to insert a filter in the line, perhaps augmented by two coils coupled in reverse, the theory being that any seepage will be neutralized in that way, by correct phase and voltage adjustment, entirely controlled by the angulation of two coils. This is a helpful method, but the author's experiments have not vindicated its complete effectiveness, not by a long shot. The theory is fine but the requirements of practice are severe and hard to meet.

We have considered the topics of output adjustment free of effect on the frequency generated, which is an important step forward; also leakage, which presents an enduring problem, and now we come to accuracy of frequency.

The calibration of the scale depends on the capacity and the rate of change of capacity. Therefore the calibration really reflects the behavior of the condenser as to capacity only. The fact that a coil is used causes the frequencies to be whatever they are, depending on an electrical formula, but since we are now aware that it is the condenser that controls the accuracy, and the coil is responsible, let us say, for the resultant frequencies with particular capacities used, we shall introduce a system of checking the condenser.

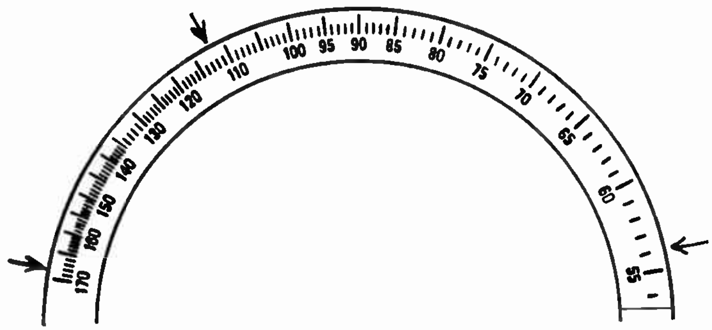
It is assumed that the calibration, although expressed in terms of frequencies, is absolutely accurate as to the capacity changes incurred, or that can be introduced by an adjustment. Although the present generator uses a tuning condenser from which trimmer is removed, if in some other device the trimmer is present, and there is a manual adjustment, this may be used, and the test to be set forth presently may be made for various settings of the trimmer until the right results accure.

TEST ON SINGLE COIL

Using therefore a coil that is somewhere reasonably related to the requirement, and that will mean also any commercial coil intended for the band on which the test is to be made, insert the coil in the oscillator, soldering connections, and select as tiedown points some frequency about two-thirds the highest frequency, and another frequency, in the same band, one-half the selected frequency. Suppose the test is being made on the 700-2,200 kc band (No. 3 coil switch

(Continued on following page)

Practical Example of Condenser—Checking



The system of establishing the right ratios in respect to the condenser, regardless of actual frequencies, is exemplified on a scale reading in broadcast channels. A frequency very near or at the low end is required as starter. An arrow denotes that as 56. The other arrows are for 2x5 = 112 and 3x56 = 168.

(*Continued from preceding page*)

position, reading from right to left on diagram, although on switch plate this would be reading from left to right). We may get a response at some frequency on a receiver, when generator reads around 1,400, and turn generator alone to 700 for next response. This is due to the second harmonic of the generator. We do not know the real frequencies, except very roughly, but we do know the harmonic orders, and the second may be heard around 1,400 kc on the receiver. Turn the generator, set now intact, to pick up a response in the reciver, now reading around 1,400 kc. We are not now concerned with frequency accuracy, but with ratios.

CORRECTION OF RATIO

Taking the fundamental of the generator as yielding a response in the receiver at around 700 kc, the second harmonic will be picked up when receiver is tuned to higher frequencies and the next consecutive response obtained. The generator when tuned to higher frequencies to renew the response will be at a capacity setting one-fourth that which obtained in the first instance. This is because frequency changes inversely according to the square root of the capacity ratio, so to double the frequency we must use a capacity one-fourth. The third setting is obtained by resetting the generator to the same frequency that produced around 700 kc fundamental, using receiver at around 700 kc, and tuning receiver to go past the next consecutive response and stop at the second next consecutive response, or, counting all responses, stopping at the third. Now the generator is tuned to produce the frequency fundamentally, also skipping the second response, and halting at the third. The capacity equals one-ninth of that present at the lowest-generator frequency (highest capacity) generator setting used.

The capacities are mentioned because they are at stake, although not known in absolute terms. We do know how the frequencies must change, due to the harmonics, i. e., the second harmonic is double the fundamental, or 1,400 kc, and the third harmonic is 2,100 kc. Now, no matter what the apparent frequencies are that one reads on the calibrated dial scale of the generator, the lowest frequency (assuming we read 700) must be doubled where the second response comes in, as we move the receiver to pick up the second harmonic of 700 kc, and then the first frequency must be trebled where the third response comes in.

DIRECTION OF CORRECTION

Suppose first read 710 kc. Suppose at the second harmonic the generator read 1,400 kc. Now we know the capacity change is inaccurate. Second reading should have been 1,420. Therefore the condenser had to be rotated farther than desired, hence there is too little capacity change to enable precise agreement, which means there is too much capacity in circuit. If the second reading were less than twice the original frequency, say, 1,380 kc on the generator, then more capacity would have to be added. This a trimmer would accomplish.

There is a little danger in connection with trimmers that they are set to produce a certain accuracy near the high-frequency end, in an attempt to compensate for inductance inaccuracy, and the result is inaccuracy at the low-frequency end. We are operating under a plan that sacrifices no accuracy.

Frequencies considerably removed from those mentioned may be read, and still our method prevails, for if receiver is at 600 kc and 650 kc is read for first (lowest frequency) generator fundamental, we still will look for 2 × 650 = 1,300 kc for the second point, and 3 × 650 = 1,950 kc for the third point. Thus we use three tiedown points.

WHAT TO DO NEXT

However, we have no trimmer, and there is another reason for omitting it, that a compression type trimmer might be used, as found on the condenser, and could not possibly be made to stay put under varying conditions of temperature and moisture, whereas the tuning condenser alone may be relied on fully.

So what can we do, now that we seem to have no control over a little discrepancy?

It so happens that most condensers have a midline tuning characteristic, and therefore it is important to set the condenser correctly in respect to the indicator and dial scale. Assume that 100 kc is the low-frequency end, set the condenser so that rotor plates are fully engaged, and lock the indicator to read 100 kc. Now at least we have a starting point. If our test shows that we do not register the three positions according to generator's first read frequency, then that frequency divided by 2, then that same first frequency divided by 3, we can unlock the setscrew of the condenser, shift the condenser a bit on the shaft, using a slightly different capacity ratio now by relocking the pointer, and try again until all three points come in where they should, judging by the proportion set forth on the dial scale, i. e., 1 × 1, 2 × 1 and 3 × 1. Simply multiply the first frequency you read on the generator scale, and the others should be made to come in on the generator scale by the multipliers stated, even though no actual frequencies are not read on the generator. *The frequencies need not be true, but their ratios must be true.*

If the shift of the condenser is made toward lower capacity then more angular displacement (more degrees of circle) are needed to encompass a given ratio, whereas if the condenser is shifted to higher capacity for the same generator scale reading, then smaller angular rotation (less rotation of the knob) is required, so from the foregoing you know in what direction to move to apply the remedy. Finally the ratios will come out exactly right.

GETTING INDUCTANCE CORRECT

After that much has been accomplished, all that is necessary is to select the right inductance, and the dial scale will be tracked superbly. A coil of practically the right inductance is assumed at hand, and in the commercial models if the inductance is wrong it is purposely made too high, because it is easier to take off turns (reduce inductance) than to put turns on (increase inductance).

However, you can decide for yourself whether the coil has too many or too few turns. Tune in a station of known frequency so that a response is obtained with generator set nearly at full capacity, never exactly at full capacity. For the band ending at the low-frequency end at 700 kc, say a station is selected at 750 kc. The dial of generator is turned and the reading is 760 kc on generator. Therefore the generator reads too high in frequency. *The rule is that if the generator frequency reads too high the inductance is too high and turns must be removed; if the generator reads too low in frequency the coil has too low inductance and turns must be added.* While the rule may seem at first blush to be contradictory, it really is absolutely correct, and it is perfectly safe for the reader to follow the rule just as laid down. Those doubting the rule may analyze the mathematical aspects at their leisure and must come to the same conclusion.

Somebody may be wondering what is the sense of making the inductance adjustment at the low-frequency end, when an adjustment made at the high-frequency end would yield a higher percentage of accuracy? The only answer that can be given by the author is that the ratio of tuning having been correctly established, the accuracy at any one point applies in theory to the other points, and besides we have taken a dial position not previously used, for low-frequency checking of inductance. Also, the adjustment is more handily made for low frequencies, the criticality not showing up so much due to stray effects from manipulation. Moreover doing the trick at the low-frequency end is a part of the regular procedure in the author's private laboratory, and the work has turned out very satisfactorily, more so than when the other end was used, probably because condensers are more nearly uniform at the selected tiedown point than at small capacity settings.

COILS FOR OTHER BANDS

Thus we have adjusted the circuit for capacity in one single, though somewhat protracted test, have gotten our tuning condenser right for one band and therefore right for all bands, and no longer need molest the condenser, but only adjust the inductances, using the same general procedure as outlined, except that for very small inductance coils, instead of removing turns to reduce inductance, the wire may be pushed away from coil center, to make the winding longer, or, to increase inductance, turns pressed longer, together, and when the coils check, then binder is put on them to make them stay put. This may be any good coil dope.

Not all problems of frequency accuracy have been solved. It is rightfully assumed distributed capacity is changed only trivially, if at all, by the small inductance changes necessary for coinciding the scale with the generated frequencies. Also it is assumed that the lowest frequency coil takes the longest leads and the highest frequency coil the shortest leads to the coil switch and back to the grid and cathode. Any considerable departure from this general apportionment of lead lengths inversely with frequency will introduce more distributed capacity than allowed for in the calibration, which is the result of actual experimental observations with precision equipment, with coils in circuit.

When all the work is done, much time may have been spent, but a fine generator, one unusually accurate, is the result.

Literature Wanted

Readers whose names and addresses are printed herewith desire trade literature on parts and apparatus for use in radio construction. Readers desiring their names and addresses listed should send their request on postcard or in letter to Literature Editor, Radio World, 145 West Forty-fifth Street, New York, N. Y.

Edward Jerome Webster, Jr., 1124 Eleventh Street, N.W., Apt. 40, Washington, D. C.
Charles A. Bloedorn, 1901 Leyden Street, Denver, Colo.
Roy Eads, Harrogate, Tenn.
Edward George, 707 N. Fulton Ave., Baltimore, Md.
A. Perrine, 6078 Selma Ave., Hollywood, Calif.
James W. Bercaw, 2423 Woodside Ave., Springfield, Ohio.
C. Findlay, 1770 Georgia Street, W., Vancouver, B.C., Canada.
Nelson M. Blackman, 3216 Hyde Park Ave., Cleveland Heights, Ohio.
Walter Owen, 1143 No. Gower St., Hollywood, Calif.
Super-Service Radio Shop, 6522 Grenshaw Blvd., Los Angeles, Calif.
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S. Lipschitz, 2942 W. 25th St., Brooklyn, N. Y.
Chas. E. Furman, Danbury, Nebr.
E. A. Phillips, Box 144, West Point, Miss.
Oliver Beaurau, 709 New Hampshire St., Lawrence, Kans.
John F. Gallagher, 707 Brunswick St., Fredericton, N. B., Canada.
A. E. Winkler, 1228 Lillie St., Ft. Wayne, Ind.
Harold Browne, Box 143, McCormick, S. C.
Joseph A. Intritola, 175 First Ave., Newark, N. J.
Chas. Sawatski, 2109 Bingham St., Chicago, Ill.
C. Stanley Johnson, c/o Southern Bell Tel. & Tel. Co., Birmingham, Ala.
John Kozar, 2508 Cedar Ave., Cleveland, Ohio.
C. Specht, 79 Dictum Court, Brooklyn, N. Y.
J. Monniax, 291 Eastern Parkway, Brooklyn, N. Y.
Frank Engstrom, Grey Eagle, Minn.
J. H. Simon, 71 Jane St., N Y.C.
E. C. Groves, Iuka, Ill.
Hugh Ricken, 1831 23rd Ave., S. W., Calgary, Alta., Canada.
A. H. Smith, c/o Simmons Co., 383 Madison Ave., N.Y.C.
Leo Lewandowjki, 3124 So. 54th Ave., Cicero, Ill.
T. W. Jett, 1304 East 11th St., Cleveland, Ohio.
Paul Grittinger, 815 Cumberland St., Lebanon, Pa.
Frank Di Spigno, 566 E. 187th St., Bronx, N. Y.
Sam Costilo, 4607 Boudinot St., Philadelphia, Pa.
William Diller, 235 Mechanic St., Boonton, N. J.
John Van DerMaten, Boyden, Iowa.
Oswick Radio Repair Shop, 1211 Scott St., San Francisco, Calif.
C. E. Nichols, 57 Hancock St., Auburndale, Mass.
J. E. Weidemann, 31 Best St., Buffalo, N. Y.
Seymour Meiner, 64 Harrison Ave., Freeport, N. Y.
H. Curley, 1038 Union St., Brooklyn, N. Y.

Vision Cameras More Sensitive

Expected to Enable End of Studio Glare

THE possibility the television camera may surpass the photographic camera as an instrument for graphic reproduction was suggested by Dr. P. C. Goldmark, chief television engineer of the Columbia Broadcasting System. Dr. Goldmark returned from a five-week inspection tour of television laboratories in England, France and Germany.

"Of greatest importance to the future of television programs," Dr. Goldmark said, "is the progress of engineers in stepping up the light sensitivity of the television camera. Developments now under way in England and Germany as well as in America promise a television camera ten times more sensitive to light than any now in use, thus rendering it even more useful for reproduction than the ordinary photographic camera using modern emulsions."

REDUCTION OF GLARE

One obvious adventage of this development, Dr. Goldmark pointed out, would be to reduce the intensity of studio illumination to a point where heat and glare would no longer handicap the performers. It would also make possible a greater depth of focus, which would enable performers to move freely about the stage without becoming blurred on the receiving screen. This in turn would greatly extend the pick-up possibilities of the camera in all situations where special lighting would be impractical.

Concurrently with efforts to make the television camera more light-sensitive Dr. Goldmark observed that scientists are striving to make it reproduce in their original intensities all colors of the spectrum. The presence of this panchromatic quality in modern photographic emulsions has given them a distinct advantage over the photoelectric surface of the cathode ray tube, which has made necessary a laborious unnatural make-up for television performances. In England, Dr. Goldmark said, the BBC has already put to practical use a television camera which has been rendered panchromatic "to a fair degree." Ordinary stage makeup suffices for actors performing before it. Used for special events out of doors, the camera requires no special makeup of any kind.

NOT MANY SALES IN ENGLAND

The high cost of television receivers has handicapped the new art as a popular entertainment medium in England, Dr. Goldmark said. Prices range from $300 to $800. Thus, although BBC has broadcast visual programs for almost a year, less than 3,000 receivers have apparently been sold to home users.

Dr. Goldmark pointed to the fine quality of outdoor pickups in England. Transmitters mounted on trucks enable the BBC to televise events taking place within a 20-mile radius of Alexandra Palace. Such pickups can be made in any daylight illumination, ranging from bright sunlight to dim haze on a foggy day.

A television receiver is turned on daily in the London office of the Columbia Broadcasting System. There, with Edward Murrow, CBS European director, Dr. Goldmark watched the television broadcasts of the Davis Cup finals at Wimbledon. Although the small size of the screen made action hard to follow, Dr. Goldmark learned that by the end of this month a British manufacturer plans to show a projection-type receiver producing images two feet wide at a price no higher than that of the small-type cathode ray tube receiver.

FRANCE TRIES TO CATCH UP

In France, Dr. Goldmark found television in a more experimental stage than in England. Broadcasts on the old 180-line standard have been abandoned, and the French government is now preparing to transmit 441-line images over the Eiffel Tower transmitter now under construction.

At the Funkausstellung, or radio exposition, in Berlin, Dr. Goldmark was able to survey Germany's technical advances in television demonstrations by the country's leading manufacturers. Many home receivers shown employed the projection-type cathode ray tube for producing images comparable in size with the home motion picture screen. One manufacturer displayed a screen 8 feet wide. Standing before it, groups of more than a hundred spectators watched images as sharply defined and as steady though not quite so brilliant as the ordinary commercial motion picture.

Public interest in the Berlin display was keen, Dr. Goldmark observed, but by order of the German Post Office, which supervises all television activities in the Reich, no prices were listed. Except for one table top model, which might be manufactured to retail at about $200, the cost of receivers was still too high for mass distribution.

STANCOR OFFERS BULLETIN BOARD

A new bulletin board available to distributors carrying a representative stock of Stancor products has been announced by the Standard Transformer Corporation. This board has been designed for prominent display in the distributor's store and will be supplied monthly with up-to-date literature exploiting new developments in the Stancor line.

First Television Tubes Released; Intended for Experimenters Only

The recent marketing of the 1800 (9-*inch*) *and the* 1801 (5-*inch*) *Kinescopes for television by RCA Manufacturing Company, raised some questions of policy, which are answered in the following release from the company:*

The two cathode-ray tubes suitable for television reception are being made available to radio amateurs, educational institutions, laboratories and others interested in experimental television. Some television equipment has been sold to the National Broadcasting Company and to the Columbia Broadcasting System, but these tubes are the first television apparatus offered for general sale by RCA in the United States.

Placing the tubes on the market for the convenience of experimenters should not be construed in any way as an announcement by RCA of commercial television apparatus for use by the general public. The tubes, known as "Kinescopes," are being made available as a result of inquiries for cathode-ray tubes suitable for television reception.

The tubes are both of the electromagnetic-deflection type and employ viewing screens on which the picture appears clearly, with a yellowish hue. They carry suggested list prices of $60 and $40, respectively.

The Kinescopes each employs an electron gun and a fluorescent screen assembled within a vacuum tube. The negative electrode delivers a stream of electrons varying in intensity with the strength of the signals received. By means of magnetic deflection coils, this beam is made to scan the fluorescent screen which then emits light in proportion to the beam intensity. The beam can be made to trace a pattern of 441 lines, 30 times a second, giving picture definition substantially equivalent to a good photographic enlargement.

The tubes will permit experimenters to build receivers to pick up experimental television transmissions. At the present time experimenters will be restricted necessarily to the areas within some 50 miles of experimental stations, since television transmissions are practically limited to line of sight distances.

Freak Makeup for Television Ruled Out

Purple lipstick, green rouge and blue powder won't be ingredients of television beauty despite stories to that effect emanating from Hollywood, said Percy Westmore, Hollywood make-up man, after a tour of the National Broadcasting Company television studio in Radio City.

"Television performers will wear natural make-up and probably less of it than the average New York woman uses for street-wear," Westmore predicted. "I am now in a position to deny those ridiculous rumors that it will be necessary to paint girls up like a surrealist landscape to televise them properly. I have had an opportunity to study studio conditions and see the television image and I am confident the development of make-up technique for television will follow the current trend in motion pictures. We are using less greasepaint today, less powder and less lip rouge. There is every reason for television to do likewise, particularly because spontaneity and naturalness are keynotes of the medium."

Make-up's two biggest contributions to television, Westmore believes, will be to define features more clearly and accentuate the planes of the face.

"Eventually," he said, "television will have its own staff of make-up experts working hand in glove with the Iconoscope cameraman. Too many people think of make-up solely as a corrective measure—to make noses look shorter or eyes bigger."

Television Committee Gets Part of Channel Request

The Federal Communications Commission in its recent allocation of channels for television, broadcasting, transoceanic, and police and aviation transmission has gone part of the way toward granting the request of the Television Committee of Radio Manufacturers Association, Inc., A. L. Murray, television engineer of Philco Radio and Television Corporation, and chairman of the RMA committee, announced.

That committee had stated to the Commission that before television experimentation could be successfully carried on toward the development of practical television, the whole band from 42 to 90 megacycles needed to be cleared for this express purpose.

According to Chairman Murray, in assigning channels from 44 to 108 megacycles the Commission had given television companies a number of the desired channels, though some of them are so high that they cannot be used today for this purpose. In addition, the television channels are sandwiched in between channels for other purposes.

"It must be borne in mind," said Mr. Murray, "that the assignment of these channels does not mean for commercial television. The Commission made it very clear that there does not appear to be an immediate outlook for the recognition of television service on a commercial basis."

How to Work 6V6-G

Beam Power Tube Circuits Given

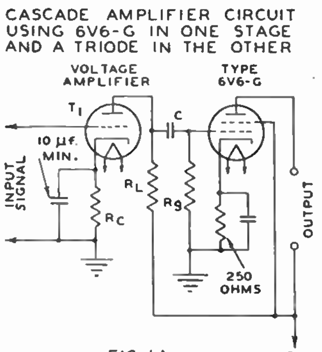


FIG. 1A

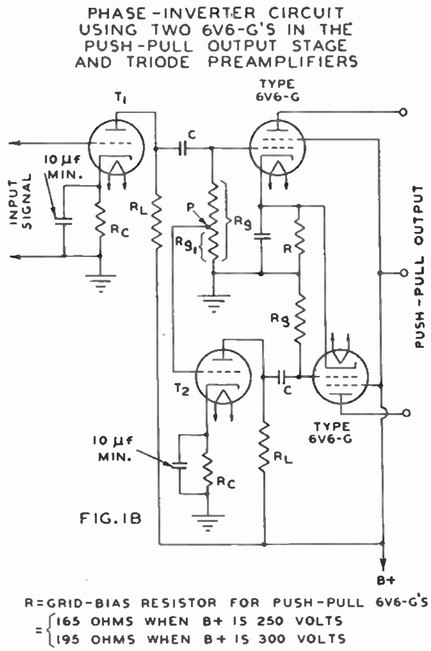


FIG. 1B

THE 6V6-G is a beam power output tube that is capable of furnishing more than 4 watts at approximately 6 per cent distortion when 250 volts are applied to plate and screen. The principle of operation of the 6V6-G is similar to that of the 6L6: directed electron beams and aligned grids are used to obtain high plate-circuit efficiency, low screen current, and high power sensitivity. The 6V6-G is usually used single-ended or push-pull in the output stages of resistance-coupled amplifiers. In a radio receiver, a single-ended amplifier is usually fed by a single-tube voltage amplifier; a push-pull output stage is usually fed by a phase inverter. The accompanying diagrams and tables furnish design information for these arrangements.

A grid-resistor value of 0.25 megohm for the output stage is listed in the tables. This value of resistor is less than the recommended maximum value for self-bias operation (0.5 megohm) and greater than the recommended maximum value for 100 per cent fixed-bias operation (0.05 megohm). Thus, 0.25 megohm is suitable for either self-bias or partial-fixed-bias operation of the 6V6-G. When the output tubes are self-biased, an additional resistor of 0.25 megohm may be used for the grid-circuit filter. The use of a higher value of grid resistor (no grid-circuit filter) does not affect performance materially because gain and output voltage are nearly maximum for the constants shown.

CASCADE AMPLIFIER

The data in Table I apply to the cascade amplifier of Fig. 1A and to the phase-inverter circuit of Fig. 1B. The output voltage from any of the voltage amplifiers listed in Table I is more than that required by either the single-ended or push-pull output stage. The values of R_L and R_g were selected on the basis of reasonable gain and good high-frequency response at less than 5 per cent distortion.

In the phase-inverter circuit of Fig. 1B, a tube T_2 having a gain G_2 obtains its signal voltage from a portion of R_g; the output of T_2 feeds one of the push-pull output tubes. The proper point P on R_g for the grid connection of T_2 is obtained from the relation

$$R_{g1} = R_g/G_2$$

where the values of R_g and G_2 are given in the tables. The values of R_{g1} are given in Table II for twin-triode tube types. The circuit for these types is shown in Fig. 2.

Table III furnishes design data for the pentode-type voltage amplifier of Fig. 3. A low value of plate load is desirable, because microphonic and hum outputs are reduced to acceptable levels. The use of a series screen resistor and self-bias for the voltage amplifier reduces the effects of varying line voltage and possible differences between tubes.

