MODERN RADIO

EDITED BY ROBERT S. KRUSE

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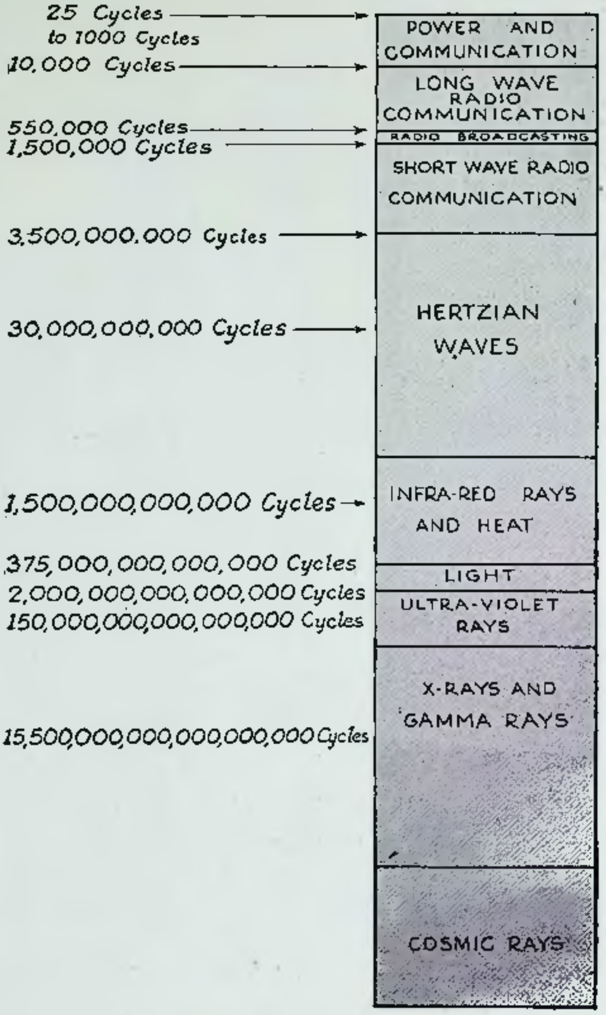

Illustration Courtesy "Good News"

Our Future

Our complacency is again to be upset. Just as we had radio nicely settled down as a household utility we find that the experimenting has barely begun—less than 1% of the available channels are in use and the entire territory "below 10 meters" awaits us. So vast is this new country that it can be shown in the accompanying chart only by using a varying scale. The "Hertzian Wave" territory is actually a thousand times as large as the SUM of the Short Wave, Broadcast and Long Wave territories. We know very little about it—but strenuous endeavors have begun everywhere. In July we will begin to chronicle some of them.

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The Horizontal Diamond-Shaped Antenna

By E. Bruce

Leibman Memorial Prize Winner

Member Technical Staff Bell Telephone Laboratories

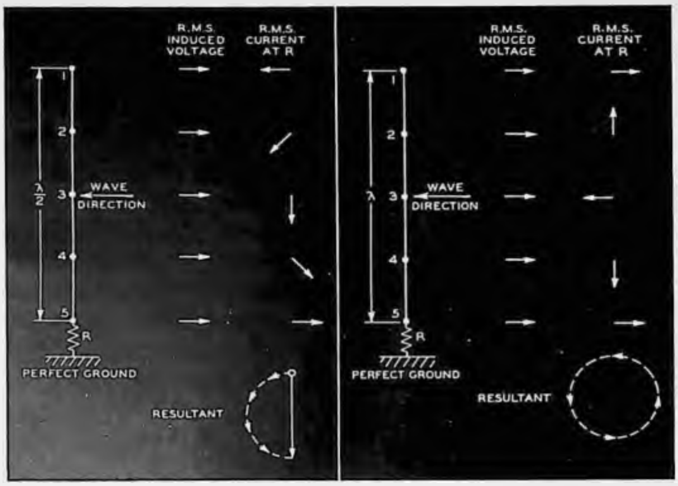


Fig. 1. The voltages induced by a horizontally propagated wave in a vertical half-wave antenna (left) are all in phase. On reaching the receiver, the resulting currents are out of phase: the vector resultant is the diameter of a half-traced circle. For a full-wavelength antenna (rear, left), summing the vectors traces a complete circle, and the resultant is zero.

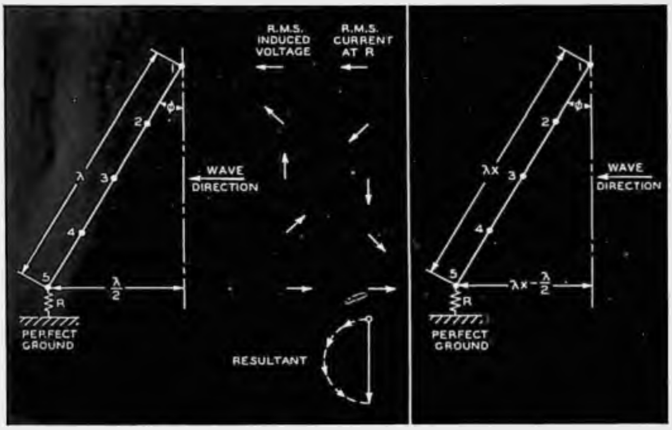


Fig. 2. This antenna also will give optimum reception if properly tilted (far right). There is a proper tilt for an antenna of any length (rear, right).

In use on the Bell System's short-wave transoceanic circuits, directive antennas have amply proven their value. As was anticipated, their selectivity of direction has effected economies in the power output of transmitters ([1]), and has increased the ratio of the signal in receivers ([2]) to the noise coming from static, from neighboring electrical equipment, and from sources inherent in receiver circuits. Justified by these suc-

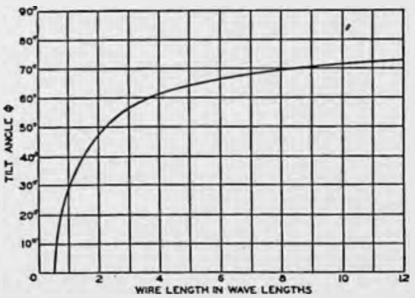


Fig. 3. The optimum tilt of an antenna approaches ninety degrees as the antenna is lengthened.

[1] Bell Laboratories Record, August, 1929, p. 502.

[2] Same, p. 514.

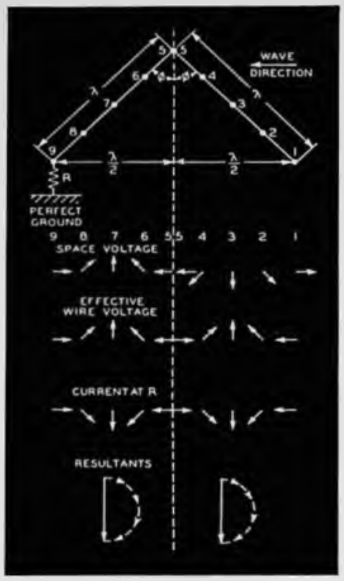


Fig. 4. The V-shaped antenna provides an array of two tilted wires which not only reinforce each other but leave the optimum direction of response unaltered over a considerable range of frequencies.

