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666th Consecutive Issue—Thirteenth Year

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DEC. 29 1934

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THE Bernard All-Purpose Antenna Coupler provides a noise-reducing method of connecting any type antenna to any type receiver.

The popular noise-reducing antenna systems, using transmission lines from doublet, can not be connected to most receivers, because most receivers have only one antenna post, the other post being ground, while the doublet's transmission line requires two antenna posts. The Bernard All-Purpose Antenna Coupler provides the necessary link between twisted pair, transposed dual leads, or other transmission lines of doublets, so that a noise-reducing antenna system can be used on the set you have.

Besides, the Bernard All-Purpose Antenna Coupler is in itself a noise-reducing device, enabling quieter operation of the receiver, due to larger ratio of signal to noise.

The Bernard Coupler may be used with broadcast, short-wave and all-wave receivers, and requires no molestation of its connections.

The Bernard Coupler is built into a Bakelite moulded conical container.

The Coupler provides the necessary flexibility of connection to serve four purposes as follows:

(1)—**Use of dual transmission leads from a doublet to a receiver equipped for doublet connection, that is, having two antenna posts.** Connect doublet leads to the two press posts marked "Ant." Connect two tipped flexible leads supplied with the Coupler to the Coupler's two tip jacks, other ends of these leads to the two antenna posts. Disconnect the spade lug from the Ground post and ignore that post of the Coupler. **A measurable reduction in noise** will result.

(2)—**Use of two transmission leads from a doublet to a receiver not equipped with two antenna posts (having only usual antenna and ground posts).** Connect doublet leads to the two press posts marked "Ant." Connect one of the flexible leads from one Coupler tip jack to antenna post of set and other flexible lead from other Coupler tip jack to set's ground post. Connect ground to the ground post of the Coupler and tighten the spade lug in the ground post. If no signals are heard the connections at the receiver are reversed, so interchange them. This use opens the whole field of noise-reducing antennas to sets otherwise denied this advantage.

(3)—**Use of standard antenna, of the inverted L, or T type, with a receiver with only antenna and ground posts.** Connect single antenna leadin to either press post marked "Ant." Connect flexible leads from Coupler tip jacks to the respective antenna and ground posts of the receiver. Connect ground to the ground post of the Coupler, tighten the spade lug in the ground post, and run a wire from ground post to otherwise unused "Ant." press post of the Coupler. Reverse connections at receiver if signals are absent.

(4)—**Use of a standard antenna with a receiver equipped for doublet connection (having two antenna posts).** Connect the single antenna leadin wire to one of the "Ant." press posts of the Coupler. Connect flexible leads from the Coupler tip jacks to the two antenna posts of the receiver. Connect ground to the ground post of the coupler and tighten the spade lug under the ground post of the Coupler.

The Bernard All-Purpose Antenna Coupler is an effective and ready means of improving reception by the use of a small, inexpensive device, one based on sound engineering principles, and built for many years of service. The Coupler may be placed at any convenient point indoors, but the closer it is to the receiver, the better the noise-reduing properties.

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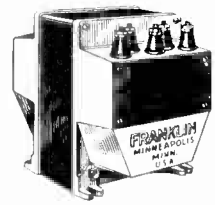

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THIRTEENTH YEAR

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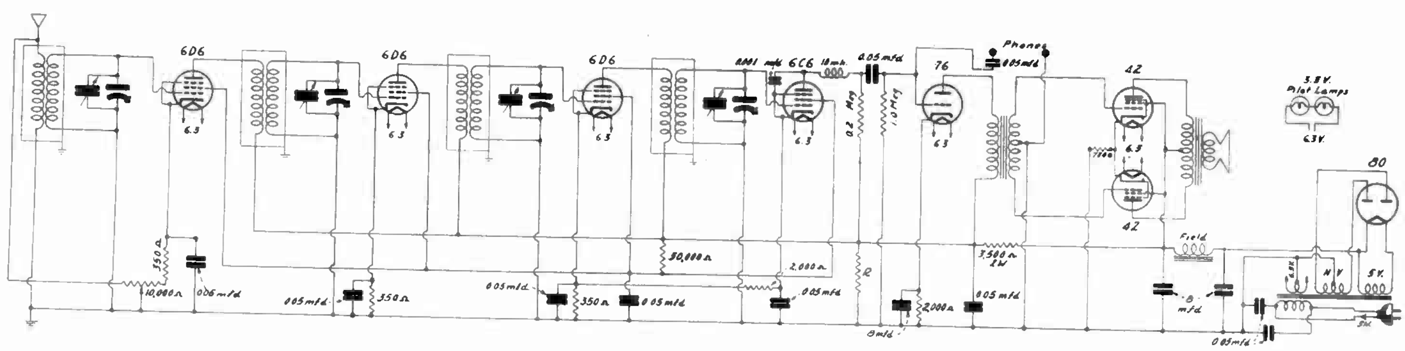
A T-R-F Set with 6.3-v. Tubes

Four-Gang Condenser Found Necessary, Also Plate Bend Rectification

By Herman Bernard



An 8-tube tuned-radio-frequency circuit, using 42 tubes in push-pull pentode Class AB, an unusual method. If the B voltage is high enough, 350 volts between cathode and B plus, the 730-ohm biasing resistor may be retained, 10 watts output. For 250 volts plate supply use 410 ohms, 6 watts output. If Class AB triode use is desired tie screen to plate of each 42 and use 730 ohms, with 350 volts. R is a resistor of 10-watt rating, to reduce B feed if 3,500 ohms in series establishes more than 250 volts.

USING eight tubes you can get more out of a superheterodyne than out of a tuned-radio-frequency set, but the t-r-f circuit is easier to build and adjust and besides more simply lends itself to quality reproduction. Whatever the reasons, there is quite a percentage of radioists that prefers the t-r-f variety.

Selectivity will be less, of course, than in the example of the superheterodyne. There is no such thing as a really selective, stabilized t-r-f set. However, excess of selectivity, as is often present in a superheterodyne, is one of the marring factors in considering quality reproduction.

Plate-Bend Detection

To attain sufficient selectivity in a t-r-f set it is necessary to use four tuned circuits. It is scarcely practical to use five, because of tracking problems. It is preferable to use the tuned circuits between tubes. Thus there are three stages of t.r.f. and a tuned input to the detector.

In line with supporting selectivity to the utmost—and it will never be excessive—the detector should be of the plate bend type, as distinguished from grid-leak-condenser or diode type. The plate-bend variety, as in the diagram, does not depend on grid current. Whenever grid or diode current is drawn it is equivalent to a resistance load across the tuning line, hence is at the expense of selectivity.

Quite a voltage may be developed at the detector input, therefore the detector has to be biased more negatively than the r-f tube ahead of it. Also for reasons of dynamic operation on a satisfactory part of the tube characteristic the negative bias must be more negative. So the bias as obtained from the drop in the cathode resistor common to the detector and third r-f tubes is augmented by the bias derived from the drop in the 2,000-ohm resistor in the 6C6 cathode circuit.

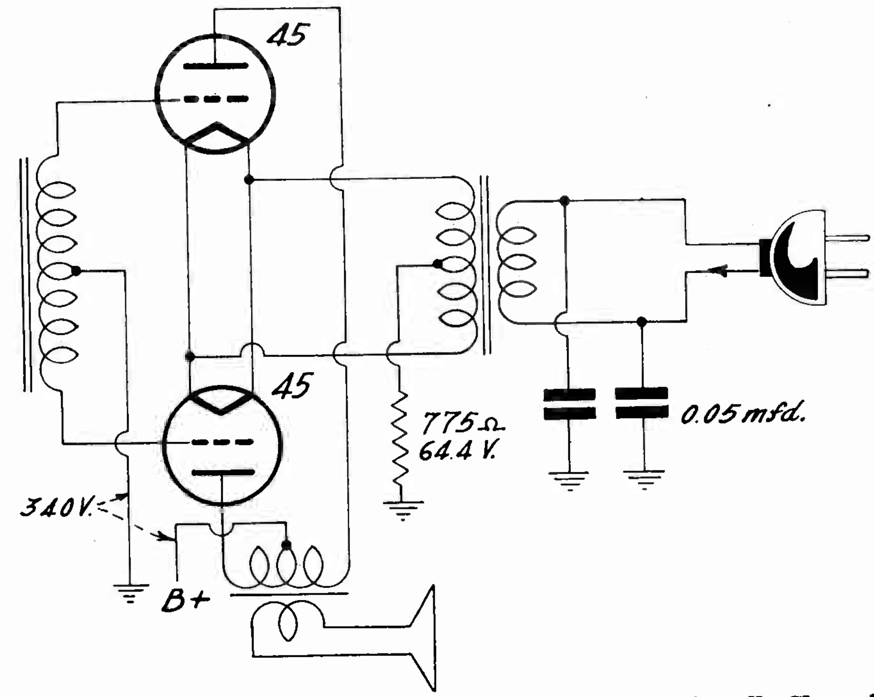
Thus the bias is much more negative than the usual recommendation for the 6C6. The reason is that the standard recommendations presuppose a small input to the detector, whereas here we may have a large one, as quite an amplifier precedes the detector, and what is desired is not utmost sensitivity but rather capability of standing a substantial voltage input and operation at a fairly sensitive point. This point was best established by using a lower value plate load resistor than usually recommended. The total voltage drop is divided unequally among the plate load, the tube and the bias on the detector, which is acceptable with plate circuit detection. Thus is the operation sufficiently removed from grid current conditions.

Precautions Against Oscillation

Naturally with three r-f stages there must be precautions against oscillation. Choke-coil-condenser filters were tried in the plate circuit but did little good unless other remedies were introduced, and when these other remedies were applied the filters became unnecessary.

The coils were constructed so that the coupling between primary and secondary was almost critical, and thus with fewer turns than usual a high primary impedance was established. The turns were adjusted until the squeals were absent under normal terminal voltages, 250 volts for the r-f plates, 100 volts for the screens. The voltage on the screens is rather critical. Not so of the plate voltage. On the output tubes the plate voltage is high, 350 volts. Some 142 volts must be dropped, and a resistor of 3,500 to 4,000 ohms will accomplish this, approximately.

The indicated voltage values need to be precisely duplicated. In fact, the voltages change a little, due to the volume control. Current through limiting resistors is greater or less, depending on whether the volume control setting causes lower or higher negative bias, the screen voltage change being about 12 volts. This produces a small detuning effect in the first stage, but the fact that input in cut down at the same time that bias is heightened results in minimizing of such frequency change. Of course the remaining circuits are affected a little, too, but not much differently than they would be due to the bias change caused by amplitudes of carriers.



Adaptation of output circuit to use of 45 tubes in push-pull, Class AB, 12 watts output, with self-bias. The plate-to-plate load requirement is 5,060 ohms. The quality is better this way than in the other methods discussed, but sensitivity is lower.

Why No. A. V. C.

It is not practical to introduce automatic volume control in a t-r-f receiver for this reason, since the biasing would be greatly different, and there would be serious disturbance of dial calibration for station frequencies, particularly for frequencies between 1,000 and 1,600 kc.

The detector feeds a 76 driver stage, which in turn works into the push-pull output. The bias on the output tubes should be close to 38 volts, if 350 volts are applied between cathode and plate. Therefore the total voltage for B and C supply is 388 volts, after the filter. Electrolytic filter condensers that will stand high voltage are necessary. Good ones, rated at 500 volts, stand up at 600 volts.

The tubes used are all of the 6.3-volt series, and all have heaters, excepting the rectifier, which is a 5-volt filament type tube. The plate-to-plate load for the output should be 8,000 ohms. This refers to the impedance of the primary of the output transformer.

The biasing resistor did not require a condenser across it, as there was no appreciable difference in the output, when a 60-cycle note was used as reference, whether condenser was in or out. The condenser would be needed, high as practical, say, 50 mfd., 50 volts rating, if there were degenerative effects, but the test disclosed absence of these.

Also there was some audio feedback through the B supply and other impedance common to the audio system, of which the detector must be considered a part because it handles audio frequencies. This is a circumstance not considered of course in mere tabulations of tube characteristics.

Pentode Output

The output tubes are pentodes used as pentodes, so that one has performance, Class AB. Theoretically the output circuit is capable of 15 watts, but that would require a driver of more powerful performance than the 76, for instance, another 42 as triode. The case is the same as that for 2A5's as Class AB, and 2A5 triode driver, for the 42 and the 2A5 are the same, except for the difference in heater voltages. Therefore it is quite practical also to use 78, 57, 56 and 2A5 tubes with 2.5 transformer winding, without making any changes in the circuit itself.

It is conceivable that during certain loud passages, for the positive peaks of the cycle, grid current will flow in the 42 circuit, and the driver should contribute some power for this purpose, thus reducing the actual grid current, that is, within the capabilities of the driver. The output rating may be taken as 0.4 watt for the 76 or 56. So it can be seen that the driver is there mostly for the voltage effect, though it will give the output tubes some lift when the positive cycles of strong audio exist. For this reason, therefore, the power output rating is not 15 watts but about 10.

Most persons run their sets at home at about 1 watt output. Higher values are within the capabilities of the receivers, and come in handy during those surge demands on the output, for instance when the steady 1-watt condition of operation becomes momentarily a 2- or 3-watt condition, due to the modulation. Rating of 5 watts is ample, 7.5 watts abundant.

Why Push-Pull Is Used

The reason for using push-pull at all is to increase the power output and improve the quality by another means, the elimination of the even-order harmonics. The class AB use reduces the nuisance of strong odd-order harmonics, particularly the third harmonic as found in pentode output tubes. It is generally stated that the odd order harmonics can not be eliminated without eliminating the fundamental, for the fundamental is an odd-order harmonic, the first. This is true. However, in signal generator experiments at radio frequencies it was found that when there was a high resistance in the plate circuit, bypassed by an appropriate condenser, while the fundamental of course was reduced in amplitude, the odd-order harmonics were reduced in greater proportion. This is a hint to power-tube practitioners who might want to try relative reduction of third harmonics.

There are two pilot lamps shown. This is because some airplane dials have two pilot lamp brackets. These lamps may be connected in parallel and to the 6.3-volt winding, for 6-volt pilot lamps; or in series, with free terminals of lamps across the 6 volts, for 3.3-volt lamps.

Hum Eliminated

For the use of an airplane dial the tuning condenser mounting spades are to be fitted with bushings ½ inch high, threaded so that they engage the spades, which have 6/32 threads. Then from underneath the chassis three 6/32 screws are inserted into the bushings and tightened.

The audio transformer is put on the inside left-hand side wall of chassis, near the radio-frequency section, to be as far as practical from the power transformer. In that way hum is kept very low. With the audio transformer attached to the center of the chassis on the under side it was impractical to eliminate the hum even when "angling" attempts were made. Hum kept out by proper audio transformer placement also eliminates the necessity for hum filter networks of the resistor-capacity type strewn throughout the detector and audio channel.

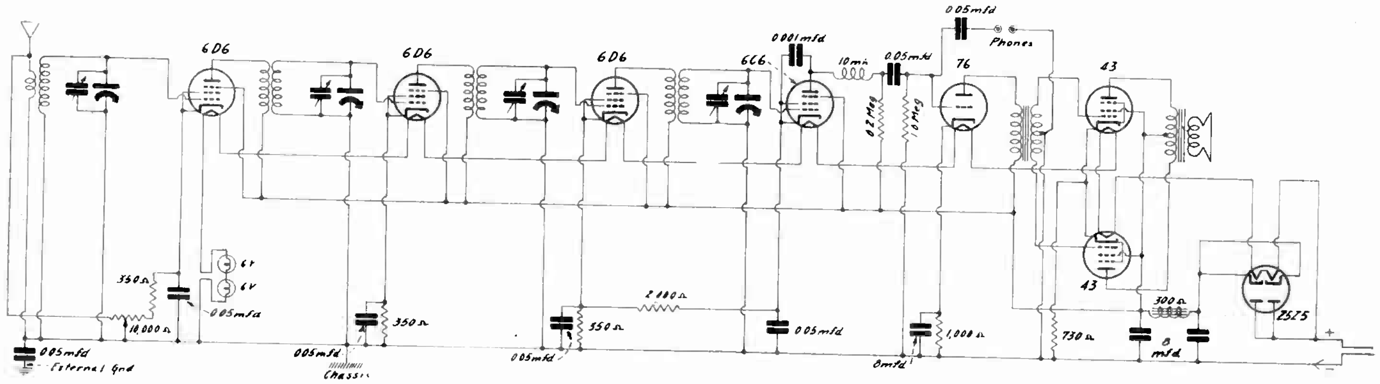
There is considerable flexibility as to the power transformer and speaker field. As stated, 2.5-volt tubes may be used. In either instance, 2.5 or 6.3 volts, the high-voltage winding may not afford the correct value, possibly too high a value. This may be corrected by leaving the voltage as found, so long as it is within the break-down voltage limit of the electrolytics, increasing the power tube biasing resistor so that not more than a total of 60 milliamperes flows through the resistor at no signal input, and increasing the limiting resistor, marked 3,500 ohms in the diagram, to whatever value is necessary to cut down the supply to the prior plates to 250 volts.

Speaker Field 2,500 Ohms

Also, speakers of various d-c field resistances may be used, the difference between 2,500 ohms being taken up by a 50-watt resistor. So if the field has 1,800 ohms, the extra resistor would be 700 ohms, 50 watts. Fields close to 2,500 ohms may be used as found, and the compensation introduced by heightened negative bias on the power tubes and r-f B voltage reduction as explained.

The output transformers on dynamic speakers differ of course as to impedances on the primary side. For any push-pull circuit, compared to single-sided hookup, the plate load would be doubled. This a 2A5 pentode takes a 7,000-ohm load, but in push-pull, plate to plate, the value is 14,000 ohms. Here we have a requirement of 16,000 ohms for the class AB tubes,

(Continued on next page)



The tuned-radio-frequency receiver adapted to "universal" use, 90-125 volts a.c. or d.c. The total voltage is dropped in the series of heaters and pilot lamps.

(*Continued from preceding page*)
plate to plate. An acceptable substitute would be a straight 2A5, 47 or 42 push-pull speaker. That would be nearly right.