The circuit of Fig. 4 is another type of phase inverter. The output of T_1 feeds T_2, which is connected in an inverse-feedback circuit. The output of T_2 is split into two phases, each of which furnishes voltage for an output tube. T_2 is usually a 6F5 or a 6C5; the values of components used in this circuit for these tube types are tabulated in Table IV.

INDEPENDENCE ESTABLISHED

The gain of T_2 is nearly independent of the tube type, because a large amount of inverse feedback is used; for this circuit, one-half the output of T_2 is fed back to the input of T_2. The stage gain with feedback is

$$G_f = \frac{G_o}{1 + nG_o}$$

where G_o is the gain of the stage without feedbeck and n is the fraction of the output voltage fed back to the input. Thus, when T_2 is a 6F5, $G_o = 63$ and $G_f = 1.94$. When T_2 is a 6C5, $G_o = 14$ and $G_f = 1.75$. For example, when the bias on the output tubes is —15 volts, the output of T_1 should be somewhat more than 15 volts peak for maximum power output. T_2 does not draw grid current until the peak value of the input signal is approximately 25 volts for the 6F5 and approximately 40 volts for the 6C5.

The phase-inverter circuit of Fig. 4 has practical advantages over the circuits of Figs. 1B and 2 in that the effects of possible variations between tubes are small. In the circuit of Fig 4, normal variations between tubes in position T_1 affect the input to each 6V6-G tube by the same amount; the effects of normal variations between tubes in position T_2 are negligible because of the inverse-feedback arrangement. In the circuits of Figs. 1B and 2, normal variations between tubes in position T_2 and variations in the value of R_g affect the input to only one 6V6-G tube; normal variations between tubes in position T_1 affect the input to both 6V6-G tubes by the same amount.

OUTPUT CONSIDERATIONS

A disadvantage of the phase-inverter circuit of Fig. 4 is the possibility of obtaining high hum output when the gain following T_2 is high.

PHASE-INVERTER CIRCUIT USING TWO 6V6-G'S IN THE PUSH-PULL OUTPUT STAGE AND A TWIN TRIODE AS THE PREAMPLIFIER

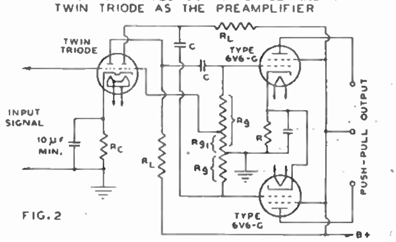


FIG. 2

R = GRID-BIAS RESISTOR FOR PUSH-PULL 6V6-G'S
= {165 OHMS WHEN B+ IS 250 VOLTS; 195 OHMS WHEN B+ IS 300 VOLTS}

Heater-cathode leakage, if present, may cause hum voltage to be developed across R_1 (the resistor connected in the cathode circuit), which is

TABLE I

TRIODE VOLTAGE AMPLIFIER (T_1 or T_2)	R_L Megohms	R_g Megohms	R_c Ohms	C µf	GAIN *
2A6, 75	0.1	0.25	2200	0.015	39
6C5: also 6C6, 6J7, 57 as triodes	0.1	0.25	5300	0.015	13
6F5	0.1	0.25	1600	0.010	49
6Q7	0.1	0.25	1500	0.015	39
6R7	0.1	0.25	3800	0.015	10
55, 85	0.1	0.25	8300	0.015	5.7
56, 76	0.1	0.25	6400	0.020	10

* voltage amplifier only

TABLE II

TWIN TRIODE VOLTAGE AMPLIFIER	R_L Megohms	R_g Megohms	R_{g1} Ohms	R_c Ohms	C µf	GAIN *
6A6, 6N7, 53	0.1	0.25	11350	1500	0.015	22
79	0.1	0.25	7350	1000	0.010	34

* One unit only of twin triode.

TABLE III

PENTODE VOLTAGE AMPLIFIER	R_L Megohms	R_g Megohms	R_d Megohms	R_c Ohms	C_d µf	C µf	GAIN *
2B7, 6B7, 6B8	0.1	0.25	0.55	1100	0.09	0.015	47
6C6, 6J7, 57	0.1	0.25	0.50	450	0.07	0.010	82

* voltage amplifier only

TABLE IV

TRIODE VOLTAGE AMPLIFIER (T_2)	R_L Megohms	R_g Megohms	R_c Ohms	C µf	GAIN * E_o/E_1
6C5	0.125	0.25	12300	0.016	25
6F5	0.125	0.25	3200	0.015	28

* approximate.

CASCADE AMPLIFIER CIRCUIT USING 6V6-G IN ONE STAGE AND A PENTODE IN THE OTHER

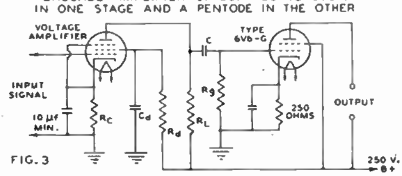


FIG. 3

PHASE-INVERTER CIRCUIT USING TWO 6V6-G'S IN THE PUSH-PULL OUTPUT STAGE AND INVERSE-FLEEDBACK IN THE PRECEDING VOLTAGE AMPLIFIER STAGE

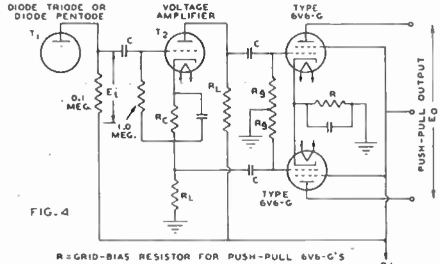


FIG. 4

R = GRID-BIAS RESISTOR FOR PUSH-PULL 6V6-G'S
= {165 OHMS WHEN B+ IS 250 VOLTS; 195 OHMS WHEN B+ IS 300 VOLTS}

impressed on the grid of T_2 through R_p. For this reason, T_2 should feed the 6V6-G tubes directly, as shown in Fig. 4.

The bias for 250-volt, push-pull operation is

(Continued on following page)

Unusual Laboratory Type Thermionic Meter by RCA

An instrument for use in laboratories and for many product tests is a new ultra-sensitive d-c meter developed by the RCA electronic research laboratory of Dr. V. K. Zworykin. Announcement of the meter was made by the Engineering Products Division of the RCA Manufacturing Company.

The meter was developed for accurate measurements of ionic and electronic currents, employing a new electronic circuit which operates with unusual stability and accuracy, even approaching that of the average reflecting galvanometer. It cannot be easily damaged or burned out by overload currents.

In current measurements the new meter provides for twelve scale ranges for measurement to 10,000 microamperes (10 milliamperes), the lowest full scale reading being .02 microampere. For voltage mesaurements, eight other scale ranges are provided, from .1 volt to 500 volts, with a meter resistance of 5 megohms. For resistance measurements, two scale ranges are provided for measurements of from .1 to 100 megohms, and from 20 to 1,000 megohms, with less than .5 volts across resistance. With 90 volts in series, up to 200,000 megohms may be measured. Conversion of the meter for the three forms of operation is accomplished by means of a selector switch.

The ultra-sensitive d-c meter is a self-contained, battery operated precision instrument, utilizing three RCA 1B-4 tubes. No external resistances or shunts are required. It is of great value for laboratory work, and is so easily portable as to be even more useful for field or location work, since it requires no special set-up or balancing.

The instrument essentially consists of a multiplicity of input circuits, a feedback-type amplifier and a meter circuit. The amplifier is so designed that the meter cannot burn out or even deviate in calibration through overload. The sensitivity in all ranges is stable to a degree previously realized only with delicate galvanometers. This stability is of an automatic nature as compared to the maintenance of critical adjustments necessary in balanced "push-pull" or bridge amplifier circuits frequently used for fractional microampere measurements.

The meter builds up the fractional currents it measures into stronger currents which actuate the meter by use of a new electronic circuit especially designed for that purpose. The over-all accuracy for all ranges of current or voltage measurements is plus or minus 2%.

The new instrument is expected to be especially suited for use in school and college laboratories. Other uses for the meter include measurements of ionic and electronic currents in the grid and other circuits of thermionic tubes; currents due to secondary emission; leakage currents between tube electrodes and between circuit elements; electron-beam currents in cathode-ray and special tubes for television purposes; minute currents in photo-electric cells; electrolysis and corrosion currents in potentials, and galvanic currents and potentials in biological research.

The meter stands 13 inches high, is 9 inches wide and about 9 inches deep and weighs 20 pounds with batteries.

(Continued from preceding page)

—15 volts. This bias may be obtained from a self-bias resistor or from a partly fixed-bias source. The rise in d-c plate and screen currents with power output is small, approximately 16 ma for fixed-bias operation; hence, a power supply with relatively poor regulation may be used without much loss in power output. The following conditions obtain for the output stage.

	Single-Tube Output		Push-Pull Output	
Heater Voltage	6.3	6.3	6.3	Volts
Plate Voltage	250	250	300	Volts
Screen Voltage	250	250	300	Volts
Grid Bias	-12.5	-15	-20	Volts
Peak-Signal Voltage	12.5	30*	40*	Volts
Zero-Signal Plate Current	45	70	78	Milliamperes
Max.-Signal Plate Current	47	79	90	Milliamperes
Zero-Signal Screen Current	4.5	5	5	Milliamperes
Max.-Signal Screen Current	6.5	12	13.5	Milliamperes
Load	5000	10000**	8000**	Ohms
Power Output	4.25	8.5	13	Watts
Total Harmonic Distortion	6	4	4	Per cent
Second Harmonic	4.5	..	..	Per cent
Third Harmonic	3.5	3.5	3.5	Per cent

*Grid-to-grid. **Plate-to-plate.

FROM APPLICATION NOTE No. 80.

64 Loose-Leaf Pages in Field Data Addenda

Owners of Ghirardi's "Radio Field Service Data" book have just received a set of Supplement Sheets consisting of 64 loose-leaf pages. These contain the Case Histories of 68 new receivers; revised explanations of the latest RMA tube type number and base terminal designation systems; a revised chart of operating characteristics, technical information and socket connection diagrams of all types of detector, amplifier and rectifier tubes manufactured to date (data on 71 new tubes, including all those used in new 1938 receivers has been added to the chart); and a new unique chart giving detailed auto-radio installations and ignition system data for 341 models of American cars (including full information on the latest models).

This is the second and last supplement supplied to owners of "Radio Field Service Data." Future supplements, which will be supplied periodically as a regular service, are to be available on a yearly subscription basis. Both the Ghirardi Service Data book and supplements are published by Radio & Technical Publishing Company, 45 Astor Place, New York City.

EDITORIAL

TELEVISION has reached a new stage of development, one in which the experimenter is given an opportunity to see what he can do about creating improvements.

Unlike radio in its infancy, television in its infancy requires something akin to engineering knowledge before one can expect to understand the process, and thereby know what the problems are, hence attempt to solve them. But the method of invention by stumbling has always been present in the world's work, and will necessarily continue to remain a possibility in television, even by those possessing best technical equipment.

Nor is the experimentation by the independent lone adventurer quite so independent as would seem at first. The better practices devolve about the cathode-ray tube, a special one for television purposes, and the experimenter can not be expected to make the tube. So he had to wait until tubes were available. Now that they are offered for experimental and educational purposes, the opportunity is at hand, but with it goes a requirement for studious resolution and an intimate comprehension of the processes.

Moreover, the whole technique is rather obscured from all save mathematicians, because the circuits and methods, though revealed in the technical press, are necessarily told in mathematics largely, some of it with symbolism that had to be invented for the purpose.

Nevertheless, the prospect is by no means hopeless. Nor need anybody feel that private experimenting will not yield fruitful results. Amateurs and experimenters have contributed much to radio's progress, and will contribute on about the same scale to the great adventure which is television. What would be very useful would be some circuit information and other data, presented for the benefit of those not so well acquainted with mathematical quantities, and especially so that those now indirectly asked to attempt to contribute their share, will not have to do so much digging into technical literature of an involved and extensive sort before they can feel at least fairly well equipped to proceed. Some very easy processes that so far have escaped the formal television laboratories may be expected from the experimenters in the private field, as well as from institutions of technical learning, where the young, fresh mind, untrammeled by imposing histories of defeat, will certainly justify youth's participation in a young industry.

When defeat is mentioned in connection with existing experimental television it is done only in the sense that obstacles, including financial ones that young minds are not likely to master, have prevented commercial attainment of the only industry in our lifetime for which the demand long preceded the supply. When the technical achievements of present-day television are considered, they must be rated as being foremost in all the developments that have marked scientific advance, for the problems are much more complex and numerous, and really little is derived from the known art of sound broadcasting. Television is a new and different field, even though its association with radio is so close that the day will come when the word television will be dropped, and we shall speak only of radio, and mean a combination of sound-sight broadcasting and reception.

One of the problems for the future is the attainment of network standing for television. Only in that way can the ultimate goal be reached, of enabling a very costly production to be enjoyed by millions of listeners. So long as the present state of the art continues, whereby only local stations can be of service, and each must have its own program production, or use movie film, the quality of the program, or its variety and scope, will not be sufficient to enable television to acquire its rightful status.

Meanwhile the local-station method will have to be applied, and in effect is being applied by the television developmental laboratories that are sending out test programs that the experimenters are invited to tune in. Naturally, the experimenting suffers from geographical restrictions, as there are precious few such stations, and unless one has a receiver relatively close to those stations, no dependable reception is possible.

Too much emphasis at present on the requirement for network status for television before commercial possibilities loom will be hurtful, because concentrating on what confronts a possibly remote future, when a multitude of problems of the living present offer enough food for thought and experimentation. The network idea is well to keep in mind, as a necessary and inevitable attainment, but not as a deterrent to progress along lines now close at hand, and requiring solution now, because the network enigma will not begin to approach solution until the lesser questions, but still vital ones, are answered.

It is no reflection on the notable work of the present organized television laboratories to say that rank outsiders will make contributions that escaped the great institutions. This is because sheer numbers have the statistical edge on concentrated small groups in any endeavor where fortunate stumbling will play at least a ratable part in promulgating an art.

DIPHONIC REPRODUCER
for Mirrophonic Sound Systems

By R. C. Miner

Transmission Instruments, Bell Telephone Laboratories, Inc.

A SOUND picture reproducing system which gives aural effects approaching the clearness of a visual image in a perfect mirror has been introduced recently to motion picture producers and exhibitors under the name of Mirrophonic Sound. One of the outstanding features of this new system is the loudspeakers, which have been named Diphonic because all sounds below 300 cycles per second are fed into one unit while those above 300 are carried by another. This distribution is accomplished by a crossover network.

The high-frequency speakers, of which either one or two may be used, are attached to a horn having tiered chambers. Both horn and speaker are commercial adaptations of those used in emonstrating the transmission and reproduction of symphonic music in auditory perspective between Philadelphia and Washington in 1934. The horn consists of fifteen individual cells, each of which tapers exponentially from five-eighths inch square at the small end to eight inches square at the flared opening. The cells are brought so close together at the small end that only a knife edge separates them and at the large end they are arranged as compactly as the geometry of the arrangement permits.

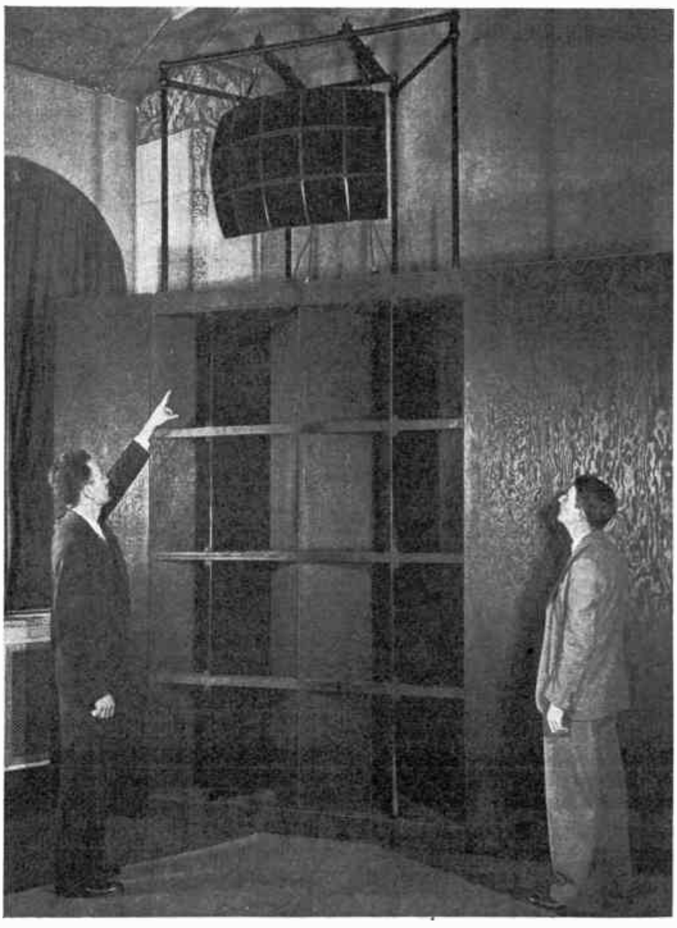


FIG. 1
The Diphonic speaker comprises two units. One of the units radiates all sounds below three hundred cycles per second and the other unit radiates those above that frequency.

NON-DIRECTIONAL

This multi-cellular construction makes the horn non-directional. A horn which has only a single air passage distributes sound uniformly over a wide angle at low frequencies but concentrates the sound on the axis of the horn as the frequency increases. This condition is undesirable in a theatre since those sitting on or near the axis will hear too great a proportion of high frequencies compared to the low ones, while the reverse will be true for those sitting at the sides. In a multi-cellular horn of good design the various cells radiate sound of all frequencies and distribute it uniformly over a wide angle, thus giving a correct proportioning of all frequencies for all parts of a theatre.

The walls of the individual cells of the horn consist of two metal sheets with an intervening layer of felt, all fastened together by a heat-softening cement. This makes a wall with very high damping to mechanical vibration and effectively prevents horn rattles. Assembly of the sixty similar walls into cells and of the fifteen cells and other parts into the completed horn is accomplished entirely by soldering.

The high-frequency speaker has annular sound passages. The moving element consists of a diaphragm made of thin aluminum alloy to which is attached a cylindrical coil of many turns of aluminum ribbon wound on edge and held together by thin layers of varnish between adjacent turns.*

GREATER DIAMETER OF DIAPHRAGM

To deliver the required amount of sound energy to the horn, the diameter of the diaphragm has to be considerably greater than the wavelength of the highest frequencies which it reproduces. If the diaphragm were coupled directly to the throat of a horn, the output at the higher frequencies would be greatly decreased because the phase of the sound coming from various parts of the diaphragm would differ. To eliminate these differences sound is taken from the diaphragm through several concentric annular passages so that the distance from any portion of the diaphragm to one of the passages is small compared with the wavelength of any sound transmitted.

The magnetic field for the air-gap of the high-frequency speaker is provided by a field coil wound for twenty-four volts, the voltage which is generally used with theatre equipment. Safety features such as a cover over the field terminals and various factors for convenience in installation and ruggedness which have been built into this speaker contribute materially to its satisfactory operation in the field.

The low-frequency speaker of the Diphonic system is also an improvement over those used previously in theatres. The driving element consists of four dynamic speakers of the cone type connected in a vertical row to a shallow cavity which flares out to a flat baffle. An approximately square post is mounted in the cavity directly in front of the speaker units so that the surfaces of the post form angles of about forty-five degrees with the plane of the baffle.

AID TO DISTRIBUTION

Two thin vertical vanes are mounted in the cavity between the post and the sides of the cavity to aid in the proper distribution of the higher frequencies radiated by the loud speaker. The construction of the parts which form the cavity and baffle is so rugged that it prevents the possibility of extraneous sound being radiated by mechanical vibration. The advantages of this loud speaker are good distribution of its higher frequencies, improved efficiency, and elimination of resonance effects which tend to distort the quality of the sound by unnaturally prolonging certain tones.

The entire loud speaker can be installed easily and dismantled quickly if required. It occupies a minimum of space on the stage and has small depth—an important consideration because some of the older theatres have very shallow stages. With its greater capacity for sound volume and improved distribution of all frequencies over the entire theatre the Diphonic loud speaker is a notable improvement in sound reproducing equipment.

**Bell Laboratories*, RECORD, *March*, 1934, *p.* 203.

Many Factors Affect Fidelity

Attainment of fidelity is progressing fast, so that now it is possible to buy a high-fidelity receiver for around $300, for all-wave coverage, usually provided with means of reducing the fidelity manually, when distant stations are to be tuned in, and high selectivity may be necessary. This is because for best selectivity of the tuner must be rather low, a band width well passed up to 8,000 cycles being required. Trained ears can tell the difference if the band width is extended to close to 10,000 cycles, provided there is any modulation from the broadcasting station with frequencies between 8,000 and 10,000 cycles. This modulation is a rarity and is restricted usually to high-fidelity stations, of which thre are a few experimental ones in the region, 1,500 to 1,600 kc, channels being in 20 kc steps, to permit wider modulation latitude.

Besides the receiver, including tuner and audio amplifier, the speaker system has to be accommodated to fidelity, which usually means some substantial outlay for this provision, and besides the room acoustics have to be considered. Even the position or level where the listener sits has a bearing.

Persons who move notice the effect of room acoustics if they turn on the radio before the rugs are laid, the tapestry (if any) hung, and the furniture disposed about the room. The softening effect of the furnishings being absent, a certain harshness seems to attend the music, although speech seems welcomely crisp. The effect is to let the high audio frequencies get a better break than they had before, although perhaps too much of a break, because of reflections. The presence of more persons in a room already furnished has the same general softening effect, or reduction of reflections from walls and floor, although this effect might be too small to be noticed.

Rectifiers for Instruments

Low Range, Linearity and Loading Considered

By H. B. Herman

ONLY a few years ago the servicemen demanded instruments for measuring a. c., and thereupon the copper oxide rectifier became popular in diagnostic devices. The rectifier type instrument therefore took firm hold, and volt-ohm-milliammeters provided for a-c readings. These were desired principally for measuring the voltage across the primary and secondaries of power transformers, including, of course, the voltage across heaters of tubes, which are either in parallel with a secondary or in series with a limiting resistance.

The resultant voltage calibrations, using this type rectifier, did not coincide with the d-c scale of the instrument. Assuming that the d-c scale is linear, and it is nearly always quite close to linearity, the a-c scale departed considerably, especially at low voltage readings of a scale. Therefore the same numerical calibration was used as applied to d. c., but the bars indicating the a-c values were placed in individual positions, the connection on scale to d-c numbers being made by a jumper drawn something like a letter S.

CHANGE IN RECTIFIERS

There was no objection to this, of course. Some manufacturers provided a separately enumerated scale for a. c., perhaps a little handier to read. But in both instances the odd shape of the curve or absence of linearity, was rather pronounced.

So much satisfactory measuring has been done on both bases that no objection could be made to either.

However, the calibration that applied to a. c. when the instrument left the factory did not necessarily retain its integrity, because of changes that took place in the rectifier. Ruin could be produced by overload, so that a new rectifier would be necessary. Or temperature and time would work their changes, and it would then also be advisable to make replacement. In recognition of serving the convenience of users of rectifier type instruments intended for copper oxide inclusion, some manufacturers have plug-in type rectifiers. Formerly these were obtainable only with very expensive instruments, but Triplett now has them for its moderately priced precision line.

When low voltages are to be measured all rectifiers used at present have their limitations, including the vacuum tube. The rectifier has what is termed a certain current density. That is, it is a current-drawing device and has inertia, so that for very low values it will tend not to rectify.

To overcome this to a satisfactory extent the lowest range may be made 15 volts, and some rectifiers carry that recommendation from the manufacturer, while some others may be used at 5 volts full-scale deflection, without much failure of movement for small values of input on the lowest-range scale, but the trouble is there, nevertheless. The idea is to get the rectifier to start moving right away.