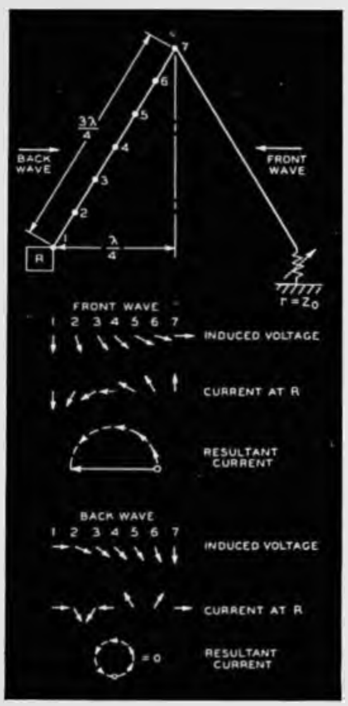


Fig. 5. A wave coming from the back of a V-shaped antenna whose legs are three-quarters of a wavelength long produces elementary currents whose phase at the receiver changes twice as rapidly as when the wave comes from the front, and which thus cancel there.

cesses, the continued development of directive antenna systems has now brought forth a new system having many definite advantages over its predecessors.

Most prominent among these advantages, perhaps, is the preservation of directional selectivity over a far greater range of frequencies. Thus to transmit and receive the daylight, dusk, and night frequencies used on a transoceanic channel, one transmitting and one receiving antenna can replace the three transmitting and three receiving antennas required heretofore. The much simpler mechanical structure of the new antenna further reduces the antenna cost per channel. For these and other reasons, antennas of the new type have been installed for use on the Bell System's new radio-telephone links with Bermuda, Rio de Janeiro and Honolulu ([3]).

[3] Bell Laboratories Record, November, 1931, p. 66.

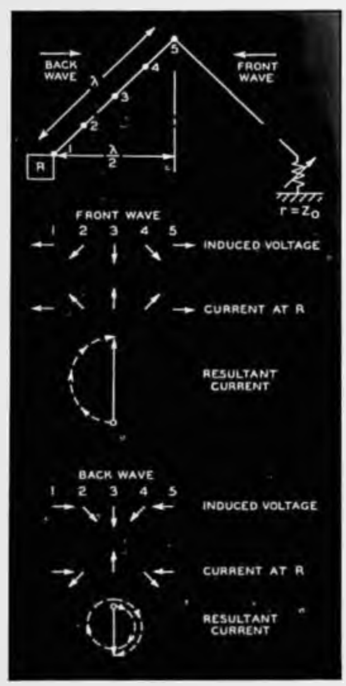


Fig. 6. A V-shaped antenna whose legs are a full wavelength long responds to waves from the back one-third as strongly as to waves from the front.

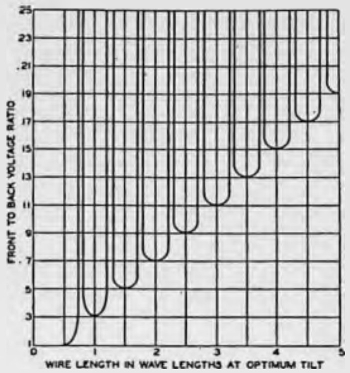


Fig. 7. V-shaped antennas the lengths of whose legs are even integral multiples of one-quarter wavelength have the lowest front-to-back ratios, but these minima become larger as the wire lengthens.

For reception the new antenna employs wires of such lengths, and at such angles to the favored direction of reception, as to cause a maximum current in the receiver from voltages induced by a wave advancing from that favored direction. For transmission the antenna is basically similar. The principles by which the lengths and angles are determined can best be explained by regarding the voltages induced in a receiving wire as lumped along the wire, producing elementary currents which separately traverse the wire to the receiver where they add vectorially.

By increasing the length of a vertical wire exposed to horizontally propagated waves, and matching its impedance by the load at its base, the load power increases until the length of the wire reaches one-half the length of the approaching wave. When this point is reached, the current in the receiver can be represented vectorially (Figure 1-A) by the diameter of the circle whose semi-circumference is traced in summing the elementary vectors. If the length of the wire is further increased, this circle is more nearly closed and the resultant becomes smaller. When the wire reaches a full wavelength, the circle is completely closed, and no current flows in the receiver (Figure 1-B).

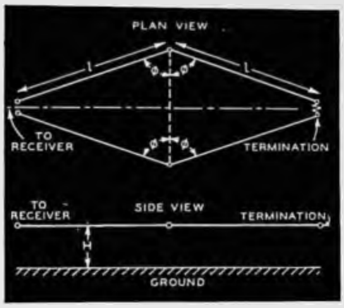


Fig. 8. When one V balances another in a diamond-shaped array, the terminating impedance need not be grounded but can be connected between the far ends of the two V's.

The instability of the resistance of a ground contact with varying weather conditions, and the not inappreciable signal-pick-up of its connecting leads, has dictated the combination of two V-shaped antennas into a diamond-shaped array (Figure 8). Here the balancing effect of the two V's removes the necessity for a ground connection. Mounted in the horizontal plane, its supporting structure is less costly, and it is responsive to the horizontally polarized components of the arriving waves, which are less affected by variation in ground reflection with weather.

(Turn to Page 29)

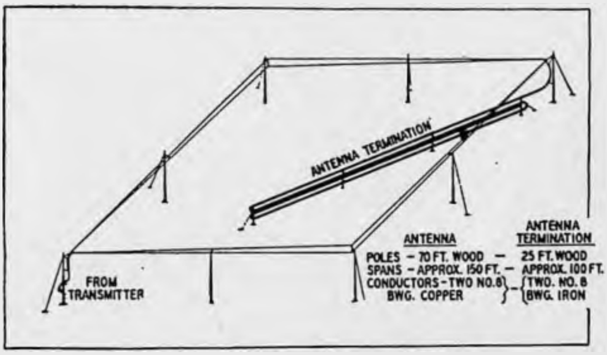
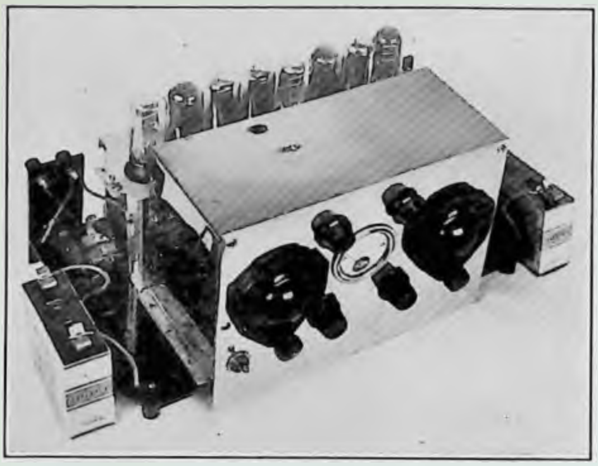


Fig. 9. For transmitting antennas, a terminating impedance of the required dissipating ability has been found in a long two-wire transmission line shorted at the far end. See note at the end of this paper.



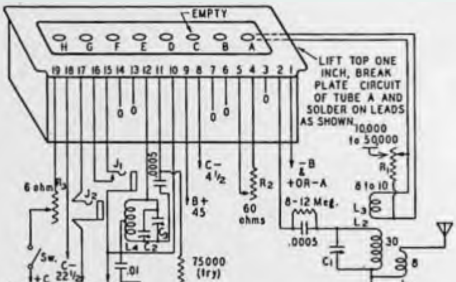
The 7-Tube $6 "Super"

The receiver complete with all bright work shined. Left dial drives C1, right dial C2. C3 knob is reached through top shielding.
Upper left knob, regeneration, upper right filament switch.
Lower left main filament rheostat R3, lower right volume control R2.
Left rear panel carries antenna and ground posts, first detector leak and condenser, also second audio (speaker) jack. Right rear panel carries A-B-C multi-plug, also first audio (phone) jack. 4½ volt C battery posts at left of base, 22½ volt C battery posts at right—the camera was mistaken in showing another 4½ volt battery!