For purposes of adjusting the push-pull circuit more nearly to a given transformer, determine from the originally intended use of the speaker what the impedance is likely to be, see whether that is higher or lower than 16,000 ohms, plate to plate. If the value is lower, decrease the biasing resistor, but no more than to permit 40 ma per tube, or 80 ma total, and if the speaker transformer impedance is higher, increase the biasing resistor. The increase in resistance may be up to 1,000 ohms total resistance, the test being whether low notes come in better. The B voltage delivered to the set then will increase, due to less current dropped in the limiting devices, including speaker field. The limiting fixed resistor in the B feed to r-f detector and first audio tubes would be increased so that 250 volts would prevail, approximately.

Removing Squeals

The main trouble has to do with radio-frequency oscillation. Coils have been prepared that will eliminate this trouble fundamentally, if the rest of the circuit is followed closely. These coils consisted of 127 turns of No. 32 enamel wire on 1-inch diameter tubing. A layer of insulating fabric is put over the center of the winding, and then a 12-turn primary put on. All four coils are alike.

If there is squealing trouble, with voltages correct, reverse the connections to the antenna winding, as transient pickup may be causing plate-circuit energy of the first tube to be fed to the primary. Then if the phase is aiding there will be regeneration, as the primary becomes a tickler. Reversing the connections, so ground goes to "Ant." terminal of the coil, and antenna to the "Gnd." terminal of the coil, will cure the trouble if arising from this cause.

Check the screen voltage, as that is a determining factor. The plate voltage is not so important on the r-f and detector tubes.

The screen voltage must not exceed 100 volts. It is permissible to increase the screen resistor from the prescribed 25,000 ohms to 45,000 ohms, if needed to eliminate squealing.

Higher Bias

The circuit will tend to oscillate rather at the lower frequencies than at the higher ones. Severe oscillation trouble would be evidenced by squealing all over the dial. The remedy is being applied in the right direction when the high-frequency squealing disappears but the low-frequency squealing continues. Correct the persistence by increasing the limiting resistor in the circuit of the oscillating tube, usually the first tube. This resistor then might be 500 or 600 ohms, if need be.

Do not overdo the application of any of these squeal-correcting remedies, as when one oversteps the mark one does so too pronouncedly and there is a decided loss of sensitivity.

Removing turns from primary in the plate circuit of the first r-f tube is another remedy. Three to five turns off should be enough, otherwise do not remove more than five turns, and use the other methods outlined, leaving the primary as reduced.

Correction of Distortion

Bad distortion may be experienced. This should not be ascribed at once to the power stage, mismatched impedances, etc., but rather to the detector bias. Increase this bias experimentally, by using a much higher extra resistance than the 2,000 ohms shown in the detector's augmentative biasing circuit.

If r-f and detector plate voltages are too high and can not be readily corrected, that is, even doubling the limiting resistor does not reduce the voltage enough, connect a 10-watt resistor of a few thousand ohms from scren to ground.

* * *

More data on the a-c operated receiver will be printed next week, issue of January 5th. Precision frequency measurements will be detailed in that issue, also.

Facsimile Standards and Terms Studied

Facsimile experiments have reached the point where organized development is being undertaken by the Radio Manufacturers Association Engineering Division. A special committee on facsimile, headed by E. W. Engstrom of Camden, N. J., as chairman, has been organized by Dr. W. R. G. Baker, chairman of the Engineering Division, and Virgil M. Graham of the Standards Committee. The new Facsimile Committee has begun to function, starting work on nomenclature and standardization. Four facsimile circuits, between New York and San Francisco, London, Berlin and Buenos Aires, are now in operation by RCA Communications Inc.

The romantic appeal as well as the service aspects of facsimile are both being considered by the RMA engineers in directing scientific progress toward eventual development of a practicable facsimile broadcasting system. The drum type of facsimile apparatus is now in use but eventual development of a continuous type of recorder, taking its paper from a feed roll, is regarded as the ultimate practical solution for broadcast facsimile recording. Higher speed also is an engineering goal.

It Sticks

Simple, perhaps, but nevertheless not to be deprecated, is the method used by Bertram Reinitz, of 18 East Twenty-first Street, Brooklyn, N. Y. When he has to pick up nuts and carry them over to tight places, whereby the socket wrench must be used with opening downward, he fills the wrench hole with soldering paste, puts the nut into the wrench, and the nut never falls out.

Canada Proposes Station in Windsor on 530 kc

Ottawa

The Canadian Broadcasting Commission is about to establish a broadcast station in Windsor, Ontario, on a wavelength of 530 kilocycles. As the United States is committed to a policy of prohibiting broadcasting below 540 kilocycles, another controversy with the Canadian Government may result. U. S. Army, Navy and other federal services now are allocated below 540 kilocycles and have strenuous objections to any extension of the broadcast band below 540 kilocycles. Canadian radio manufacturing interests also are reported opposing the establishment of the proposed Windsor station on 530 kilocycles.

Hearings on Communication

The Federal Communications Commission's Telegraph division held hearings in the matter of recommending laws to Congress that would authorize the consolidation of communication companies.

The following interests attended:

Postal Telegraph-Cable Company
Western Union Telegraph Company
Continental Telegraph Company
American Telephone and Telegraph System
American Radio News Corporations
Radio Corporation of America
Leon Cammen
Association of Western Union Employees
Commercial Telegrapher's Union
United Telegraphers of America
New Hampshire state government
Navy Department
War Department

Current Meter Use Extended

Voltages and Resistances Determined in Switch Instrument

By L. C. Forster

NEARLY everybody has some kind of a current meter and would like to extend its usefulness. It is assumed the meter reads direct current. Of course, the more sensitive the meter the better. At least it should be a 0-1 milliammeter. Now the 0-500 micrometer is gaining popularity. This is twice as sensitive as the other meter.

If the meter is of the less sensitive type, say 0-5 milliamperes, it may be used for the extended purpose, but the accuracy will not be so good, because the meter will draw from the measured circuit what may be unreasonably large current. More current may flow through the meter than through the circuit, hence the voltage reading with meter in circuit, while correct for that condition, will not be a determination of the voltage when the meter is not in circuit. So a 0-1 milliammeter is about as low in sensitivity as one would reasonably select, if he had any selection to make. Therefore some data will be presented on the use of a 0-1 milliammeter, although the same principles may be applied to more or less sensitive instruments.

Meter Measures Only Current

The meter always measures current and only current. However, if resistors are used in series with the meter the scale may be calibrated in volts, because different voltages will cause different currents and different needle deflections. In other words, the current differences due to different voltages are calibrated in volts.

Let us assume a 0-1 milliammeter divided mainly for 0.2, 0.4, 0.6, 0.8 and 1.0 milliampere. There will be subdivisions also. We note from the scale that the factor 1 represents full deflection. For the unmolested meter this represents a current of 1 milliampere. For any other purpose to which we shall put the meter, the same factor 1 always represents the same condition, that is, when needle points to 1 there is 1 milliamperes flowing through the meter. There may be other current flowing through a resistor in parallel with the meter, or the same current flowing through a resistor in series with the meter, but these do not change the range of sensitivity of the meter itself, but only of the circuit comprised of parts of which the meter is one part.

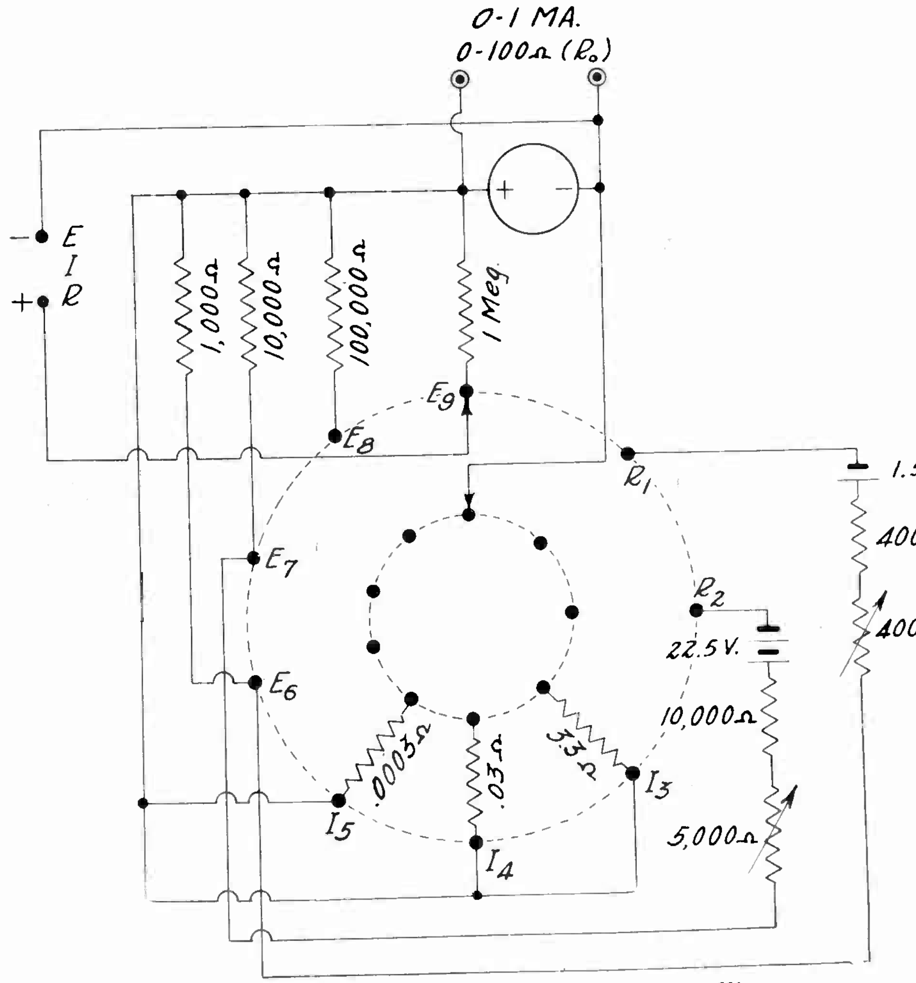
Now suppose we desire to convert the system to one for voltage measurement. We must ascertain the required resistance per volt. This is easily done, using Ohm's law. For 1 volt the resistance is 1/0.0001, from the formula $R = E/I$, where R is the resistance in ohms, E is the voltage in volts and I is the current in amperes. For a 0-1 milliammeter therefore the ohms-per-volt rating is 1,000.

The Accuracy Rating

Incidentally, this condition applies only to full-scale deflection, and for any readings less than full scale the actual ohms per volt will be less and the accuracy in use may be less. Therefore meter accuracy is based on one setting only, full-scale deflection, and all meter ratings should be considered accordingly. The accuracy of some other types of instruments, such as signal generators, applies to any setting. This difference must be carefully noted.

Now, if we have a meter that requires 1,000 ohms per volt at maximum deflection when used as a voltmeter, for 10 volts we would need 10,000 ohms, for 100 volts 100,000, for 1,000 volts 1,000,000 ohms.

Since the scale reads 0-1 we may use the decimal factor conveniently, and then will not have to do any longhand figuring to determine a measured voltage. Thus, for the 10-volt scale, any reading within range, multiply the milliampere calibration by 10. To continue the decimal system we must select 100 as the next voltage maximum. We would multiply the meter calibration by 100. So for 1,000 volts multiply the calibration by 1,000.



Circuit for switch operation of a volt-ohm-milliammeter.

Sensitivity of Meter

Now we may note carefully that when we use the instrument for voltage measurement, since we do not put any load across the meter terminals alone, we do not detour any current, so when the reading is 1,000 volts, or 100 volts or 10 volts, the full-scale deflection for these ranges, the current is maximum, too, that is, 1 milliampere. The same is true if we use simply 1,000 ohms in series, for 0-1 volt service.

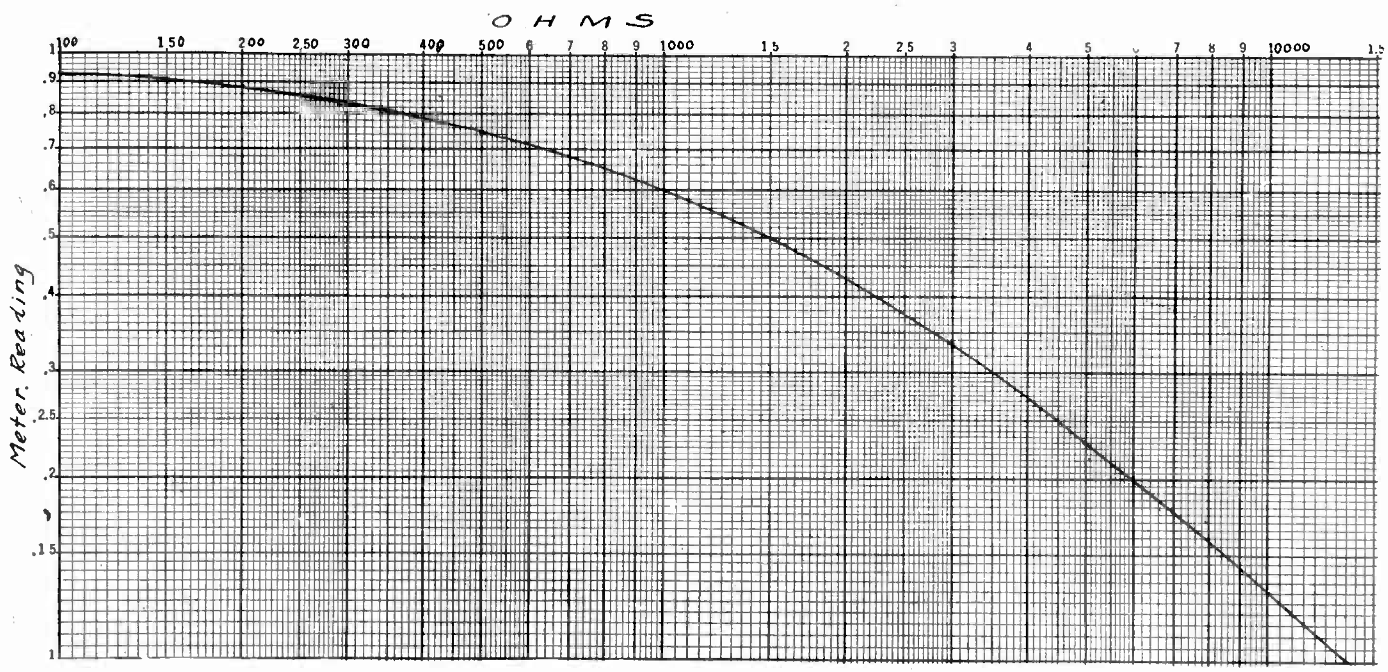
By bringing out one meter terminal and connecting the other terminal to a switch that picks up the various series resistors, we have switch operation for selection of the voltage ranges. Of course these ranges should be recorded on some sort of template, or engraved on the panel, so we shall not have to rely on memory for the range and service.

The sensitivity is built into the meter. Many ask whether they can not do something to a 0-5 milliammeter to make it a 0-1 milliammeter. The answer is no. Nor, strictly speaking, can anything be done to make a 0-1 milliammeter a 0-10 or 0-100 milliammeter. Remembering that the sensitivity of the meter alone can not be increased or decreased, no associated circuit can increase the sensitivity, either, but an associated circuit can decrease the sensitivity of the system of which the meter then becomes a part. That is what happens when a resistor is put across the meter, so that the total current flowing is divided, more flowing through the parallel resistor (called a shunt resistor, or simply shunt) than through the meter itself.

How to Determine Shunts

At this point it becomes necessary to determine what the value of the shunts should be for establishment of practical ranges we have in mind. Let us say that

(*Continued on next page*)



The case of the unknown series resistor

From this curve, it is possible to obtain the value of an unknown series resistance directly from the reading of the 0-1 milliampere meter used in this test. Example: meter reads .5. Look up the left-hand column where a meter reading of .5 will be found. Follow this line horizontally until it strikes the curved line, then note which vertical line intersects. Following this vertical line up to the scale, we read 15. This is 1500 ohms, the zeros having been left out on part of the curve sheet because of the cramped space. In like fashion, the 2 represents 2000, the 25 represents 2500, etc. If the battery voltage and series limiting resistor are increased divide the new battery voltage by 1.5 and multiply the read resistance by the factor.

(Continued from preceding page)

the extension is to include 0-10, 0-100 and 0-1,000 milliamperes. We must know what is the resistance of the meter itself. This in general is the resistance of the magnet coil winding. The manufacturer will supply the information. In two popular type meters, made by one manufacturer, the 0-1 milliammeter resistance is 30 ohms, while another manufacturer's meter is 32 ohms.

The formula for determining the shunt is:

$$R_s = \frac{R_m R_f}{R_m - R_f}$$

where R_s is the unknown shunt resistor, R_m is the meter resistance and R_f is the effective resistance resulting from R_s in parallel with R_m.

If the meter resistance R_m is divided by the extension factor, R_f is obtained. Thus for a 30-ohm instrument, 1 ma, to extend the range to 10 ma the factor is 10, and R_f is 30/10 or 3. So applying the formula for 10 milliamperes we have

$$R_s = \frac{30 \times 3}{30 - 3} \text{ or } \frac{90}{27} = 3.33 \text{ ohms.}$$

Simpler for Bigger Ranges

The greater extension factors the meter resistance may be divided by the factor, as the error is less than 2 per cent., the accuracy of the meter, so

$$R_s = \frac{R_m}{K}$$

where R_s is the unknown shunt resistance, R_m is the meter resistance and K is the extension factor.

If we are to limit ourselves to a commercially obtainable two-deck, nine-position switch (double-pole, nine-throw type) we could bring out the meter terminals themselves for 0-1 milliampere, especially as we shall have another use for them, and could devote the nine positions to four voltages (1, 10, 100, 1,000 volts); three currents (10, 100, 1,000 milliamperes), and two resistance ranges, medium and high. The medium range could be afforded by a 1.5-volt cell and 1,500 ohms in series.

As we have 1,000 ohms from the 1-volt scale we could use a carbon or metallized resistor of 400 ohms or so and a 400-ohm rheostat, and thus have a zero adjuster. And for the high-resistance range we could use a 10,000-ohm inexpensive limiting resistor and a 5,000-ohm rheostat, picking up the 10,000-ohm voltmeter series resistor, as we would use a 22.5-volt battery, requiring 22,500 ohms.