The situation facing the rectifier may be assumed to be the same as caused by a small negative d-c bias put on the plate. This bias the incoming a-c voltage, or unknown, must overcome. It can be accomplished readily by using a highly conductive rectifier, but then another condition obtains, whereby there will be appreciable current flowing at no external input. Naturally the input that causes current to flow is derived from the circuit energizing the rectifier, e. g., the heater supply. Some electrons from the cathode have a contact potential and are sufficiently numerous to make the rectifier conductive, the virtual load being the resistance of the rectifier in its practically minimum conducting state.

If the load resistance is made high, meaning a high voltage range, the drop required across the external load becomes large compared to the internal drop, and the trouble comparatively disappears.

TROUBLE AT ZERO INPUT VOLTS

Thus, zero input volts, using a highly conductive tube rectifier on the 5-volt range, may read .5 volt on the d-c scale. It is only necessary to have that position refer to zero a-c volts, while 5 volts will be the other extreme. Low resistance loading of the rectifier is required for the low voltage range, unless a very sensitive meter is used (50 microamperes). Not only must the meter resistance be allowed for, but also the resistance of the rectifier itself, and the load resistor is the computed required value less the sum of the other two. Thus for the 5-volt range on a 0-500 microammeter, instead of the computed 10,000 ohms being present in the external load resistor, almost half of the resistance is in the rectifier, and the difference constitutes the series load. This would then be around 5,000 to 6,000 ohms.

Hence some means must be used to justify the situation to the use of the same general multiplier resistors as used for d.c., as by including a resistor permanently as a series adjunct for d. c., equal to the rectifier resistance, and not picking up this for a. c., when the value is replaced by the rectifier resistance.

The same method may be used with copper-oxide rectifiers, or a fixed condenser may be put across the lowest-range d-c limiting resistor, as it has no effect on d. c., but does increase the meter current when a. c. is applied. Thus the switching of the resistance equal to the rectifier is avoided. The capacity will be around 1.25 mfd. for most applications. The method does not apply to condenser-diode rectifiers.

FOLLOWING D-C SCALE

On ranges of 50 volts or more, for a tube rectifier, the same multipliers serve adequately for a. c. and d. c. without any special precautions, since linearity becomes effective, assuming the load resistor is at least 50,000 ohms (0-1 milliammeter or more sensitive instrument used). Hence the a-c scale will follow the d-c scale for 50 volts and up, but not for less. A separate scale or calibration for the lowest range would be needed.

The highly-conductive rectifier offers the readiest example of a device for enabling a low voltage range, as it has been possible, using 6C6, with all elements except heater and suppressor tied together as effective plate, with suppressor to cathode, to have a full-scale deflection voltage of only 3 volts r. m. s. This goes lower, therefore, than any of the service instruments of which the author has knowledge.

Compensation of the resistor network, to enable the use of the same d-c multipliers later on, is necessary, but for the lowest range just discussed, the rectifier has its own separate load resistance for condenser-diode or straight diode rectification. The change is not linear on this range, though linear on 50 volts, 500 volts etc.

The difficulty surrounding the interia of the rectifier, or its "preference" not to be disturbed from its quiet state, is thus overcome, and with limiting resistor specially chosen so that full scale is 3 volts r. m. s., there is a special calibration, so no difficulty arises in making the r. m. s. values real and accurate.

Remembering that the rectifier presented a case of stubbornness, and that conductivity of a high order was utilized, by interconnecting elements of the tube for a generous plate, we shall encounter two different problems, depending on the type rectifier used. If it is a vacuum tube the load resistance of which is completed through the unknown, then we have the usual diode rectifier, which responds to the average of the a-c- wave. This may be considered near enough to r. m. s. values.

The other type of rectifier possible is the condenser-diode type, where the d-c load resistance is unaffected by the unknown, which is connected between one side of a stopping condenser and cathode, load resistor being between plate and cathode permanently. The condenser-diode rectifier responds to the peaks, therefore for duplication of the d-c load resistors the readings will be too high, referring to the d-c scale.

Two solutions are: (1), shunt the meter to make up the difference, which is about .3 of the full-scale current; (2), adjust the rectifier so that its efficiency (conductivity) is less by the right amount. Any method introduced has to be generally applicable, i. e., no modification for each separate a-c range above the lowest would be quite acceptable, for it leads to overcriticality and complication.

The rectifier is easily adjusted either by leaving the normal grid free for the higher ranges, or, if this favors the inertia too much, by connecting the grid to plate through a resistance of the right value to make the d-c scale read r-m-s values. This method was devised by H. J. Bernard and works particularly well.

RCA Victor Enters Field of Office Communication

Two new inter-communicating call systems, one of which requires no wires, were announced by the RCA Manufacturing Company, signaling the entry of the company into the inter-office communication field.

The new systems are to be known as RCA Victor-Phones. The larger of the two systems includes a master unit which incorporates an amplifier, volume control and station selector switch feeding into five remotely operated units. Power for the master unit is obtained from any 110-volt a-c or d-c circuit, while the remote units require no power. Each remote unit is connected to the master unit with a simple individual wiring system which insures secrecy of communication. The remote units may be placed as far distant as 1,000 feet from the master unit. The cost of the master unit is $39.95 complete with tubes. Remote units are $12.50 each.

The system is so built that any one of the remote units can be used to talk with the master unit, and after the contact is made one may both listen and talk without turning the switch or holding it open with the hand. Each unit is housed in a small, attractive walnut-finished cabinet.

The master unit has three controls. A selector adjusts the unit to communicate with the remote units, and a volume control insures convenient operation. The third switch is pressed for talking. The system was built for service in factories, offices, homes and other places where efficient, low-cost inter-communication is desirable.

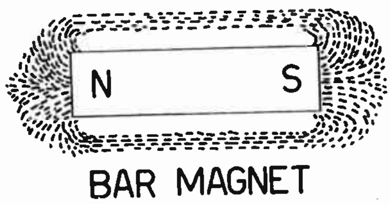
The second RCA Victor-Phone system requires no wires. The communication units of the system are placed in service by merely plugging them into the electric light socket. The system, which costs $76.50 complete per pair, operates on the carrier frequency principle, each unit being a miniature transmitting station sending high frequency signals along the electric wires. There are no wires or batteries, no installation costs.

The carrier frequency of 100 kc may be adjusted to plus or minus 25 per cent, thus permitting as many as three systems to operate in close proximity without interference. Voices up to 10 feet from the unit will be picked up and reproduced at the receiving end with sufficient volume to fill an ordinary room. Each unit is provided with a volume control.

Electro-Magnetism Explained

Simple Tests Applied to Widely-Used Phenomenon

By M. N. Beitman



N stands for north pole and S for south pole. A bar magnet is shown, with flux path.

MAGNETIC force plays a very important role in the operation of many radio components. Transformers of many types, phonograph pickups, loudspeakers and other parts operate on the principle of magnetism. Being similar to electricity we cannot actually see or feel magnetism, but the effects of this force can be noticed and accurately measured.

There are certain natural magnets found already magnetized. These are called *lodestones* or leading stones, since they were first used to give direction. If a piece of hard steel is stroked continuously in the same direction with a piece of lodestone, the steel will become magnetized. Natural magnets are not used commercially, because many alloys of iron have been developed that make more satisfactory magnets for present-day applications. For practical use small percentage of nickel, chromium, cobalt or tungsten are added to steel for making permanent magnets that have greater magnetic strength and other desirable properties.

Just as in the case of electrical charges, unlike magnetic poles attract each other, like magnetic poles repel each other.

WHY FILINGS STICK

Also it is important to remember that the force of attraction or repulsion between two magnets in inversely proportional to the square of the distance. North and south magnetic poles will attract each other four times as much at one-inch distance as at two-inch distance. This is why the space between the field and the armature in a generator is made as small as practical.

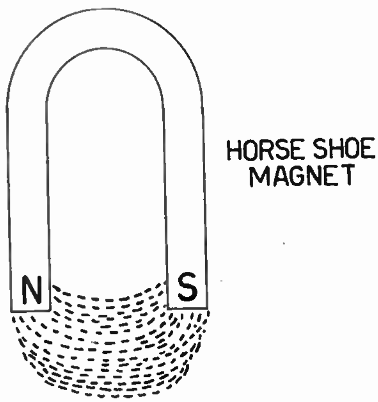
When a magnet is dipped in iron filings, most of the filings stick to the poles, indicating that the attractive force was the greatest at the poles. This magnetic effect is noticeable for a considerable distance around the magnet. This force constitutes the magnetic field and is made up of lines of force. The filings around the magnet follow the lines of force.

If a strong magnet is dipped in a barrel of nails made of soft iron, many nails will be picked up. Some nails in turn will hold other nails, becoming themselves temporary magnets. However, once these nails are removed from the magnet, their magnetism will be lost. Hardened steel substances, on the other hand, will retain some magnetism once they are brought into contact with a magnet.

Although many devices in radio circuits depend on permanent magnets for their operation, magnetism produced by the flow of electric current through a conductor finds even greater application. Every wire carrying electric current has an associated magnetic field proportional to the current strength and the arrangement of the wire.

THE COMPASS TEST

The fact that an electric current in a conductor has an associated magnetic field may be easily proved. If a compass is held near the wire the needle of the compass (actually a small magnet on a pivot) will take a position at right angles to the wire. If no current



The flux linkage in a horseshoe magnet is illustrated.

is present in the wire, the needle will assume its natural N-S position.

By winding a number of turns of wire in the form of a coil, a much stronger magnetic field can be created, since the fields of all the individual turns will add up. Since the magnetic field of force of each turn adds to that of the next turn, the greater the number of turns of wire the coil has, the stronger will be the magnetic field.

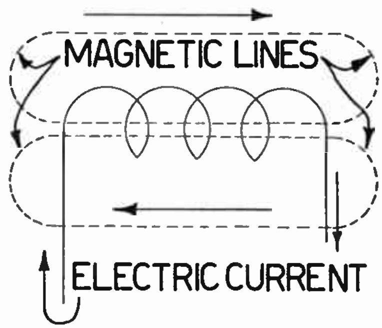
The total magnetic flux (lines of force) depends on the number of turns and the current strength. If the current is strong relatively few turns of thick wire will be needed to produce a given magnetic field. On the other hand, if the current is very minute, a great many turns of fine wire will be needed.

If a bar of iron is placed in the center of the coil, the iron will become magnetized when the current will flow through the coil, but will loose its magnetism once the current is discontinued. This principle is used to operate relays, door bells and other similar devices.

WHAT PERMEABILITY IS

If a coil with an air core has a constant current passing through, a magnetic flux of certain value will be produced. If an iron core is slipped in, replacing the air core, the electromagnet so formed may have a flux 200 times as strong. By using special nickel-iron material for the core, the strength can be made even greater. The ratio of the strength of the magnetic field with a given substance to the strength of the field when air is used as the core is the *permeability*. The permeability of air is taken as 1, so magnetic substances have a permeability greater than one.

The effect of the applied magnetizing force will be diminished after the magnetic material's limit is reached and, if the force is increased beyond a certain higher limit, no further effect will be noticed. The substance is then said to be saturated. For example, wrought iron will



Flux production by electromagnetism, by passing current through a coil.

have a very strong flux when inserted in a coil of 10 ampere-turns. Increasing this to 20 ampere-turns only increases the lines of force per square inch from 89,000 to 97,000. At 40 ampere-turns this figure is only 106,000 lines per square inch. Saturation is reached when a further increase in ampere-turns has no effect on the flux.

Come-and-Go Reception Perplexing

The commonest trouble in a receiver is known as fading, but hasn't anything to do with what was termed fading before servicing became the important industry it is. Formerly fading meant only the waxing and waning of strength of received signals, due to their arrival by different routes partly or completely in and out of phase. Great strength, great silence, and in-between values, too.

Naturally, when intermittent reception was due to other causes, though the symptoms were not quite the same, the word fading was applied. It is commonly due to a defective fixed resistor or fixed condenser. Either one breaks down, partly or completely, when subjected to an unusual current, as perhaps the result of a strong signal, and may become healed the moment the overload disappears, only to break down again on repetition. Therefore, suspected resistors should be tested with ohmmeter across them when a strong signal is applied from a signal generator, and condensers "shocked" by the heat from a special power oscillator, known as an impact generator.

Of course, the "commercial fading" may be due merely to a poorly soldered or loose contact making and breaking due to mechanical or electrical causes.

These intermittents give servicemen more "headaches" than any other fault in a receiver.

Owners of radio sets have an almost general feeling about this internal fading, that it is something too mysterious for repair, and often suffer the trouble for months, or even years, without calling in a serviceman.

There is not a single instance of internal fading that is incurable, and, although the set-owner does not know it, the serviceman does, and should take pains to inform present and prospective customers that he is well equipped by training and instrumentation to cope with this problem.

Fidelity for the Masses

Microphone Playing Part in March to Goal

ALTHOUGH the vacuum tube is described as the heart of the radio circuit, and to it must go the honor of making present-day broadcasting possible if a sweeping statement on the subject is requisite, nevertheless no small part in the radio drama has been played by the microphone. While without the tube we would not know how to send forth the radio waves in space at a great variety of frequencies, and with relative economy, nevertheless without the microphone we would not know how to impress on those waves the speech and music that constitute the bulk of transmitted intelligence.

The microphone is a device for changing the sound waves in space to equivalent values of electrical current passed along wires.

EXAMPLE OF MICROPHONE

The simplest illustration is that provided by the carbon microphone. Here carbon granules are stacked up, to form a unit called a button, a dry cell is used too for causing an excitation current to flow through this button, while connected in parallel with the series battery-microphone circuit is the primary of a transformer, the secondary of which usually goes to the grid of a vacuum tube. When a sound is made in front of the microphone, the resistance of the button changes, and this in turn causes a change in the current through the microphone and associated transformer, hence a voltage change across the transformer. Because the electrical changes are fairly true counterparts of the sound changes, and take place at the same time, the sound waves which consist of changes of pressure upon the air (condensations and rarefactions), are converted into changes of electrical pressure upon the circuit external to the microphone. The microphone output is then amplified.

There are different and better types of microphones than the single-button carbon type just described. For instance, the double-button type, having a stretched diaghragm, is far more correct as a converter of sound, though less sensitive.

SENSITIVITY DECREASED

Practically all the better grades of microphones are less sensitive than the single-button carbon type, as the whole improvement has been in the direction of fidelity, plus special uses, while general sensitivity became less and less. This was not a serious drawback, except for some mobile work, since amplification is inexpensive, and atones for the microphone's low sensitivity. So we find most of the preferred microphones require pre-amplifiers, which are small units ahead of the main amplifier.

The velocity and dynamic microphones are two examples, the condenser microphone another, the velocity being low impedance type, the condenser type being high impedance. As grid circuits require a high impedance input, because their own impedance is high and short-circuiting effects, or losses, are to be avoided, a transformer is used with low-impedance microphones, low side to the microphone, high side to the grid. The condenser microphone needs no transformer, but instead may be direct-coupled to a high-resistance loaded grid circuit.

All microphones work on the same general principle of producing current changes in the output, in electrical values, that duplicate the sound changes produced in front of them.

DIFFERENT REQUIREMENTS

Not all microphones must be addressed head-on, however, as some require for best fidelity that the sound be picked up from the side, or, if one is speaking, that he speaks across, instead of straight at, the microphone. Others have about the same sensitivity in all directions.

The fact that some microphones pick up better in one direction than in any other is used for focusing effect. Suppose that a band is crossing a noisy football field, and it is desired that the music alone be sent out over a network of stations. The announcer and his aids have a special microphone, which, when directed at the band, picks up the band's music primarily, to the relative exclusion of sounds coming from other directions. Thus directional effect, becoming so important in beam antennas, for both transmission and reception, is used likewise in microphone practice, though the technique is far different.

DEMONSTRATION AT PARADE

Bell Telephone Laboratories, Inc., has been working on a directional microphone that has something of the appearance of a telescope, and is mounted on a tripod. At the recent American Legion convention in New York City, the microphone was used for picking up the music of a brass band that was marching along Fifth Avenue in the memorable parade. When the band was passing the Empire State Building, the microphone trained on the musicians picked up the strains, which the stations thus were able to broadcast, to the exclusion of interfering sounds from other directions, which were many. The device is still in an experimental state, but the first important field test did prove successful.

When one begins to experiment in radio and needs a microphone he naturally uses the single-button type, which is passable for speech, but of small worth for music, because of the much wider frequency response range that music requires, and which the single-button carbon microphone cannot fulfill. However, it is the cheapest type, and for some special sort of work is valuable, e.g., where not much frequency

Focusing Microphone Proves Success

A focusing microphone has been developed by Bell Telephone Laboratories, Inc., and is shown in use at the parade of the American Legion in New York. The Empire State Building is at left. The Western Electric microphone is pointed by Sergeant Harry P. Goodwin at a brass band, the sound from which was picked up to the relative exclusion of other sound. This is a difficult feat. The device is still experimental.

range is required, and the input is within the frequency limits of the device.

The high grade microphones cost much more money, but in very recent years so great has been the development of the microphone, that at around $25 or $30 the experimenter can obtain a good grade microphone, even one that will give good results on music.

Still experimenting continues, and it is certainly true that much has yet to be learned about the microphone. The basic principles are well understood, but Nature uncovers oddities, some still surpassing understanding, as the experimenting continues, so that it is not too much to expect that the next few years will disclose great improvements in microphones, at least along the line of bringing high-fidelity types within still more reasonable cost. At present practically a perfect microphone can be produced, but not at a cost that almost anybody can afford. Far form it. Fidelity for the masses is one of the achievements that radio will take in its stride, and which is nearing attainment as the problem is tackled at transmitter (including microphone), receiver and reproducer.

Bypassing Meter Important If Frequencies Are High

Where a d-c meter is used in a circuit through which is flowing pulsating d.c., it may be advisable to bypass the meter with a condenser, if the frequency is high enough, because of the appreciable impedance of the internal coil of the meter. However, for power line frequencies this is scarcely practical, e.g., at 60 cycles the reactance of a 1 mfd. condenser is about 2,650 ohms, and the meter resistance (reactance assumes about the same at 60 cycles) may be 100 ohms or less.

However, as the frequencies get into the "radio" region, say, are above 20,000 cycles (20kc), the condenser may be necessary to insure true readings. If the frequencies are among those usually expressed in megacycles, a relatively large capacity mica condenser is preferable for bypassing, and may be put across the 1 mfd. paper condenser. A mica unit of .01 mfd. is suggested, but values lower than that should be avoided.

Problems of H-F Filters

Q Limitation Removed by Crystal

UNTIL about five years ago filters were used very little for frequencies above 150 or 200 kilocycles. In fact, at that time, the largest demand for filters in the Bell System was in the three-channel open-wire carrier-telephone systems with a top frequency of about thirty kilocycles. At radio frequencies, tuned circuits were generally employed to obtain the required frequency selectivity. This was the most practical and economical method at these high frequencies, because of the comparatively ample frequency space and the narrowness of the transmitted band with reference to the mid-band frequency.

Today the situation is quite different, says C. E. Lane, of Bell Telephone Laboratories. Filters with their sharp cut-offs and uniform transmission bands are now commonly used for frequencies as high as two or three million cycles and sometimes as high as fifty or sixty million cycles. More and more filters at higher and higher frequencies will undoubtedly be needed to provide high-quality and efficient high-frequency carrier systems utilizing cable, open wire, concentric conductor, and radio space. The term carrier system is here used in its broader sense to include all radio systems.

While filters are practically essential to single-sideband transmission, they may also be required where both bands are transmitted to provide efficiency and high quality, and to eliminate interference.

HOW NEEDS ARISE

The requirements to be met in the design of band filters for high frequencies arise primarily from the needs of carrier systems. In their normal frequency allocation, the essential frequency components of signals—as for example, those required for speech and music—fall in a definite band defined by an upper and lower frequency limit. For transmission in carrier systems this band is relocated by modulation to some higher frequency position.

The band width in cycles, however, remains exactly the same after relocation as before, except in the case of double-sideband transmission where the band width is twice that of the highest frequency of the original signals. A large number of channels may thus be provided in the same transmitting medium by locating the channels in adjacent frequency ranges. If the medium is to be used efficiently, the channels must be close together over the transmission path and must be segregated from each other at the terminals by the use of filters.

There are three main requirements to be met by the filters used in carrier systems. First, they must restrict the frequency range of the signals by eliminating all components which otherwise would fall below or above the frequency range considered essential. If the frequency range provided by the transmitting medium is to be used efficiently, single sideband transmission must be used, and thus the second requirement is that the filters must eliminate either the upper or lower sideband arising from modulation and yet permit the free transmission of the opposite sideband.

SAME SIDEBAND WIDTH

Regardless of the frequency range to which the signal is shifted for transmission, these two sidebands are exactly the same number of cycles apart, twice the number of cycles of the lowest frequency to be transmitted in the original signal. The third requirement, to minimize energy loss and distortion, sometimes exists because a number of the filters must work in parallel, and to meet it each filter must offer a high shunting impedance in the transmitting ranges of all the other filters.

Filters for such uses are primarily of the band-pass type. If but one step of modulation is to be employed, and the filters are to be equally good, they should have the same band width in cycles at any frequency allocation; they should have the same maximum loss for all frequencies in the transmitted band; they should provide the same discrimination against unwanted frequencies; and as the frequency allocation of the filter is increased, there should be no greater number of cycles required for the loss to rise from the low value in the transmitted band of the filter to the high loss required outside the band. This definition of what constitutes equally good filters for use at higher and higher frequencies is rather idealistic but it provides a basis for studying the nature of the problems that are encountered.

FILTER CONVENTIONS

The usual method of designing such filters is to connect together a number of ladder filter sections which have like image impedances at their junctions. The filter will consist of one or more sections having infinite attenuation at zero frequency and at infinite frequency; and of other sections having very high loss at frequencies not far from the edges of the transmitting bands of the filter. When this procedure is followed, the same filter schematic can be used, and hence the same number of elements, regardless of the position of the pass band in the frequency spectrum.

While some general schematic would apply to a different mid-band frequency, the values of the coils and condensers and certain of their characteristics would have to be different. Thus, if over the pass band the impedance, of the filter is to be held constant, the maximum values of inductance and of capacitance, would be the same for all values of frequency. In order to

CASH AWARDS OFFERED

For Ideas on Volt-Ohm-Milliammeter That Also Makes Capacity, Inductance and Other Measurements

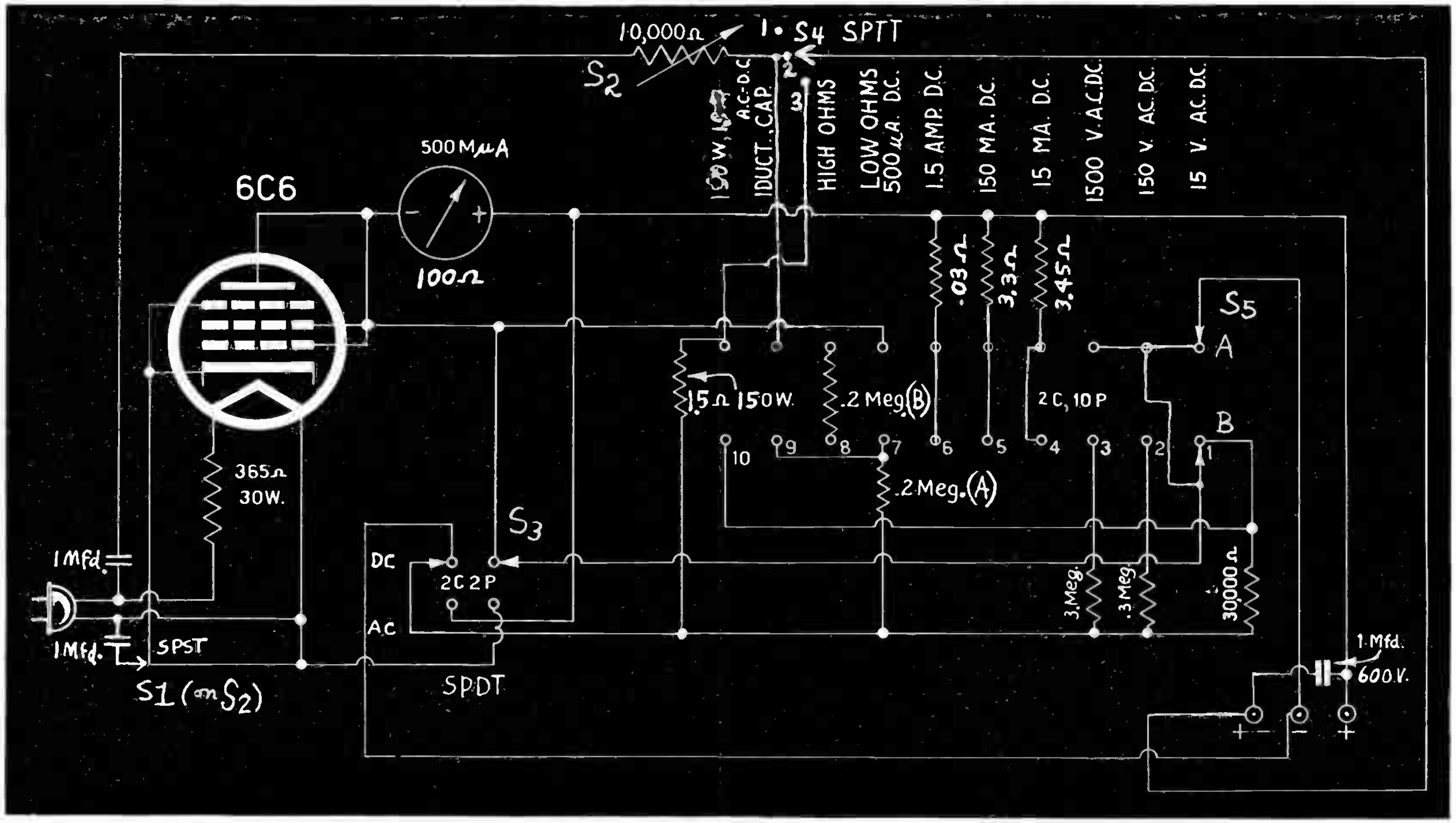


FIG. 1
A circuit for making various measurements, and which offers possibilities, and requires few parts. There are in the diagram, two short circuits and one typographical error of electrical importance, just to keep readers alert. See text.