Transmitters speak for themselves, but receivers need the aid of printer's ink. Few of the folks between Porto Rico and Hudson's Bay who have been requesting descriptions of the transmitter at W1BNR seem to suspect that the station receiver is just as unusual. The following description is accordingly offered through the courtesy of Mr. Louis Toth, owner and operator of W1BNR.

The receiver is intended for amateur 'phone work, where the imperative need for selectivity naturally causes one to turn to a double-detection receiver, which we generally call by the trade name of "superheterodyne". Supers have a habit of costing money—and that's where the trick comes in. This super is based on a Radiola eight-tube "catacomb" (!!!!!) such as used in the Radiola 28, et. seq. These may be had at various places for prices ranging from $4.00 down—mainly down. The proper ones bear stamped-in numbers such as E193160. If the number is otherwise—no matter—but if the letter is different be sure you don't have one of the old six-tube variety, or the old hit-or-miss UV sockets.

After clipping off all the old wiring the top is lifted and the tickler loop brought from the plate of tube A as shown in the diagram. Then the whole coffin is fastened down on an insulating base-plate as shown in the photograph, and an operating panel plus other supports added to suit the builder. In the particular set shown the controls were mounted on a bakelite panel, on which



xx "Picture diagram" as seen from the rear of the so-called "catacomb".
C1 Detector tuning, midget type, .000025 to .000035 ufd.
C2 Oscillator tuning, midget type, about .000010.
C3 Oscillator range, midget type, same as C1.
R1 Regeneration control, R2 volume (second detector filament).
R3 Main filament rheostat. For coil dimensions see text.
Most of the wiring and small parts go under the base-panel or on the auxiliary panels — see photograph.

was superimposed the metal panel of an old Priess "straight nine" with cutouts large enough to clear all shafts. This saved working up bushings, yet stopped all hand-capacity effects. The meter, incidentally, was also an old Radiola 28 attachment. The shielding over the tuning systems was made of the metalwork in a Stromberg-Carlson "treasure chest", which by chance had a circular opening at just the right place to permit reaching the knob of the oscillator range-setting condenser C3, which is mounted on a bracket and shunted across C2, the oscillator tuning condenser. This shield is not strictly necessary, but keeps out dirt and stray fingers, also it cost nothing. For that matter, the base panel and rheostats came from an old Murdock neutrodyne, and a metal partition inside the shield-can was taken from a Steinite set, thereby eliminating several other losses.

The set can be driven from a two-cell storage battery and dry B and C batteries, or it can be run from a "B sub". None of the voltages are critical in the least. The so-called "catacombs" are not altogether uniform and one may need to reverse the A battery, hence the curious terminal marks on the diagram. If the second a.f. stage isn't wanted, just leave terminals 17 and 18 blank. One can then use a 90 volt B battery (135 not needed) and omit the 22½ volt C battery.

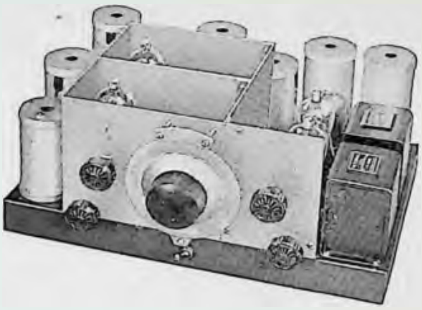
The coils should be reasonably apparent from other practice. If wound on UX tube bases they are cheap and easy to make, so any range may be had at will. For example, one can depend on the 3900-4000 kc. range being on the scale if one uses the condensers listed and an oscillator coil having 36 turns of No. 28 D. S. C., center-tapped. The connection to the pins can be as you please. The detector coil has an eight turn primary of the same wire, then a 3/16" gap, and then a secondary of 30 turns, and finally a tickler of 8 to 12 turns, located either at the top of the socket or slipped inside.

"I am certainly amazed at the clear and concise manner in which 'Modern Radio' is put together."

Robert Aldrich,
Fort Grange Radio Dist. Corp.,
Albany, N. Y.

5-METER SUPERHETERODYNE

National's new ultra-short-wave superheterodyne is one of the few real novelties of the year. It is, as far as we know, the first commercial high-sensitivity receiver for this range—and it is also a high-quality amateur phone band receiver. The belief that a super will not work at 5 meters was never



sound—but in the National set special precautions are taken against all the difficulties, R-39 insulation clear through permits good gains, the use of electron-coupling in the oscillator and first detector, as well as a resistance pad between antenna and set avoids all the frequency shifts that have been supposedly insuperable. It is suited to amateur 5-meter phone work, also to receiving from the Empire State Building, and similar ultra-high-frequency stations—of which there will soon be many more.

CANADIAN—NOT AMERICAN

Like the pup that puts joyous feet on your clean shirt front, we are much chagrined to find that our friendly remarks anent the speeches of the Canadian Provincial Premiers have been in some places received in quite another manner. The pup's oversight was as to the mud on his paws—and ours was in forgetting that "American" not only means a denizen of the American Continents but also (unfortunately) means a United States citizen.

Improved Cathode Biasing

* By Boyd Phelps

It is very common in modern receivers to obtain the grid bias by inserting a resistance in series with the cathode and chassis ground, making the plate current flow through this resistance, and utilizing the IR drop developed thereby for the desired control grid bias voltage as illustrated in Fig. 1. The plate current

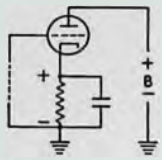


Fig. 1.

flows from cathode down through the resistor to ground which is the most negative part of the series plate circuit. Therefore the cathode is positive with respect to ground and the average grid voltage is negative with respect to cathode.

If a "C" battery is used instead, an increase in plate voltage would cause a very considerable increase in plate current that might shorten the life of the tube, but with the cathode resistor system this is more or less automatically taken care of because the increased plate current causes a great IR drop which is a proportionately greater bias tending to bring the plate current back to normal for the increased plate voltage. Conversely, decreased plate voltage or current will not cause "cut-off" bias but only reduced bias in proportion. Thus far we have a review of a clever idea disclosed in patent number 1,403,932 to R. H. Wilson.

At about this time and the early days of Prof. Hazeltine's Neutrodyne, the writer experimented with circuits similar to Fig. 1 for neutralizing purposes, but of course without the by-pass condenser across the resistance.

A simple mathematical analysis of Fig. 1 may be interesting. Let

* Consulting Engineer, Box 247, Hicksville, L. I.

Eg be a small a.c. voltage impressed on the grid circuit.

u be the voltage amplification factor ("mu") of the tube.*

R be the resistance shown (Fig. 1) in the common grid and plate return to the cathode.

Rp be the internal plate impedance of the tube.

When the a.c. voltage Eg is applied to the grid it causes an a.c. voltage of u(Eg) to appear in the plate circuit. The a.c. plate current is:

u(Eg)/(Rp plus R)

and as a result of this current there is a voltage-drop across the resistance R, equal to:

(u)(Eg)(R)/(Rp plus R)

This a.c. voltage drop is 180 degrees out of phase with Eg and for complete neutralization we will therefore set them equal to each other as follows:

Eg equals (u)(Eg)(R)/(Rp plus R)

Solving for R and simplifying, we find that under these conditions it is necessary that,

R equals Rp/(u—1)

Therefore it would appear that the resistance required to cause a balance would be equal to the plate impedance divided by one less than the amplification factor. With screen-grid tubes, or other high mu tubes the "one less" is negligible. For almost all tubes the value of R comes out around 1000 ohms. Thus a 2000 ohm cathode resistor by-passed by a 0.1 microfarad condenser (which at 800 cycles has a capacity reactance of 2000 ohms) would make a parallel combination having an 800 cycle impedance of about 1000 ohms, which would seem to cause neutralization of incoming signals impressed on the grid.