The Zero Adjusters

The reason for the adjusters is that the battery resistance changes with age and use and must be compensated for, so the zero adjustment is made each time resistance is to be read. Because of the zero adjustment the inexpensive resistors become practical in the ohmmeter circuit only. All other resistors should be wire-wound, for constancy.

The resistance ranges so far discussed may be considered as 100 to 5,000 ohms and 1,000 to 2,000,000 ohms. What the range limits are depend to some extent on what you consider fairly legible conditions. The difference between unknowns of 1,000,000 and 2,000,000 ohms is small, between 2,000,000 and 3,000,000 ohms so small that it is not well to assert that 3,000,000 ohms can be defined, except as greater than 2,000,000.

Now there often arise occasions when low resistances have to be determined. This is ordinarily done with a high-current circuit. However, we have no such circuit in our ohmmeter inclusion, nor any batteries or cell that will stand high current. But we do have a meter that, when closed as an ohmmeter for either of the two ranges discussed, can be shunted. Since the meter resistance is low, and known to be 30 ohms, we can determine what currents will flow when unknown small resistors are shunted across the meter alone, with other ohmmeter circuit closed. The medium-resistance circuit is selected for closing (by switch setting to position R1), and the two terminals of the meter, brought out for 0-1 milliampere reading purposes originally, will be used for connection of the small unknowns, R_o.

Calibration for Ohmmeter

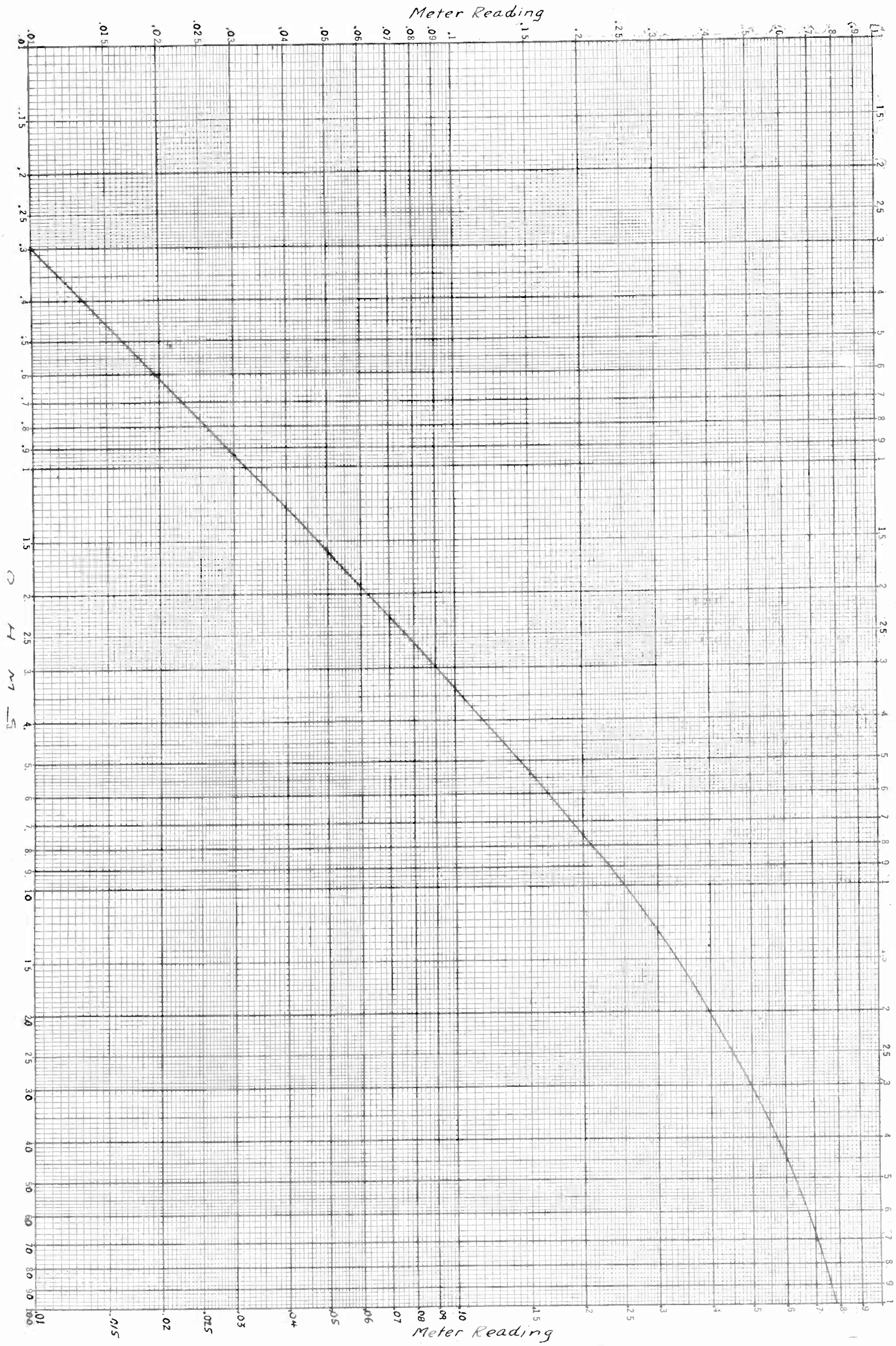
Let us take the simplest example. If the meter resistance is 30 ohms, and a circuit is set up to cause full-scale deflection, suppose a small unknown is shunted across the meter, and causes the meter reading to be 0.5 milliampere. What is the resistance of the unknown? It is obvious that the same 1 milliampere total is flowing, but exactly half of this current is flowing through the meter, the other half through the shunt. What resistance shunt will detour exactly as much current through itself as it permits through the meter? A resistance equal to the meter resistance. Therefore the unknown is 30 ohms. Thus one may tell quickly whether a resistor is equal to, more than or less than 30 ohms. Of course one would desire integral values.

The ohmmeter service in general is not a part of the calibration because the meter scale is linear for current (hence for voltage readings), but is far from linear for any resistance measurement. Hence the original meter calibration can not be interpreted. Instead, either a special scale must be used, or one may refer to charts. The chart for 0-1 milliammeter, 1.5-volt dry cell, and 1,500 ohms limiting resistor, is herewith. The high-resistance scale is applicable to this curve as explained in the caption above. The low-resistance example is given on a separate curve-sheet.

The switch stops are given position numbers, 1 to 9 inclusive. E9 reads the highest voltage, 1,000; E8, E7, E6 the succeeding lower voltages. So the highest current, 1 ampere, is read at the I5 posi-

(Continued on page 10)

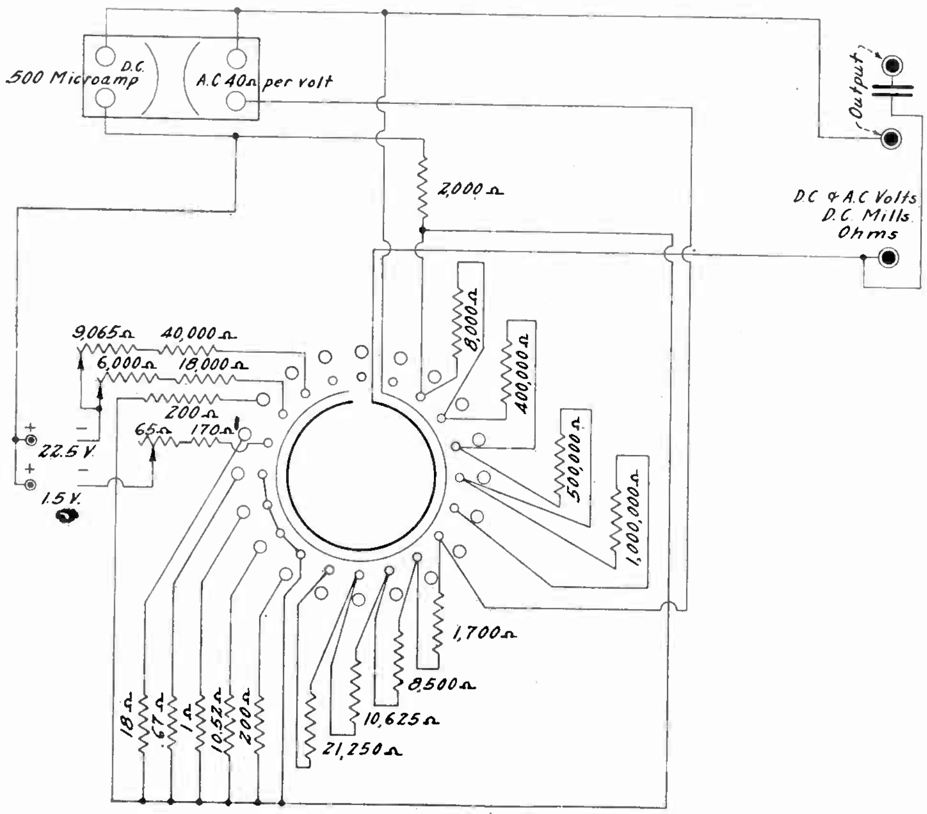
Shunt Meter to Measure Small Resistance



The case of the unknown shunt resistor

When the meter is shunted by the unknown resistance, quite low values of resistance may be measured by reference to the curve shown. The procedure here is similar to that employed with the other curve and accordingly need not be repeated here. Any condition causing full-scale deflection makes this curve apply to the 0-1 milliammeter.

How to Determine Unknown Shunt Resistances



For d-c use, the circuit illustrated in other diagram may be used. For both a-c and d-c use, a diagram like the one above may be followed, where the meters are independent. The above diagram is of the Triplett 1200 unit.

(*Continued from page 8*)

tion, 100 milliamperes at I4 and 10 milliamperes at I3. The 1 milliampere range is taken care of at the extra binding posts. R2 is the highest-resistance range, R1 is the medium resistance range, while R0, the low-resistance range, is taken at the extra binding posts when the switch is at R1 and the plus-minus terminal posts are closed. At these posts voltage, current and resistance are read, excepting 0-1 milliampere and the low-resistance range, read when the unknown resistance or current is at the extra posts.

The Shunt Resistor Method

For determination of the value of the unknown resistance, when the meter is shunted, the formula is:

$$R_x = \frac{R\ I_m}{1 - I_m}$$

where R_x is the unknown, R is the resistance of the meter, I_m is the meter current as read, and $1-I_m$ is computed.

If the meter resistance is not known, put a variable resistance of 100 ohms or so across the meter, when the meter is operated at full-scale deflection, then adjust the shunt until the meter reads half scale, measure the resistance of the shunt externally, and the answer is the resistance of the meter also. The resistance measurement may be made by putting high current through the removed shunt, measuring the voltage drop across the resistor, and applying Ohm's law, resistance in ohms equals voltage in volts divided by current in amperes.

Stated in words, the formula requires this practice: Read the meter current when the unknown is across the meter. Subtract this current from 1 (for the case of a 0-1 milliammeter). Divide the meter current by the difference current. This ratio, applied to the meter resistance, yields the resistance of the unknown.

It would be handier if some simple method took care of the situation in terms of the meter current alone, compared to the meter resistance, but this does not seem possible. By considering meter current alone we require a reciprocal term, $1/I_m$, that is harder to handle than the differential.

Non Code-Readers May Use These Data

The National Bureau of Standards sends in code CQ de WWV on its standard frequency (see next week's issue for measurement methods.)

For those not familiar with the code, CQ de WWV sounds like this:

—.—. ——.— —.. . .—— .—— ...— The frequency will then be given which is a combination of the telegraph code numbers as follows:

1 .————
2 ..———
3 ...——
4 ....—
5 .....
6 —....
7 ——...
8 ———..
9 ————.
0 —————

In this fashion 5000 will be sent as: ..... ————— ————— ————— or sometimes a long —— is substituted for the five dashes of the zero which will then sound like ..... —— —— —— for the 5000 just alluded to.

Improved Standards for Sets and Tubes

Nomenclature of radio receiving sets and also of tube numbering standards have been perfected by the General Standards Committee, of Radio Manufacturers Association, Virgil M. Graham, of Rochester, New York, chairman. In considering the industry definitions of receiving sets, the committee revised two standards, as follows:

"A Standard Broadcast Receiver is one which will respond to the entire broadcast frequency range of 540 kilocycles (555.2 meters) to 1600 kilocycles (187 meters)."

"An All-Wave Receiver is one whose tuning ranges will respond to all frequencies between 540 kilocycles (555.2 meters) and 18,000 kilocycles (16.6 meters)."

Definition of the "Standard and All-Wave Broadcast Receiver" is having further study by RMA committees with a view to a better definition.

The General Standards Committee has also adopted as RMA standards the "Requirements on Power Operated Receiving Appliances" of the Underwriters' Laboratories. This action is to effect adoption of these standards by the American Standards Association for establishment in pending ordinances of New York City and other municipalities in local regulation.

The new tube standards adopted by the General Standards Committee provide for designation of types of receiving tube bases by a system of three digits, the first being a letter indicating the size and type of base shells; the second digit being a figure, indicating the number of pins. and the third digit a letter, indicating the pin arrangements.

Average Hourly Wages 53.3 Cents in September

Radio excise tax collections during October, 1934, were 280,699.11. This compares with excise taxes of $305,291.91 during the previous month and with $292,332.20 in October, 1933.

The September, 1934, report on radio factory employment of the U. S. Department of Labor, Bureau of Labor Statistics, indicates slight changes in employment conditions from those of last August. During September, 1934, fifty-eight radio and phonograph establishments reported employment of 39,999 employees as compared with 39,063 employees reported in sixty radio establishments during the previous month. No wage changes during September were reported.

During September, 1934, per capita weekly earnings of the reporting companies were $18.36, an increase of 2.1 per cent over August, 1934, and 8.7 per cent over September, 1933.

Average hourly earnings of radio employees during September, 1934, were 53.3 cents as compared with 53.9 cents during August, 1934, but 12.4 per cent. larger than average hourly earnings during September, 1933.

Radio employment indices during September 1934, compared with the three-year average of 1923-1925, were 219.9 per cent, an increase of 12.3 per cent over September 1933. Payroll indices during September 1934 as compared with the three-year average were 127 per cent., an increase of 22 per cent. over September 1933.

THE AMATEUR ORACLE

Address Questions Concerning Amateur Regulations and Technique to M. K. Kunins (W2DPS), Technical Editor, Radio World, 145 West 45th Street, New York, N. Y.

B Eliminator Trouble

I HAVE a three-tube ham short-wave receiver which works fine on batteries. However, I recently bought an eliminator for this set and cannot stop a loud low-frequency oscillation from creeping in. Is it at all possible to get rid of this disturbing noise?—M. L. K.

You are probably experiencing the phenomenon known as "motorboating." This is caused by the fact that the various stages of your receiver are intercoupled through the eliminator which causes these low frequency audio oscillations to be generated. You may attempt to minimize this reaction by placing an audio choke coil in the detector plate supply lead of sufficient size to prevent this action. Another scheme utilizes a resistor of about 10,000 ohms in series with the high voltage lead. Shunted across the high-voltage line on both sides of this resistor should be placed a 2 mfd. condenser for bypass purposes. This arrangement will of course require that the original B voltage be slightly raised to compensate for the drop in the series resistor.

* * *

Television Amateur Work

WHICH AMATEUR band is mostly used for television purposes? To construct an amateur short-wave radiophone, can a custom-built short-wave receiver be used as the receiving end? Which amateur frequency is unlimited in its use for radiophone?—V. W. C.

The majority of amateurs who have engaged in television transmission have used the band 1715 to 2000 kilocycles. However, now that the ultra short waves are being more exploited, it would not be surprising to see this endeavor soon utilize the other band available for amateur television work—56,000 to 60,000 kc. The manufactured receiver that you mention in your letter may be used for the reception of amateur short-wave messages. However, in this connection, it is apropos to mention that ordinary all-wave receivers put out by broadcast receiver concerns are not as suitable since they do not possess the necessary selectivity for the crowded signals of the amateur bands. The government has set aside the following bands for radiophone communication that can be used by beginners not licensed with Class A licenses; 1800 to 2000 kc., 28,000 to 28,500 kc., 56,000 to 60,000 kc., and 400,000 to 401,000 kc. Of course, it is understood that the operator possesses either a class B or C operator's license.

* * *

Quiet Hours

WHAT ARE the quiet hours that the Government may impose upon an amateur transmitter that causes interference with other services?—H. G. N.

In the event that the operation of an amateur radio station causes general interference to the reception of broadcast programs with receivers of modern design, that amateur station shall not operate between the hours from 8 p.m. to 10:30 p.m., local time, and on Sunday from 10:30 a.m. to 1 p.m., local time, upon such frequency or frequencies as cause such interference.

* * *

Condenser Voltage Test

HOW MAY a condenser's voltage rating be most effectively tested?—I. O. M.

Solid dielectrics, as used in fixed condensers, will break down at different voltages dependent upon the temperature, the length of time they are subjected to the voltage, and sometimes the humidity. Therefore, Radio Manufacturers Association, Inc., has specified that the voltage test for fixed condensers should be: Connect the condenser to a source of d-c potential that is twice the rated working voltage. This connection should be maintained for fifteen seconds and must not break down under these conditions. The condenser should then be immediately discharged through a suitable resistance that will limit the discharge current to not more than one ampere. The working voltage is usually marked on the case of the condenser and should be known since it is this value that it is desired to verify.

* * *

Wavelength Formula

WHAT IS the formula that is used in the calculation of frequency from wavelengths?—L. M.

This relation is:

$$\text{wavelength} = \frac{\text{Velocity of radio wave}}{\text{frequency}} = \frac{V}{f}$$

It will be seen that to convert frequency and wave length, it is necessary to know the velocity of the radio wave. Until a few years ago, this figure was accepted as 300,000,000 meters per second. However, subsequent measurements of greater accuracy have evolved this figure as 299,820,000 meters per second. Incidentally, it should be appreciated that this velocity will vary slightly in accordance with the character of the terrain over which the wave passes, so that the computations should in reality utilize a wave velocity that is variable. But, of course, the present state of the art does not provide us with these exact measurements and also since their effect upon the final result is trivial, this factor need not concern us too much.

Rochester Convention Feb. 9

The ham gang at Rochester, N. Y., intends to have its annual convention in that city on Saturday, February 9, according to Johnny Long, chief engineer at WHAM. Several notable speakers, including Clark Rodiman of the A. R. R. L. and Dr. B. T. Simpson, W8CPC, will be heard.