PRACTICALLY every reader has built some sort of voltmeter, ohmmeter, ammeter or the like, and therefore is in general familiar with the objectives he desires. Here is an opportunity to get paid cash for acceptable suggestions based on your experience or desires.

A circuit is printed herewith and will be analyzed in the following text. You are to study the circuit so that you can suggest improvements. Send in your written suggestions, with or without diagram, to the author, c/o RADIO WORLD, 145 West 45th Street, New York, N. Y., and for every such letter accepted for publication and printed in these columns $5 will be paid, and for every such diagram printed in these columns an extra $5 will be paid, and for each letter printed, editorial rates of 2c per word will be paid additionally. So if you send a 1,000-word letter and a diagram, and they are printed (the letter in full), you will receive $5 for the letter alone, $5 more for the diagram, and $20 for the words in the letter, a total of $30.

RULES SIMPLE AND HELPFUL

A little spare change like that will come in handy for anyone, and besides it is very self-instructive to take a diagram so seriously that you try to make it do more things, or render present services more accurately, or more simply, and thus share in the design of a valuable device which, in final form, can be built and described so that readers may construct the same instrument, without doing any calibrating themselves.

A set of simple rules is printed herewith,

(*Continued on following page*)

(*Continued from preceding page*)

and in abiding by them you are in no way hampered in your ingenuity, but in fact the task is simplified for you. So read the problem carefully, as it appears in this article, and then put on your best thinking cap and see whether you can contribute something considered of real value, and get paid for it, if not over-generously, at least fairly well. The editor of RADIO WORLD is to be sole judge and his decisions final on everything.

Let us start with the objectives of the instrument. First, the usual measurement of d-c volts and currents and of d-c resistances, are to be made. Also, a-c volts are to be measured, preferably using the same multiplier resistors as served for d-c measurements. Then such other measurements are to be performed as can be encompassed with an eleven-position, two-circuit switch. The switch shown, designated as S_5, with the two decks A and B, has

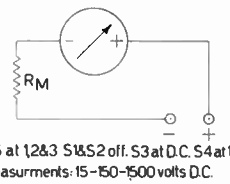


FIG. 2

D-c volts are measured in the usual manner, by introducing a multiplier resistor, Rm, in series with the meter, and connecting the input posts across the unknown voltage. One of two short circuits in Fig. 1 prevents this from being accomplished.

only ten positions, but an eleventh position, for both decks, is permissible, because commercial products enable eleven throws, and one has been omitted so that ingenuity may be applied to best use of the eleventh.

BREAKDOWN OF CIRCUIT

There is no limitation as to the other switches, except the general one that no more than eleven positions may be used for them, and all switching should be absolutely minimum.

Of course, the diagram itself offers the solution to the main problem, except for two short circuits and a typographical error purposely introduced, and the idea is to improve on the diagram, and to neable readers to do this, the circuit will be broken down, and each operation to be permitted by the circuit arrangement considered in detail.

The meter used is unalterable, and consists of a 500 microampere movement having a coil resistance of 100 ohms. Since the ohms per volt equals the number one divided by the full-scale deflection in amperes, we have $1 \div .0005 = 2{,}000$ ohms per volt. So for the d-c purposes, for the 15-volt range the resistance is 15 x 2,000 or 30,000 ohms (neglecting the meter resistance), and for the other ranges of d.c. the same factor applies.

R_m in Fig. 2 is the generalized multiplier resistance, 30,000 ohms for the 15-volt scale, .3 meg. for the 150-volt scale and 3 meg. for the 1,500 volt scale. It is not expected that anything much, except correcting mistakes, can be done about the d-c voltage circuit, nor the d-c current circuit, either, as these are standard, although conformity of voltage multipliers to a-c purposes remains a problem. Also no way is shown of measuring small a-c currents.

Under the diagrams of the breakdown circuits the draftsman has lettered the details of switch positions, and resultant measurements, so we find that we have taken care of the three d-c voltage ranges with Fig. 2. It is permissible, of course, to criticise the voltage ranges themselves.

The intended method for measuring a. c. is shown in Fig. 3. The meter, the rectifier and the load resistor are in series for d.c. The load resistor is between plus of meter and cathode, while one binding post connects to cathode and another to a condenser that goes to meter plus. This is known as the condenser-diode type of rectifier, and it functions on the basis of peak volts, i.e., the d.c. developed is practically equal to the peak of the unknown a-c input voltage.

MEASUREMENT OF LOW OHMS

On this score we encounter a recurrent problem, where the same multiplier resistors are to be used for a.c. as for d.c. In the more usual type of rectifier, with unknown in series with the rectifier load, and possibly with a filter condenser across that load, the rectifier responds to the average of the a-c volts, which is close to the d-c value when the same resistors are used for multipliers in both instances. Our problem at present, if we retain the rectifier as shown, includes establishment of coincidence between d-c and a-c scales, if that is possible, to avoid having to put six calibrations on the meter scale instead of only three that are used twice each. It may be added that the rectifier as shown is linear, particularly if the load resistance is fairly high, so one reason for selecting a meter of 500 microampere sensitivity is to permit such linearity on the lowest range. On the other ranges linearity prevails without any special meter precaution.

The device of turning the load resistor around, so to speak, for a-c use, should not prove confusing, as the diagram, Fig. 3, assumes the multiplier, R_m, is in the same position in space as in the d-c example, and the connection of leads shows the reversal jut mentioned.

For d-c current meaurements, shunts across the meter are used, a separate shunt for each of three ranges. Of course it is permissible to use more ranges of current or voltage, always however, with the thought in mind that there are only eleven positions for the main switch, S_5, and each such extra range requires an additional switch position. So, although the problem is necessarily presented piecemeal, it must be considered finally as a whole.

In the d-c current diagram, the range of 1.5 amperes d.c. is marked 1,500 ma, which is merely another method of expressing the same quantity of current.

Low ohms come next. The a-c line is used for supply voltage to the rectifier, and a suit-

keep both band width and loss slope constant, the spread in element magnitudes—the ratio of the smallest to the largest values of inductance and capacitance—must vary directly as the square of *f*. Since the maximum values are constant, this means that the minimum values must also vary inversely as the square of the frequency. To maintain the same loss over the the pass band, the Q of the coils, or the ratio of their reactance to their effective resistance, must vary directly with *f*. The Q of the capacitances is not generally a matter of any concern since it is usually many times that of the inductances.

DIFFICULTIES AND SOLUTIONS

Difficulties are encountered as an effort is made to build good filters at higher and higher frequencies. The best Q obtainable at reasonable cost for inductance coils is usually between 200 and 300 in the frequency range from 100 to 100,000 cycles, and the very small values of inductance and capacitance required at the higher frequencies are of the same magnitude as the inductance of the short lengths of conductor used to connect the filter sections, and as the stray capacitances within the filter. When the inductance and capacitance of the connecting leads of a filter become appreciable with respect to the actual coils and condensers, the filter ceases to be the same group of elements that its design called for, and it thus ceases to behave in the proper manner. Also, when very small inductances are required because of very high mid-band frequencies, it becomes difficult to obtain coils of precisely the value desired.

There are two means that can be employed to overcome partially some of these difficulties encountered with coil and condenser filters. These two means, however, do not affect the Q's of the coils to any great degree, and their application, therefore, permits coil and condenser filters to be applied to higher frequencies than would otherwise be possible provided the value of Q obtainable is not the limiting factor.

USE OF TRANSFORMER

One of these means is the introduction of an impedance transformation within the filter itself. The results obtained are equivalent to the insertion of ideal transformers at desired points internal to the filter, so that the magnitudes of certain elements may be increased or decreased as desired within limits depending on the filter. This results in removing the restrictions due to the maximum and minimum values of inductance and capacitance. Impedance transformation usually results in a modification of the filter schematic, but the characteristics of the filter remain unaltered.

The second means employed to make filters of coils and condensers applicable to higher frequencies is the use of shielding. By the proper use of shields, the effects of distributed inductances and capacitances, which exist between the inter-connecting leads, may be localized at definite points, and made to become part of the actual values required. The capacitances between the shields and the connecting leads are made to serve as actual circuit elements.

Another method of providing filters for higher frequencies is the use of sections of coaxial conductors as the filter elements. The values of Q associated with the inductance of such conductors are some ten times greater than for ordinary coil inductances so that considerable improvement is possible.

QUARTZ AND Q

These methods all fail at high frequencies for band filters with sharp cut-offs, because coils with sufficiently high Q's can not be obtained. Fortunately, however, quartz crystals connected in an electrical circuit provide effective inductances that have Q's a hundred times as great as those of coils. For frequencie from about 50 kc to 2000 or 3000 kc, filters may be made which use quartz crystals in place of the coils and some of the condensers.

By these various means many of the inherent limitations to the use of band filters at high frequencies have been removed. The particular means employed will vary with the conditions, but the overall result is that these filters, instead of being largely restricted to a mid-band frequency of perhaps 150 or 200 kc, may now be employed for frequencies many times higher.

Tube Tester Can Play Pranks That Mystify

A LITTLE trouble arises now and again in the use of an emission type tube tester, especially when a certain tube tests O.K. on a tester of certain make, and on another tester, of same make, and same production run, the same tube checks N.G. The serviceman blinks and wonders why.

It is well recognized that the emission type tester fills a need, but is not infallible. Also, the testers do not always give the same reading for the same tester manufacture, and certainly not for different makes, though the tube is identical, therefore, no single criterion exists. Moreover, an emission tester may show a tube as being good which is bad, or may read bad for a tube that is good—unusual possibilities, to be sure, but true nevertheless. Despite all these shortcomings, the emission tester is handy and usefulness, but certainly cannot be called definitive.

Power output testing is more satisfactory. The only reason power output testers aren't universally used is that they cost much more.

ADJACENT TUBES COUPLE

IS there any coupling between tubes that are of the glass type and fairly close together?

Yes. Especially is this true if one or both of the tubes is an oscillator, or, if either or both are amplifiers, are worked at high gain. In some beat-frequency audio oscillators the two radio-frequency oscillators are sometimes purposely coupled by this method.

able load resistance selected so that full-scale deflection obtains on the meter. An adjustment that is made necessary by line voltage variations, or differences in different localities, is made by a series rheostat of 10,000 ohms. This is assumed to be wire-wound, though it may be of any higher value in which wire-wound units are made, as under some circumstances, to appear later, it may be necessary to put more current through it than the diagram would indicate. The second short in Fig. 1 affects line voltage selection.

When the rectifier is instituted and supplied, the meter terminals themselves are exposed to the positive and negative binding posts, hence any unknown resistance, if small enough, say, less than 2,000 ohms, will cause some deflection. First the test leads are shorted for full-scaling, then the unknown inserted. This is known as the kickback method of resistance measurement, because pointer is assumed at maximum and reads less for unknowns. As crowding results for relatively high unknown resistance values, not more than 500 ohms maximum is advised. The high resistance scale will read well below 500 ohms, anyway. So there will be abundant overlap.

THE HEATER KEPT ALIVE

The very same binding post facilities now permit the use of the meter for current purposes at its unreduced sensitivity, 500 microamperes. Of course the rectifier is disconnected. The imprint on Fig. 5 gives the proper directions for doing this.

Incidentally, no switch is included to interrupt the line feed to the heater, but this was done intentionally, so that an extra switching operation would be avoided, although for sufficient reason the switch could be included. The other measurements are not molested if the heater keeps going, also tube life is not shortened unless the emission current is drawn, and moreover with heater always working, no time is lost in waiting for it to heat up if one desires to switch from a d-c to an a-c measurement.

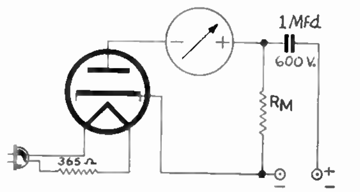
High resistance is measured by feeding the line to the rectifier, but leaving the load resistance circuit incomplete. For purpose of establishing full-scale deflection, as in any other ohmmeter, the two test leads in the proper posts (Fig. 6) are shorted, and then the unknown is introduced. It is possible to read much higher resistance this way than by using the unknown resistance in series with the line feed to rectifier. That is, the unknown is preferably in the d-c circuit. Some small deflection is obtainable even at 5 meg.

THE IMPEDANCE MEASUREMENTS

For capacity and inductance determinations, the d-c circuit of the rectifier is complete of itself, but the a-c line feed is interrupted. Again, for full-scale deflection close the proper binding posts (Fig. 7). Unknown capacities and inductances will reduce the current flowing on the a-c side, therefore reduce the a-c voltage delivered to the rectifier, and thus reduce the direct current that the electromagnetic meter passes.

The capacity measurement method is not perfection, and perhaps some readers will want to offer suggestions for improvement. The method does have respectable precedent, however. Its shortcoming, if you care to call it that, consists of the fact that it is an impedance measuring system, and ascribes the whole effect of the impedance to the capacity reactance. For a condenser of very high merit, including mica dielectric and paper dielectric, there is reason for such a procedure being acceptable. But if the condenser has high leakage, as even some passable electrolytics may have, then there may be an error in the capacity measurement, because capacity reactance alone may have too small a relative effect on the impedance.

The total opposition to alternating current flow offered by all sources constitutes the impedance, whereas the capacity reactance de-



S5 at 1,2&3. S1&S2 off. S3 at A.C. S4 at 1.
Measurements: 15-150-1500 volts A.C.

FIG. 3

For reading a-c volts a condenser-diode rectifier is used, where the former multiplier resistor, Rm, now is a load resistor to complete the d-c circuit, while a.c. is applied between cathode and rectifier plate, through a stopping condenser. One of two short circuits in Fig. 1 prevents this, too, from being done.

pends only on capacity at a particular frequency (here deemed 60 cycles for all purposes), so the capacity reactance must have an extraordinarily high relative effect on the limiting the current flow, compared to the effect of the resistance, for the impedance method to be justifiable.

As for voltage drops, the high capacity condensers will drop less voltage, and therefore their breakdown need not be feared in making the tests for capacity, whereas the small capacity condensers will likely be mica-dielectric, or perhaps paper-dielectric, and naturally would be such as will stand 100 volts or more. The usual mica condenser will stand 1,000 volts and the usual paper condenser 200 volts minimum.

INDUCTANCE MEASUREMENT

The inductance determination is also based solely on impedance, although other components than inductive reactance figure in that impedance. The situation is the same as that for condensers, except that the higher the inductance the less current flowing, whereas the higher the capacity the greater the current. The load resistor limits the maximum current to meter full scale, representing infinite capacity, or a short circuit.

(Continued on following page)

(*Continued from preceding page*)

The inductance readings are not deemed to apply well to values below 10 henries, and measurements may be made to 1,000 or even 2,000 or more henries. The inductance is calculated either from the experimentally obtained capacity calibration, or from an experimentally determined resistance calibration, where the resistance is additional to the rheostat in series with the a-c line. The inductive reactance of one henry at 60 cycles is 376.8 ohms, and so, for acceptable approximation, the henries are plotted as one each for each 380 ohms resistance, so 3,800 ohms would be taken as 10 henries and used as minimum.

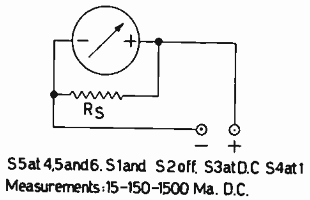


FIG. 4

By shunting the meter for d-c purposes, currents of a higher order than those permitted by the meter alone are measured. The typographical error in Fig. 1 affects this service.

Since coils in the audio range are considered, many of them chokes through which direct current passes, and since the greater the direct current the lower the inductance, though the coil itself is held intact, a provision should exist for permitting application of the d.c. at which the coil is to be worked. In fact, the coil may be a speaker field in a set and the measurement is to be made then and there. It can be done, because the line is blocked against d.c. by the two 1 mfd condensers, provided the second short circuit is removed from Fig. 1.

WHAT ABOUT D-C LINES?

Of course, inductance and capacity can not be measured if the line supplying the device is d.c., although all other measurements may be made, including a-c volts and a-c power and amperes. It does not actually appear from Fig. 1, nor in the breakdown for high resistance, Fig. 6, that line d.c. can be used for this measurement, but if the stopping condensers are shorted, the circuit is continuous to d.c., and the rectifier may be floated or not. It is well worth considering whether a switching operation should be included for this, say, as a rear cabinet wall acmodation, or whether there is not enough d.c. in use for house, office and factory wiring throughout the country to justify such inclusion.

Wattage measurement is unusual in service instruments, and perhaps some other service would be preferred, thus releasing a position on the main switch, and of course there is the eleventh position still open. Or, if you think that wattage is really important, two positions for wattage, instead of one, may be used, thus consuming the eleventh possibility.

Those considering the circuit seriously might give attention to the wattage measurement method. It consists of putting a small resistance across the lowest voltage range, and since this resistance value is known, and the voltage drop is known from the meter calibration, the wattage may be computed. The present method requires a separate scale for wattage, which follows current-squared values, and a separate scale for 10 amperes.

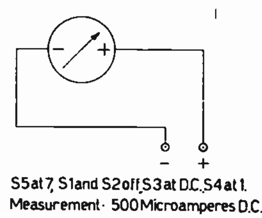


FIG. 6

The same post and switch positions as for Fig. 5 permit using the meter at its own sensitivity, 500 microamperes. This particularly exposes the meter to possibility of damage through erroneous external use, so be careful. The switching present for Fig. 5 is released to some extent, as imprinted by the draftsman.

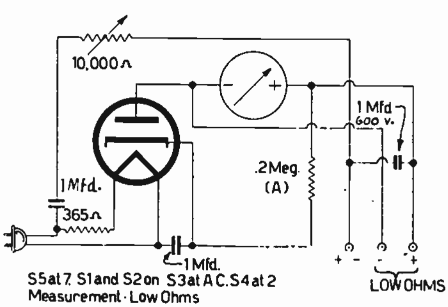


FIG. 5

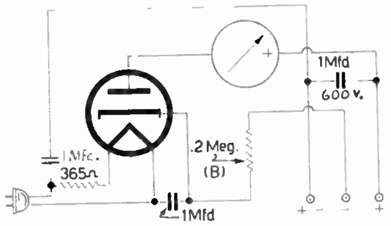
Output posts pick up the meter terminals. Posts are first shorted, the 10,000 ohm rheostat adjusted for full-scaling, whereupon with posts freed, the unknown is inserted and the meter theoretically kicks back.

Weigh carefully whether a lower voltage range than 15 volts is valuable, and if so, how can it be accommodated to a-c, if the rectifier's resistance then becomes sizeable compared to the load resistance, whereupon a scale or multiplier for d.c. would not apply to a.c. There could be a separate scale for the low a-c voltange range only. Then, too, the wattage measurement could be made to better advantage with a smaller resistor placed in parallel with the input. (Fig. 8). Say the lowest range is 5 volts, easily worked for d.c. not so readily for a.c., because of the inertia of the rectifier.

LOWER RESISTANCE SHUNT

However, if it can be done by some ready means, or by application of resourcefulness.

using either tube or other rectifier, it is open to admission as a means of improvement. Then 10 amperes still could be the current, say through .5 ohm and the watts would be 50 watts, sufficient maximum for measuring the power dissipation of nearly all receivers in a serviceman's shop and increasing the accuracy. As it is, power consumed isn't measured in service practice, although the measurement is often a ready key to trouble existing in a set, particularly if the standard wattage rating is known. Even if it is not known accurately, it can be



S5 at 8. S1 and S2 on S3 at A.C S4 at 2
Measurement · High Resistance

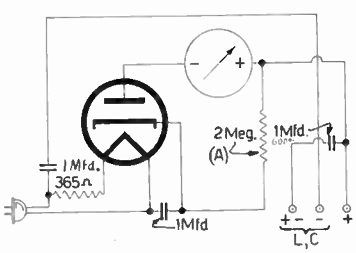
FIG. 7

The usual method of high resistance measurement is followed. After full-scaling by shorting, insert the unknown to complete the resistance load on the d-c circuit.

estimated closely enough from experience, and if wattage runs much too high or too low, the clues are numerous enough to be of great value to a serviceman, although beyond the scope of the present article.

The wattage and high amperage measurements are applicable to d.c. as well as to a.c. The switching has to be done properly (Fig. 9), and the right binding posts used. Wherever there is any unusual use of binding posts, the correct ones to use are identified by a bracket in the breakdown diagrams, none of which includes the three purposely-introduced errors in Fig. 1.

Well, there we have the circuit, discussed



S5 at 9. S1 and S2 on, S3 at A.C S4 at 1.
Measurements · Capacity and Inductance

FIG. 8

Capacity and inductance are measured by bringing one side of the line to the minus binding post, and swinging the feed around to the plate side of the rectifier through the unknown and the meter. Full-scaling applies as for high resistance, by shorting.

piecemeal, and offering quite some service when errors are eliminated, although no idea is held that it is even nearly final.

LIST OF LIMITATIONS

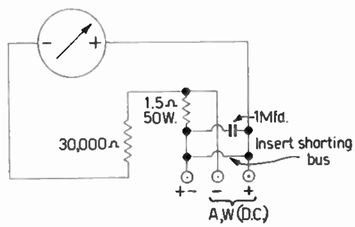
As it will soon be time to consider original improvements, the reader should bear in mind the limitations imposed:

1. The meter must be 0-500 microamperes, of 100 ohms resistance.

2. The meter scale must be assumed to be only large enough to provide room for nine calibrations. This has an important bearing on using separate scales for a.c. and d.c., because six calibrations would be used that way, leaving only three more, although some of the six could be used for currents.

3. The main switch (S_5) may consist of two or more circuits, but of not more than eleven positions.

While a tube rectifier does not have to be used, it is preferable to avoid rectifier reactance. Also it is essential that the circuit be simple, and that it shall not be costly to build, for by putting in switches, coils, tubes, condensers, transformers, etc., without regard to



S5 at 10. S1 and S2 off S3 at D.C. S4 at 3.
Measurements 10 Amperes D.C., 150 Watts D.C.