Actually, Fig. 1 is not quite so simple and was found not to be a good circuit for complete neutralization as a reduc-

* It is the standard practice of "Modern Radio" and "Electronics" to use a small "u" in place of the Greek "mu". This practice is recommended to other radio publications.

tion of a.c. plate current caused a reduction of a.c. grid voltage and this reacted on the plate current again so other circuits shown in patent number 1,829,013 granted to the writer were found better suited.

Returning to the cathode bias resistor, as it is increased from zero there is a very rapid reduction of over-all amplification of the stage due to this neutralization effect. The circuit of Fig. 2 was found convenient in a receiver chassis at hand by simply bringing out grid and

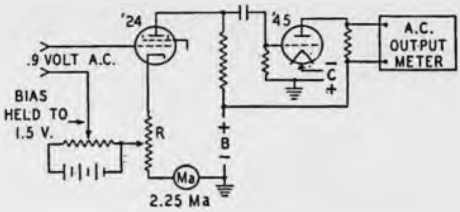


Fig. 2. The Test Circuit.

cathode leads. As the grid return tap was varied on R, the bias voltage obtained therefrom varied so the potentiometer and battery were necessary as shown to bring the grid back to the same operating point on the tube's characteristic EgIp curve. This was most easily done by adjusting the bias to bring the plate current back to the normal value of 2.25 milliamperes which was the current with a bias of 1.5 volts on the '24 and therefore the average bias was maintained at 1.5 volts by this procedure.

Check measurements were made at various frequencies but the wave form, it was feared, had considerably more harmonic content than the lighting circuit so 60 cycles was introduced into the grid circuit at 0.9 volts r.m.s. This input was maintained as it gave a deflection of exactly 100 on the rectifier type output meter and did not seem to seriously overload anything or change the average plate current as read on the plate milliammeter. This full scale reading of 100 was obtained under the conditions of none of R being included in the grid circuit and the total bias of 1.5 volts being obtained from the battery. All other combinations gave output readings equal to or less than this. The output meter readings were proportional to the square of the voltage, so represented proportionate power level changes or percentages of maximum output of 100.

Fig. 3 shows how the readings on the output meter fell off as various amounts of R were included in the grid circuit. For example, the particular chassis used formerly had a 1470 ohm resistor in series with the cathode and the output (without by-pass condenser) fell to 28% of the power output obtained when the same bias was obtained from a battery, or a loss of 72% on all frequencies.

Hatry and others have noted that reducing the size of the by-pass condenser results in the loss of low frequencies, but the above indicates that with no condenser at all this does not result in distortion but rather a sort of neutralization of all audio frequencies resulting in uniform low signal output on all frequencies. Therefore, adding condensers across the cathode bias resistor must bring up the level of the high frequencies first, which is not contradictory but merely another way of saying the same thing and a better basis for what is to follow.

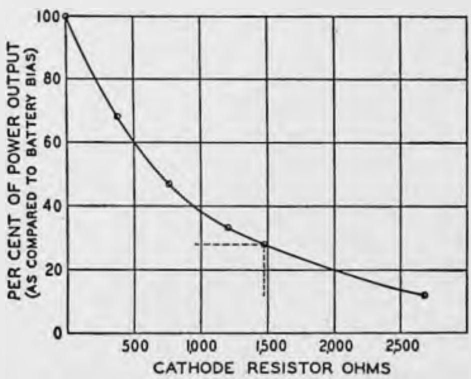


Fig. 3.

All condensers have a certain capacity reactance which is equal to $\frac{1}{2 \; f \; C}$, and for a certain frequency can be expressed as equivalent to a resistance of a definite number of ohms by this formula. A few of these are given in the following table as examples:

Recalling that reciprocal of the sum of the reciprocals formula for resistances in parallel, one will see by inspection that unless the resistor by-pass condenser is quite large, its effect in reducing the effective resistance of R will not amount to much, especially on low frequencies. Take for example, the 0.1 microfarad condenser that was found across the 1470 ohm resistor in the chassis used for these tests. It has a reactance of 159 ohms at 10,000 cycles, according to the table above, which across 1470 ohms gives a resultant of 143.2 ohms. Now looking at the curve in Fig. 3, we find this would result in a drop of output from 100 to 85,—about all we should tolerate. At 1000 cycles the reactance is 1,592 ohms which about cuts the effective value R in half or 763 ohms and from the curve this would give only 46% of full output. Similarly at 100 cycles the output is only 30% while with no condenser at all 28% would be the lowest it could fall with a cathode resistor of 1470 ohms. This chassis in question would be quite terrible for audio quality but it had been designed for television and seemed to give fine image detail tolerably well in that field.

A number of measurements and calculations were made with various shunt capacities at various input frequencies and illustrated in Fig. 4. It may be rather surprising to some folks to learn that the common one and two microfarad condensers should show up so poorly but it is so. To have the output drop to not less than 85% of normal at 50 cycles due to the effects discussed would repquire about 26½ microfarads!

All the above values are readings taken or calculated on the '24 tube used and do not exactly apply for other tubes and receivers but as the theoretical balance point figures around 1000 ohms for all tubes by the formula developed above, and the cathode bias resistor figures around 2,000 ohms for most all tubes, it is felt that the principle, and quite closely the figures, will apply.

The circuit shown in Fig. 5 is similar to Hatry's Fig. 3 in March "Modern Radio" and represents an interesting and cheap dodge to avoid the very large capacities that would otherwise be required to give fidelity on low tones. R1 is the same 1470 ohms as before, R2 is made high to force the "lows" through C2 rather than be allowed to pass through R1 and C1 which contain only

TABLE OF CONDENSER REACTANCES

Frequency	2 ufds.	1 ufd.	¼ ufd.	0.1 ufd.	0.01 ufd.
50 cycles	1,592	3,184	12,700	31,840	318,400
60 cycles	1,325	2,650	10,600	26,500	216,500
1,000 cycles	80	159	635	1,592	15,920
10,000 cycles	8	16	64	159	1,592

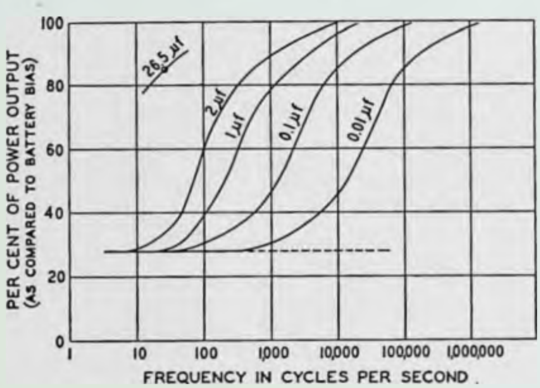


Fig. 4. Unless one uses push-pull, or a circuit like Fig. 5, it is necessary to use high-capacity bypasses on audio cathode resistors. The common ½ to 1 mike is absurd—unless one has a poor filter and must get rid of hum and bass together!

partially cured low frequency fluctuations. The output circuit is not shown but is a duplicate of Fig. 2. The input was kept constant at 0.9 volts, 60 cycles and the following readings noted:

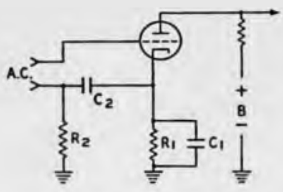


Fig. 5. Test circuit with which the following values were obtained.