THE "CAP" OF A TUBE

The metal projector at top of screen grid tubes is often called a cap, but the clip or cup put on it comes nearer to being a cap.

Improvised Kite Aids Ham Solve Antenna Problem

Carl L. Gartner, of 200 East Sixteenth Street, New York City, had handicaps in putting up a short-wave antenna, because he lives in a 20-story apartment house. How he solved the problem he tells as follows:

"The house antenna system is far from efficient for short waves. Having a short-wave set I was desirous of installing an antenna of my own, but the landlord's orders were that this could not be done. I finally decided on running wires along the window ledges the length of the apartment, but the difficulty was that mine is a corner apartment and I would not have sufficient length of wire on any one side.

"To get around the corner to the next window seemed almost impossible, as I am on the eleventh floor and I didn't have enough wire to drop two lines to the street, and that would be also too apparent to the doorman or visible to some other tenant as the line passed his window. Each of the windows I had to work from was some ten to fifteen feet from the corner and there was no way to pass around.

"I made a miniature kite out of a tiny piece of paper and attached it to a thread of sufficient strength. Fortunately the wind was from West to East that day, the direction the wire first had to take, and my kite carried out past the end of the building. Now, as you may have often observed, when a breeze passes a building of this nature, there is bound to be a back eddy at the end of the building. Thus my kite quite promptly shot around the corner and then it was only a matter of waiting a few moments for the string to pass my hand at the second window, draw it in, attach my wire back at the first window and then draw it carefully around the corner, I assure you that the results obtained with this new aerial quite repaid the effort expended and I proceeded to get a veritable treasure of DX on the 49-meter band, a range that I had previously skipped on the old antenna.

Literature Wanted

Readers desiring radio literature from manufacturers and jobbers should send a request for publication of their name and address. Address Literature Editor, **RADIO WORLD, 145** ***West*** **45th** ***Street, New York, N. Y.***

G. C. Willecke, Box 24, Unity, Wisconsin.
Florian Poeschl, 0702 Charlevoise St., Point St. Charles, Montreal, P. Q., Canada.
Eugene Popik, 1316 Duss Avenue, Ambridge, Pennsylvania.
George J. Heldman, 2836 Southport Ave., Chicago, Ill.
Jack Downes, 32-23 110th Street, Corona, N. Y.
Fred Moon, Box 254, Lewiston, Idaho.
John W. Norkett, P. O. Box 201, Chicago, Ill.
J. W. MacNeal, Box 152, Albuquerque, New Mexico.
Adams Adams, Second Casual Co., Fort Slocum, N. Y.
A. E. Beck, 535 So. W. A St., Richmond, Indiana.
A. E. Bryant, 411 Warren Ave., Lynchburg, Va.
Chesser Radio Service, P. O. Box 3347, Beaumont, Tex.
Jock Finnerty, Jr., c/o R.K.O. Prospect Theatre, 327 - 9th St., B'klyn, N. Y.
James Gantt, Route 1, Box 94, Teesville, S. C.
Clinton James, Bryn Athyn, Pa.
H. V. Landers, 38 Oliver St., Binghamton, N. Y.
Joseph Novick, R.F.D. 2, Box 61, Altoona, Pa.
John A. Ostrom, 145 Main St. East, North Bay, Ont., Can.
C. H. Primus, 651 E. 37th St., Los Angeles, Calif.
T. B. Perkins, 9803 - 75 Ave., S. Edmonton, Alberta, Can.
Lepido Ricart, Avenida Bolivar, No. 22, Santa Domingo, Dominican Republic.

FACTORS THAT DETE

By M. K

SEVERAL years ago the ordinary broadcast receiver in a console was quite the rage. Time however soon rendered this type of installation secondary and the midget and pygmy receivers were introduced to stem the tide of a waning market. These gadgets proved to be the answer to the public's prayer since they were purchased by many because of the low cost. The depression caused the public to lay more stress upon the monetary side of their purchases so that the poor quality rendered by these small receivers was forgiven. However, the more universal did these receivers become, the more apparent was the blatant cacophony, so that a waning interest again became general.

Instead of answering this complaint with high-quality reproduction, most manufacturers decided that other selling points were necessary and accordingly initiated all-wave and short-wave receivers of fair quality. However, there are a few more substantial manufacturers that appreciate the call for good quality and have developed receivers that can boast a high fidelity in the reproductions of the signals intercepted by them.

Effect of Channel Width

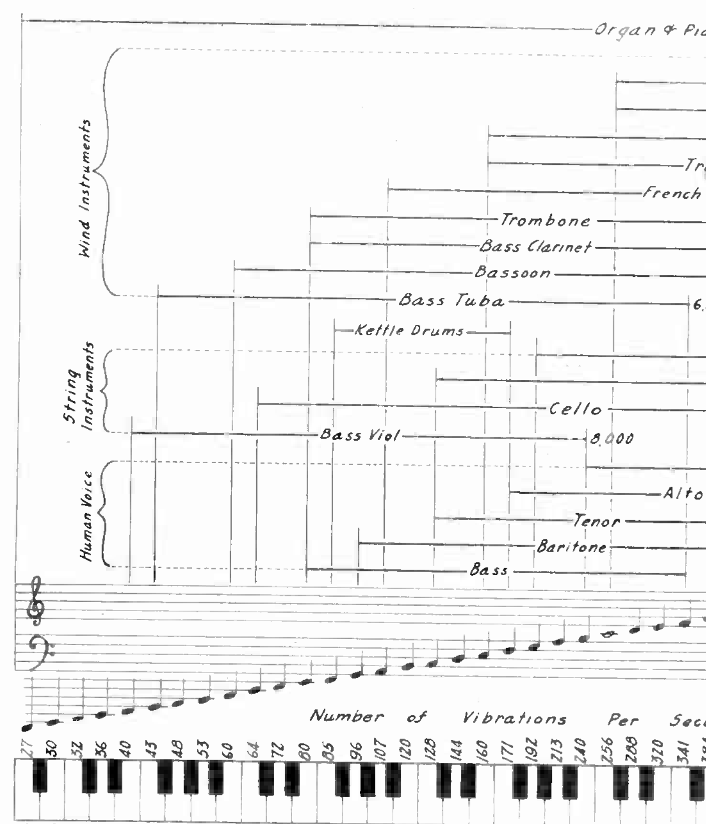
Though the operation of these high fidelity sets is limited by the fact that broadcast stations are allocated every ten kilocycles which allows a maximum audio channel 5 kilocycles in width, it is hoped that eventually this limitation will be obviated by a change in the allocation scheme, or perhaps through the general use of transmitters with single side bands. Until that takes place, it is necessary to equip these high fidelity sets with a variable control of the audio band width according to whether or not a station in an adjacent channel is powerful enough to mar results above 5000 cycles.

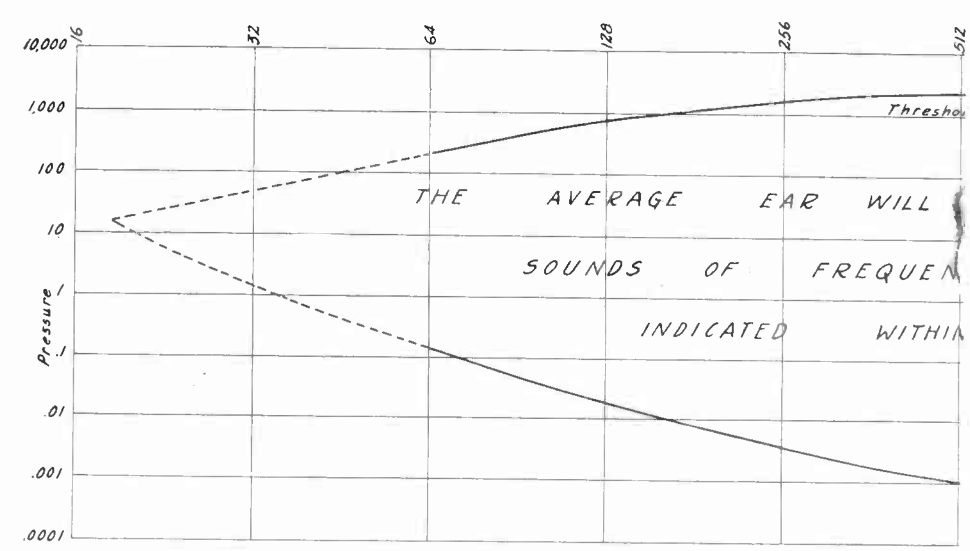
It should be generally conceivable that the adoption of high fidelity characteristics for broadcast receivers is a real substantial benefit to the enjoyment of broadcast programs. But what is high fidelity and what determines its limitations? To understand that, it is necessary to allude to the diagram showing the ranges of various musical instruments, etc., in connection with an appreciation of the characteristics of the human ear.

Broadcast programs comprise audible modulations of a radio wave which when received and suitably rectified by a receiver will be made to affect the human ear. In this process, the broadcast transmitting apparatus, the receiving apparatus and the ear will determine what the results will sound like. Of course, the person at the receiver can not control the operations of the transmitter and so a consideration of this phase can be neglected here.

Many Stations Do Well

This does not necessarily indicate that broadcast transmitters are in need of consideration in this respect since many of them have been refined to the point where they may be classed as high fidelity instruments. Accordingly, the output of a great many of the transmitting plants of the broadcast stations around the country may be considered to be of good quality.

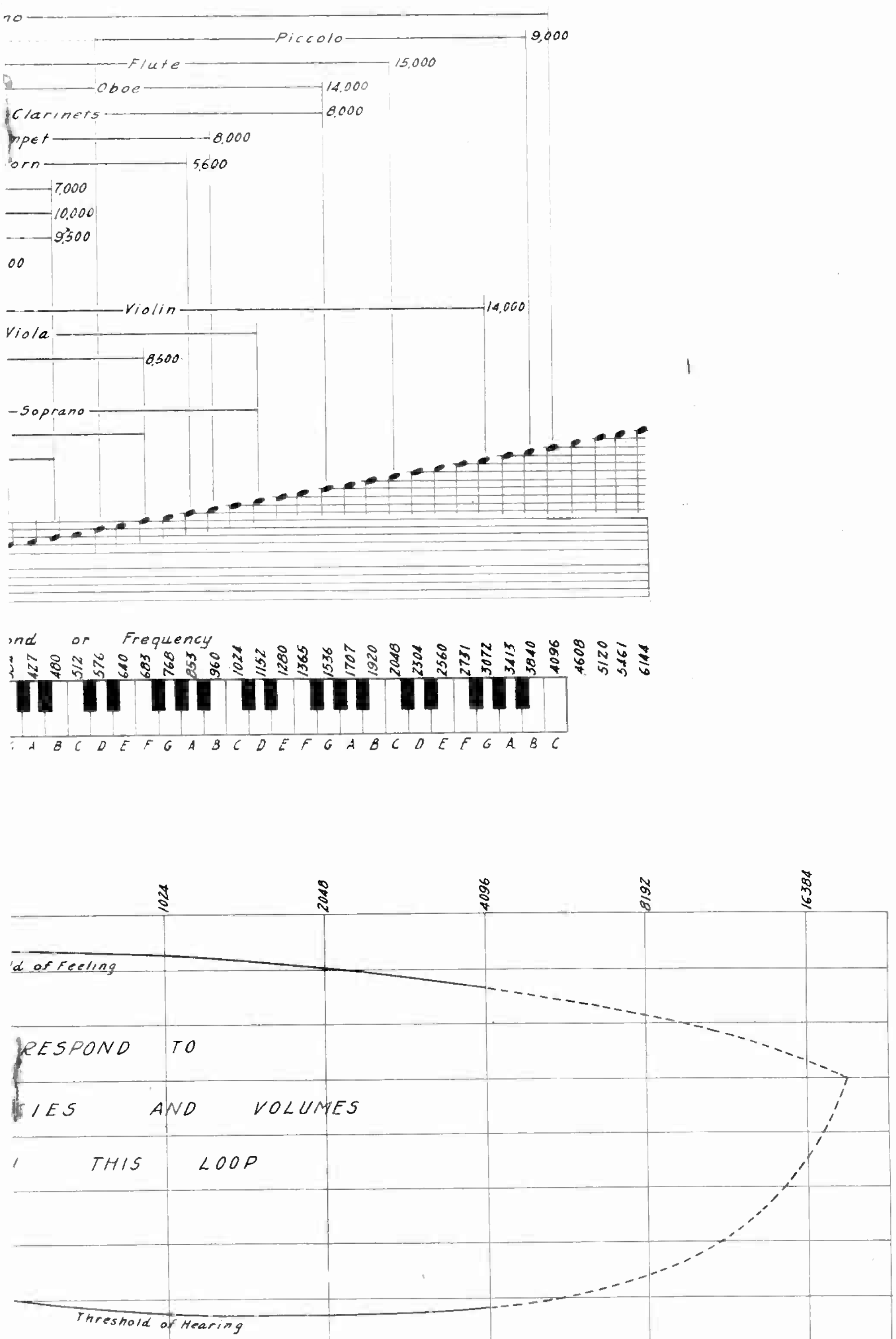




The fidelity with which a sound is reproduced by a radio receiver after the marily upon the faithfulness with which the studio walls, the transmitter, t sound's electrical counterpart. These sketches indicate, in the lower part, indicates the pitches that emanate from various musical instruments an pitch ranges of the various instruments represent the limits

RMINE HIGH FIDELITY

.. Kunins



wave has traveled over the vast spaces of its ethereal journey depends pri- e receiver and even the listener's ear will affect or be affected by the original ow a normal ear will react to various sounds. The upper part of the sketch d human voices. The numbers appearing after some of the lines indicating the to which the harmonics of the individual instruments extend.

All that remains now is that the receiver be suitably constructed so that it does not distort the received signal but rather transmits it to the auditory mechanism of each listener just as it was received from the transmitter.

What the results of the action of a receiving set will be as interpreted by the listener's ear depends upon the individual listener. This is so since the capabilities of the human ear varies with age, state of health, etc. It is because of this variation in ears that the diagram illustrative of the ear's sensitivity is shown by dotted lines at the lower and higher frequencies. Thus, a child in good health may be able to hear up to 20,000 vibrations per second whereas, an adult may cease to hear above 10,000 vibrations.

Attributes of Sound

This is not a phenomenon attributable to deafness, since the hearing at the lower frequencies may be perfectly normal.

It will be understood that sounds possess three attributes: Pitch (synonymous with frequency of vibrations and tone), Volume (synonymous with air pressure in dynes per square centimeter), and Timbre (synonymous with overtones and harmonics). It will be noted in the sketch that the overtones of various instruments are indicated as numbers at the end of the lines showing pitch range. The curves that have been referred to above indicate the potentialities of the average human ear with respect to various volumes of different pure sounds of one pitch. It will be seen from it that the ear will respond to all sounds within the area of the closed loop of the curve that have the volumes indicated. When the volume of the sound is such that it is below the lower curve of the loop, it will not be audible to the ear.

In this connection, it is interesting to see that the notes corresponding to the octave on the piano between the vibrations of 1024 and 2048 will affect the ear most easily. That is to say, these notes require the least energy to make themselves just audible to the average human ear.

Effect on Ear

On the other hand, when the volume of the sound is such that it occurs above the upper curve of the loop, it will affect the ear with a sense of feeling rather than with hearing. To put it another way, the auditor will feel his head vibrating when these high intensities are inflicted upon him. This is, of course, not a desirable state of affairs and should be avoided, for, continued subjection to such intensities would be disastrous physiologically. Further deductions may be drawn from these curves. It will be seen that the lowest frequency to which the ear is sensitive is in the vicinity of about 20 cycles, and that the upper limit is at about 20,000 cycles. Thus, we needn't concern ourselves with frequencies below or above this range since the ear will not hear them.

From the upper portion of the diagram will be seen the tonal ranges of various common sounds that are heard on broadcast programs. It will be noted that these ranges are given as the pure tones ren-

(Continued on next page)

(*Continued on next page*)

dered by these instruments, in other words, it concerns only the fundamental frequencies involved. A most important factor of musical instruments is that the tones derivable from them contains a great number of overtones or harmonic frequencies which comprise the instrument's timbre.

Recognition Made Possible

It is these overtones that permit the auditor to recognize one instrument from another. Should these overtones not be heard, the identity of the instrument would be lost and the efforts at high fidelity would be defeated. It is accordingly pertinent to mention that the ranges of the instruments shown should in reality be continued further so as to include the overtones.

If this were done, it would be found that the overtones of the piano occur up to 5500 cycles, the piccolo to 9,000 cycles, the flute to 15,000 cycles, the oboe to 14,000 cycles, the violin to 14,000 cycles, the cello to 8500 cycles, etc.

Interesting additional sounds are those due to handclapping which require a frequency range of 150 to 16,000 cycles; jingling keys, a range of 1,000 to 16,000 cycles; foot steps, a range of 100 to 13,000 cycles and the snare drum, a range of 90 to 14,000 cycles. Thus, it can be seen that for absolute high fidelity reproduction of sound, it is necessary that the equipment be capable of transmitting frequencies between about 20 cycles to about 16,000 cycles.