FIG. 9

The connections are for wattage measurement for d.c. If the lowest voltage range is 15, and that is used in the wattage test, a condition develops whereby full rated wattage could not be measured unless the source had a drop of at least 15 volts. Thus 150 amperes from a 6-volt storage battery could not be measured.

cost, almost any measurement could be made. That is not the point. Bear in mind that accuracy is an outstanding consideration, simplicity comes next and economy next.

The tube rectifier was included because the a-c measurements are practically non-reactive, at least to 1,000 kc. Even at higher frequencies the error is not serious, although when one goes into multiple megacycles the input capacity causes a wide departure of the read voltage from the real voltage. Thus the device is a vacuum-tube voltmeter, even though it does use some current. But this it draws only at the peak of the wave. During the rest of the positive alternation the a.c. created by the peak action on the rectifier closely equals that peak in voltage value, but during the rest of the alternation bucks the a.c. and there is no current

(Continued on following page)

(Continued from preceding page)

drawn from the unknown. When the negative alternation is on plate, the rectifier does not draw any current because it is not functioning.

MORE CALIBRATIONS

Little attention need be paid to the values of resistors, as it is assumed that correct ones are to be inserted, so that any who want to suggest other ranges or purposes may do so, and explain why, without having to compute any values. Also, the fact that the meter has a stated resistance is of no significance for any purposes except where the meter itself is to be shunted, unless a very low voltage range is to be included, when 100 ohms might be sizeable compared to the required total multiplier resistance. This would require higher current through the 10,000 ohms in the a-c line, as mentioned previously.

Services that are applicable by computation and thus may be included on the scale should be suggested. However, as an example is to be given, it should be borne in mind that this particular suggestion need not be made, as it will not count. What are wanted are your own ideas.

The extra service that could be included would be to establish some acceptable zero level,

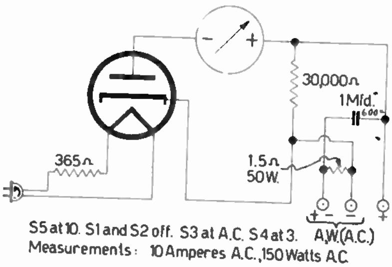


FIG. 10

Here wattage is measured for a.c., with the same limitations. Some suggestions are very welcome regarding the wattage measurements, including power decibels.

and install calibrations for decibels up and down, based on a-c voltage ratios.

What would be worth while would be a way to include ratios for power (not for voltage), where the unknown works into definite impedances at rated power. Now .006 watt is standard output at which receiver sensitivity is measured. Not only because the rectifier draws a little current, for that is of no particular account in power output work, but because for 500 ohms load the voltage would have to be less than any current-drawing rectifier at present will indicate without amplification, there a distinct limitaiton placed on the decibel power calibration as the circuit stands. So this part of the decibel situation is wide open to your ingenuity.

OPPORTUNITY FOR ALL

It must be borne in mind that other impedance values are used than 500 ohms, and that

Data on Which Curve For %M Was Based

The percentage modulation curve is based on application of the formula for a single tone, for eleven different percentages calculated from 0 to 100 in steps of 10. The tabulation of the eleven points follows:

%M	E (up)	E (down)
100	5.0	0
90	4.75	.25
80	4.5	.5
70	4.25	.75
60	4.0	1.0
50	3.75	1.25
40	3.5	1.5
30	3.25	1.75
20	3.0	2.00
10	2.75	2.25
0	2.5	2.5

Note that the sum of E (up) and E (down) always equals 5.

Only the 5-volt a-c scale is considered, with 2.5 volts as the zero level, and the needle moving either up or down, depending on the type of oscillator generating the carrier.

However, assuming a-c voltage scales of 5-50-500-5,000 volts, due to decimal repetition, the zero level could be 2.5, 25, 250 or 2,500 volts, and the percentages would still apply. Unknown input has to consist of carrier alone, adjusted to produce zero percentage indication, then modulation added, the new voltage causing the reading to be in percentage modulation.

a tapped transformer, with primary facing the meter, and secondaries selected for matching the load, offers a possibility. However, the decibel power consideration must not be assumed to be stressed strongly, for it may not be of great importance. You will decide that for yourself.

Some readers will be able to handle some parts of the problem and not other parts. For instance, without mathematical training one can not handle the decibel problem satisfactorily. There is no need to withdraw from the case, for the most important improvements will possibly concern the most important servicing aids that the instrument can afford, and decibels are hardly yet among these.

The problem therefore offers possibilities to everybody. Any suggestions are welcome. All will be given close attention. Diagrams need not be included, if the reader deems the suggestion scarcely requires illustration. So think over the case. When you develop any suggestion, send it in. If another idea strikes you, even one quite different, or an improvement on the first one, send that in. Send in as many suggestions as you like. The field is open. And there's money in it—maybe for you!

FICTITIOUS MR. I. GILLESPIE MAKES UNFACTITIOUS REPLY

As an aid to readers who intend to tackle the problem set forth in the accompanying article, I decided to follow a current song and sit right down and write myself a letter. It is in the spirit of another song, this one for boys, wherein the name of the fictitious but boastful character is appended as signatory:

Mr. H. J. Bernard,
RADIO WORLD,
145 West 45th Street,
New York, N. Y.

Dear Sir:

My suggestions are:

(1) Use a lower voltage scale than 15, say 5.

(2) Use more than three voltage scales, for better definition, say 5, 50, 150 and 500, which also brings most commonly encountered high d-c voltages within the best accuracy range of the highest voltage scale; thus the extra voltage reading uses up the eleventh position.

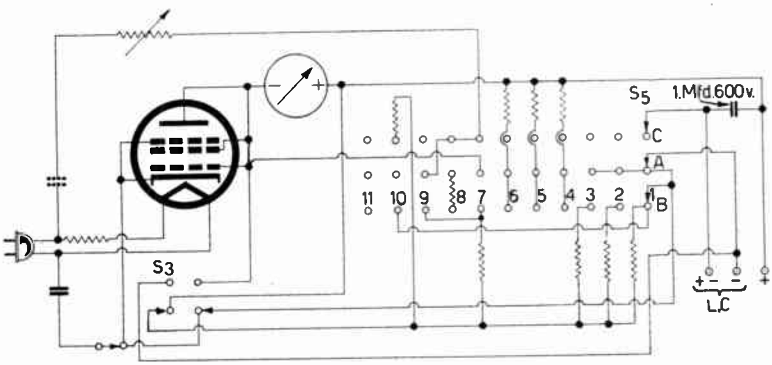
(3) With the 5-volt a-c scale as basis, introduce a calibration for percentage modulation (single tone). This requires no extra switching.

Use a three-deck switch for S_5 to simplify operation and safeguard the meter. This eliminates a control, so adds no cost.

The lower voltage scale requires its own multiplier resistor, and the scale may have to be calibrated separately, a.c. unlikely to duplicate d.c. for lack of linearity on that range.

The four voltage scales will give better value on work that servicemen most frequently perform, i.e., voltage measurements. Currents are not nearly so often measured.

The curve drawn on semi-log paper is based on the formula for percentage modulation



C deck on S_5 suggested by "I. Gillespie," who also eliminated one short from Fig. I but not the other.

with single tone, $\%M=100d\div E_c$, where M is modulation, d is the difference between voltage readings, carrier unmodulated and carrier modulated, and E_c is the voltage of the carrier unmodulated. The curve is based on unmodulated carrier volts input to meter equalling 2.5, thus falling at midpoint on the proposed 5-volt scale. (Curve is on following page.)

The formula applies to modulation upward, the usual instance encountered in servicing, also for downward. For modulation that reduces the amplitude, the unmodulated carrier voltage is subtracted from the carrier voltage. Reading the ordinates at left from bottom to top gives the modulated carrier volts for upward modulation, and reading them down at right gives the modulated carrier volts for downward modulation. The adjustment to 2.5 volts zero level the operator performs by changing the coupling between unknown and instrument, through coils, condensers or otherwise.

The tester diagram adheres to the one you printed, as far as pertinent, except that the third deck, C, is added. Your two decks for S_5 are left in their relative positions for simplicity of designation. You will note absence of danger to the meter. By using the a-c (±) post and the d-c minus (—) post for unknown input for inductance and capacity, instead of using both d-c posts, 1 mfd. condenser you show, from the upper side of the a-c line to the rheostat, may be omitted, for the 600-volt condenser, already present, is made to serve the purpose.

I. GILLESPIE

Four Easy Rules to Follow

IN the foregoing article the main objectives were set forth for instituting a volt-ohm-milliammeter that also provides additional services, and a basic working diagram given. Just to make things a bit harder, and more interesting, two short circuits were purposely put into Fig. 1, the basic diagram, also a typographical error purposely made by the draftsman in his imprinting of that diagram. However, there are enough hints distributed throughout the text to enable a radio-wise technician to get rid of the shorts and fix up the typographical error. The corrections may be discussed in letters and diagrams submitted.

The four rules to follow are simple:

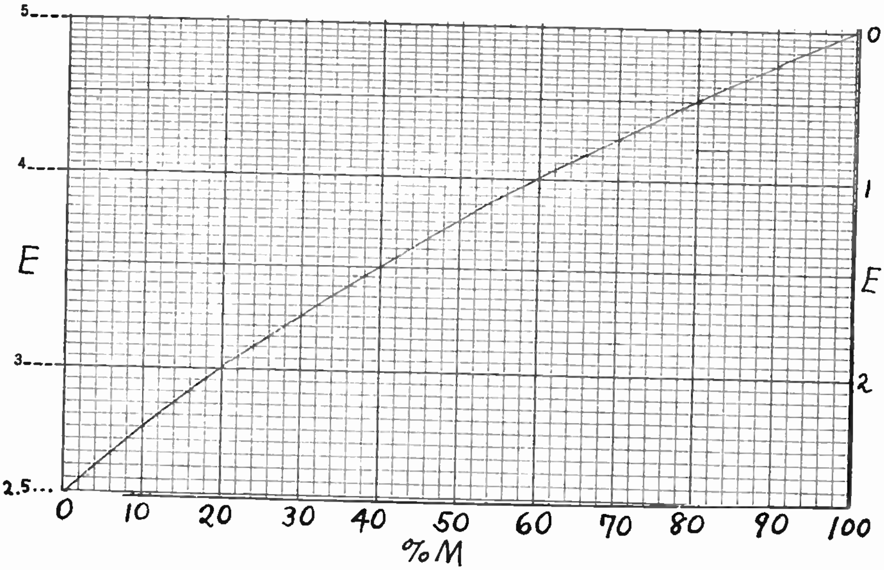
1. Letters should be typewritten or handwritten on one side of the sheet only.

2. If diagram or diagrams are to go with the letter, enclose them in the same envelope with the letter.

3. If, in case letters and diagrams are not acceptable, their return is desired, be sure to include enough return postage.

4. The editor of RADIO WORLD will be sole judge of everything and his decisions will be final.

For each letter accepted and printed, $5 will be paid, plus 8c. a word for each word in the letter as printed. For each diagram accepted and printed, $5 additional will be paid. Checks will be mailed immediately on publication of the issue. There is no time limit on submissions.



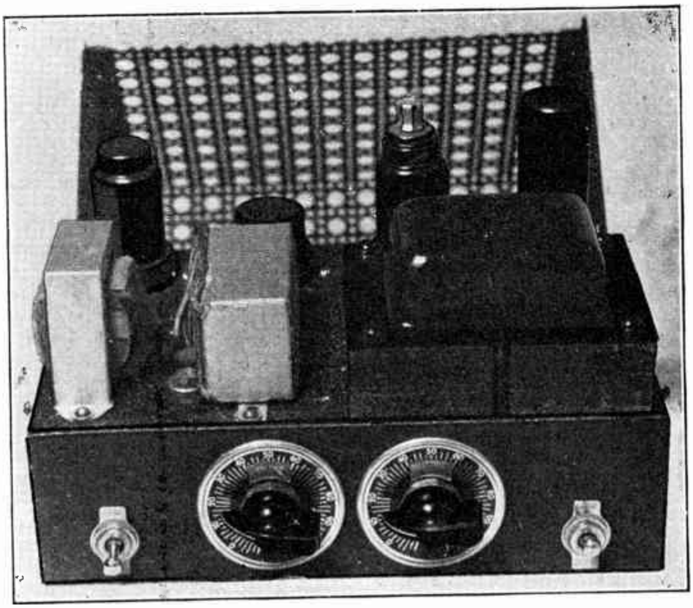
When unmodulated carrier input is adjusted to a-c meter used on the 5-volt scale, so that needle reads exactly at midscale (2.5 volts), any change in amplitude, whether in grid-leak-controlled self-excited oscillators, or fixed-biased, or semi-fixed biased oscillators, may be expressed in terms of percentage (for single tone), by consulting the chart. For any non-reactive a-c meter having 5-volt scale this curve applies to a comparison of unmodulated and modulated carriers for percentage modulation.

THE VOLUME EXPANDER

In Improved Form Fulfills Real Need

By Tom Waite

Douglas Radio



View of the built-up expander, with the volume control and level control bar handles shown in foreground, also line switch and use - disuse switch, latter marked SPDT at upper right in diagram. It is convincing to compare the difference between expander included and expander excluded, as may be done by throwing SPDT.

WHEN a station broadcasts a program it does not allow the modulation of the carrier, or effect of the audio frequencies on the transmission, to follow in every respect the sounds as created before the microphone. The ratio of intensities is far too great, as developed by a symphonic orchestra, for instance, for the capabilities of the transmitter.

If the single-tone modulating voltage is equal to the carrier voltage alone, then the addition of the modulation makes the amplitude twice that of the carrier alone, which represents 100 per cent. modulation, whereas the symphonic orchestra might produce intensities that appear at the output of the modulator as requiring a modulated carrier being five or more times the amplitude of the carrier alone.

As any percentage modulation in excess of 100 is merely another name for distortion, the station would become very successful in sending out a lot of distortion, which is exactly what it does not want to do. Nor does the listener desire any such disservice, either.

AUTOMATIC STOP ON EXCESS

So there must be some remedy, some means of preventing the modulation from exceeding the modulating capabilities of the transmission, and there is. It is known as compression, which means that audio values too intense to be handled distortionlessly are automatically reduced in intensity, so that their values fall within the capabilities of the system.

If compression were not practiced there would not be nearly so much enjoyment of fine music, or even speech or other broadcasts where there is a considerable change in the amplitude level of the source of sound, as where a speaker changes from half a whisper during meditative passages, to feverishly excited words uttered with deep breath, in passages that may have more fervor than logic in them. So it is not only the symphonic orchestra that is the "offender," but any group or individual before the microphone could conceivably cause trouble. However, the automatic regulator takes care of that.

Not only in broadcasting, but also, and to a greater extent, in recording is compression practiced, because the capabilities of the record are more severely limited in this respect. The de-

(Continued on following page)

(*Continued from preceding page*)

gree to which the reproducing needle may safely vibrate being one of these, so we again face the problem of having music particularly, and sometimes song and speech, toned down by an automatic process.

EXACT DUPLICATE

The same general situation obtains in a steam generating plant, where the governor prevents the boiler from developing too much compression. The moment that a certain pressure level is reached, say, 30 pounds in a home plant, a relay trips, and the boiler lets off steam. This may be considered the "100 per cent modulation point" to which the boiler is restricted.

Now, with the boiler we do nothing to recapture the excess, for it has gone into the air, has vanished, and we have no means to recapture it. But when what is taken out of the radio program, or out of the rendition for making recording is desired to be restored, this may be done, by using a principle which is the reverse of the compression method, and is known as expansion. So if everything that was compressed were equally expanded we would have the exact amplitude duplicate of what took place before the microphone, otherwise we would not.

There is a certain zest and depth that attends the precise reproduction of the original broadcast or recording, vigorous passages become lifelike and vital, and the feeling is experienced that one is in the studio, right beside the microphone.

"THAT SOUND"

It is often quite easy to tell the difference between an original rendition and a reproduction, whether by phonograph or by radio. A person remarks he can tell the difference by "that sound." In the early days of both phonograph and radio that meant a very irritating sort of distortion, which in singing had nasality, and in music a kind of tinniness attended by semi-squeaky vibration. But in later years, with such fine quality possibilties in both radios and phonographs, the severe distortion criterion disappeared, but the expression "that sound" may still remain, to distinguish the natural from the unnatural.

Although persons not versed in the ways of broadcasting and of recording might not know the real difference, if they were musically trained they could tell it by that indefinable something which, still "that sound," distinguished the real from the unreal. With the explanation that the suppression of amplitude of the more energetic passages was the cause, they might feel that they had struck the truth at last, for with every other factor of distortion eliminated, this tampering with the peaks of some of the audio is necessarily and frankly a form of distortion, and for fidelity and realism must have its compensation.

While with radio receivers the need for the expander may be less, it is still present, while with phonograph reproduction that need is really of importance. So the volume expander has come to find a place in the category of acoustical science, and as its circuit becomes more and more nearly perfected, the popularity of the device increases.

It so happens that the expander circuit, basically the same since first introduced, has undergone improvements, until to-day it is offered as something that readily provides the remedy for which the tone-conscious listener had been seeking, perhaps even without knowing just what he had been seeking, except that it was something to overcome the obvious presence of "that sound" which distinguished the original from the duplicate.

The basis of the operation is the utilization of the properties of the 6L7, a multi-grid tube, the third grid of which greatly controls the conductance.

HOW TO MAKE CONNECTIONS

Referring to the circuit diagram, it will be seen that two binding posts are market "Input" and two are marked "Output." To the Input posts either phonograph pickup or tuner output is connected. If a pickup is being used, then the connection is made directly, and needs no further explanation. However, if a receiver is being used, the detector output is no longer fed directly to the audio amplifier of the receiver, for the output posts of the expander, in either example of radio or phonograph use, are connected from grid to ground in the audio amplifier. A receiver naturally would have its own amplifier, but for a pickup an amplifier would have to be provided.

Therefore the connections for phonograph use are very elementary, but for radio use, while simple, require that the detector be disconnected from the audio amplifier, and output of the detector connected instead to the upper input post in the diagram. It is assumed that the plate or anode load on the detector is complete, and that a transformer or stopping condenser intervenes between detector output and expander input, so there will be no d-c short circuit. Assurance against audio short-circuit is then automatically provided.

DIVIDED OUTPUT

Now the output of phonograph pickup or radio receiver detector is divided, the full value of signal voltage being applied to the grid of the 6C5 in the expander, for audio amplification, while the input to the first grid of the 6L7, which is the control normal grid, is subject to manual volume control.

Looking at the lower branch of the circuit, consisting of the 6C5 and the 6H6, we find that the amplified audio is fed to the diode rectifier, which on examination proves to function just as any automatic-volume-control tube does. That is, the greater the a-c amplitude—and note that we are using audio to derive our d.c., and not radio frequencies—the more positive will the common cathode become. By suitably introducing this voltage change into the 6L7 circuit, so that the sensitive third grid is swung by the control voltage, we have the case of a grid being made more positive, the greater the audio amplitude. In the usual a-v-c example of course a controlled grid is made more negative, because controlled tubes are returned to the plate side of the diode rectifier, cathode being grounded.

Because we use the a-v-c system backwards, and particularly because we apply the d-c voltages to a grid of a tube (6L7) that makes for much greater conductance as the voltage on it rises, we come finally to the attainment of increased amplitude of response for increased amplitude of received audio. That is, the rule of the louder, the louder prevails, and that exactly expresses the case for expansion, because what we are counteracting is a case of the louder the softer (beyond a certain limit).

APPRECIATED BY ALL

It is necessary of course to establish the limit in the expander, so that it jibes with the recording or the broadcast situation, but this is easily done by levelling with the 2,000 ohms, using the ear as criterion. The effect should be that which produces the greatest realism, and particularly those appreciative of good music will find the acoustically correct level, while others, too, will enjoy the expander, because the control will be set so that the results are those which most please their ears, which after all is the goal, since we listen for purposes of enjoyment, and what pleases us most is what we enjoy the best.

Every one will appreciate the effect of the expander, especially when those crescendoes come smashing in with the duplication of original fervor, instead of orchestras sounding as if they were playing at a monotonous level. The purpose of the expander therefore may be briefly expressed as a law to end monotony in music.

Only the highest-priced receivers and phonograph amplifiers have expanders built in, and the design herewith lends itself to ready attachment to set or amplifier.

LIST OF PARTS

Coils

One power transformer; 115-v. primary; 5-v., 6.3-v. c.t. and 550-v. c.t. secondaries
Two 15 henry filter chokes, 500 ohms d-c resistance

Condensers

One 10 mfd., 35 volts
Two .05 mfd., 400 volts
Three .25 mfd., 400 volts
Two .5 mfd., 400 volts
One .1 mfd., 400 volts
One dual 8 mfd., 550 volts
One separate 8 mfd., 550 volts

(The high capacities just enumerated are electrolytics)

Resistors

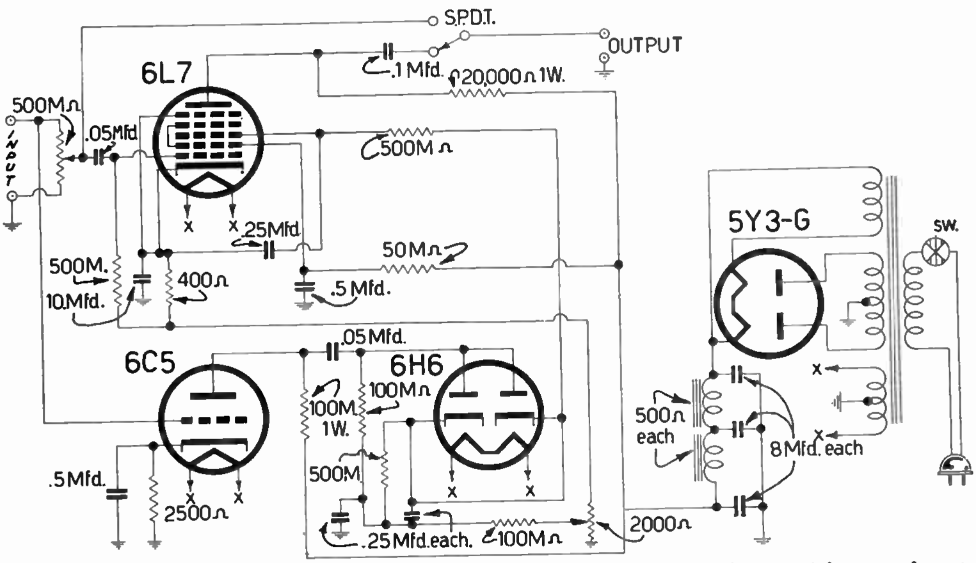
One 500,000-ohm potentiometer
One 2,000-ohm potentiometer
One 2,500-ohm, one-half watt
One 400-ohm, one-half watt
One 400-ohm, one-half watt
Three 500,000-ohm, one-half watt
Two 100,000-ohm, one-half watt
One 100,000-ohm, one-watt
One 50,000-ohm, one-half watt
One 20,000-ohm, one-watt.

Tubes

One 6L7, one 6C5, one 6H6 and one 5Y3-G.

Other Requirements

One four-prong socket
Four octal sockets
One SPST switch
One SPDT switch
Two input posts
Two output posts
Hardware, grid caps, hookup wire

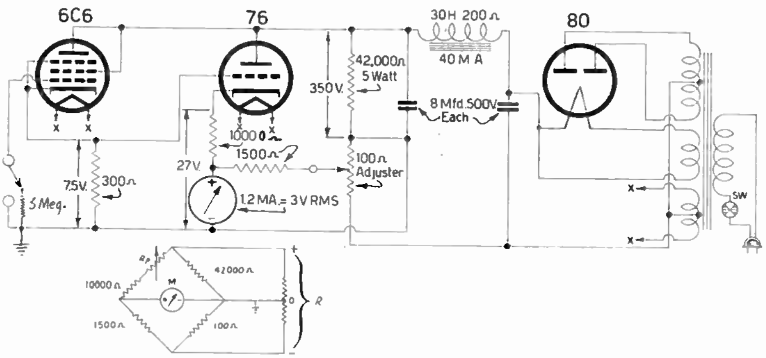


The volume expander circuit, in improved form, is an effective corrector of a special type of protective distortion introduced in the studio. Four tubes are used, and the object is to make amplitude values much greater above a certain level than they would be otherwise, to atone for the supressions above that level protectively practised in the studio.