C1	C2	R2	Output Percentage
		(battery bias)	100
1 mfd.	1 mfd.	100,000	100
0.1	1.0	100,000	97
0.1	0.1	100,000	68
1.0	1.0	50,000	97
1.0	1.0	33,333	74
0.0	0.1	100,000	67
0.0	0.0	100,000	28
0.1	0.0	100,000	30
1.0	0.0	100,000	35

A considerable mess of curves could be made up to show the effect of varying the above three factors in Fig. 5 but a study of the data in the above table should suffice. In short, C1 is relatively unimportant, because dropping it from 1 to 0.1 microfarads dropped the power output from 100 to 97 and in another case where the output was 68 with the condenser at 0.1 it only dropped to 67 when it was removed. This is a great relief from circuits resembling Fig. 1.

C2 seems to complain if it is dropped much below 1 mfd. but at that value is about equal in effectiveness to 30 mfds. in Fig. 1 type circuits or practically the same as battery bias.

Variation R2 gives outputs of 100, 97 and 74 for resistance values of 100,000, 50,000 and 33,333 ohms respectively which tells its own story. No doubt there is a resemblance to a bridge ratio arm in the effect of varying C2 and R2, the latter of which should be large with respect to the capacity reactance of C2 for any desired frequency in order to keep the output high, as explained before.

If C1 is made small, signal fluctuations with respect to ground do occur in the cathode, but if the grid varies also with the cathode by virtue of a high R2/C2 ratio, then these fluctuations are not included in the input circuit of the tube to any bothersome degree.

The final circuit seems to have good response on low audio frequencies, is cheaper than any other method producing equivalent results without batteries, introduces no new difficulties, and in fact, has many possible other uses as it better isolates the grid from motor-boating and other evils often encountered by common couplings.

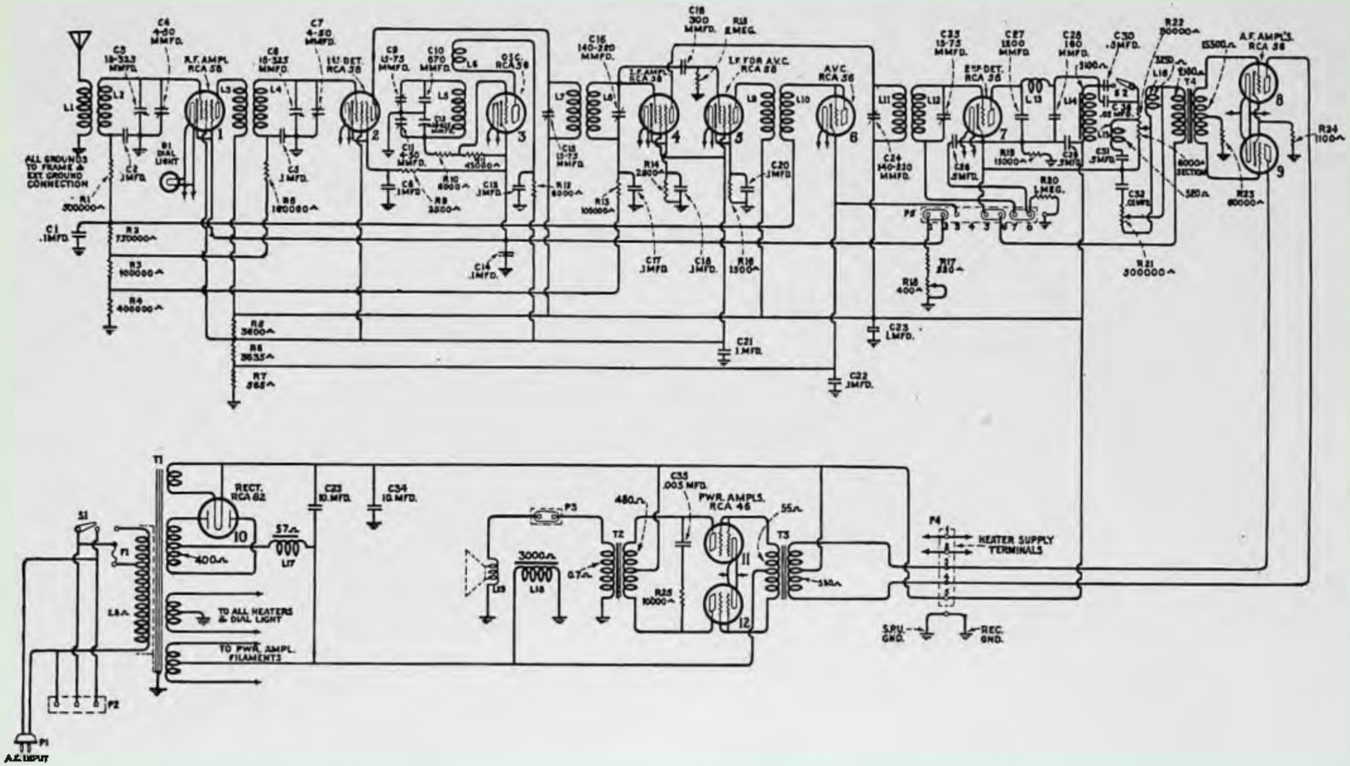
Q. E. D.

The Gift Horse

The amateur has been a football of the Federal Radio Commission's "free-service" long enough. If they put a tax on him, he'll at last be able to demand service. With revenue in sight it might be possible to put licenses through with something like the promptness formerly accomplished by the Bureau of Navigation. The preposterous delays of the present system are no fault of the offices of the district supervisors—for they were part of the old system, and are working harder than ever.

BOOM!

Another form of fake bass is that due to a bass resonance, either electrically introduced in the amplifier or mechanically (accoustically) added by speaker, cabinet or room. This produces an effect of strange and tiresome monotony to most ears, yet there are some who prefer it. It would be interesting to test the reaction of such a listener to Indian dance music—consisting of hitting a deep-toned drum at 80 beats per minute for nine hours.



The circuit diagram of the new G. E. 12-tube J-125, a receiver that sounds as though it had the tone-quality we have so frequently seen in advertising "quality curves" the past few years. The frequency range claimed for the audio reproduction is from 35 to 5200 cycles and two tone-chambers, built integral with the cabinet, are used to eliminate peaks in the reproduction curve according to the manufacturer. The power audio tubes are Class B 46's which are rated for 20 watts maximum of undistorted output. Also this receiver uses none of the tubes we have been familiar with the past two seasons.

The General Electric J-125

New sets with the new tubes have begun to be. The first to our knowledge is the General Electric J-125, a 12-tube receiver, which uses the 56, 58, 46 and 82 (for tube details see "Modern Radio" for April).

The diagram is replete with useful information: we have in it the information that the 56 tube is sufficiently like the 27 that as a power detector it uses a 15,000 ohm bias resistor. A resistor this low means that the choice probably was made on a "strong signal" basis, a sensible conclusion.

The receiver has one trick of interest. A separate and special 58 is the i.f. amplifier for the A.V.C. 56. The reason for this stunt is probably the fact that the 56 is used as a diode or two element rectifier which means of course that the 56 takes and needs appreciable power. The extra 58 gives this power and does nothing else. It is biased by means of a 1500 ohm resistor: whence we learn that the 58 normally needs a resistor between 2500 and 1500 ohms, since both 58's just mentioned run on the same potentials.