Frequency Range

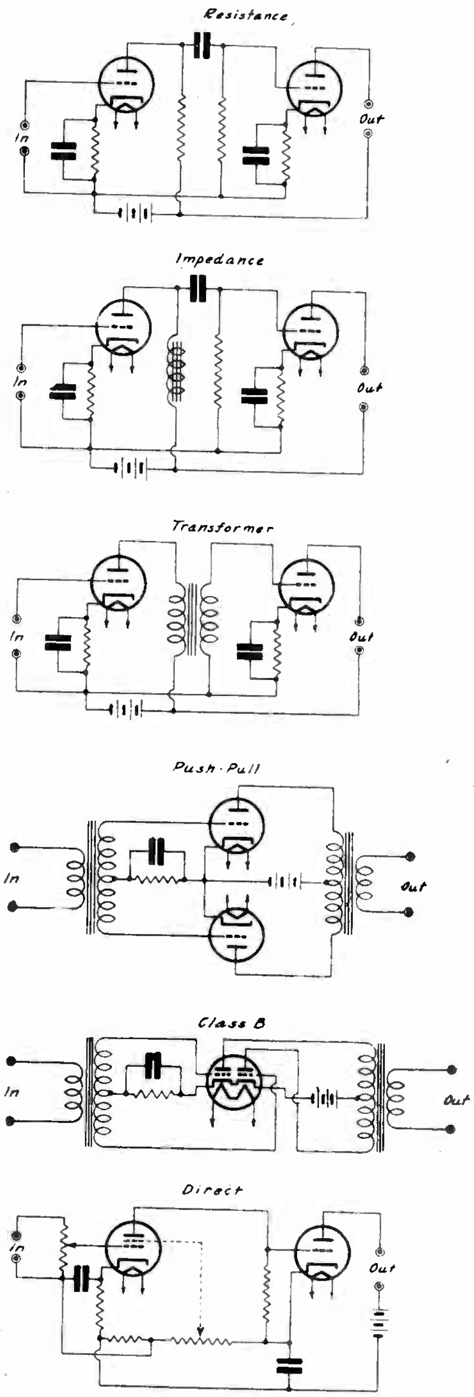
Well, the ear will do that or it will be restricted in this ability by various human frailties; but this is our starting point. We might consider this ideal case so that a condition which isn't as comprehensive in scope may still be satisfactory for the average person.

This frequency range would thus require that the radio frequency carrier of a transmitter be capable of modulation up to 16,000 cycles. This would necessitate that broadcast stations be allocated into channels that are further apart than 10 k.c., but, since such a condition does not exist at present, present day high fidelity set manufacturers have decided that the upper limit can be 7500 cycles without too serious effect upon the fidelity. This may be accepted since most of the sound energy exists in this region and those harmonics which come outside this pale are quite weak and not readily missed by the average ear.

Now that we understand the limitations imposed by the human ear, we should realize that the receiver is the next consideration which will affect the sound to be reproduced.

Quite a Problem

It is quite a manifold problem to design receiving equipment that will render a frequency band up to 7500 cycles with equal effectiveness since this ability is affected by all the gadgets in the equipment. These gadgets may be categoried into the r-f stages, the oscillator stage, the i-f stages, the detector stage, the a-f stage, the loudspeaker, and any other special devices. In all stages except the audio, tuning instruments are provided. Because no variations are thus permissible in the audio stages, the selectivity and fidelity of this part of the circuit will be fixed under ordinary circumstances. Since no variation can be obtained, as ordinary sets go, it is desirable that the audio stages be designed especially for fidelity purposes. We shall accordingly consider the various types of audio frequency amplifiers available.



Audio frequency amplifier stages may be coupled together in any one of the methods shown above. Each has its special advantages and disadvantages and so has its individual applications.

Audio-frequency amplifiers are classed into three groups generally and may be one of the following types: (a) resistance-coupled; (b) impedance-coupled, (c) transformer-coupled. (See first three diagrams on this page.)

Although the resistance-coupled audio amplifier is the simplest type of audio amplifier from an elementary point of view its design and construction present considerable practical difficulties. To obtain an amplification per stage approaching the amplification factor of the tubes used it is necessary to use an inserted plate resistance considerably larger than the internal resistance of the tube and this means that the plate voltage supply must be quite large so as to enable the tube to operate at the desirable portion of the characteristic.

The use of tubes with low amplification factors taking plate currents of a few milliamperes is limited in resistance amplifiers. This limitation is removed by the use of tubes with high amplification factors and high resistances in which the plate current is only on the order of 100 microamperes. This current of course does not cause an excessively low effective plate voltage despite a high load resistance and so the difficulty mentioned is minimized. By this means, a plate voltage supply in the order of 180 volts is quite satisfactory.

Problem of Resistors

Serious progress in the design of resistance-coupled amplifiers started when the plate resistances as high as 3 meg. were used in conjunction with tubes having voltage amplification factors as high as 35. Since then, progress in design has been rapid. The high amplification obtainable from resistance-coupled amplifiers using these tubes has rivaled the results obtained by the transformer method.

A resistance-coupled amplifier is preferable to that of the impedance or transformer methods due to its better frequency characteristics, assuming that the capacity shunting effect of the succeeding stages is negligible. Owing to the lack of step-up action, however, the amplification factor of the tube must be high if the overall amplification of the stages is to compete with transformer coupling. Since this high amplification factor as yet can only be obtained by a tube with a high internal resistance, the plate resistor inserted into the output circuit must be large and the plate current necessarily becomes small. The design of this resistor has presented problems in itself, since the old compound and carbon types have small power dissipation, and create microphonic difficulties. Wire-wound resistors, on the other hand, were found preferable but the self-capacity was large and the dimensions such that the component was bulky. The vacuum type of resistor using a metallized filament has to a some extent replaced previous forms of plate resistor because of small self-capacity and bulk.

The Capacity Effect

A high amplification factor tube with a large plate resistance gives a large input impedance, and the shunting effect of the complete stage is serious, thereby reducing the effective plate impedance of the preceding stage at high audio frequencies. This effect plays a very important part in the operation of the amplifier and somewhat detracts from the virtues of the tube with the high amplification factor. The coupling condenser between stages must be large if the low audio frequencies are to pass and this condenser must have a very high insulation resistance, since it is connected directly between the plate of one stage and the grid of the next. If this condenser is too large, the time constant of the condenser and grid leak circuit may be so large as to cause the system to suffer from temporary paralysis of action due to grid condenser charges resulting from occasional abnormally large signals.

These defects have led some to use more stages of tubes with low amplification factors and small coupling resistors, the lower plate resistors serving to prevent serious frequency dependence and the lower grid resistor serving to maintain bias stability, due to low resistance confronting any possible grid current.

To generalize the foregoing, it might be stated that (1), the use of tubes with high amplification factors causes a small plate current to flow with a high plate resistor if the plate potential supply is kept within reasonable limits. This means that the input impedance of the system will be low due to a large stage factor, with consequent reduction in the amplification at high audio frequencies which will result in frequency distortion. (2)

The use of tubes with low amplification factors permits an improvement in the frequency characteristic of the amplifier but a larger coupling condenser becomes necessary to maintain the low frequencies. The difficulty here lies in the possibility of the grid charges temporarily paralyzing the normal action of the tube and the requirement of the use of a greater number of stages.

Combined Method

Notwithstanding the difficulties outlined above, the resistance-coupled amplifier offers a better general amplification—frequency characteristic than the transformer type of amplifier, though usually at the sacrifice of amplification. The combination of a resistance stage which maintains the low audio frequencies, and a transformer coupled stage which can be designed to maintain the higher audio frequencies appears to be an excellent arrangement for a two-stage audio amplifier.

A single stage of amplification that combines the advantages of resistance coupling with those of transformer coupling seems to be a desirable solution of the problem of uniform amplification at all frequencies. By such an arrangement both low and high audio frequencies can be equally transmitted through the system.

In concluding these statements on resistance coupling, it might be well to indicate that when a coupling condenser of 0.006 mfd. is used, the range of frequency response is extended to as low as 30 cycles. This good response on the low frequencies, however, increases the possibility of trouble from a common plate potential supply. The by-pass condensers ordinarily used are not very effective at very low audio frequencies and therefore the common plate supply acts as a coupling between stages. This coupling gives rise to oscillations in the amplifier called "motor boating." Such action may be avoided by using a low resistance grid leak across the input circuit of each stage or by using a smaller coupling condenser.

Impedance-coupled Amplifier

The impedance method of coupling consists, usually, of the same circuit as the resistance coupled system except that the plate resistor is replaced by an audio choke coil. The action of such a circuit is similar to the resistance-coupled amplifier. With the choke coil in the output plate circuit, however, it is possible to obtain an arrangement whereby a high impedance is presented to audio frequencies at the same time that a low resistance is presented to the current from the plate potential supply. Thus the plate supply's potential need not be as great as in the case of the pure resistance coupling method. Of course, this is obviously an advantage. However, this advantage is somewhat nullified by the poorer frequency characteristic of such an amplifier because the inductance which has a definite frequency discrimination towards the higher audio frequencies. It is for this reason that the impedance type of coupling has been practically discarded.

Transformer-coupled Amplifier

The transformer-coupled amplifier has been more generally used because of the greater amplification available through the step-up action of a transformer. Its more universal use has been prevented, however, by the fact that its frequency characteristic is not so good as that of the resistance-coupled method. Accordingly, to put it differently, it can be said that the advantage of step-up effect obtainable by the use of transformer coupling so that the amplification factor of the stage is greater than the voltage amplification factor of the tube alone is obtained only at the expense of certain disadvantages. The frequency response of the early type of transformer was so poor that resistance coupling was vastly superior. But, due to the development of transformers with large primary inductance and low secondary self-capacity, the transformer stage of audio can now give a characteristic which in some ways is preferable to the resistance coupled type. In general, the transformer-coupled stage is found to possess a frequency response characteristic that has two peaks corresponding to the first and the second resonance points in the transformer. The sharpness of these peaks and the frequency at which they occur are largely dependant upon the internal resistance of the tube. By suitably arranging the tube constants, it is possible to damp out almost completely the first resonance point and maintain the second one at a frequency in the neighborhood of 4,000 cycles or over. The characteristic is therefore lifted at the upper frequencies where the resistance coupled stage tends to fall off.

Voltage Amplification

Although a well-designed resistance-coupled stage using low amplification factor, low internal resistance tubes gives a better frequency response than the transformer type, a well designed transformer stage usually gives a better response characteristic than can be obtained with a resistance stage using high mu tubes, owing to the shunting effect of the stray and interelectrode capacities. The combination of the resistance and transformer types of amplifiers gives the best arrangement for an amplification up to about 500 times the input voltage.

The purpose of the amplifiers mentioned above has been to increase voltages so that the output voltage is greatly increased as compared with the voltage fed to the input circuit. However, effectively to work modern dynamic speakers it is necessary that large power rather than high voltage be introduced into the voice coil of the speaker. Therefore, the need exists for an amplifier that amplifies power rather than voltage and, in this connection, the reader is referred to the next two sketches in the diagram, where the push-pull and Class B arrangements are shown. Strictly speaking, the Class B amplifier is a special case of the push-pull arrangement. An explanation of these two circuits follows.

Case of Class B

It has been intimated that the power stage is a converting mechanism whereby high voltage changes are transformed into high power changes. Since the output that is demanded is large, tubes of high mutual conductance and with a long straight characteristic are needed. The push-pull arrangements fulfill the need capably and appear in either one of two types; the form known as a "push-pull" and the form known as "Class B." The push-pull arrangement involves two tubes operating back to back on the straight portion of each individual tube's characteristic. The Class B arrangement operates on the portion of the characteristic ordinarily occupied by detectors—at the lower bend. In the push-pull circuit it is not essential that the tubes be perfectly matched although it is preferable for best operation. However, in the case of Class B amplification, it is imperative that these two tubes be perfectly matched. It is for this reason that the two tubes have of late been constructed in one envelope, like the 53 and 79 type tubes. Thus, automatically, two matched tubes are obtained.

Push-pull amplification has four major advantages over ordinary amplification.

1. It more than doubles the limit of volume output because the output is the sum of the output wattage of both tubes, plus the extra volume limit obtained by the amplifier working over a curved portion of its characteristic. The amplification of a single tube is limited to the straight part of its characteristic. Enough voltage on the grid to cause the characteristic to bend causes distortion. Push-pull amplification practically removes this limitation.

2. Distortion, due to tube overloading when operating at the upper volume limit, is reduced. Voltages in phase in grid circuits cancel out and do not appear in output — permitting greatly increased power output. These grid voltages are due to the amplifier working over a curved part of its characteristic—introducing harmonics of the original frequency. Due to phase relations, these cancel out and no distortion is introduced in the output. The working range in a push-pull amplifier is not limited to the straight part of the tube curve.

3. A. C. hum in the speaker is practically eliminated by using A. C. on the filaments of power tubes. Hum voltages on the grids of the two tubes cancel out in the output.

4. Saturation of the core by the constant component of plate current from the output transformer, is eliminated, together with the tendency to cause wave distortion at the low frequencies.

Power Tubes

The importance of a power tube (two, in push-pull) in the last stage of a receiving set cannot be over-stated. A loud speaker demands a certain amount of power expressed in watts. This power can only be furnished by a power tube capable of delivering sufficient wattage.

Direct Coupling

It will be noted from the diagram that the direct coupling method of audio-frequency amplification takes a radical step by connecting the plate of the first stage directly to the grid of the second stage. At first glance this would seem to indicate that the grid of the second tube is at the same high positive potential that the plate of the first tube is. If this is so, how does the tube operate? It is a fundamental concept that grids should never go positive in order to avert distortive influences, let alone a high positive potential.

All this is true, but we have not studied the circuit sufficiently. It is to be understood, first, before reverting to the diagram, that the potential on the grid of a vacuum tube is not what the potential of a battery connected to it is, but rather it is the potential that exists between the grid and cathode within the tube itself.

Thus, if 100 volts positive are impressed upon the grid, and the cathode has impressed on it 110 volts negative, the potential across the grid and cathode of the tube will be the algebraic sum of these two potentials, or, 10 volts negative and not the 100 volts positive of the original potential. This is the situation in the direct-coupled amplifier. If we now revert to the diagram, it will be seen that the cathode of the second tube is at a higher potential than the first tube, so that the seeming high positive potential on the second tube's grid is in reality a negative bias—just as it should be.

The advantage of the use of this system are cheapness, low weight, low bulk, high gain and the fact that any frequency can be handled with practically no frequency discrimination or wave-form distortion. The amplifying possibilities are limited only by the amplification factor of the tube, and accordingly, it is advantageous to utilize a screen grid tube in the first stage because of its high amplification factor.

(*Continued on page 21*)

An Understanding of Light
As Groundwork for Photo-Electric Cell Use

By Samuel Wein

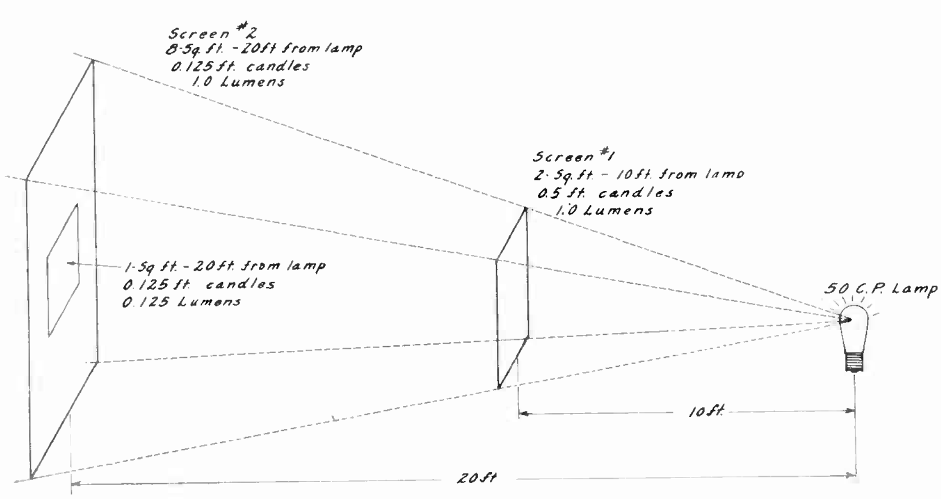


FIG. 1

The light from a 50 candlepower lamp varies inversely as the square of the distance between the source and a surface. Various light units are handy in the description of light conditions on a surface as shown in the sketch

IN the last five years the photo electric cell has received more combined attention of engineers and students than has its first cousin, the multi-element vacuum tube. I don't want to be misunderstood in my comments that the vacuum tube has made no progress; on the contrary, it has. But the progress made in photoelectric cell technique in the last five years surely exceeds that of the vacuum, including adaptations, though the "cell" is so closely knit with the multi-element vacuum tube.

If I were to be asked to co-ordinate all of the uses to which cells are put in technical as well as commercial uses, it would fill one issue of RADIO WORLD from cover to cover.

The number and types of light-sensitive cells in common use are becoming great in number. Each of these cells has its particular physical characteristics.

It is well that we first have a review of the physical characteristics of light, for association of these the characteristics of the cells.

Ratings Considered

When we purchase electrical devices as, for instance, a motor, to serve a particular purpose, it is necessary that we know the requirements of the motor, so that we can intelligently adapt it for the use to which it is to be put. In other words, the motor is rated in horse power (HP), volts (EMF), current in amperes (I), watts (W), kilowatts (KW), etc., in terms of generally accepted electrical units used. In photo-electric art, it is equally essential that the conditions to be encountered for a particular installation be understood, and that some standard terminology be adapted which may be readily interpreted by another who is familiar with this work.

For this reason the following definitions of light units are given, together with practical information as to the actual values of such units in tangible form.

Before we discuss these light terms we show the various forms or means for creating light to affect these cells and which have been used from time to time.

The definitions given here have been taken from the report of the Standards Committee of the Illuminating Engineering Society, and in some instances amplified.

Unequal Eye Sensitivity

For the purposes of studying the effect of electrical effects of light, light is radiant energy evaluated in proportion to the luminous sensation produced by it.

Visible radiation or luminous flux lies roughly between the wavelengths of 400 and 700 microns, which is less than one octave of the electromagnetic spectrum. Radiation in wavelengths immediately below the violet end of the visible spectrum (400 milli-microns) is called ultra-violet rays, which are invisible. Radiation immediately beyond the red end of the visible spectrum (700 milli-microns) is called infra-red rays, which are also invisible.

The eye is not equally sensitive to all colors in the visible spectrum for the same intensity of radiant flux. For example, if a yellow light, a blue light and a red light have the same intensity of radiant flux, that is, if they radiate to a surface the same amount of energy per unit area, per unit time, the yellow light produces much more illumination or luminous flux than the blue or red.

Samuel Wein, the author of this article, is a well-known inventor in the field of photo-electricity. Although best known as the inventor of the Wein cell, he has had more than 30 years of experience with the electrical effects of light on various metals and on numerous compounds. More than 100 U. S. patents and numerous foreign patents, all related to various phases of the manufacture and use of light-sensitive cells, verify the substantial nature of his background of experience. As far back as 1914 Mr. Wein demonstrated a system of sound motion pictures using the sound-on-film method. He is also responsible for the application of the photo-electric principle to a modern exposure meter used for photography as manufactured by a prominent firm.