A Stabilized Tube Voltmeter

Double Inverse Feedback is Used

By Capt. Peter V. O'Rourke



A stabilized vacuumtube voltmeter, using double inverse feedback. The equivalent bridge circuit in which the meter M is placed is shown at lower left. R is the rectifier resistance and also may be considered the d-c voltage supply.

VACUUM-TUBE voltmeters usually have amplifiers, so that low voltages may be read, and the amplifiers must be direct coupled so as to enable correctness of readings practically regardless of frequency. Some types measure only a.c., others measure only d.c., and still others measure both a.c. and d.c. Any of them that have amplifiers must have direct-coupled amplifiers, which are direct-current amplifiers, so as to be non-reactive.

The tube voltmeter shown in the diagram was built for making measurements of both a.c. and d.c., no extremely low voltages being required, so what turned out to be 3 volts full scale rms proved satisfactory. The main point about the design is its stability, for where non-reactive amplifiers are concerned in tube voltmeters, some measure of instability is necessarily expected. Direct-coupled, or direct-current, amplifiers behave that way.

The circuit diagram contains imprints of the measured resistance, voltage and, in the case of the meter, current values. The 40 ma designation under the choke in the B feed refers to the rating of the choke, and not to the current, through it, which was somewhat less.

THERE IS NO AMPLIFIER

No amplifier is used. The 6C6 tube, which may seem at first glance to be an amplifier, does not have to be in circuit, for the grid connection of the 76 may be made to pick up one side of the unknown alone, other side of unknown to ground, and about the same reading will prevail, because the difference between the d-c voltage drop across the 300 ohms is about equal to the unknown rms.

The main consideration of the circuit, establishing stability and non-reaction, is the inverse feedback resulting from absence of by-pass capacity across the two series cathode biasing resistors. So instead of inverse feedback once, we have it twice, which increases the stability, and therefore reduces, or almost completely eliminates, creepage, which is one of the outstanding vices of some tube voltmeters.

CONNECTION TO 76

In particular, the circuit consists of an input tube, which, during absence of unknown across the binding posts, is closed to ground through a high resistance. Because there is no grid current, closure through this resistance makes no difference in reading than shorting grid directly to ground. As a test for grid current, the two methods may be tried, and if there is difference there is grid current, and the 300 ohms would have to be increased. As it is, this resistor is pretty low in ohmage for the high plate voltage, even though the 6C6 is used as a suppressor triode. More conservative working than at 27 ma, which reduces tube life, might be preferred by some.

The cathode of the 6C6 is connected to grid of the 76 and thus a low resistance loading of the 76 prevails, as in the 76 the measurement is actually made in a bridge circuit.

The negative bias on the 76 is obtained in a double manner. First there is a cathode series resistor of 10,000 ohms, a fixed unit having been used, although this could be made variable to increase the range to higher voltage, say, to 7 volts, requiring readjustment of the 100-ohm potentiometer. The 10,000-ohm resistor is returned to ground through the indicating meter, while the positive side of the meter is connected to the moving arm of the low-resistance potentiometer through a limiting resistor. The object of the limiting resistor is to avoid any considerable shunting effect of the meter by the connnection to the potentiometer, which, as stated, has low resistance.

This low resistance is the result of a heavy bleeder current in the B supply. Note that B plus is returned to B minus through the total resistance of the potentiometer, and that B minus is *not grounded,* but the upper side of the low resistance potentiometer is.

The condition for meter reading zero, regardless of how much current is flowing through the 10,000 ohms and the 1,500 ohms to B minus through the utilized lower part of the potentiometer, is that meter feed from the arm is at a point equally negative in respect to ground as is the negative side of the meter. The current through the meter is from positive to minus as fed from the cathode, and from minus to positive as fed from the bleeder circuit so that when the two currents are made equal, by adjustment of the 100-ohm potentiometer, the net current through the meter is zero, the meter reads zero, and any increase of current results from the action of the 76 alone. If there were not a heavy bleeder this independence would not be so fully preserved.

SELECTION OF METER

Another way of looking at the bridge circuit is to say that due to the cathode idling current positive of the meter is established at a certain small voltage, and when the same positive voltage is obtained from the bleeder circuit for the negative side of the meter, there is no difference in voltage across the meter and therefore no current through the meter.

Any meter of a *sensitivity* of 1.2 milliamperes or more may be used, e.g., 1 ma, and for known input of 3 volts rms the meter, if more sensitive, may be shunted by a resistor so that exactly full scale is registered. The voltage curve then is practically linear, in other words, the meter calibration for d.c. may be followed, applying any necessary constant factor for a full-scale calibration not decimally related to 3.

Adjustment to a meter of somewhat lower sensitivity, say, 2 ma or so, may be made by choosing a different value of limiting resistor (shown as 1,500 ohms).

The bridge circuit in which the electromagnetic meter is nested is d.c. and is shown on the diagram, where R_p is the plate resistance of the tube, which is the variable; 10,000 ohms is the cathode series resistor; 1,500 ohms is the limiting resistor; and the 42,000 ohms and 100 ohms are the series resistors in the bleeder circuit. R is the resistance of the rectifier, which includes the 200 ohms of the B choke.

HOW TO USE THE VTVM

The resistor marked 3 meg. at the input should not be any higher, though may be lowered to 2 meg. or even 1 meg. Its chief purposes are to close the input, and avoid leaving the 6C6 grid open, which prevents balance, and for providing d-c continuity when measuring a.c. in an external circuit lacking d-c continuity.

The method of use is as follows: Plug the primary into the a-c line, open the line switch on the instrument, see that the unknown input switch is closed, and put the 100 ohms at halfway position. Then introduce the 1,500 ohms, or other value resistor of that order. until the meter reads zero or nearly so. As fixed resistors are supposedly used, exact zero may not be registered, but get as close to zero as conveniently practical. The object here is the use of the 100 ohms as effectively as possible over a wide range.

Now insert the unknown, whether a.c. or d.c., across the input binding posts, open the switch at that point, and read the volts on the electromagnetic meter. The input switch at upper input binding post is left open always during measurement, unless needed for d-c continuity in a-c circuits, since d-c circuits always will have such continuity.

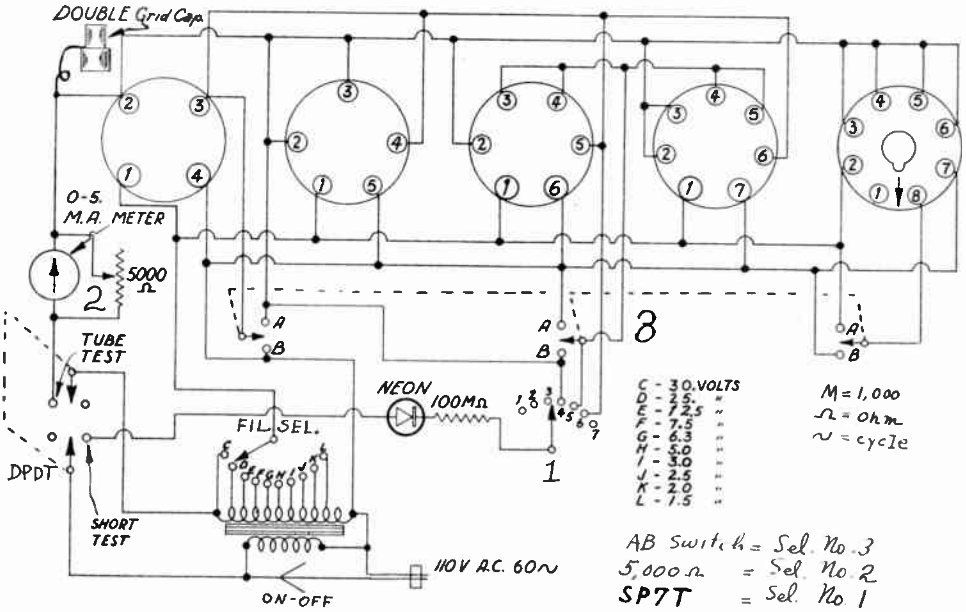
On a-c the behavior is that of a full-wave detector and therefore relative freedom from error of reading due to wave form distortion is enjoyed. When measuring d.c. put positive toward the grid. This is because what detection takes place in the 6C6 causes a little more response to the positive alternation, hence the drop across the 300 ohms reads up.

Plan to Consolidate All Service Groups Progressing

Announcement of the formation of Radio Servicemen of America brought a large number of applications for membership from existing local groups of servicemen including groups in Cleveland, Chicago, Binghamton, Denver and Duluth.

These men represent only a small percentage of the servicemen in the country who are now considering affiliation with the Radio Servicemen of America. The work of contacting the various groups and individuals is going ahead rapidly, but due to magnitude of task many have not been contacted. Any group or individual who has not been contacted is invited to write RSA, Room 1533, 304 South Dearborn Street, Chicago, for application blank and information on how to become a member. Where a number of servicemen form a group, such groups are invited to inquire concerning charters for their local groups.

Jerome J. Kahn, Standard Transformer Corporation, 850 Blackhawk Street, Chicago, is reorganization trustee.



This tube checker, briefly described in the October, 1937, issue, aroused considerable interest. Questions concerning it are answered in consolidated form in the accompanying article. A table listing all the important tube types, with filament volts, and setting of the rheostat (Selector 2), was printed in the October issue

TUBE TESTER POINTERS

Questions on Construction and Operation Answered

By Henry Burr

THE tube tester described in the October, 1937, issue, the diagram of which is reprinted herewith, has raised some questions which it is the purpose of this article to answer.

One reader asks whether the bottom view or top view of the five sockets is shown. While this was not specifically stated, it is common practice to prefer the bottom view in diagrams, as actual construction and wiring are done with this view exposed, and so the view presented is the bottom view. The sockets were terminal numbered according to the code of Radio Manufacturers Association, Inc., clockwise from 1 to 4, 1 to 5, 1 to 6, 1 to 7 and 1 to 8, which, to any one familiar with radio, means that the bottom view is shown, because 2, which is plate practically without exception, is to the left of 1. Of course, any one not familiar with the code of "rotation" of pins could be confused.

The 5,000-ohm rheostat used for shunting the 0-5 Readrite milliammeter, which has Good-?-Bad scale, was stated to be non-linear. The question naturally arises, What is the taper? It is not standard. However, the rheostat is commercially obtainable for 65c.

HOW RHEOSTAT READS

The scale for the rheostat reads 0-100 to encompass the full span of the rotation of its moving arm, and 0 represents zero resistance, or complete shorting of the meter, since the rheostat is in parallel with that indicator.

In the absence of a Good-?-Bad scale on the meter, the operation of the tube checker, to conform to the chart for all important tubes, printed in the October issue, may be based on division of the meter scale into three equal parts. The area for Good is at right.

The rheostat value, also the meter sensitivity, are based on a commercial model tube tester manufactured by Superior Instruments Company, and are related, of course, to the power transformer. If the voltage is higher than that used in the commercial instrument the readings will be too high, or if the voltage is lower, the readings will be too low, for correct indication. The transformer likewise is based on a line voltage of 117 volts, and while a line voltage departure of 5 per cent will not make any appreciable difference in the testing, a much wider variation would of course have the same effect as a transformer with wrong secondary voltages connected to a line of the right primary voltage.

A HANDY SOLUTION

Moreover, the chart is related to these factors directly, and applies only when the conditions are correct. However, there is a ready solution. As in a bridge from which the pointer for direct-reading has been removed, and the reset value is desired, if a known resistor is inserted, and the pointer made to indicate that resistance, the indicator will be properly set for all purposes. So here if a tube of known first-grade quality is used, and the table for that tube consulted in the October issue, an adjustment that gives the proper reading for that tube will enable correctness for all other purposes. Nearly all the way over on the Good part of the scale will make the instrument a severe judge of tube worth and quality, which is perhaps preferable procedure, for if there is any doubt it should be resolved against the tube, and a replacement made.

The proper setting referred to, wherein a tube of known excellent quality is used as guide, affects the rheostat as well as the meter. Nothing much can be done about the taper of the rheostat, as that is what it is, although the departure from linearity is not great, and those using linear rheostats will have a workable instrument nevertheless, though one that does not afford quite as critical an evaluation of all tubes as if the proper taper were introduced.

METER OF DIFFERENT SENSITIVITY

On occasions this rheostat has to carry considerable current, so only wire-wound types may be used. All of these will have sufficient current-carrying capacity, or wattage-dissipation capability.

Considering the possibility of using some meter of higher original sensitivity, as some have done, say 0-1 ma, they have shunted it with a proper value resistor to reduce the sensitivity to 5 ma, or quintuple the current-carrying capacity. This is all right. But the Readrite meter has a high internal resistance, and the shunted 0-1 milliammeter will have a very low resistance. Normally the resistance of a 0-1 milliammeter is around 30 to 50 ohms, and the proper shunt for 5 ma would be the meter resistance divided by 4. For the more favorable case of the 50-ohm meter, referring only to the smaller departure from high meter resistance required, the shunt for the 5 ma service would be 12.5 ohms and the effective resistance (meter of 50 ohms paralelled by 12.5 ohms) be 10 ohms. It would then become feasible, instead of shunting the meter with the rheostat, to put the rheostat in series, which likewise may be done with the 0-5 original meter if the transformer voltage is too high, again using a tube of known quality as standard. But it is preferable to follow the diagram as shown, unless use of an already possessed meter is of controlling importance, because the charted values will be more accurately applicable.

TWO MORE QUESTIONS

The two remaining questions raised refer to the short test and concern the fact that the neon tube always lights, and that there are seven positions for short tests, only three of which (Nos. 4, 5 and 6 in the diagram) are connected anywhere.

Taking up the neon tube first, it is obvious that the circuit in which it is placed is continuous, and voltage is applied from the line, at any one of these utilized positions, hence there will be a glow even if the tube elements are rightfully "open." However, it will be noticed there is a 100,000 ohm resistor in series with the lamp, and thus there will be a dim glow, whereas if the element being tested is shorted there will be bright illumination. Moreover, dimness is usually accompanied by a glow on only one plate of the neon tube, whereas a short causes bright ignition of both plates. Leakage less than a short is determined by comparison of "open" glow and "short" glow.

For the short test Selector 2 (left center) is at right, Selector 1 (not ennumerated on the diagram) is for picking up the correct filament voltage, and Selector 3 is for short test (upper position) or for tube test for quality (lower position). These positions refer to the diagram, but the mechanical operation of the switches actually used need not conform literally to "lower" and "upper" as just set forth.

VOLTAGE PRECAUTION

The unused positions for short test are for enabling the device to test shorts of any other circuits by introducing binding posts or leads, or for anticipating tubes with more than eight elements, or socket connections, to minimize obsolescence.

The precaution must always be repeated in connection with use of a tube tester having selective filament or heater voltage supply that the right voltage be picked up for the particular tube to be tested, especially that the applied voltage be no higher than that needed. It is best practice to select the filament or heater voltage (Selector 1) before the tube is inserted, throw DPDT to the short test position, and after this test is completed, throw DPDT to the tube quality test position.

As can be imagined from the foregoing, the article on the tube tester created a good deal of interest, and while it is believed that all questions asked have been answered in consolidated form, as well as answers given to anticipated questions, nevertheless readers interested in any aspect of the tube tester, or who have any doubts they want cleared up, are at full liberty to write to the author, care RADIO WORLD, 145 West 45th Street, N. Y. City, as he will be glad to give the queries prompt attention.

In conclusion, it should be repeated that this is an emission type tube tester, that the maximum filament voltage is 30 volts, also the RMA recommendation for plate voltage quality test, and that many commercial instruments according to the diagram herewith have been produced and have proved satisfactory in operation.

NEW TUBES INCLUDE:

Power Amplifier, Super Control Amplifier and a Rectifier, All of G Series

THREE new glass type tubes were announced recently. They are:

6AC5-G, a high-mu power amplifier triode.
6U7-G, a triple-grid, super-control amplifier.
6ZY5-G, a high-vacuum full-wave rectifier.

The 6AC5-G is intended for use in the output of a-c receivers. Two of these tubes when operated as Class B power amplifiers are capable of delivering approximately 8 watts power output, using an input between grids of 950 milliwatts. A single 6AC5-G when operated as a "direct drive" power amplifier, with a type 76 tube as driver, can deliver 3.7 watts.

The 6U7-G is similar to the 6D6.

The 6ZY5-G is intended for supplying rectified power to radio equipment having relatively small direct-current requirements.

The tentative data on these tubes, according to RCA Manufacturing Co., Inc., are as follow:

6AC5-G
High-Mu Power Amplifier Triode

Heater Voltage (A.C. or D.C.)	6.3	Volts
Heater Current	0.4	Ampere
Maximum Overall Length	4⅛"	
Maximum Diameter	1 9/16"	
Bulb	ST-12	
Base	Small Shell Octal 6-Pin	

Static and Dynamic Characteristics

Heater Voltage	6.3	Volts
Plate Voltage	250	Volts
Grid Voltage	+13	Volts
Amplification Factor	125	
Plate Resistance	36700	Ohms
Transconductance	3400	Micromhos
Plate Current	32	Milliamperes
Grid Current	5	Milliamperes

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

As Class B Power Amplifier

Plate Voltage	250 max.	Volts
Peak Plate Current (per tube)	110 max.	Milliamperes
Average Plate Dissipation	10 mox.	Watts
Typical Operation—2 tubes:		
Unless otherwise specified, values are for 2 tubes.		
Heater Voltage	6.3	Volts
Plate Voltage	250	Volts
Grid Voltage	0	Volts
Peak A-F Grid-to-Grid Voltage	70	Volts
Zero-Signal D-C Plate Current	5	Milliamperes
Effective Load Resistance (plate to plate)	10000	Ohms
Power Output*	8 approx.	Watts

*With peak input of 950 milliwatts applied between grids.

As Dynamic-Coupled Power Amplifier with Type 76 as Driver

Operating Conditions:		
Plate-Supply Voltage	250 max.	Volts
Average Plate Dissipation	10 max.	Watts
Grid Voltage	‡	Volts
Average Plate Current	32	Milliamperes
Average Plate Current of Driver	5.5	Milliamperes
Input Signal to Driver	16.5	Volts RMS
Load Resistance	7000	Ohms
Harmonic Distortion	10	Per cent
Power Output**	3.7	Watts

**When driver is operated up to the grid-current point, it is possible to obtain a power output of 4.3 watts with approximately 16% distortion.

‡Bias voltage for both the 6AC5-G and the driver is developed by the "dynamic-coupled" connection shown in the circuit arrangement. The main purpose of the 25000-ohm resistor is to prevent a current surge when the 6AC5-G is warming up. The total d-c resistor in the grid circuit of the driver should not exceed 1.0 megohm.

Pin Connections

Pin 1—No Connection	Pin 5—Grid
Pin 2—Heater	Pin 7—Heater
Pin 3—Plate	Pin 8—Cathode

(Pin numbers are according to RMA system.)

6ZY5-G
High-Vacuum Full-Wave Rectifier

Heater Voltage	6.3	Volts
Heater Current	0.3	Ampere
Maximum Overall Length	4⅛"	
Maximum Diameter	1 9/16"	
Bulb	ST-12	
Base	Small Shell Octal 6-Pin	

As Full-Wave Rectifier

Operating Conditions (Condenser Input to Filter):		
Heater Voltage	6.3	Volts
A-C Plate Voltage per Plate (RMS)	350 max.	Volts
Peak Inverse Voltage	1000 max.	Volts
Peak Plate Current per Plate	150 max.	Milliamperes
D-C Output Current	35 max.	Milliamperes

When the d-c resistance of each half of the secondary of the power transformer is less than 225 ohms, sufficient resistance should be added in series with each plate to provide this minimum of resistance.

*The d-c potential between heater and cathode should be limited to 400 volts.

Under no condition of operation should the normal operating heater voltage of 6.3 volts ever fluctuate to exceed a maximum of 7.5 volts.

Pin Connections

Pin 1—No Connection	Pin 5—Plate ‡
Pin 2—Heater	Pin 7—Heater
Pin 3—Plate ‡2	Pin 8—Cathode

(Pin numbers are according to RMA system.)

Curves revealing the average plate characteristics of the 6AC5-G, and a diagram for direct drive by a 76, appear on opposite page.

6U7-G

Triple-Grid Super-Control Amplifier

Heater Voltage	6.3	Volts
Heater Current	0.3	Ampere
Direct Interelectrode Capacitances:		
Grid to Plate (with shield-can)	0.007 max.	$\mu\mu f$
Input	5.2	$\mu\mu f$
Output	6.8	$\mu\mu f$
Overall length	4 7/32" to 4 15/32"	
Maximum Diameter	1 9/16"	
Bulb	ST-12	
Cap	Small Metal	
Base	Small Shell Octal 7-Pin	

As Class A_1 Amplifier

Operating Conditions and Characteristics:			
Plate Voltage	100	250 max.	Volts
Screen Voltage‡ (Maximum)	100	100	Volts
Grid Voltage (Minimum)	—3	—3	Volts
Suppressor	Connected to cathode at socket		
Amplification Factor	375	1280	
Plate Resistance	0.25	0.8	Megohm
Transconductance	1500	1600	Micromhos
Grid Bias for: Transconductance = 2 μmhos	—50	—50	Volts
Plate Current	8.0	8.2	Milliamperes
Screen Current	2.2	2.0	Milliamperes

* * *

The 6U7-G is similar in performance to the 6D6. The 6U7-G has octal base.

As Mixer in Superheterodyne Circuit

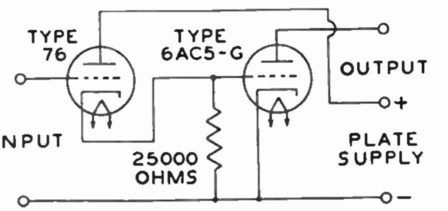
Operating Conditions with Variable Bias:			
Plate Voltage	100	250 max.	Volts
Screen Voltage (Maximum)	100	100	Volts
Grid Voltage* (Approx.)	—10	—10	Volts
Suppressor	Connected to cathode at socket		

*The grid bias shown is minimum for an oscillator peak voltage of 7 volts. These values are optimum.
‡The internal shield in the dome of the 6U7-G is connected to the cathode within the tube.

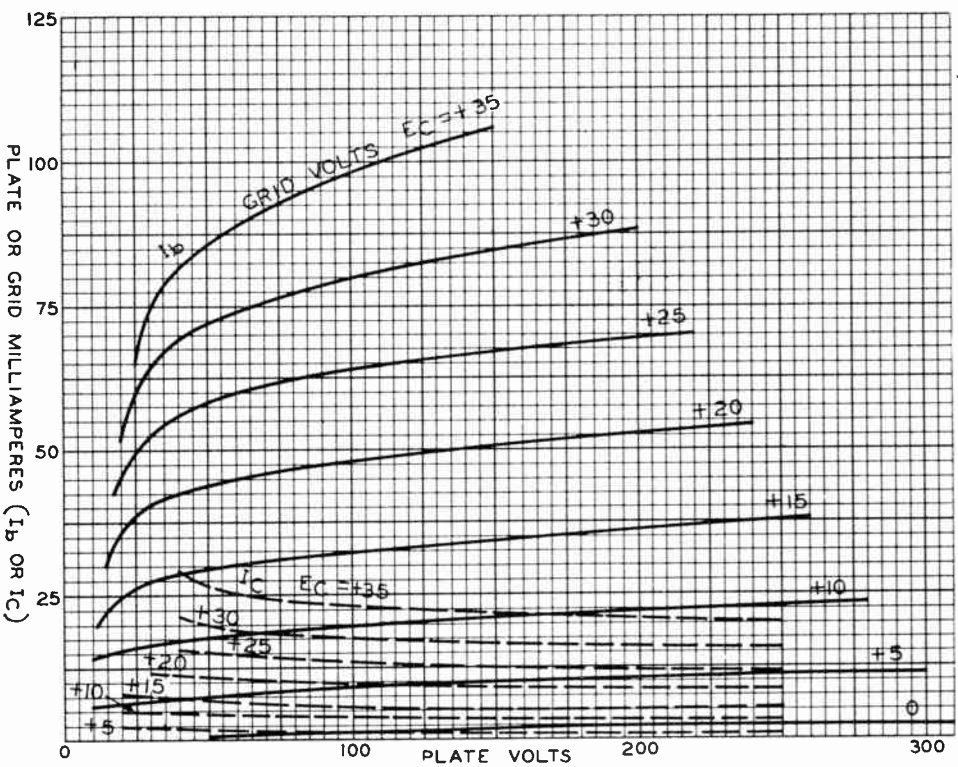
Pin Connections

Pin 1—No connection
Pin 2—Heater
Pin 3—Plate
Pin 4—Screen
Pin 5—Suppressor
Pin 7—Heater
Pin 8—Cathode
Cap —Grid

(Pin numbers are according to RMA system.)