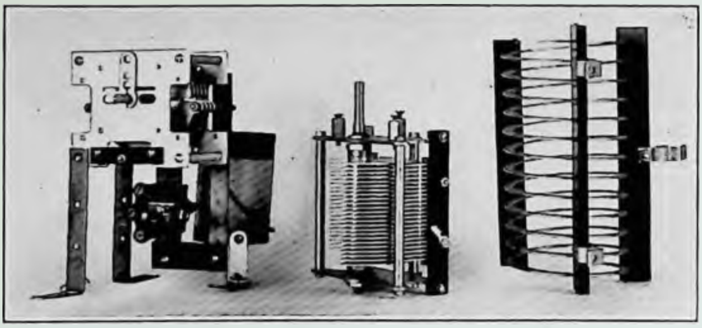
We learn too that under these circuit conditions the diode 56 for A.V.C. requires a total external circuit resistance of 1,250,000 ohms for controlling the 58 tuned r.f. amplifier. Now this receiver in Hartford shows a particularly wide range of A.V.C. action. Therefore we who service, and we who experiment with A.V.C., should be decidedly interested in the other features of the A.V.C. system of the receiver. For example, the control bias provided by the A.V.C. tube is not only applied to a tuned R.F.A. and an I.F.A. but also to the FIRST DETECTOR. Although described before the I.R.E. five or six years ago, controlling the first detector has been up to now neglected. Notice that R2-3-4 comprise the potentiometer for dividing up the controlling bias. Notice that the i.f. tube only gets about a third of this bias and that the first detector gets 5/12 of it: also that a 58 variable-mu pentode is used as first detector. In a sense this last is not so much a surprise; superhet first detectors have a habit of acting much less like detectors than amplifiers.

The G. E. Type J-125 Receiver.

It is too bad that a class B audio push-push amplifier is so simple now that the 46 tube is with us. An editor can't very well elaborate it.

But the receiver still owns one more feature of direct interest, the volume control. This control has combined with it a trick choke and condenser rig giving increasing bass (without attenuation of highs) with decreasing volume, a feature that makes up very beautifully for the ear's loss of bass at low volumes. The receiver of course also includes the usual type of tone-control on another knob to attenuate trebles and please the jazz devourer.

All in all this new receiver in performance and in engineering details shows considerable thought and something really surprising in all around performance for a receiver of its price. Six months ago these results cost twice the price without all the features—a nice saving.

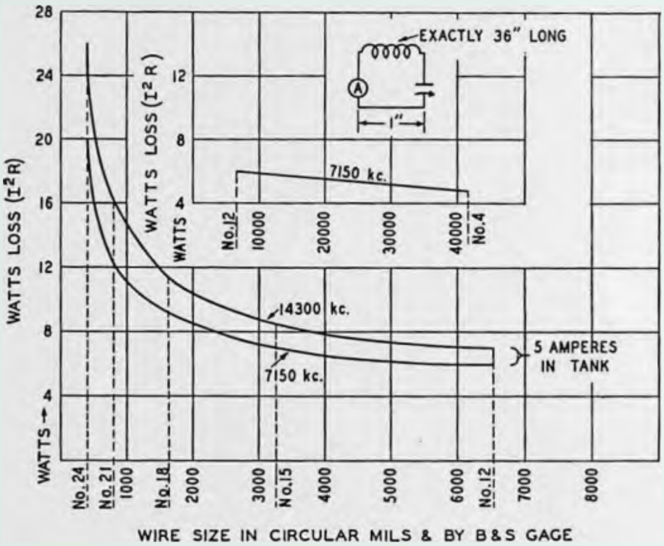


Better Tank Circuits

By John L. Reinartz

Plain curiosity started this investigation, which is by no means finished. However, the results so far are hereby tendered. It may be that some reader will be in a position to carry the study to conclusion and give us the results much sooner than the writer.

The following tests were made and the results are shown graphically. Remember, this does not discuss low or high C circuit desirability, it is only some information regarding the losses in a tank circuit under a given condition. It gave the writer something to do, keeping him from underfoot and, incidentally, running the light bill higher than ever before.



Tests were made at 7,150 and 14,300 kilocycles. If you are fortunate enough to own a wattmeter for high voltage work, connect it into the high voltage supply to the tube, otherwise use a milliameter and a good voltmeter, the product in that case giving you the watts consumed in the tube circuits—as readily as the wattmeter. Now we don't care about the tube circuits for we are not going to measure them, we are going to take a separate tank circuit and measure it; also we are going to use a good condenser, in this case it was a Cardwell (adv.). Wire sizes were selected so that the circular-mils doubled for each inductance. Starting with number 24 B. and S. gauge wire we used wire sizes to number 12, then skipped all others to number 4, this was done because the curve began to slope so little near number 12. Someone else may wish to carry it through more thoroughly: so much the better, it will add to the information.

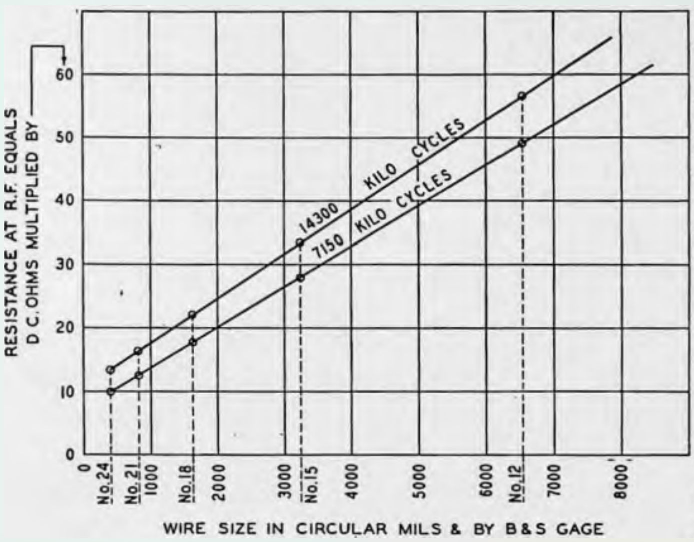
The capacity was kept constant, the

* Connecticut Agricultural College, Storrs, Conn.

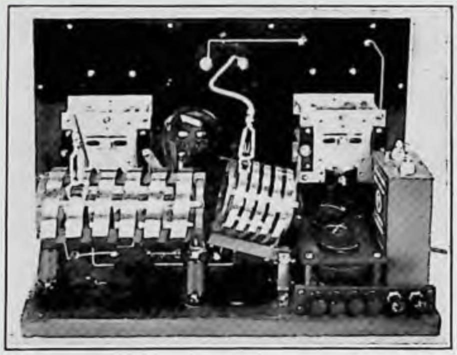
change in frequency to cause resonance was accomplished by changing the separation between turns of the inductance, the inductance in each case was just 36 inches of wire. In order always to have the same radio frequency current for each check, the tested tank circuit had in series with it a Jewell 5 ampere radio frequency meter (adv.), and the radio frequency current was kept at that value exactly for each wire size by changing the coupling. The resonance point was carefully found and set at a safe distance from the driving circuit, after which the tank under measurement was moved closer and closer until the ammeter showed just 5 amperes. The ammeter was not disturbed in its zero calibration from the start to finish of the test, nor was the setting of the condenser.

Just about now someone is going to rise up and say that we also had some loss in the condenser and the Jewell meter: True, we had, and have, but, we did not change them in any way while we did change the wire size, so any change in reading got was due only to the change in the wire size. However, the curves are not supposed to represent the losses of the wire only, but that loss was the one that varied as the wire size was changed, all other factors were kept the same, even the frequency, which in this case had a crystal to keep it where it belonged at least for this test.

Now let's do a little tabulating, taking the 7,150 kilocycle test first and starting with number 24 wire we find that at 5 amperes the product of the voltmeter and the ammeter before we coupled the tank subtracted from the product of the same meters after we couple the tank leaves us with 19.51 watts loss. We don't want that wire size, let's try number 21, which goes down to a little more than 12 watts loss; number 18 gives us 9 watts loss, number 15 gives us 7 watts loss and number 12 gives us 6 watts loss. When we drop to number 4 wire the loss has decreased to 4.75 watts only. Evidently there isn't much use in locating somebody's still to take some ½" copper tubing from, as the loss seems to go down pretty slow from here on.