Radiant Flux

This is the time rate of flow of radiant energy. It is expressed preferably in ergs per second or in watts.

Luminous Flux

Luminous flux is the time rate of flow of light.

Lumen

This is the unit of luminous flux. It is equal to the flux in a unit solid angle (steradian) from a uniform point source of one candle, or to the flux on a unit surface all points of which are at unit distance from a uniform point source of one candle.

If a 21-candlepower lamp had its filament placed at the center of a sphere of one foot radius, it would deliver 21 lumens to each square foot of the sphere's surface.

Luminous Intensity

Luminous intensity, in a given direction, is a solid angular flux density in the direction in question. Hence, it is the luminous flux on a small surface normal to that direction, divided by the solid angle (in steradians) which the surface subtends at the source of light.

Mathematically a solid angle must have a point at its apex, the definition of luminous intensity therefore applies strictly only to a point source. In practice, however, a light emanating from a source whose dimensions are negligible in comparison with the distance from which it is observed may be considered as coming from a point.

Candlepower

This is luminous intensity expressed in candles. An international candle is one candlepower, two international candles constitute a two candlepower light source, etc. The candlepower was uniformly used extensively in rating incandescent lamps. Many such lamps are now rated in wattage consumption. However, automobile lamps which are commonly used as light sources for photo-electric applications are rated in candlepower. The candle power is generally given for a specified direction from the lamp, since obviously the light flux emitted in the direction of the base is not the same as that from other parts of the bulb. If a lamp is rated at 21 horizontal candle power, this information is intended to mean that in a horizontal plane the lamp produces the effect of 21 international candles theoretically placed at the position of the filament.

Illumination

The density of the luminous flux on a surface, or the quotient of the flux by the area of the surface when the latter is uniformly illuminated.

Foot Candle

This is the unit of illumination when the foot is taken as the unit of length. It is the illumination on a surface one square foot in area on which there is a uniformly distributed flux of one lumen, or the illumination produced at a surface all points of which are at a distance of one foot from a uniform point source of one candle.

The Lux

This is the practical unit of illumination in the metric system, equivalent to the "meter-candle." It is the illumination on a surface one square meter in area on which there is a uniformly distributed flux of one lumen, or the illumination produced at a surface all points of which are at a distance of one meter from a uniform point source of one candle.

Brightness

This is the quotient of the luminous intensity of a surface measured in a given direction by the area of this surface projected on a plane perpendicular to the direction considered.

In practice, no surface obeys exactly the cosine law of emission or reflection; hence, the brightness of a surface generally is not uniform, but varies with the angle at which it is viewed.

The Lambert

The unit of brightness is equal to the average brightness of any surface emitting or reflecting light at the rate of one lumen per square centimeter, or the uniform brightness of a perfectly diffusing surface emitting or reflecting light at that rate.

For most purposes, the millilambert, 0.001 lambert, is the preferable practical unit.

Brightness expressed in candles per square centimeter may be reduced to lamberts by multiplying by π.

Brightness expressed in candles per square inch may be reduced to lamberts by multiplying by $\pi/6.45 = 0.487$.

The "lux on white" used by some European writers is of the same kind as the lambert, and is equal to 0.1 millilambert.

Cosine Law

The illumination upon a surface which is inclined to the direction of the light rays is less than it would be if it were perpendicular to it, and is equal to the illumination perpendicular to the direction of the light multiplied by the cosine of the angle of incidence. Combining the inverse square and cosine laws we get

$$\text{Illumination} = \frac{C_p}{D^2} \cos\Theta$$

where Cp is candlepower of the source, D the distance between the surface and the source, and Θ is the angle of incidence.

Radiation

Radiation is the transmission of energy through space by electromagnetic waves. Radiant energy may emanate from a body by reason of its temperature, as for example from a heated filament of an incandescent lamp, or as a result of electrical or other excitation, as for example in the gas tube such as a neon lamp.

All of the known forms of radiant energy, such as cosmic rays, gamma rays, X-rays, ultra-violet rays, visible light, infra-red rays, Hertzian waves and radio waves, are electromagnetic waves, the only difference between them being in the frequency or wavelength. The known electromagnetic spectrum extends from a wavelength less than 0.00005 milli-microns in the cosmic-ray region to more than 20,000 meters, which is a long radio wave.

Inverse Square Law

The intensity of illumination produced by a point source varies inversely as the square of the distance from the source. For example, the illumination on a surface placed at a distance of two feet from a luminous source of one candle is one-quarter (1-4) of a foot-candle.

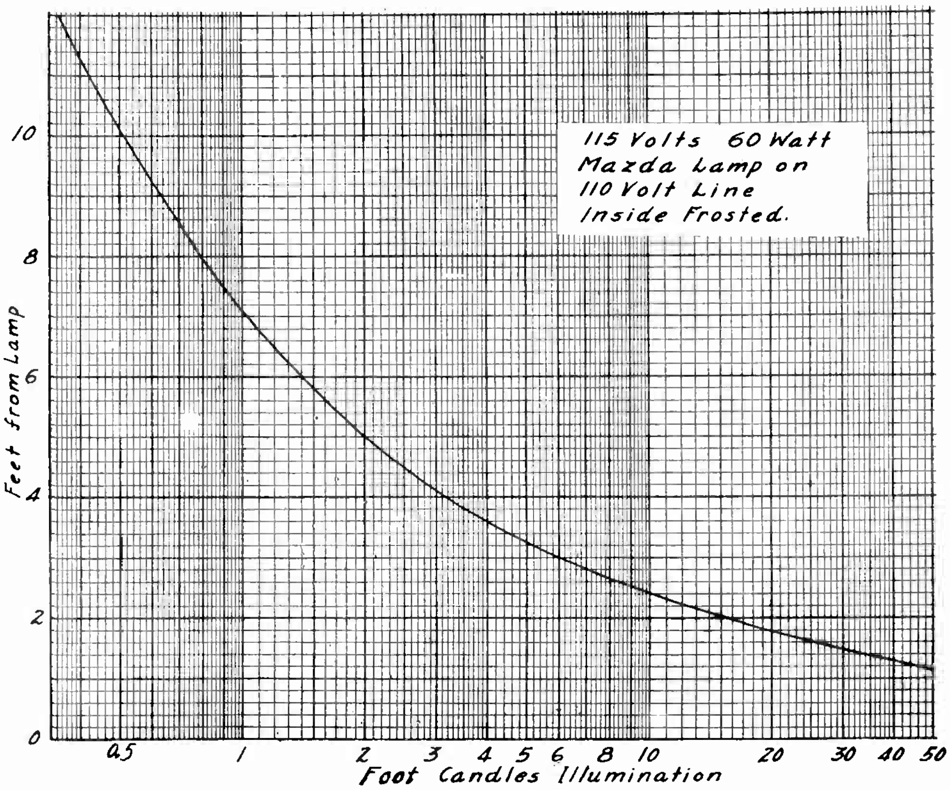


FIG. 2

Showing how the intensity of light radiated by a 115 volt 60 watt Mazda inside frosted lamp operating on the 110 volt line varies on a surface at various distances from the lamp.

To carry the example of the 21 candle-power lamp further, we may say that the illumination of one foot from the filament is 21 foot candles, because 21 lumens of light flux are intercepted by an area of one square foot at this distance. In other words, to say that a surface has an illumination of 21 foot candles is equivalent to saying that it received 21 lumens per square foot.

As a practical example of the size of a foot candle, it is to be noted that the illumination in a home is usually somewhere between 2 and 5 foot candles while the illumination in an office ordinarily varies between 3 and 10 foot candles. An illumination of 15 foot candles is good lighting for either an office or a home. The illumination in direct sunlight may run as high as 10,000 foot candles.

Light is a form or radiant energy and emanates from its source in straight divergent lines. As a result the illumination falls off according to the inverse square law of radiant energy as you recede from the light source. This law states that the illumination (foot candles) is inversely proportional to the square of the distance from the light source. Thus, at a distance of two feet our 21 candle power lamp gives an illumination of one fourth of 21, or 5.25 foot candles, and at 10 feet it gives one hundredth of 21 foot candles or 0.21 foot candles.

To review the above definitions we shall take another example:

Given: A 50 c.p. lamp; also a screen No. 1 having an area of two square feet placed ten feet from the lamp filament, also a screen No. 2 having an area of eight square feet at 20 feet from the filament.

Questions:

1. What is the illumination in foot candles on screen No. 1?
2. What is the amount of light flux in lumens falling on screen No. 1?
3. What is the illumination in foot candles on screen No. 2 (with screen No. 1 removed)?
4. What is the amount of light flux falling on screen No. 2 (with screen No. 1 removed)?
5. If screen No. 2 at 20 feet were only one square foot, what would be the illumination on it and how many lumens would reach it?

Solutions:

Question No. 1. From the definition of candlepower we know that the lamp has a light-emitting power equal to 50 international candles. From our definition of illumination it follows that at a distance of one foot from the lamp the illumination is 50 foot candles or 50 lumens per square foot. According to the inverse square law the illumination at 10 feet will be one hundredth of what it is at one foot. Thus the answer to question 1 is:

Illumination at 10 feet = 0.01 X 50
= 0.5 foot candle
= 0.5 lu. per sq. ft.

This value is independent of the screen area (for small screens which approximate the curvature of a sphere).

Question No. 2. The number of lumens falling on screen No. 1 is directly proportional to the area of the screen and inversely proportional to the square of the distance.

Therefore, since we know that 50 lumens falling on an area of one square foot at a distance of one foot, the light flux incident on screen No. 1 is:

$$\frac{50 \times 2}{100} = 1 \text{ lumen}$$

The answer to question No. 2 may also be arrived at as follows:

Having determined the illumination of screen No. 1 to be 1-2 foot candle, the number of lumens is determined by merely multiplying the area by the illumination.

(Continued on next page)

(*Continued from preceding page*)

Thus the answer to question No. 2 is:

$$2 \times .5 = 1 \text{ lumen}$$

Question No. 3. The illumination on screen No. 2 is $\frac{50}{(20)^2} = \frac{50}{400} = .125$ foot candle and at one foot from the lamp, the illumination is 50 foot candles and at 20 feet it is $\frac{1}{400}$ of this value.

Question No. 4. The number of lumens of light flux intercepted by screen No. 2 is:

$$\frac{50 \times 8}{400} = 1.0 \text{ lumen}$$

because there are 50 lumens intercepted by one square foot at one foot from the lamp, and the 8 square foot screen at 20 feet would intercept $\frac{8}{400}$ as much.

As before, the light flux could be calculated from the known number of foot candles and the area. Thus, the light flux on screen No. 2 equals $8 \times .125 = 1$ lumen.

Question No. 5. If the scren No. 2 were reduced in size to one square foot, the illumination would still be the same on this screen: namely $\frac{50}{400} = 0.125$ foot candles, since the illumination on a surface does not depend on the area of the surface.

However, with one square foot screen at 20 feet, the lumens of light flux intercepted would be:

$$\frac{50 \times 1}{400} = 0.125 \text{ lumens}$$

instead of 1.0 lumens found in question No. 4.

From this example we can deduce the following formulae—Given: Candle power of lamp in a specified direction—C.P.

Foot candles—Ft. C.

Lumens—L

Distance from lamp filament—D

Area of screen in sq. ft.—A

$$\text{Ft. C.} = \frac{\text{C. P.}}{D^2} \quad \text{Formula (1)}$$

$$L = \frac{(\text{C. P.}) \times (A)}{D^2} \quad \text{Formula (2)}$$

$$L = (\text{Ft. C.}) \times (a) \quad \text{Formula (3)}$$

Experiment Suggested

In order that you may obtain a definite conception of the approximate illumination represented by a given number of foot candles, the following experiment is suggested. A new 60-watt, 115-volt inside-frosted Mazda lamp operated on a 115-volt line (a.c. or d.c.) will give approximately 55 foot candles illumination at one foot from the center of the lamp. At 5 feet the illumination is approximately 2 foot candles. The curve shown herewith in Fig. 2 is for such a lamp from which the distances can be read at which various illumination values may be obtained.

Color Temperature

The color temperature of a source of radiant energy is the temperature at which a complete radiator (black-body radiator) must be operated to give a color matching that of the source in question.

Color temperatures are usually assignable only for sources which give a spectral distribution of energy not greatly different from that of a black-body radiator.

A complete (black-body) radiator is one which absorbs all radiant energy falling upon it, and which at any temperature radiates the maximum possible amount of energy in all parts of the spectrum.

Color temperature is measured from the absolute zero in degrees of the centigrade (C) scale, and to distinguish the absolute scale from the usual centigrade scale, it is designated as degrees Kelvin, as for example, 3,000° K.

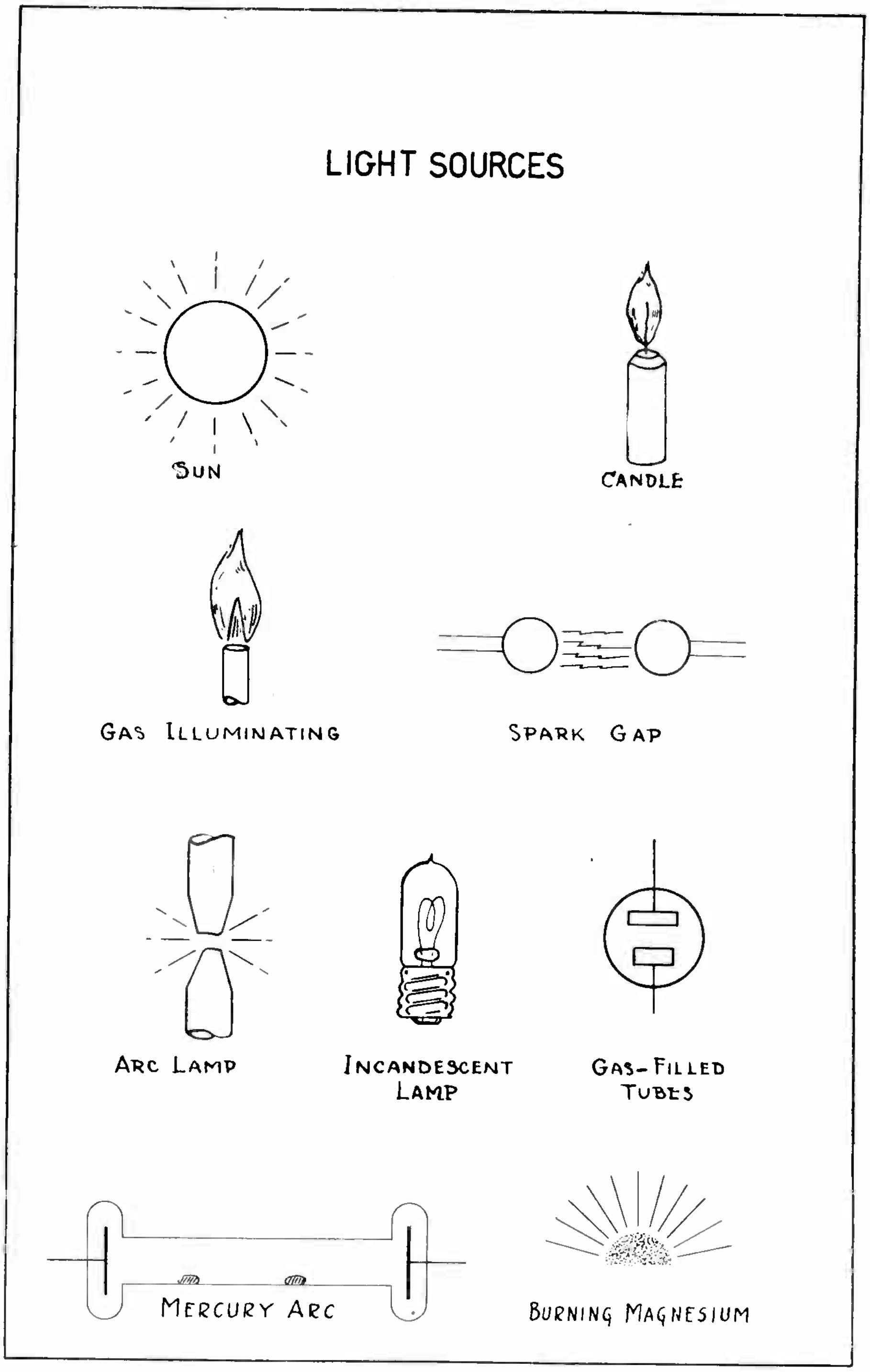


FIG. 3

Although the sun is the primary source of light, man has availed himself of the sun's energy that has been stored in other materials so that he can generate light by other means indicated above.

The actual temperature of the source or body may not be at all comparable with its color temperature, for example, blue sky, which of course is actually very cold, may have a color temperature of 25,000° K.

JUST IN TIME!

AND WHY NOT A MERRY CHRISTMAS! The world has, we admit, changed much during the passing of the centuries, but the cycles are not so different today from what they were in the days before electric lights, railroad trains, airplanes, radio and Einstein came along to add interest, luxury and almost uncanny knowledge to the curriculum of everyday existence. Human nature is still the greatest problem, the greatest asset and the geratest wonder there is, and that is why we do not hesitate, even in the face of odd events and terrific happenings, to broadcast the most beautiful message of the ages: Merry Christmas to everybody, everywhere, now and always.

Code for Special Group In Industry is Denied

Washington

Until the pending Radio Manufacturers Association application for an independent code for the entire radio industry is settled, no action will be taken by the National Recovery Administration on proposed supplemental codes for separate groups of radio manufacturers. Such directions were given by NRA legal counsel at a hearing on the supplemental code, proposed by National Electric Manufacturers Association, for the so-called "radio transmitting and public address apparatus and commercial radio receiver industry." The directions of NRA counsel sustained a protest made to NRA by William Sparks and the RMA Code Committee. The NRA ruling is expected to hasten final action.

A Separately-Tuned Converter

Padding Rendered Unnecessary—Diverse Capacity Used

By Leslie C. Cambridge

THE design of a short-wave converter shown herewith is reduced to simplicity consistent with performance. The 6C6 is the modulator, the 76 is the oscillator and the 1-V is the rectifier. The circuit works on 90-125 volts a.c. or d.c.