Circuit for using a direct-drive 76 ahead of the 6AC5-G, for 3.7 watts output at 10% distortion.

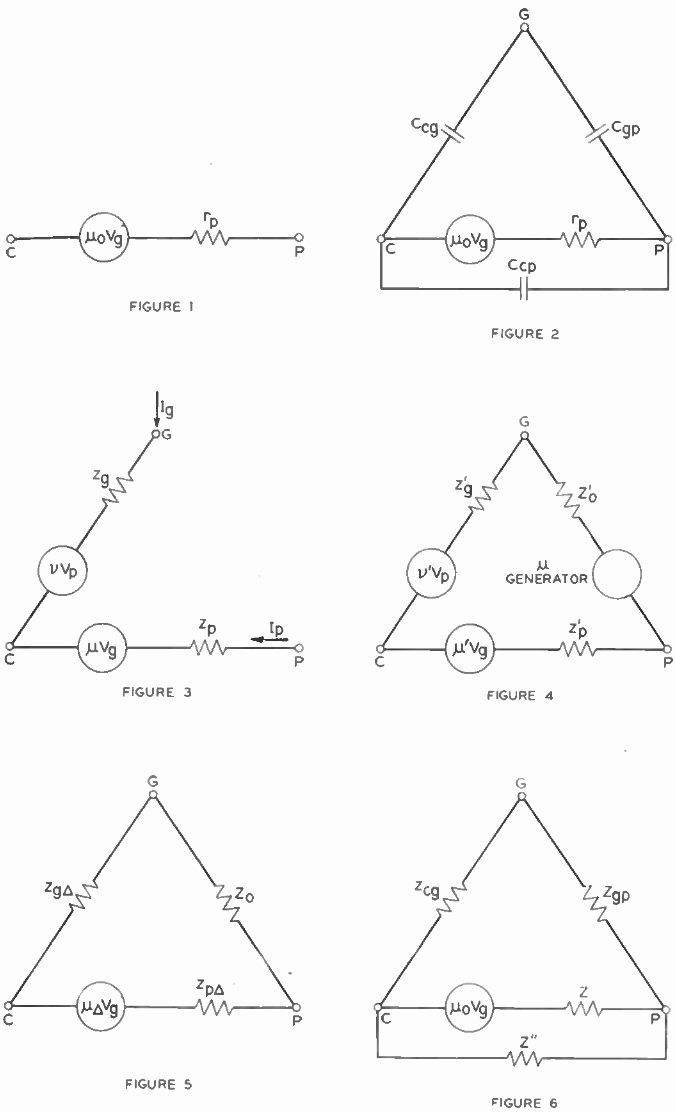


Average plate characteristics of the 6AC5-G. Heater voltage is 6.3 volts.

Equivalent Networks for Negative-Grid Triodes

By F. B. Llewellyn

Circuit Research, Bell Telephone Laboratories, Inc.



FIGS. 1 TO 6
Steps in the evolution of the equivalent network of negative-grid, three-element vacuum tube.

THE equivalent network of a vacuum tube brings to the mind of practically every radio engineer a combination of resistances and capacitances together with an internal generator of voltage which can be used in calculating the effect of the tube in electrical circuits. When low frequencies only are involved, this network may consist simply of a resistance in series with a source of voltage. If higher frequencies have to be considered it has been found necessary to allow for capacitance between all three elements of the tube and now with the advent of very high frequencies a further modification is required. This consists of the addition of series resistors in the internal cathode-grid and cathode-plate paths.

INFINITY

The concept of the equivalent network for negative-grid vacuum tubes was originally developed from the relation that the plate current of a vacuum tube is a function of the plate voltage plus a constant times the grid voltage. This constant is the well-known amplification factor μ, and when the non-linear relationship between current and voltage in the tube was investigated mathematically for straight amplification effects, it was found that the tube might be represented by the equivalent network shown in Fig. 1.

Here C represents the cathode and P the plate of the vacuum tube. Between them the internal plate resistance r_p acts in series with the fictitious generator $\mu_o v_g$. This network satisfies conditions between the cathode and plate only at very low frequencies, where the impedance between the grid element and the other electrodes is so high that it can safely be disregarded in making calculations.

SYMBOLS EXPLAINED

With the advent of higher frequencies it became evident that the internal tube capacitances played an important rôle in the operation of the device. The lengths to which early workers went to include the capacitance effects are illustrated by the complicated formulas which they developed. Further study, however, showed that the complexity could be largely overcome by modifying the simple network of Fig. 1 to introduce capacitances between all three elements of the vacuum tube. The result is Fig. 2, which has been adequate in the past for all purposes.

In comparatively recent years increasing frequencies have required that further changes be made. The necessity for revision first became evident with the discovery that the impedance measured between grid and cathode, when a very large condenser was placed between plate and cathode, showed an important resistive component at very high frequencies. The simple combination of Fig. 2 which involved only capacitances for the grid-cathode and grid-plate impedance was no longer valid.

A modification which overcame this difficulty was based on a theoretical analysis of the motions of electrons within vacuum tubes. With the reservation that it applies strictly to planar rather than cylindrical tube structures, the results should therefore require little further change for some time to come.

MODIFIED DELTA NETWORK

The theoretical analysis gave at first an equivalent network which, on the face of it, resembled Fig. 2 only remotely, but which was in fact exactly equivalent to it at very low frequencies. This generalized theoretical network is shown in Fig. 3. It consists of two branches only, which are located respectively between cathode and grid and between cathode and plate. Both branches contain internal generators and, in general, the impedance in neither branch is a pure resistance but depends on a number of factors, including the time required by electrons to traverse the vacuum tube.

Mathematical manipulation of the equations shows that the theoretical network of Fig. 3 may be represented just as well by an infinite number of other equivalent networks. Naturally our aim is to choose the form which adapts itself to the greatest number of practical applications, and contains the smallest number of internal generators. A second consideration in the choice is that the network should resemble hte familiar delta equivalent of Fig. 2 as closely as may be, so that results based on that figure may be interpreted readily in terms of the more general network.

Fig. 2 is actually a modified form of a delta network. The most general delta would be the one shown in Fig. 4, which consists of three series branches, each containing an internal generator in series with an impedance. When the mathematical transformations from Fig. 3 to Fig. 4 are carried through, a proper choice of definitions for the various impedances reduces Fig. 4 to the network shown in Fig. 5. Here only one internal generator remains, and that generator acts in series with the internal plate impedance of the tube. Therefore, Fig. 5 does not quite conform to the popular network where a capacitance is assumed to shunt the internal generator by acting directly between plate and cathode. However, it can be shown that Fig. 5 may be transformed to Fig. 6; and by a proper choice of the two impedances z′ and z″, the internal generator reduces merely to our familiar low-frequency amplification factor multiplied by the grid-potential variation.

Thus, Fig. 6 with the associated definitions of impedance represents the generalized form of the equivalent network of negative-grid vacuum tubes and is valid until the velocity of the electrons approaches that of light or until the distance between elements of the vacuum tube becomes comparable to the free-space wavelength of any ultra-high frequency considered. The expressions for the various impedances in Fig. 6 are naturally long and complicated. However, at frequencies where the effects of transit time of the electrons are only moderately important, the complication reduces enormously and we have Fig. 7, which now replaces Fig. 2 for all ordinary frequencies. The modification consists only of the addition of series resistors in the internal cathode-grid and cathode-plate paths, which avoid the necessity for a phase angle in the amplification factor at very high frequencies.

RESISTANCES MASKED

At low frequencies, the resistances are masked by the high reactances of the capacitances in series with them, and this is the reason why the network of Fig. 2 has served so well in the past. The impedance in series with the μ-generator is the well-known internal plate resistance as given by the slope of the static characteristic of the tube. The capacitances are likewise those we have used all along but the mathematics now enables their dielectric constants to be computed. Fig. 7 is valid at any of the frequencies for which negative-grid tubes are now contemplated for commercial application, including those where the transit angle is about half a radian.

Perhaps the most interesting aspect of the equivalent diagram is the fact that the resistance in the grid-plate arm is negative in sign, while the one in the cathode-grid arm is positive. At first sight, the presence of such a negative resistance may seem disturbing. A rough explanation may be obtained by noting that the forces on the electrons which result from the grid potential are opposite in direction depending upon whether the electron is in the region between the cathode and grid or between the grid and plate. Thus, if the grid potential

(Continued on following page)

(*Continued from preceding page*)

accelerates electrons near the cathode, it follows that those near the plate are decelerated by the grid, and vice versa. Hence, the work done by

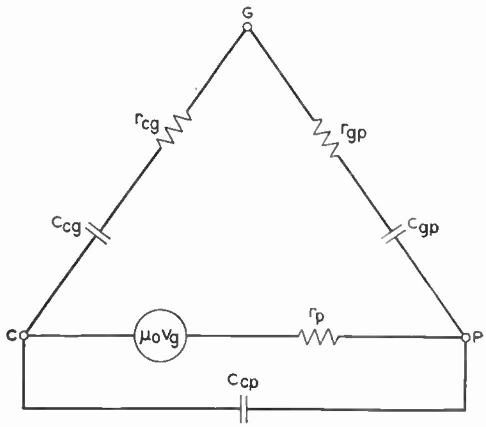


FIG. 7
Network equivalent of vacuum tubes valid both for low and for moderately high frequencies.

the potential of the grid on the electrons in the two regions is opposite in sign.

RESISTANCE RELATIONSHIP

The negative resistance in the grid-plate arm in many tubes is about ten ohms, while the positive resistance in the cathode-grid arm is about five times as large. The dielectric constant of the grid-plate capacitance is slightly less than unity, and that of the cathode-grid capacitance somewhere around 4/3, while for the cathode-plate capacitance is slightly less than this latter value. The grid-plate capacitance varies in the opposite direction from the other two when the operating potentials are changed.

Much has been said and written of late years about the active grid loss. This would be determined in Fig. 7 by placing a large condenser between the cathode and plate and measuring the input impedance. As shown by the figure, the resistive component arises from the resistances in the two arms of the delta which are now in parallel.

An interesting result of this investigation is the slight modification required in our conventional network for the negative-grid tube to make it accurate even in the ultra-high-frequency range. The amplification factor is the familiar one used for low frequencies, and at moderately high frequencies the only alteration needed in the conventional diagram is the addition of two small but very important resistances—one in the cathode-grid path and another, with negative sign, in that between the grid and plate.

National Union Enters Filter Condenser Field

H. R. Peters, president of the National Union Radio Corporation, announced from the company's New York City headquarters the entry of his company into the field of condensers for radio service specialists. Said Mr. Peters:

"We will provide a complete line of electrolytic and paper condensers. We have worked closely with the service specialist field for several years and have studied the condenser problem closely. We intend to fill a need for a quality condenser line which will be merchandised along lines similar to National Union radio tubes. The same policies which have earned National Union tubes a leading place in the radio service profession will be applied to the new N. U. condensers."

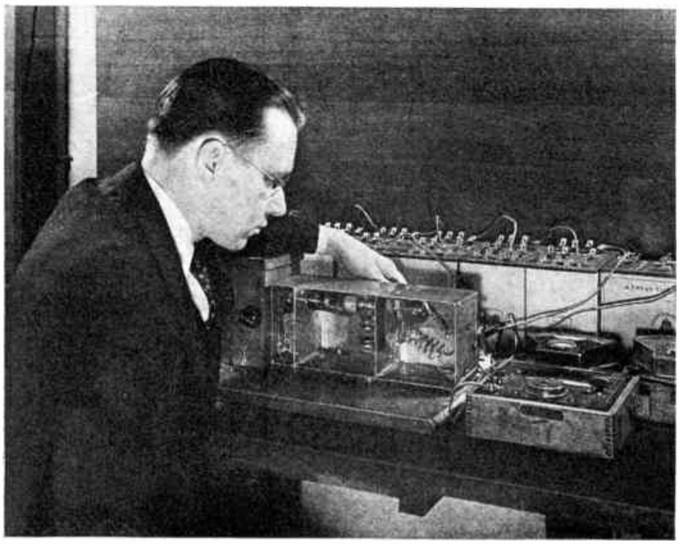


FIG. 8
An investigation is in progress of the behavior of vacuum tubes, for checking the equivalent network used for closer computations than those that obtained formerly. The increasing importance of higher and higher frequencies has actuated the improved technique.

RADIO CONSTRUCTION UNIVERSITY

Answers to Questions on the Building and Servicing of Radio and Allied Devices.

DRY CELL AS VOLTAGE STANDARD

AS I am desirous of having a convenient standard of low-voltage d.c., for calibration purposes, and can not afford the standard cell that is accurate to .01 per cent. at no current drain, I was wondering if I could use a No. 6 or equivalent high-current-capacity dry cell?—K. E. F.

Yes, that is a suitable choice. In general, the e.m.f. of the cell remains the same. The apparent voltage may change due to the voltage drop across the increased resistance of the cell, but this may be circumvented sufficiently by using a few fresh cells in parallel, and limiting total current drain to 1 ma or less. Also, the parallel cells will "average" the apparent voltage. Measurements disclose that for an accuracy of 3 per cent. the cell voltage is around 1.55, instead of the nominal 1.5 volts. A good test as to whether the cell resistance is too high during a draw of even small current is to note the voltage across the cell as only the voltmeter current is drawn, and then the voltage (again across the cell) when 25 to 50 milliamperes are drawn. If there is scarcely any noticeable change, the cell resistance is low enough. Another possibility is to use the cell in connection with a true potentiometer circuit, where a d-c galvanometer is put between cell positive and a positive B voltage, adjustable to a value where meter reads zero. Then the B voltage alone is read and equals the cell voltage. A limiting resistor of around 1,000 ohms protects the meter until current is near zero and then is removed for more accurate determination of zero current.

* * *

TONE IN MIDGETS

A DISPUTE has arisen in our family as to whether good tone quality is obtainable from a small mantle type set, known as a midget. I contain that there is not sufficiently large baffle area for excellent tone.—K. E. H.

What constitutes good tone quality may be a matter of opinion, since persons depend on their own ears for the determination, and their ears can not be considered accurate standards. However, your position is entirely tenable, and the small sets, though they serve a real purpose of convenience and compactness, are not high fidelity, can't be at the prices at which they are sold, and the other conditions imposed on them, and do not compare in performance on a fidelity basis with elaborate sets built especially to attain tonal distinction.

* * *

AUDIO OUTPUT PUZZLE

WHAT is a good way of obtaining audio output from a condenser-diode rectifier? I refer to the circuit having a stopping condenser between preceding tube's plate and rectifier anode, and a load resistor in series with the rectifier but effectively in parallel with the coil.—W. S. E.

There is no ready way to obtain audio output, as this type of rectifier is used merely to influence a d-c meter, or provide d-c output to feed a vacuum-tube amplifier.

* * *

RUNNING-BOARD AERIAL

WHEN a running-board aerial is used on an automobile, for serving the radio, is there not danger that obstructions in the road will hit the aerial and ruin it?—W. D.

This type of aerial has been used for years and is serviceable. The antenna problem has been tackled by engineers so that now there are special types of antennas for particular sets, and receiver and antenna go together, being matched, at least to some extent. This matching could be made true in fact and probably will be, in years to come. However, as to the physical danger to the running-board aerial, this is nothing to worry about, if you don't mount curbstones to avoid shuttling the car when parking at curbside.

* * *

FUNDAMENTAL REACTANCES

WILL you please give me a few words to help me understand the direction in which the fundamental units change in respect to frequency?—W. F. C.

The three fundamental units are inductance, capacity and resistance. For a series inductance, the impedance increases as frequency increases, whereas for a series condenser the impedance decreases as frequency increases. In other words inductance and capacity work in opposite directions. So, for a given frequency, the counterpart holds true, that the higher the inductance the greater the impedance, and the higher the capacity, the smaller the impedance. In general, resistance is nonreactive, i.e., independent of frequency.

BRITISH COMPANY GIVES DUBILIER FINE TESTIMONIAL

In the early days of William Dubilier's radio career, while he was engaged in the development of portable transmitters for airplanes and motorcycles, certain obvious difficulties were presented by the Leyden jars, the only type capacitor then available. To overcome these

William Dubilier, who recently received an illuminated address from the Dubilier Electric Co., Ltd.

difficulties and the inherent impracticability of the Leyden jar, Mr. Dubilier endeavored to design a capacitor that would be more permanent, sturdy and stable in electrical characteristics. His now famous pioneering efforts led to the present highly-perfected fixed capacitor. Had it not been for Mr. Dubilier's engineering genius and foresight, the radio industry as a whole might not have advanced to the position it holds as the seventh leading industry in the world.

TRIP TO RUSSIA

Aware of the importance of his development, Mr. Dubilier immediately offered it wholeheartedly to the United States Government. Unfortunately the authorities at that time could see no immediate value in the Dubilier patents covering the construction and design of the static capacitor.

In 1910, immediately after the formation of the American Dubilier Company, at the invitation of the Russian Government, and at that government's expense, Mr. Dubilier was induced to travel to Russia on the promise of a large contract from that country.

Having installed a wireless telephone station in the Palace of St. Petersburg, and after nine months spent in various cities in Russia, Mr. Dubilier stopped in England on his return trip, and was invited by prominent engineers, scientists, and indeed by the Government itself, to demonstrate his static capacitor invention. This visit resulted directly in the formation of The Dubilier Electric Company, Ltd., subsidized by the British Government, which also placed substantial orders for condensers to take the place of the Leyden jar.

Leyden jars at that time were in the hands of one central-European nation which, for this reason, was able to control indirectly all radio communication, including apparatus in use in the United States.

GREW TO GREAT STATURE

In 1912, the Dubilier Electric Company, Ltd., began production in a small factory on Tottenham Court Road, London. From this first humble laboratory of two rooms the English Dubilier plant steadily grew until today it is one of the largest condenser manufacturing companies in the world. its resources amount to many millions of dollars, its plant covers some eight acres, over four devoted to actual factory space.

For laboratory and experimental work a completely separate brick building has been constructed, which is fully equipped with probably the finest testing equipment in the world. Many of the original engineers and crew are still with the English company.

Phillip R. Coursey, who had come direct from London University, where he acted as assistant to Prof. Fleming, is now Dubilier's chief engineer abroad. Mr. Coursey is well known in scientific circles and is the author of the only books published on the subject of condensers.

William H. Goodman, who organized the British company with Mr. Dubilier, is its managing director today. A most impressive group of scientists and physicists composes the Dubilier staff abroad. Results of all development and experimental work are placed at the disposal of the American Cornell-Dubilier Electric Corporation—a close cooperation existing between the two companies at all times.

GETS ILLUMINATED ADDRESS

An illuminated address was recently presented to Mr. Dubilier by the British company and is only one of the many expressions of affection and gratitude that organization has bestowed upon its founder.

Fully outstanding has been the progress of the American Dubilier Company, established in 1910, known today as the Cornell-Dubilier

(*Continued on page* 58)

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RADIO'S NEWEST FEATURES AT LOWEST PRICES!

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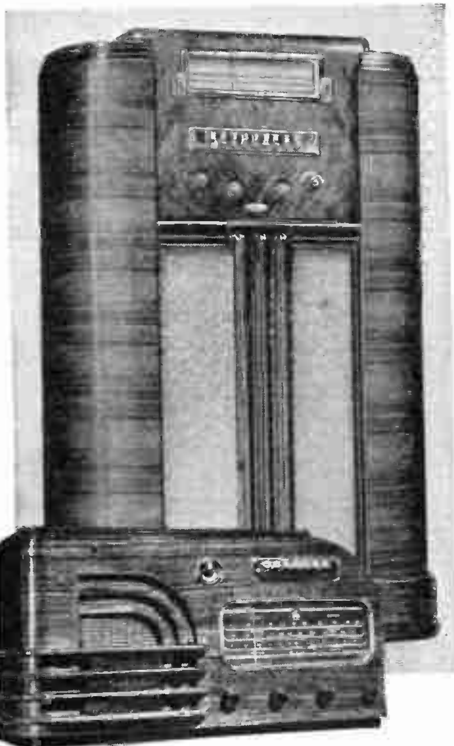
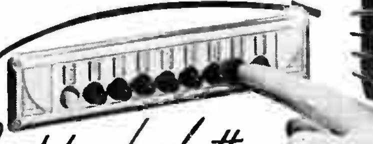
ALLIED leads again in value with 61 new Knight Radios combining radio's newest features at the season's lowest prices. Advanced R.C.A. and Hazeltine licensed circuits, with Electric Push-Button Tuning—a station a second, Select-O-Matic Dials, the Electric Eye, Automatic Frequency Control, Full Voice Speakers—broadcast Studio tone quality, world-wide range—all these features and many others at prices that challenge the industry. From 5 to 16-tube models—for AC, AC-DC, 6-volt, 32-volt, battery and auto operation. ALLIED'S volume and low distribution costs make KNIGHT radio's greatest values, offering biggest profits for you. See all models in ALLIED's great 1938 Catalog—





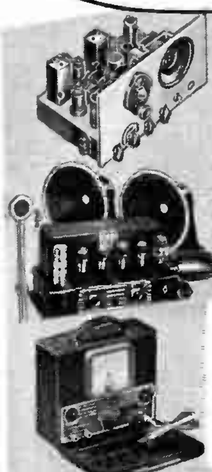
Just touch a button—
THERE'S YOUR STATION!

KNIGHT 11-TUBE Push-Button Tuning —All-wave . . ONLY **$58.95**

KNIGHT 6-TUBE Push-Button Tuning —3 Bands . . ONLY **$28.85**

Everything in Radio at Lowest Prices

Whether you're a Dealer, Service Man, Sound Specialist, Amateur or Experimenter, you need ALLIED'S 1938 Catalog. It brings you everything you need in one great book—Parts, Kits, Sound, Amateur, Test Equipment, books, tools, accessories—every radio requirement spread before your eyes. ALLIED'S complete stocks and fast service save you time—ALLIED's low prices save you money. Send coupon today for free copy of ALLIED'S 1938 Catalog — radio's complete supply guide!



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P. A.
TESTERS

ALLIED's Catalog offers over 12,000 parts —Builder's Kits (Write for free Parts Lists) — Sound Systems, Amateur gear, Test Equipment,—all at lowest prices.