The test with 14,300 kilocycles is just as interesting, it has moved up the scale for all wire sizes, meaning that as the frequency increases there is also an increase in resistance. So far we have only looked at the I^2R loss, let's see what has happened to R in our test, evidently it is not just its d.c. resistance that we use in the I^2R formula as that value would never have given us the results we actually got. So let's take the formula watts divided by I^2 and see what the resistance actually is, at 7,150 we find it to be .785 ohms, while the wire has a direct current resistance of only .07845 ohms for the 3 feet we are using, the increase is just ten times and we find that it keeps right on going up as the wire size gets bigger and bigger, so we tabulate the rest of the test and find that for the number 4 wire the multiplier is 250 times the direct current resistance. We must not forget that this whole calculation also involves the resistances of the condenser and the meter, but remember these are constants and would merely bring the whole curve down while keeping its shape.



? ? ? ? ?

The curve we made from the I^2R value to get at the resistance is not such a bad looking curve if we do say it ourself. It must be that some care was taken to get the readings as otherwise we would have had a curve that would look more like a poorly rectified plate supply.

One more thing, we used 5 amperes in our test, had we used 10 amperes the loss would have been four times that shown, what tank circuit is satisfied with a measly little five amperes? We shudder at the losses in some of our high C circuits.

Anyway, we find that there isn't such a big advantage in these large copper tube things after all and for the little set the number 12 is going to do the work without much grumbling.

There's more to this story—watch for it in "Modern Radio".

"Modern Radio" may be bought from the dealers listed on page 28.

CORRECTION FEATHERWEIGHT PHONES

Due to incomplete information our May issue, page 21, carried a short article implicitly incorrect regarding the Trimm Featherweight Headsets.

Mr. E. P. Bottorff calls attention to the following omissions: The Trimm Featherweight is entirely custom built and may be had in d.c. resistances from 2 to 4800 ohms, the 4000 ohm size in fact is rapidly striding into aamteur prominence. The manufacturing tolerances are small enough so that the use of paper diaphragm washers is unnecessary. When desired by the purchaser the Trimm Co. will be glad to furnish impedance data or other engineering information. Low-impedance headsets are available for use with matching transformers where it is necessary to minimize the dangers of electrolysis. The manufacturer is prepared to supply headsets to match any output transformer whose impedance is given.

We regret these omissions and apologize to both the Trimm Co. and our readers.

NEW CRYSTAL OVEN

Western Wireless, Ltd., of 95 Minna Street, San Francisco, has a new crystal oven which should be welcomed by amateurs. It is aggressively compact, being only 4" long, 2" wide and 1¼" high.

The case is made of heat-resisting black Durez and is in two pieces, sandwiched between which is the "conduction" plate heat reservoir made of thick monel metal. A long vane, adjustable bimetallic thermostat holds the constant to within 1 degree, more than sufficient for amateur purposes: For aircraft use its compactness, and its use of the standard aircraft voltage of 12 make it admirable.

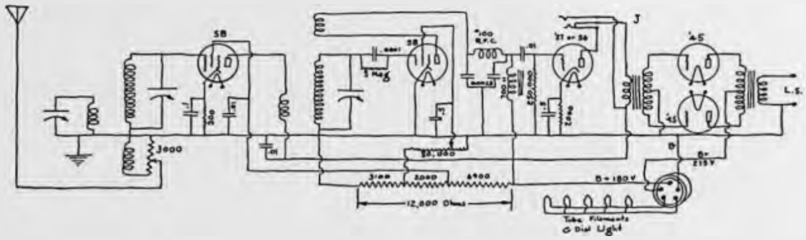
The principle of this type of oven was described by D. E. Replogle in "Modern Radio" for April, on page 3.

The SW-58

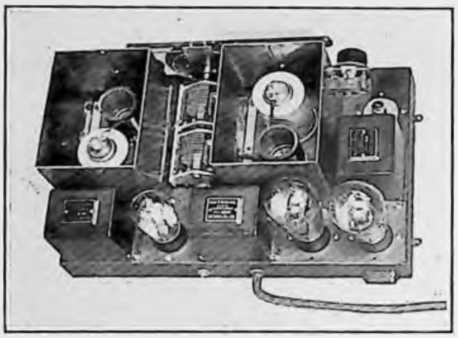
Successor to SW-5

In a year of cheap-John radio it is a joy to see that National's new all-wave receiver maintains the ideals of the SW-5. The audio system terminates in an honest push-pull '45 stage. Pentodes are used in the r.f. and detector sockets. They are of the '58 type and lend their name to the set, also improve its gain materially.

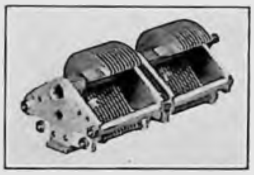
The '58 wisely continues the use of the circuit which has met with so much approval—a stage of high-gain r.f. followed by a regenerative detector, in preference to working a superheterodyne over the entire great range of 9 meters to 2000 meters. The difficulties of the latter scheme have been discussed before in these pages.



All-wave T.R.F. sets have had three principal weaknesses, lack of short-wave amplification, an excess of controls, and lack of an entirely proper volume control, which is to say a control that was completely free from any interlocking with either the tuning or the regeneration controls. The first two of these were successfully attacked in the SW-5 by refinements in design and materials. In the SW-58 the third difficulty has been defeated by a design which practically suppresses interlocking—on which see "Modern Radio" for January, page 14. For this purpose the '58 tube was used, the shielding increased, and the new "isolated rotor" type of condenser gang devised. This last is a construction in which the condenser bearings are bushed with bakelite and the rotors driven through an insulating coupling. The only connection to them is through an insulated wiper-spring. The troublesome coupling loops are thus avoided. The stator insulation is of isolantite. Nice work!



Top rear view. Audio system nearest the reader, r.f. compartment at the right, detector at the left. Between is the "isolated rotor" tuning gang.



The special tuning gang is also available separately.

Book Reviews

"Radio Frequency Measurements", 2nd Edition, by E. B. Moullin, 487 pages, 289 illustrations, published by J. B. Lippincott Co., Philadelphia. Price $9.

Moullin's 1st edition is so widely known that little reviewing is needed. The advances made in the art since 1926 have been incorporated in the 2nd edition, with the same viewpoint as before, namely with regard to the principles involved, rather than with any intention to discuss the specialized measurement devices which are prominent in the radio factories of the United States. English radio production is not on such a basis as to require these devices also it is better to be well grounded in the principles than to know all about a few devices. The author has chosen wisely in writing an excellent book on fundamentals—probably the best book.

R. S. K.

"Below Ten Meters" is the third of the family of short-wave manuals published by the National Co. of Malden, Mass. The price is 50c.

This third manual, compiled by James Millen and the editor of "Modern Radio", is confined to the practical use of ultra-short-waves. It begins, wisely, by telling the reader the difference between the regular short-waves (10-200 meters) and those below 10.

The intensely practical nature of the book will delight the heart of the experimenter and undobutedly create a new experimenter where only a reader walked before.

The list of chapter titles is a fine guide to what you may expect from the

(Turn to Page 20)

manual: Chap. 2. Generating the Ultra Short Waves. 3. Radiating the Ultra Short Waves. 4. The Ultra Short Wave at Work. 5. Experiments and Theories. 6. Measurements. 7. Amateur Radio Communication Below 10 Meters. 8. Receiving in the Ultra Short-wave Bands. 9. Receiving Television Signals at Ultra Short Waves. A page is devoted to references to AVAILABLE literature and a page to the "Mile-Posts of Ultra Short-wave Communication" with dates and names. That this book has only a table of contents and no detailed index is considerably to be regretted since it stands alone on the subject.