The modulator should be a sensitive tube, and the 6D6 is that, for it is has the same characteristics as the 57. Only that the heater voltage is different, 6.3 volts. The 76 is likewise comparable to the 56. The 1-V is the halfwave rectifier of the 6.3-volt, 0.3-ampere series of tubes. The limiting resistor to reduce the line voltage to the 18.9 volts total drop across heaters may be built into the line cord.

Capacity Coupling

The modulator is coupled to the oscillator by means of a small capacity, 0.6 mmfd., from grid to grid. This is a commercial product, but about the same capacity can be produced by using two pieces of flexible insulated wire about 2 inches long, twisting them together, and connecting one pair of ends to the respective grids and leaving the other ends free. In this way the capacity between the twisted wires is used.

Output is taken through a broadcast transformer "used backwards," so to speak. The primary is the large winding and is tuned. The capacity of the condenser across this determines the most effective frequency of transfer and this of course should be the intermediate frequency. Selection of that frequency in the receiver will provide the clue. In general, the lower end of the dial is to be used, speaking of frequencies, as then the operation is quieter, and also the selectivity is much better.

The selectivity meant is derived from the receiver more substantially at that end than at the other, but the selectivity against interfering stations and images at the short-wave level is lessened by the lower ratio of oscillator and modulator frequencies. This ratio is constantly changing, but is directly related to the intermediate frequency. Generally speaking, using 545 kc as intermediate frequency, compared to 1,500 kc, you would have to square the number of tuned circuits in the receiver to get as much i-f selectivity compared to use of 545 kc.

The Ratios of Tuning

Having decided on an intermediate frequency, it is necessary to prepare the coils accordingly. That is, the oscillator frequencies are determined considerably by the intermediate frequency. So if we desire to start tuning at 1600 kc. with an intermediate frequency of 545 kc. using a higher oscillator than modulator frequency, we would require striking 2145 kc at the low end. Using a condenser that has a 4-to-1 capacity ratio, we would wind up at 4290 kc for the first band, since the frequency ratio is the square root of the capacity ratio. The modulator would have to tune from 1,600 to 3,745 kc, a ratio of 2.31, obtainable from a condenser with a capacity ratio of 5.34. It can be seen that the capacities will be different and that no attempt is made to use a two-gang condenser, for then a separate variable would have to be put across the modulator section to the same effect.

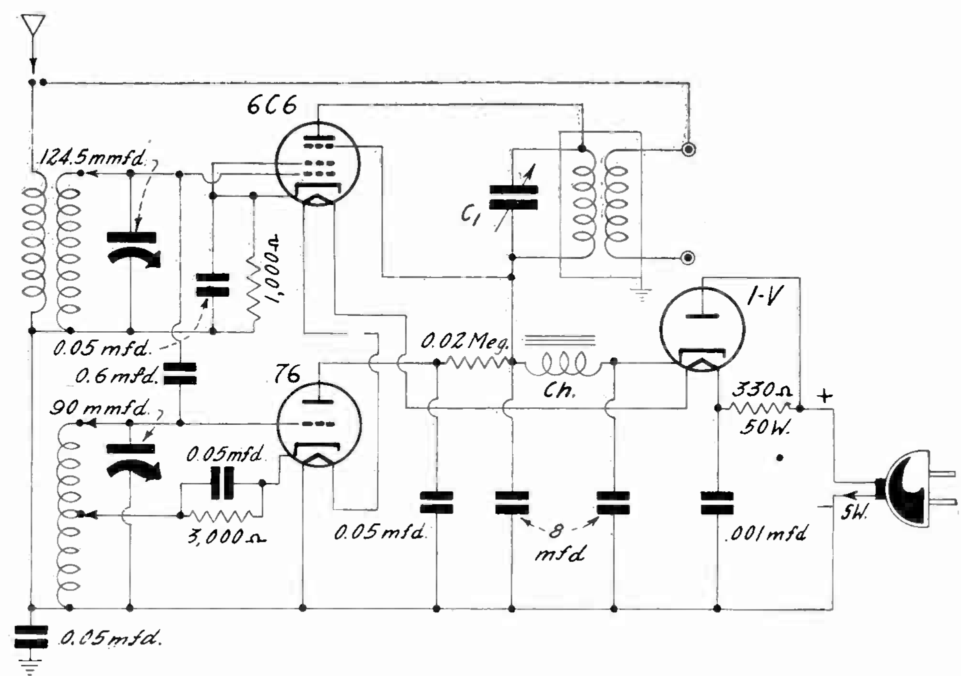


Diagram of a simple converter, using a smaller capacity in the oscillator than in the modulator. The condenser marked 0.6 mfd. should be 0.6 mmfd.

The condensers required for the purpose have a capacity of 90 mmfd. for the oscillator and 124.5 mmfd. for the modulator and are commercially obtainable as midget midline capacities. Separate dials are used, a small vernier affair for the modulator, a larger and closer vernier for the oscillator.

Frequency Ranges

By using the condensers this way there is no need to resort to the difficulty of padding.

The required tuning ranges are therefore as follow:

	Modulator	Oscillator
Band 1	1600-3745	2145-4290
Band 2	3700-8045	4245-8590
Band 3	7500-15550	8049-16100
Band 4	15000-30550	15545-31100

It can be seen that the usual four bands for short-wave special devices is retained.

Allowing for the usual circuit conditions, the inductances required would be as follows, turns on 1¼ inch diameter.

Band 1. Modulator 80 microhenries. 44 t. No. 32 en.
Oscillator. 65 microhenries. 38t. 32 en.

Band 2. Modulator. 14.5 microhenries. 20.5 t. No. 22 en.
Oscillator. 16 microhenries. 22 t. No. 22 en.

Band 3. Modulator 3.5 microhenries. 9.4 t. No. 18 en.
Oscillator. 4.4 microhenries, 11 t. No. 18 en.

Band 4. Modulator. .85 microhenries, 3.9 t. No. 18 en.
Oscillator. 1.3 microhenries. 5 t. No. 18 en.

The directions are for close winding. The taps are at center for Bands 3 and 4 and at ¼ turns from ground end for Bands 1 and 2. Primaries for the modulator are ¼ the number of secondary turns, and with ⅛-inch separation between primary and secondary, except for Band 4, when separation is ⅜ inch.

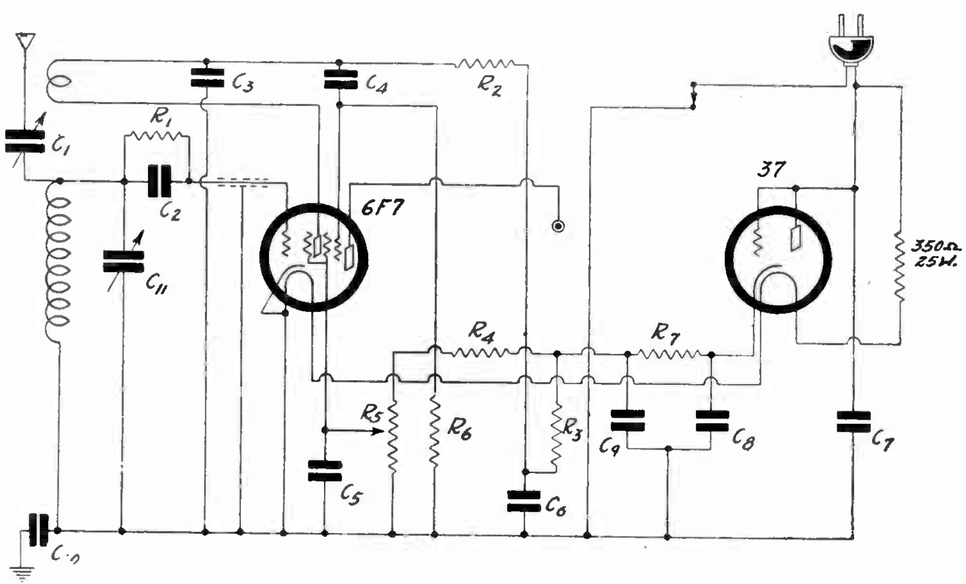
The circuit may be used with plug-in coils, if desired, as the winding data are for diameters obtainable in that class, or switch operation may be used, total shielding not being introduced, an extra section of the switch being used to short such adjacent or other coil that may otherwise cause dead spots.

OCTOBER EXPORTS

Radio exports during October, 1934, totaled 57,678 receiving sets valued at $1,454,593; 673,329 receiving tubes valued at $292,259; 20,911 loudspeakers valued at $50,184; parts and accessories valued at $437,442; transmitting sets, tubes and parts valued at $92,986, and other radio accessories valued at $51,434.

Radio University

ANSWERS to Questions of General Interest to Readers. Only Selected Questions Are Answered and Only by Publication in These Columns.



A short-wave set with resistor capacity filter.

Resistor-Capacity Filters

YOU HAVE mentioned that resistor-capacity filters serve a good purpose, that is, reduce hum well, if the current is very low. I assume that a two-tube short-wave set would come under this classification. Therefore please show a diagram of such a set, with a small rectifier tube.—I. L. E.

In the diagram of a universal short-wave two-tube earphone receiver the conditions are such that the current will be small enough to meet the purpose prescribed. The resistor R7 is 25,000 ohms, C4 and C8 being the 8 mfd. filter condensers, which may have 175-volt rating. C1 is 50 mmfd., C2, 0.0001 mfd.; C3, C4, C5, C6 and C7 are 0.05 mfd.; C10 (lower left) is 0.05 mfd. and C11 is 0.00014 mfd. R1, 2 meg.; R2, 0.02 meg.; R4, 0.05 meg.; R5, 0.025 meg.; R6, 0.02 meg. The tubes used are the 6F7 and 37, the latter the rectifier. The earphones are put between the binding post from plate of the pentode, to the point on the B plus line directly below.

* * *

Still, the Condensers Do Go

IN THE SEPTEMBER 1 issue of RADIO WORLD, there appeared the statement that irremedial damage could be done to electrolytic condensers in a-c/d-c sets when the sets are connected to the a-c line in the wrong polarity. Since a rectifier tube will not pass current of the wrong polarity, I fail to see how this damage can accrue. Current will not reach the condensers, being stopped by the rectifier. Please explain this paradox.—J. A.

It should be realized that when a voltage is supplied to a circuit, regardless of whether it is a.c., or d.c. in its steady state, a transient voltage will be induced that may reach great instantaneous proportions. Accordingly when an a-c d-c set is plugged into the d-c line, even though the polarity is reversed, high instantaneous voltages may be set up across the condensers in the circuit that may result in damage to them. Of course, high-grade condensers that are capable of withstanding higher voltages will not be as likely to this destructive influence as a poorer grade. It should be appreciated that whenever any sort of voltage is applied to a circuit, even though a negligible amount of current flows, transient voltages in the order of thousands of volts may sometimes be induced that can be damaging. Since transients are of instantaneous nature and occur only for an infinitesimal fraction of a second usually, such results do not always take place, though this is no reason for carelessness. As to the rectifier tube preventing current flow, when the tube will not rectify due to wrong polarity its effect in the circuit is that of a resistance, and leakage current will flow.

* * *

When Radiation Is or Isn't

WHEN THE STATEMENT is made that a vacuum tube is to be reduced from a state of generation or oscillation to one of regeneration, does that refer to a difference that is sharp and distinctive, or gradual? Is there no radiation under a condition of regeneration, that is, operation just below the point of oscillation, which I understand is the most sensitive point?—L. O.

There is some radiation when tubes in a radio-frequency circuit are operated at or near their maximum sensitivity point, especially at high frequencies. The condition referred to as generation or radiation is one in which there is a pronounced effect. For instance, if there is radiation it is possible to pick it up on another receiver, in the same room, in the same neighborhood or perhaps even a distance of miles. Where the propagation is so meagre that it is practically impossible to pick it up more than a few inches from the set, it is not classed technically as radiation at all. If you will bring your hand within a few inches of a tube working at a highly sensitive point at radio frequencies, the detuning effect due to body capacity will be noticed. The coupling between hand and circuit is due to the radiation field, which may be electromagnetic or even electrostatic, or may be a combination of both components. The change in tube operation from spill-over to non-spillover is abrupt, which makes tuning a regenerative receiver a critical process, but even below spillover there can be a highly localized field, though it is too weak to be classed technically as a form of radiation.

* * *

Audio Regeneration

TO IMPROVE the low-note response in a receiver I have built I have thought about using audio regeneration. Can you state a simple method of accomplishing this? Can one readily determine the constants?—K. W. C.

Audio regeneration may be introduced by uniting cathode current of two audio tubes in a common circuit. For regeneration to be present the phases must be the same, or nearly so, but not opposing, for then there would be negative feedback, or degeneration. A method suggested is to connect a resistor from the cathode of one tube to the cathode of another, each tube having its own biasing resistor. The bypass condensers may be omitted, as regeneration will have the cancellation effect on negative currents. It is difficult to suggest any formula that would be practical, because the impedance of the B supply and other factors are unknown quantities, and the solution on a theoretical basis would be speculative. Better use the cut-and-dry method, especially as only the value of a single resistance is at stake. In general, the circuits united would have to be alternate, hence detector and output tubes would be concerned, where there is a driver between. If two successive tubes are to be used it is necessary to have a transformer between them, and reverse the connections either of secondary or primary, in the event that negative feedback is encountered. This may be identified readily because of lowered sensitivity and a strong attenuation of the low notes. When regeneration is introduced it may be raised to just below the point where audio oscillation begins, usually called "motorboating." This may be of any frequency, from a few cycles, or a fraction of a cycle per second, up to 10 kc or so. If the note is near the higher limits specified, the circuits may be continued to be regenerated in this way, and a condenser put across the audio line, of capacity just large enough to remove the note. Around 0.00025 mfd. to 0.0005 mfd. might be sufficient.

* * *

Soldering Iron Too Hot

MY SOLDERING iron gets too hot. I have been told that a series resistor may be used to remedy this. The trouble is that the tip gets carbonized too quickly, and a new tip is pitted the first night I use it.—L. O.

A series resistor may be used, but it would have to be of large wattage, and might prove troublesome due to the presence of a hot body near one's work, especially a body on the presence of which one does not count much when busily engaged. It is therefore suggested that you use a long tip. This is standard. If instead of a 2-inch or 3-inch tip you use one 5 or 6 inches long you will find that the overheating of the tip will stop.

* * *

Pilot Lamp Shunts

IN USING PILOT LAMPS in series with heater tubes of the automotive variety, is it necessary to shunt the pilots with resistors, and if not, why are shunts shown so often?—I. K.

Where the resistance of the pilot lamp would be a ratable factor in the determination of the voltage drop across the heaters it is advisable to shunt the pilots, because of the non-uniformity of the resistance of pilot lamps inherently, and also the fact that the resistance of the lamp will change considerably with use. Shunting the lamps with resistors of about half the lamp resistance makes the voltage drop across the parallel circuit more nearly constant and reduces the lamp current. However, if the lamp resistance is negligible compared to the sum of the heater resistances, the shunt may

(*Continued from preceding page*)
be omitted, and then, too, the pilot lamps serve as fuses for the heater lead. Otherwise a short at the source would not be protected in this line, because of the shunts carrying whatever current flows, or maintaining the continuity even if the lamps go out.

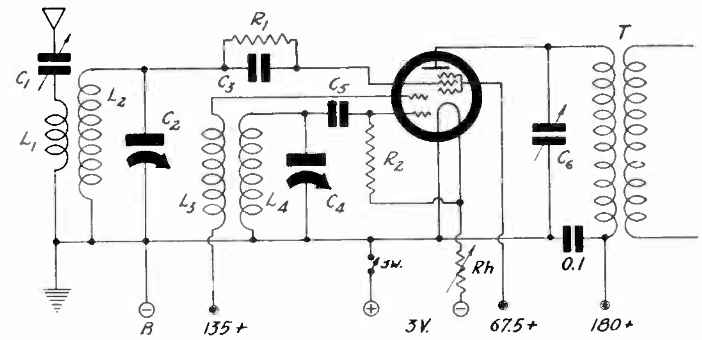
* * *

1C6 in a Converter

WILL YOU KINDLY explain the use of the 1C6 in a short-wave converter, with output transformer to feed the set? A diagram would be appreciated.—R. D. S.

The 1C6 is a pentagrid converter tube with twice the conductance of the 1A6 and therefore more suitable for short-wave, use, because it will oscillate at higher frequencies. The signal-carrier frequency is introduced into the control grid circuit, (No. 4), represented by the metal head on the tube. A simple method for use in battery sets, to attain modulation, is to use leak and condenser. The modulator is a pentode tube, hence there are plate and screen. The screen consists of two joined elements, and numerically is Grids Nos. 3 and 5, shown as suggestively of this condition in the diagram, with single socket connection. That is, there is only one base terminals for these two grids. Then there are Grid No. 1, for the oscillator control, and Grid No. 2 for the positive grid, or you might say plate, of the oscillator, although the element is not structurally a plate but a rod. Now the two frequencies are introduced, the signal-carrier wave and the wave generated by the local oscillator. There is electron coupling in the tube, meaning that the emission current paths of the two distinctive tubes, hence frequencies, in the one envelope are united. L1L2, L3L4 may be plug-in coils, C2 and C4 separate 0.0001 + mfd. condensers, R1 2 meg., C3, 0.0001 mfd.; C1, 50 mmfd.; C5 0.0001 mfd.; R2, 0.05 meg. to 0.1 meg.; Rh a rheostat that for 3-volt supply may be 10 ohms and adjusted until the filament voltage is 2 volts: C6, a 0.00035 mfd. condenser set once across the larger winding of a broadcast coil, of which the right-hand winding is the primary.

A short-wave converter, using the 1C6 pentagrid converter tube for battery operation.



(*Continued from page 15*)
The desire to obtain linear frequency amplification characteristics from all types of audio frequency amplifiers is due to a lack of exact knowledge regarding the response characteristic of the loudspeaker and the assumption that the amplifier service is perfect if the linear relationship holds. Since the amplifier is a link in the chain, its properties are dictated by the apparatus preceding it and the loudspeaker after it.

A good deal is known about the apparatus that lies before the amplifier but little is known concerning the loudspeaker performance, and until exact information is available, the design of amplifiers will continue to rest upon the assumption that uniform amplification at all audio frequencies means that the result is perfect.

The ultimate quality from a loudspeaker depends upon:

(a) The response characteristic in connection with the original acoustic energy to the microphone with the modulated energy in the transmitting antenna.