FREE *Catalog*

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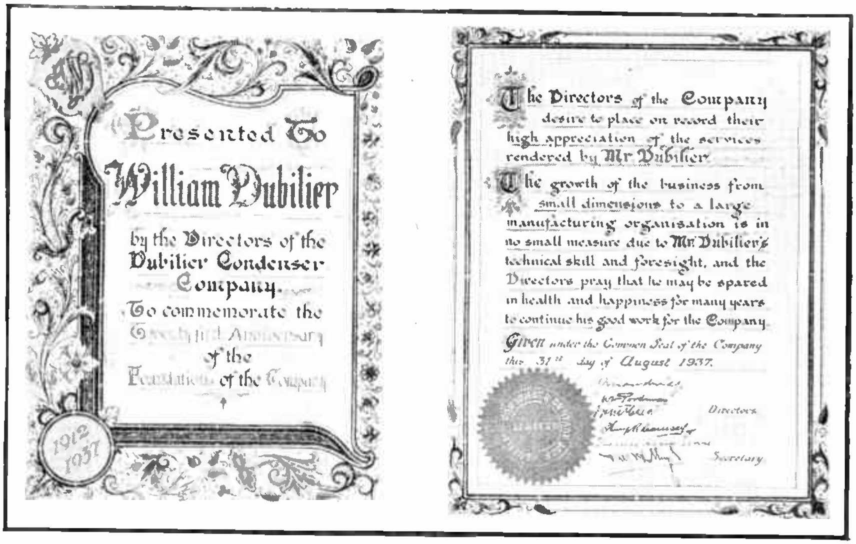
833 W. JACKSON BLVD., CHICAGO


Presented To
William Dubilier
by the Directors of the
Dubilier Condenser
Company.
To commemorate the
Twenty-fifth Anniversary
of the
Foundation of the Company
1912
1937

The Directors of the Company
desire to place on record their
high appreciation of the services
rendered by Mr. Dubilier.
The growth of the business from
small dimensions to a large
manufacturing organisation is in
no small measure due to Mr. Dubilier's
technical skill and foresight, and the
Directors pray that he may be spared
in health and happiness for many years
to continue his good work for the Company.
Given under the Common Seal of the Company
this 31st day of August 1937.
Directors.
Secretary.

Greatly reduced reproduction of the illuminated address.

(Continued from page 56)

Electric Corporation. By virtue of a merger made in 1933 production facilities extend through eleven buildings occupying more than thirty-three acres in New Jersey. The laboratories and extensive engineering facilities of the Cornell-Dubilier Electric Corporation, as well as of the Dubilier Company abroad, are under the close supervision and direction of Mr. Dubilier.

Words of Approval

RADIO WORLD is the most practical serviceman's magazine in the field. It's a radio course in itself.

OLIVER B. BEAMAN,
709 New Hampshire St.,
Lawrence, Kans.

* * *

Your publication is a serious reference book that every radio technician should have on his bookshelf.

JEAN WIENER,
c/o Electric Lighting Co.,
Port au Prince, Haiti

* * *

I have read your magazine for the past six years. A study of the articles convinces me that RADIO WORLD is the best in its field.

L. COLWELL,
6548 Greenwood Ave.,
Chicago, Ill.

KESSLER APPOINTED BY TRY-MO

Bill Kessler, one of the best informed radio parts men in the business, has just been appointed General Manager of Try-Mo Radio, 85 Cortlandt St., New York City.

Kessler has a background that goes away back to crystal-set days.

Ghirardi's Case Histories Reach a Total of 1,500

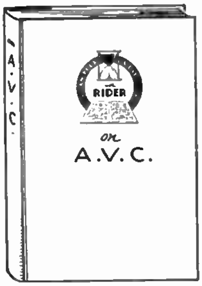
After a recent investigation among radio service men Alfred A. Ghirardi, author of "Modern Radio Servicing," "Radio Field Service Data" and other popular radio servicing texts, reports that service men are rapidly giving up the old method of trying to keep Case Histories on a file of 3x5 index cards. The rapidly increasing number of new sets on the market has rendered these "home-made" filing systems as obsolete as the even older method of pasting miscellaneous clippings in scrap books, collecting notes, data sheets, etc.

Mr. Ghirardi tackled the task of forming one central "pool" of Case History information which he has published on loose leaf sheets which have been inserted in alphabetical and numerical order in his "Radio Field Service Data" book. The important problem of keeping service men supplied at all times with the latest up-to-date Case History data on new sets as they come out, has been solved by providing a regular Supplement Sheet Service to his Data Book.

According to Mr. Ghirardi's publishers, Radio & Technical Publishing Company of New York City, the latest Supplement Sheets to the Data Book brings the total number of Case Histories up to well over 1,500!

Mr. Ghirardi, a former school teacher of physics, has made a specialty of writing or servicing and radio physics.

"AN HOUR A DAY WITH RIDER"

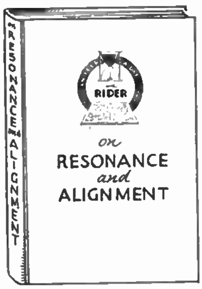


John F. Rider has written a series of pocket-sized books, 60c each, with the idea readers will spend an hour a day reading and studying them, and thus acquiring a full servicing knowledge. Latest of these is devoted to automatic volume control (a.v.c.). The subject is fully covered. 64 pages. Well illustrated. Order Cat RAVC postpaid @ 60c

"ALTERNATING CURRENTS"

"Alternating Currents in Radio Receivers," Hour-a-Day, is a comprehensive book covering the basic functions of the various components of a radio receiver, what each unit does and how it works. Various types of parallel and series resonant circuits, different kinds of coupling, inductance, reactance, impedance, and how these electrical phenomena are employed in radio practice, are fully explained. 80 pages. Order Cat. RAC, postpaid, @ 60c.

A clear explanation of what happens when a circuit is tuned to resonance. All types of circuits described and how and why they work. How these circuits should be aligned so that maximum efficiency is obtained. Knowledge of the latest high-fidelity i-f. amplifiers is becoming more and more necessary and "Resonance and Alignment" tells what you should know about all this. 64 pages. Order Cat. RRA. postpaid. @ 60c.



"D. C. VOLTAGE DISTRIBUTION"

Every receiver contains some sort of d.c. distribution system supplying the d.c. voltages from the power unit to the elements of the tubes. The many different forms these systems take are thoroughly described in Rider's "D.C. Voltage Distribution," which explains networks from the simplest to the most complicated. The calculations of the value of the resistors and their wattage ratings are more clearly described than ever before, in this brand new combination of theory and practice. 64 pages. Order Cat. RDCVD, postpaid, @ 60c.

[Above four "Hour-a-Day" books are all of the series published to date. All have hard covers. The order of their publication is No. 1 A.C.; No. 2, Resonance; No. 3, D.C.; No. 4, A.V.C.]

RIDER'S MANUALS

Vol. VII—(new) Rider's Volume VII has 1600 pages! This is the biggest and best Manual that has ever been published. In Volume VII the number of manufacturers has been increased and therefore the size of the book was ncreased. The greatest collection of servicing data ever gathered and not only from the large manufacturers, but the smaller ones as well. Not only 1936-37 sets, but many old timers. 100-page Index $10.00

Vol. VI—Data on sets produced up to October, 1935—the start of the metal tube era—are contained in this Manual. Double-Spread pages are used for the more complicated receivers. 1240 pages, $7.50

Vol. V—Sets manufactured up to October, 1934—and older sets, too—are covered in this volume. Electrical and mechanical data are given so that everything is where you want it. 1,200 pages........ $7.50

Vol. IV—In this volume will be found information on receivers manufactured up to March, 1934. 1,060 pages $7.50

Vol. III—Sets released from the middle of 1932 to June, 1933 are presented in this volume. 1,070 pages $7.50

Vol. II—Data are here contained on sets manufactured between early 1931 and the middle of 1932. Many sets unavailable when Vol. I was published will be found in Vol. II. 800 pages............ $6.50

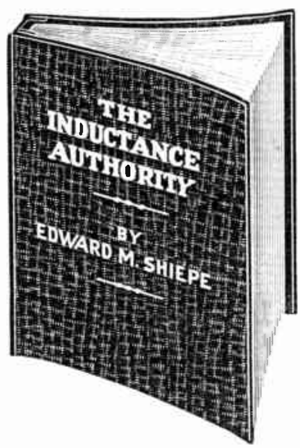
Vol. I—This volume contains information on the old timers—from 1919 up to 1931—and there are still many of these in use today. 1,000 pages.... $7.50

[Order Rider Manuals by volume numbers as listed above. Remit with order. Books will be sent postpaid.]

Radio World, 145 W. 45 St., N. Y. City

COIL WINDING; NO COMPUTATION!

SOLENOIDS for all radio frequencies, from the fringe of the ultra highs, to the fringe of audio, may be wound, using popular wire sizes and form diameters, with no computation, yet at 1% accuracy. This is made possible by a series of quick-answer charts constituting "The Inductance Authority," by Edward M. Shiepe, plus an 18 x 20" supplement.



Winding solenoid coils for radio frequencies requires knowledge of the number of turns of any selected type of wire on any sensible diameter to attain an inductance suitable for the tuning condenser and lowest frequency. Hence, with capacity and frequency known, there are two unknowns: (1), the required inductance; (2), the number of turns to establish that inductance. The answers are obtained by consulting "The Inductance Authority," and the supplement. On the large supplement are plotted the "curves of frequency, capacity and inductance in straight lines, so for a desired low frequency and known capacity the unknown inductance is solved by mere inspection. The number of turns for attainment of that inductance, for all popular tubing diameters and all generally used wire diameters and wire insulations, is read from the inductance-turns charts which are in the bound volume. Coil and set manufacturers, as well as home and shop experimenters, students and teachers freely use this book. The only book of its kind in the world.

Order Cat. INA (price includes bound volume and supplement) postpaid anywhere on earth............... **$2.00**

Or send $5.00 for a two-year subscription for RADIO WORLD, regular rate, and this valuable book and supplement will be sent FREE and postpaid anywhere on earth. Order Cat. PR-IAC.

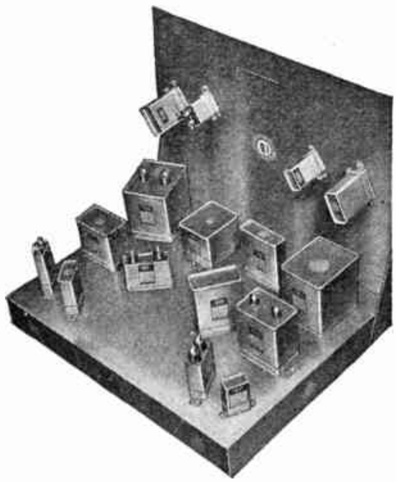
RADIO WORLD

145 West 45th Street New York City

NEW PRODUCTS

Any Position Mounting Features C-D Condensers

Mechanical difficulties in mounting high-voltage filter capacitors are entirely eliminated with the universal mounting brackets introduced by the Cornell-Dubilier Electric Corporation. As the illustration shows, mounting in all positions is easily accomplished.



New mounting flexibility of Cornell-Dubilier Condensers eliminates the need for brackets.

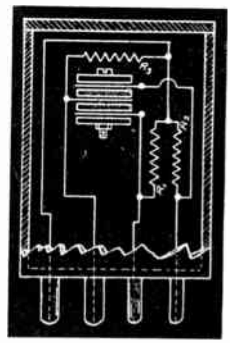
Impregnated and filled with dykanol in hermetically sealed non-corrosive containers, the C-D type TJ-U high-voltage filter capacitors may be mounted in any position without altering or affecting the electrical characteristics of the unit. The universal mounting brackets are supplied at no extra cost with each C-D type TJ-U filter capacitor. For catalog listing of these new capacitors, write to the Cornell-Dubilier Electric Corporation, South Plainfield, N. J.

MICA CONDENSER CATALOGUE

The Cornell-Dubilier Electric Corporation has made available to broadcast and radio engineers catalog No. 153A, a comprehensive folder listing in detail Cornell-Dubilier mica transmitting capacitors. This catalog can be obtained by addressing request to the Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey.

Triplett Has Plug-in Copper Oxide Rectifiers

The usual practice has been to build copper oxide rectifiers into measuring instruments. Line surges, accidental misuse, etc., frequently cause burnout of copper oxide rectifier and this has heretofore required not only the problem of opening up, getting at and replacing the copper oxide unit, but also recalibrating.



R-1—1000 ohms R-2—1000 ohms
R-3—Calibrating Resistor

Cross section of plug-in type rectifier (reduced).

Triplett's new exclusive plug-in rectifier makes this problem as simple as renewing a burnt-out fuse.

The rectifier is mounted in a small plug with regular tube base prongs. In the shell with the rectifier are the necessary calibrating resistors, making possible the interchangeable feature of the plug-in unit.

If in the future users of Triplett test equipment burn out the rectifier, it will be necessary only to order the new rectifier, plug it in the tester and be ready for further servicing. No need to return tester to factory when rectifier goes bad.

Plug-in rectifiers are now provided for Models 1125-A, 1241, 1502, 1503, 1504 and 1601 testers.

Triplett has brought out a line of square type meters of the precision type that is proving very popular.

BIRNBACH ISSUES CATALOGUE

A new list price Birnbach catalog, the first in three years, has just come off the press. Profusely illustrated and beautifully printed in two colors, it lists more than 3,000 items, including a complete line of antennae and antenna accessories, insulators of all kinds, sockets, jacks and plugs. Wires, conductors and cables are covered in completeness. A copy may be had by addressing Birnbach Radio Co., Inc., 145 Hudson Street, New York City.

Hammarlund Announces 2 to 10 Mmfd. Neutralizer

Another new condenser for transmitting has been developed in the laboratories of the Hammarlund Manufacturing Company, Inc. It is a neutralizing condenser and is called the N-10. This newest addition to the Hammarlund transmitting condenser family is exceedingly compact and designed for horizontal adjustment.

It has heavy aluminum round-edged plates, polished over all surfaces, which are mounted on a pair of strong Isolantite bars. These bars will not shift or pull out of position. The movable plate of this condenser is controlled by a finely threaded screw, allowing micrometer control. A positive locking nut permits extremely accurate settings. The special design of the adjusting screw prevents any possibilities of plate touching or short circuits. The capacity range of the N-10 is from 2 to 10 mmfd., while the air gap can be varied from 1/16-in. to ⅝-in. At the minimum spacing, the peak voltage rating is 3,000 volts. The base is drilled for 2-hole mounting. The condenser is only 2⅝-in. high by 1 13/16-in. deep.

Matched Dial Plates Made for Yaxley Controls

Matched dial plates are announced for all standard Yaxley controls, rheostats and potentiometers.

These plates are marked in 100 divisions of the active rotation, and are calibrated numerically from 1 to 10. The rotation covered by the terminals and the switch short out is clearly marked so that it is easy to set the plates in their proper position on the panel. The plates are 2¼" in diameter and are finished with polished aluminum markings against a satin black back-ground.

If the control is of the linear type (Yaxley No. 4 taper), a setting of "5" on the plate indicates that one-half of the resistance is in the circuit. A setting of "1" indicates that one-tenth of the resistance is in the circuit, etc. When a plate is used with a tapered control (Yaxley No. 1 or No. 2 tapers) in the proper circuit, the calibration is in proportion to the audible intensity of the signal—thus a setting of "5" would indicate 50% volume as heard by the ear.

POWERTONE MAKES CABINETS

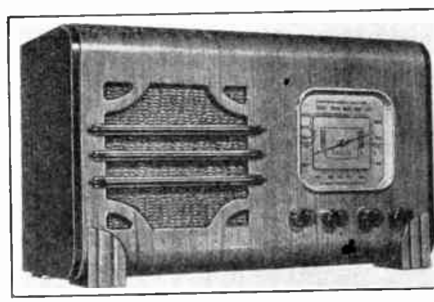
Powertone Electric Co., 177 Greenwich Street, N. Y. City, owned by Louis Lager, has added a cabinet and table making enterprise to its activities.

Allied Has New Knight Set for Trailers and Farms

A versatile new Knight 5-tube superheterodyne for universal operation from 110 volts a.c. or from a 6-volt storage battery is one of the latest 1938 models offered by Allied Radio Corporation, of 833 West Jackson Boulevard, Chicago.

Designed to meet the needs of automobile-trailer travellers and of residents in rural areas, this new receiver offers a practical solution of a former insoluble problem. By using a circuit which incorporates a special type built-in vibrator unit and new type tubes the receiver is operated just as efficiently from the storage battery as from regular a-c line. No circuit changes or additional units are required for shifting from a.c. to the storage battery or back again.

Features of this new Knight model include a 6-inch permanent magnet speaker, 5-inch square airplane dial, tuning range from 175 to 555 meters, automatic volume control and tone control. The tubes are one 6D8G, one 6S7G, one 6T7G, one 41, and one 6ZY5G.



The new Knight 5-tube superheterodyne for trailers and rural areas.

The receiver is housed in the walnut table cabinet illustrated. This new Knight model is distributed exclusively by Allied.

Blan's Magnetic Feats

Being an inveterate experimenter at heart, Michael Blan, who conducts a radio store under the title Blan the Radio Man, Inc., at 64 Dey Street, New York City, has been tinkering with electrogmagnetism for more than fifteen years. He now has developed a bar magnetized at four poles, so that it is active and inactive by turns, as customers make mystifying tests. He also has on his counter numerous "sky hooks" and other devices, which by magnetism suspend small bars apparently in midair, and other devices that appear to be magnetized or nonmagnetized b turns, according to his whims.

Blan's dexterity with magetism has been the means of attracting to his store not only radio customers but also persons who like to learn ways of performing parlor tricks with magnetism.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933.

Of RADIO-WORLD, published monthly at New York, N. Y., for October 1, 1937.

State of New York }
County of New York } ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Roland Burke Hennessy, who, having been duly sworn according to law, deposes and says that he is the editor of RADIO WORLD and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, and as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor and business managers are: Publisher, Hennessy Radio Publications Corporation, 145 West 45th St., New York, N. Y.; Editor, Roland Burke Hennessy, 145 West 45th St., New York, N. Y.; Managing Editor, H. J. Bernard, 145 West 45th St., New York, N. Y.; Publisher, H. J. Bernard, 145 West 45th St., New York, N. Y.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.) Hennessy Radio Publications Corporation, 145 West 45th St., New York, N. Y.; Roland Burke Hennessy, President-Treasurer; Roland Burke Hennessy, Jr., Vice-President; H. J. Bernard, Secretary.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the twelve months preceding the date shown above is ....

(This information is required from daily publications only.)

ROLAND BURKE HENNESSY, Editor.

Sworn to and subscribed before me this 30th day of Sept., 1937.

ELIZABETH ANSBACHER.

Notary Public, N. Y. Co., No. 500.

(My commission expires March 30, 1938.)

When writing to Advertisers please mention that you saw the Advertisement in RADIO WORLD.

What Are Decibels, Anyway?

What on earth are decibels? Does anybody know? Can the decibel notation be understood by anybody except a mathematician versed in logarithms?

The decibel has caused more comprehension trouble than anything else with which the serviceman has had to contend. Whether the decibel can be understood without an appreciation of logarithms is hard to say, as those who know their log find it easy, and those who don't know their log find it hard.

However, the word decibel has been used for years in radio, and it is easily recognized as being a measure of comparison, and so the word passes from lip to lip at least with the realization that the more numerous the "decibels up," the more sensitivity, and the more numerous the "decibels down" the less sensitivity. There is a change, possible in two directions, and sensitivities may be compared with a standard level, say, .006 watt (6 milliwatts).

What decibel refers to is a ratio, usually a ratio of two powers. Thus any one power level may be compared to another power level in terms of decibels. One decibel is one-tenth of a bel. The bel is not being mentioned much because it represents far greater value than commonly encountered in practice.

If the larger power is P_2 and the smaller power is P_1 then $db = 10 \log_{10} (P_2 \div P_1)$. Without going into the logarithms at all, one may consider that the decibel changes are on the basis of the response characteristic of the human ear, so that twice as many decibels up means twice as great quantity of sound, and twice as many decibels down means half as much quantity of sound.

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Day and Evening Classes—*Booklet Upon Request*

NEW YORK Y. M. C. A. SCHOOLS
3A W. 63rd Street, New York City

INDUCTANCE BOOK

Free! Every solenoid for every radio-frequency or intermediate frequency may be wound of standard wire on standard form diameters without any computations by using "The Inductance Authority," by Edward M. Shiepe. This $2 book sent free, postpaid, with supplement, on receipt of $5 for a 2-year subscription for RADIO WORLD.

RADIO WORLD, 145 W. 45th St., N. Y. C.

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Radio World is $2.50 a year (12 issues), 25c. per copy. Canada and foreign, $3.00 yearly. Offers of Radio World and other worthwhile publications for one full year on each (NET):

☐ RADIO WORLD and SHORT-WAVE and TELEVISION, $3.50.

☐ RADIO WORLD and POPULAR SCIENCE MONTHLY, $3.50.

☐ RADIO WORLD and RADIO-CRAFT (12 issues), $3.50.

☐ RADIO WORLD and RADIO INDEX (monthly, 10 issues), stations, programs, etc., $3.50.

☐ RADIO WORLD and SERVICE (monthly), $3.50.

☐ RADIO WORLD and EVERYDAY SCIENCE AND MECHANICS (monthly), $3.50.

☐ RADIO WORLD and BOYS' LIFE (monthly, 12 issues), $3.50.

☐ RADIO WORLD and TRUE STORY (monthly), $3.00.

Select any one of these magazines and get for an entire year by sending in a year's subscription for RADIO WORLD at the regular price, $2.50, plus a small additional amount, per quotations above. (Add $1.50 for extra foreign or Canadian postage for both publications.)

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☐ If renewing an existing or expiring subscription for RADIO WORLD, put cross in square.

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Special Trial Offer for Radio World only: $1.00 for 5 months, postpaid. Mail order with remittance to Radio World Office. NET.

RADIO WORLD, 145 W. 45th St., New York

CLASSIFIED ADVERTISEMENTS

7 cents a word. $1.00 minimum.

AMATEUR RADIO. Commercial Radiotelephone and Radiotelegraph licenses, complete training. Resident and correspondence courses. Every graduate a licensed operator. NEW YORK WIRELESS SCHOOL, 1123 Broadway, New York.

WANTED ORIGINAL POEMS, SONGS, for immediate consideration. Send poems to Columbian Music Publishers Ltd., Dept. 95, Toronto, Can.

HAVE YOU BACK NUMBERS of Radio World, for May, August, 1935, or April, June, September, October, 1936? If so, please communicate with Radio World, 145 West 45th St., New York, N. Y.

NEW DELUXE SUPERIOR GENEMETER, sell for $10. Burns, 1204 East 39th St., Kansas City, Mo.

INSTRUCTIONS, DISTANCE RECORD CRYSTAL SET, 17 others, with "Radiobuilder" year —25c. Laboratories, 151 R.W. Liberty, San Francisco.

LEARN MOTION PICTURE THEATRE BUSINESS. Home-Study Training: Management, Advertising, Projection. Free Catalog. Theatre Institute, Dept. R.W., 345 Washington, Elmira, N. Y.

WE MANUFACTURE ELECTROMAGNETIC DEVICE for locating all metals. Plans for building same $3.00. Metal Prospectors, Dept. R.W., Route 40, Box 1270, Mobile, Ala.

1,000 BUSINESS CARDS, CARD CASE, $1.50. QSL, SWL Cards, reasonably priced. Miller, Printer, Ambler, Penna.

RADIO EXPERIMENTERS AND SET BUILDERS: parts and kits of parts for improved Little Giant R235, six tube R233, Pre-amplifier R228, Portable battery R223, Little Giant R220 and 205 and 6 volt R238. Guaranteed specified parts. Lund Manufacturing Co., Dept. R.W., 43 East Ohio, Chicago.

MILLION AC-DC ALL WAVE OSCILLATOR

6-BANDS
LINE FILTERS
SEPARATE AUDIO
6" x 7" x 10"

$19.95 Dealers Net Cash Price

Your Jobber's Name and 20% Deposit Required on All Direct Orders.

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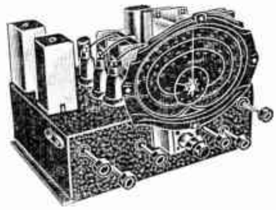
Meissner

ALL WAVE "8"



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A Popular Price ALL METAL TUBE SET Using The

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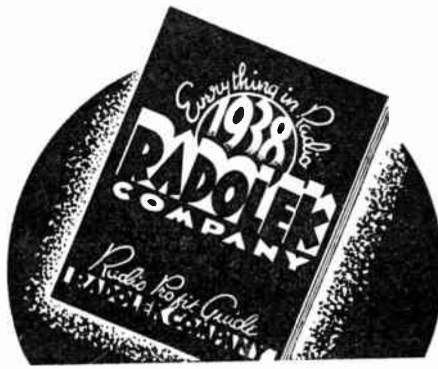

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