(b) The overall frequency-amplification characteristic of the receiver.

(c) The energy-frequency characteristic of the loudspeaker in free space.

(d) The loudness level which includes the listener's aural mechanism.

(e) The acoustic qualities of the room in which the speaker is operated.

From a consideration of items (a) and (c) it does not follow that the overall characteristic of the receiver should give equal amplification at all frequencies. Certain types of loudspeakers require an amplifier characteristic that dips in the middle audio register to give due prominence to the low and high audio frequencies, the amount of such dip depending upon the loudness level. For other types, the amplifier should give a prominent low audio frequency resonance to compensate for the insensitivity of the speaker at these frequencies.

Having obtained the most satisfactory characteristic for a given loudness level, there are still two salient defects:

(a) The absence of stereophonic effect or auditory perspective or the sense of directivity or location.

(b) Resonances introduced at various parts of the system, such as around the speaker.

Blurring Explained

A variable overall characteristic can be obtained by various artifices inserted in the tube coupling units, such devices taking the form of filter circuits. So far as low-toned instruments are concerned, a good fundamental is required for realism; they should not be "sensed" by their overtones. Comparatively inconspicuous resonances often become prominent with increasing intensity. The time required for the resonating component to decay to inaudibility increases with the intensity, and with the diaphragm type of speaker the lower the frequency of the resonance note, the more sustained is its effect, because the damping is usually less for the low than for the high tones. Hence, at high intensities, the time taken for the natural vibration to die away to inaudibility is usually appreciable and causes an unpleasant blurring distortion of the output. Horn resonances are not particularly objectionable for the weaker sounds, but with loud sounds the low tones are usually badly defined. Owing to the lack of exact information on these important points, there is a need for research on the acoustic aspect of this subject with a view to defining the required characteristics of the amplifier.

It should be pointed out, however, that this is only an expedient to correct the faults of the loudspeaker by a suitable amplification-frequency characteristic from the amplifier. The correct procedure would be to develop a loudspeaker with the required characteristics but since this is more difficult, such amplification modification is justifiable at present. Of course, a decided disadvantage of this sort of treatment is that a particular amplifier would need to be designed for every different loudspeaker.

STATION SPARKS

BY ALICE REMSEN

TO YOU AND ALL!

HERE'S a Happy New Year to all my friends. The outlook seems to be much better this year, both in radio and general business. The spirit of cooperation in the air which bids fair to make the coming season a memorable one. . . . Only a short time ago the powers that be in radio put thumbs down on women announcers. They even raised disapproving eyebrows at women who essayed to announce their own numbers—but the old order changeth. And here is Elsie Janis joining the NBC staff as the first woman announcer. Well, Elsie has had experience enough as an entertainer and producer to at least know enough to inject personality into written lines. Here's wishing her jolly good luck with her new assignment. . . . Wondered what had become of Doc Rockwell, that rollicking comedian of the stage, screen and radio. Have just discovered that he is writing and producing a new radio series called "Doughnuts and Coffee." He is trying to solve the age-old question of what husbands and wives discuss between arising and catching the 9:15. Two characters, Joe and Stella, will place an NBC microphone on their breakfast table daily, except Sunday, at 8:30 a. m. EST. If you'd like to know what it's all about, turn your dial to WJZ and network at that time. . . . The Road to Romany has returned to NBC microphones under the direction of Alexander Kiriloff. Celia Branz, distinguished concert contralto, is the soloist. Each Sunday at 2:00 p. m. EST. WEAF and network.

LAWRENCE TIBBETT ON DECK

Lawrence Tibbett's Tueday night broadcasts will continue to be heard through the winter over an NBC-WJZ network at 8:30 p. m., EST., according to a renewal of contract which became effective Christmas Day, December 25. While the weekly programs at present are heard only in the East and Midwest, his winter broadcasts will be released from coast-to-coast. Wilfred Pelletier, Metropolitan Opera conductor, who leads Tibbett's supporting chorus and orchestra, and John B. Kennedy, noted radio news commentator, also will be heard on the winter broadcasts, which will be half an hour in duration. The Packard Motor Car Company, sponsor of the present series, will also sponsor the future broadcasts. All types of songs will make up the Tibbett weekly recitals, including standard arias and concert numbers, as well as the best works of Broadway and folk melodies of the Negro spiritual and cowboy ballad variety.

Tibbett will soon start intensive preparations for the opera season. One of the Metropolitan Opera Company's biggest drawing cards, he will appear in a number of stellar roles. The popular baritone has appeared in every American work produced at the Met in the past ten years, and this season he will again pioneer in a new opera, "In the Pasha's Garden," by John Lawrence Seymour of California. . . . Phil Baker is back in New York and broadcasting from Radio City. He stayed only three weeks in Boston, where he played with the new musical show, "Calling All Stars." Now Phil is making a dash from the theatre to studio each Friday night. . . .

FRANK BLACK DIRECTS 'EM

The new Coca-Cola series, "The Pause That Refreshes," heard each Friday at 10:30 p. m. over an NBC-WEAF network, uses nearly a hundred musicians and singers under the direction of Frank Black, in an unique voice and instrument blend. The voices and instruments work together as a single organ of melody. Quite an interesting experiment. . . . Grace Moore, of screen and operetta fame, cames to radio in a new series on January 1st over an NBC-WJZ network. She will be heard in a half hour concert each Tuesday night, from the NBC Hollywood studios under the sponsorship of the Vick Chemical Company. The time is nine p. m. Don't miss it! . . . Bradley Kincaid, "The Mountain Boy," is back on radio after an extensive vaudeville tour. He may be heard Fridays, Saturdays, Sundays and Mondays at 8:00 a. m. over an NBC-WEAF network. . . . And here comes Beatrice Lillie, on January 4th, for her first extended radio engagement. She has signed a contract to sing under the sponsorship of Borden. She will be supported by an orchestra and vocalists. Every Friday night at 9:00 p. m., NBC-WJZ. . . . Another new series opening on January 2d, is "Penthouse Party," sponsored by Eno. Mark Hellinger, Broadway columnist, and his wife, Gladys Glad, former Ziegfeld Follies beauty, will be featured. Mark will write the stories himself. Each Wednesday, NBC-WJZ network at 8:00 p. m. . . . Radio's "Carefree Carnival" has won a sponsor for the new year. This program has been on the air since June, 1933, originating on the Pacific Coast. Crazy Water Crystals have taken it for better or worse—at least for a time; it will be heard, as usual, each Monday night, for one half-hour, at 8:30 p. m. over a Coast-to-Coast NBC-WJZ network. . . . There will be an extra "Let's Dance" broadcast on NBC for New Year's Eve—from 10:30 p. m. to 1:30 a. m. The National Biscuit Company has made its program available on both NBC networks at that time as a New Year's gesture to their many customers. . . .

WE REFER TO O'FLYNN

The historical episode of an attempt by men allied with William of Orange, ruling England by virtue of the sword, to steal a pearl necklace from the Queen of dethroned James II in their Seventeenth Century warfare, will be depicted during the first broadcast of the colorful new series of music drama's titled after and based upon the glamorous and adventurous Irish figure, "The O'Flynn." The program will be heard over the WABC-Columbia network from 10:30 to 11:00 p. m., EST.

The O'Flynn, in real life Captain Flynn O'Flynn, is the romantic subject of historical records extant in Ireland, and the music dramas are based upon a modern story of the character, entitled "The O'Flynn." It is from the pen of Justin Huntly McCarthy, who wrote the book on which "The Vagabond King" was based.

Viola Philo, well-known soprano, and Milton Watson, baritone, will sing the leading roles in the music drama, and a cast of veteran radio actors will be co-featured with them. The dramatists will include Ray Collins, who will play the role of Captain Flynn O'Flynn; Lucille Wall, the role of Lady Benedetta Mountmichael, lady-in-waiting to the queen of James II; Leigh Lovell, the role of Roger Hendrigg, an ally of William of Orange; Jack Smart, the role of Jacques, servant and constant companion of "The O'Flynn," and John Gregg, the cook. Nathaniel Shilkret and a thirty-piece concert orchestra will provide the music, all of it written especially for the radio series, and David Ross will be the announcer.

Walter Preston, baritone, has been chosen to sing on a new program with Gladys Baxter, soprano, and Victor Arden's Orchestra, over a CBS-WABC network each Saturday at 7:30 p. m. starting January 5th. Program is titled "Outdoor Girl Beauty Parade." . . . Another new feature to be heard over CBS-WABC commencing January 3d is the Linit "Hour of Charm," which will present Spitalny's All-Girl Band. 8:00 p. m. each Thursday. . . . "Buck" Rogers becomes a Coast-to-Coast feature on CBS beginning January 7th. CocoMalt sponsors this popular program. . . . Santa Claus brought a contract renewal for Burns and Allen. Their sponsors, the General Cigar Company, gave it to them for a Christmas gift. Pretty nice, eh what! . . . That ABS-WMCA network program "English Coronets," heard every Sunday at 9:00 p. m., is very colorful and well acted. This series is written by Kay Van Riper, who also plays the role of Ane Boleyn during the series. . . .

STUDIO NOTES

Jolly Coburn, NBC orchestra leader, has a 32-foot cruiser; he calls it Ham and Eggs. . . . Muriel Wilson, soprano star of Maxwell House Show Boat, is engaged to be married to Fred Hufsmith, popular NBC tenor. Muriel is sporting a big diamond solitaire. . . . Lawrence Tibbett says he would rather sing than do anything else on earth. . . . "Senator" Edward Ford, author and leading man of "The Grummits," heard over NBC networks, has just completed a wax model of Blackbeard the Pirate guarding a treasure chest in a tropical island setting. . . . Abe Lyman has been trying to acquire a Southern accent since he was made a Kentucky Colonel. . . . Chester Stratton, actor on the CBS March of Time, has a part in the new Broadway production, "Tomorrow's Harvest."

A THOUGHT FOR THE WEEK

HERE'S TO GOOD OLD 1934—mark it down, mark it down! Let's try to remember, without being at all sentimental or bromidic, that 1935 will probably be just about as good to us as we are to 1935.

And let's remember again something to which we might have called attention before, but which it would be well to repeat more than once during the coming year. You remember the slogan on the front page of good old "Judge," the humorous paper of ripe memory: "We'll more than win success—we'll deserve it." Which we keep on repeating for the same sentimental reason that the New York Sun repeats each year the query, "Is there a Santa Claus?" and the wonderfully human answer thereto.

Elsie Janis Is First NBC Woman Announcer

Elsie Janis is NBC's first woman announcer.

The former star of musical revue and vaudeville became known to millions who never had seen her in the theatre when, during the World War, she brought her tune and songs to the A.E.F. camps in France.

As a regular member of the NBC announcer staff, Miss Janis will guide many network programs from gong to gong each day. She was recently initiated into the mysteries of the announcer's panel and other studio intricacies.

Miss Janis is not a novice at broadcasting, as she has been heard as guest star in many NBC programs during the past few years.

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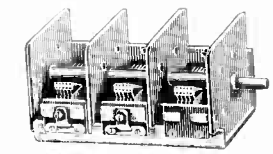
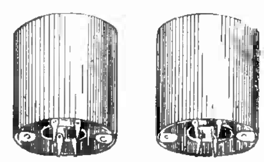
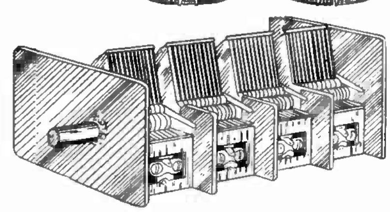


Three-gang 0.00014 mfd. tuning condenser, with high shields between sections. Trimmers built in on two of the sections. Section with trimmer off is to be used for antenna-stage tuning. As a series variable antenna condenser, of 50 mmfd. or somewhat less, is recommended, and changes the tuning of this stage, no fixed trimmer is necessary here. The condenser has brass plates, such as the most expensive condensers have, and has ⅜" shaft. Shipping weight 4 lbs. Send $3.00 for 26-week subscription for RADIO WORLD (26 issues, one each week), and ask for P-1031. We pay transportation on these condensers.

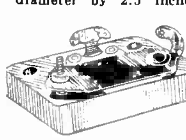
Radio World, 145 W. 45th St., New York, N. Y.

DUAL-BAND TUNING UNIT





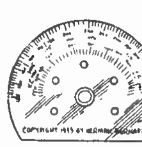
FOR broadcast eception, plus coverage to higher than 4,000 kc, thus yielding a total span of 540 to higher than 4,000 kc. We have an exceptionally precise combination, consisting of three r-f coils, one of which is used as antenna coupler, and one oscillator coil, also the necessary four-gang condenser and the correct padding condenser (Hammarlund adjustable type). The tuning coils for the r-f level have secondaries tapped so that the condenser stator may be switched from full inductance to just enough inductance to pick up the broadcast band where the full inductance left off. The oscillator coil is appropriately tapped, also, for this purpose. A four-pole, double-throw switch would be required (not furnished). Coils aluminum shielded, 2-1/16" outside shield diameter by 2.5 inches high. The four-gang condenser is very compact (5 x 2.25 x 2.75 inches). All material is specially made for this premium offer and is of highest calibre.

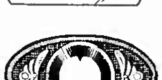


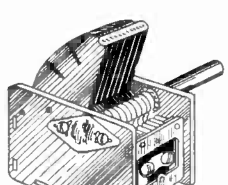
Order Cat. PR-BCTU-465 for use with 465 kc intermediate, and enclose $9 for 18-month subscription (78 issues, one each week), and four-gang condenser, four coils, and 350-450 mmfd. padding condenser, but no switch, will be sent, small transportation charges collect.

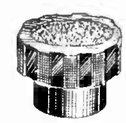
Same as above, same terms, except oscillator is for 175 kc and padder is 850-1,350 mmfd. Order PR-BCTU-175.

TUNING UNIT FOR TEST OSCILLATOR









HERE is your very first opportunity to get the parts for constructing a universal, modulated test oscillator to cover fundamentals from 135 to 380 kc, and read higher intermediate frequencies and the entire broadcast band, by harmonics, all imprinted right on the dial. That is, the escillator will be direct frequency-reading. The parts consist of one metal-etched scale, one metal escutheon, one 0.000406 tuning condenser with trimmer built in, one oscillation transformer (secondary inductance accurate to 0.1 per cent.), and one knob for condenser. Circuit diagram supplied for universal model modulated test oscillator (90-120 volts a.c., d.c. or batteries, same oscillator works on all three). Instruction sheet for lining up at broadcast and intermediate frequencies included. Line up the oscillator with one adjustment on broadcast band, beating with some station on 1,200 to 1,400 kc. Whole dial then will track. Order PRE-TUTO and send $6.00 for one-year subscription for (52 issues). Sent postage prepaid.

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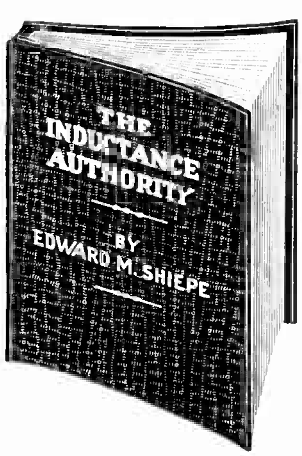

The biggest help any one can get who desires to wind radio-frequency coils for any frequency from just below the audio range to the fringe of ultra frequencies is to have a book that tells just what inductance is required for the condenser one possesses, and just how many turns of any kind of wire on any sensible diameter are needed to produce that inductance. "The Inductance Authority," by Edward M. Shiepe, gives you just that information, to an accuracy of 0.1 per cent. Send $4.00 for an eight-months subscription (39 issues) and order PRE-IA sent postpaid.

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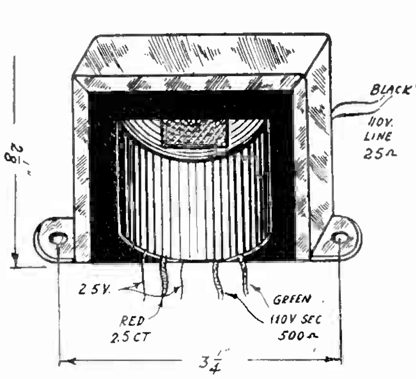

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Secondary A-2.5 volts, center-tapped.
Secondary B-110 volts, no center tap.
Splendid for powering a-c test oscillator or any other rectifier for not more than three small tubes.

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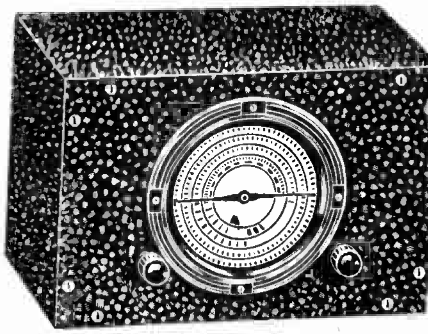
WITH DIRECT-READING AIRPLANE DIALS

MODEL 339, FUNDAMENTALS 54 kc. to 17,000 kc.



Model 339 All-Wave, Fundamental Type Signal Generator, and Model 334-A have the same external appearance, except that the 339 has three knobs. The differently-calibrated airplane dials give results in frequencies and wavelengths.

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300 ohms..... 9c	6,000 ohms.. 10c	60,000 ohms.. 11c
400 ohms..... 9c	7,000 ohms.. 10c	80,000 ohms.. 11c
500 ohms..... 9c	8,000 ohms.. 10c	.1 meg...... 12c
600 ohms..... 9c	9,000 ohms.. 10c	.15 meg...... 12c
700 ohms..... 9c	10,000 ohms.. 10c	.2 meg....... 12c
800 ohms..... 9c	12,000 ohms.. 11c	.5 meg....... 12c
1,000 ohms.. 10c	15,000 ohms.. 11c	.6 meg....... 12c
1,500 ohms.. 10c	17,000 ohms.. 11c	.7 meg....... 12c
2,000 ohms.. 10c	20,000 ohms.. 11c	.8 meg....... 12c
2,500 ohms.. 10c	25,000 ohms.. 11c	.9 meg....... 12c
3,000 ohms.. 10c	30,000 ohms.. 11c	1.0 meg...... 13c
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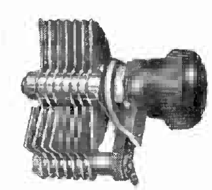

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