National is to be congratulated on taking the initiative, and the editors of the book on the excellent job they have done.

L. W. H.

In volume 2, the "Manual of Short-wave Radio" we at last have a book to replace the Manual of Short Wave Radio of which so many dealers have been saying for so many months—"We are sorry, but every copy is sold."

Volume 2, is completely new in every detail. It also is due to the genial Zeh Bouck. Whether you build or buy, your new receiver or converter is here, clearly described, well illustrated and honestly rated. The design principles behind them are set forth as well. What more do you wish? Schedules—they are here in excellent form: International time charts—turn to page 57: means for identifying strange stations—see page 17; code practice information—see page 9. It is all there.

Does this sound like a $3 book? It isn't; it may be had for 50c from the National Company of Malden, Massachusetts.

P. O. B.

REGRETS

Mr. R. R. Batcher's article on the practical uses of the remarkable new and simple 1932 cathode ray tubes has been delayed because Mr. Batcher has just given a demonstration of the same thing before a New York meeting of the Institute of Radio Engineers. Preparing the talk used up the time reserved for writing—also produced some fresh information which we will give you next month.

It's nice to have a radio receiver in your car—so you can listen to the advertisements when it's too dark to read the billboards.—*Hartford Times.*

How to Install and Service Automatic Volume Control

Part 2—Basic Circuits and Installations—Continued

By L. W. Hatry, Associate Editor

Now the application of the R. C. A. circuit to any receiver involves the problems of getting the additional a.v.c. voltages out of the power-pack. The R. C. A. 80 makes the job easy: it has a double-choke rig in the negative lead of its power supply. The exact circuit of Fig. 4 is almost directly applicable. The lack of directness results from L1 having too great a voltage drop, the bias has to be reduced somewhat. To lower the bias connect as in Fig. 5. The grid-circuit is relatively a non-current circuit so a high resistance potentiometer of 500,000 ohms is O. K., but so is anything from 10,000 up. The arm picks off the desired potential: and this leads us to a detail of operation.

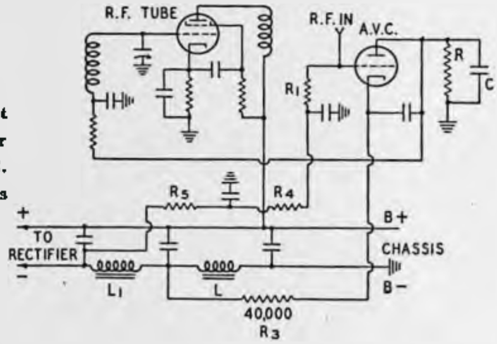


Fig. 4. A practical triode A.V.C. tube circuit showing wiring through to the r.f. tube under control. R is 200,000 ohms for 224 tubes. A.V.C. is a 227. The A.V.C. plate to cathode by-pass is a .01 ufd. mica condenser.

In Fig. 4 one tube is shown under control. This tube has a normal bias supplied by its cathode resistor. The a.v.c. bias is additional and picked up from the drop across R. As long as the a.v.c. tube gives no bias the r.f. tube will show the same operating conditions as though no a.v.c. were in use. Thus when using the adjustment of Fig. 5 an ordinary set analyzer is plugged into the r.f. tube socket and the r.f. tube in the analyzer. The tube, with no signal coming in (or the a.v.c. tube out) will show, let's say, 3.7 ma. plate current. Variation of the potentiometer of Fig. 5 will adjust the plate current conditions on a.v.c. and thus the bias on r.f. We adjust the potentiometer and find that the plate current of the r.f. tube will be adjustable from normal 3.7 ma. to zero. This is because varying the bias on the a.v.c. tube causes it to take more or less plate current through R. The varying voltage across R is sent through to the r.f. as extra bias. Naturally, to have an a.v.c. tube sensitive to relatively weak signals we are to adjust the potentiometer to the point that causes a.v.c. to just barely affect the plate current of the r.f. tube. If we desire the a.v.c. tube to act only on stronger signals we give it more bias from the potentiometer. We learn right off that different '27 tubes require different settings of the potientiometer and thus learn one source of possible trouble in such a.v.c. systems. We also learn that in adding such a control to a receiver we can wisely embody the adjustable bias feature in the setup so that adjustments can be made for new '27's —to fit in with local conditions.

However, once we have found the potentiometer setting as shown in Fig. 5 we can substitute fixed resistors for

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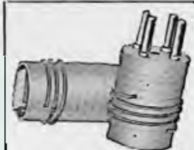

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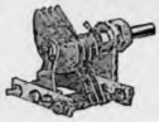

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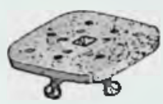

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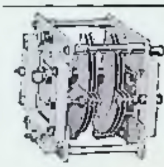

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A smaller dial with the famous V.V. mechanism for small receivers and transmitters. Fixed ratio only. Type BMD dual range 0-100-0; type BMC 200-0 clockwise.

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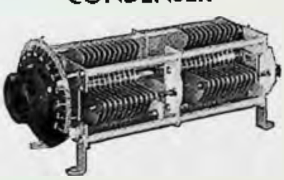

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the potentiometer. In the R. C. A. 80 it happens that the potentiometer setting is to center of resistance range. That means, of course, that correct voltage division will be got if two resistors of the same size (almost irrespective of size) are used with the middle point as source of a.v.c. tube bias: in other words proportionate setting is what determines the ratio of resistor sizes.

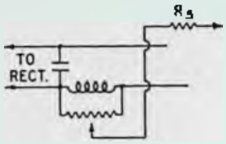

Fig. 5.

Other Practical Pointers

Of course we have the problem of magnitudes in dealing with the various voltages involved in such a system. We have many suitable practical guides that are hard to beat, such as circuits of Stromberg and R. C. A. sets in service manuals.

For instance, if a.v.c. is being put on a screen-grid outfit. We know that Stromberg uses 200,000 ohms for the plate resistor R of its a.v.c. tube in several models where 22's are controlled. Thus applied to an R. C. A. 80 the resistor R is 200,000 ohms and the tuned r.f. amplifier tube and the first, i.f. tube are wired for automatic bias. The rest of the circuit is shown in Fig. 4. Since we also should know from tube data that the 224 is driven to cutoff (at 180 v. plate) with about 13 to 20 v. of grid-bias we also know that the a.v.c. tube by ohms law must have about .2 milliampere plate current at maximum exitation from the r.f. source. The best chance of getting this large r.f. exciting voltage is the highest point of r.f. so we feed the grid of the a.v.c. tube through a condenser (about .00025) connected to the plate of the second i.f. tube in the "80". The results of such an installation are excellent, strong locals actually having slightly lower volume than weak stations. This defect may be overcome partly by taking a lower and separate tap off R for the second tube under control, but since it is an advantage rather than a disadvantage it is a matter of personal choice.

When 235 tubes are controlled we find the standard set a.v.c. tube to have an R of 500,000 ohms, so we have suitable values for a tube requiring greater bias control.

Arriving at a value for the applied plate and grid voltages for the a.v.c. tubes is not hard. In general the tube will need a plate voltage at least 50% higher than the bias voltage it must give. Thus we can figure that a tube furnishing 20 volts bias across R must have at least 30 volts between cathode and R since 20 volts are lost in R. For 30 volts, an effective 30 volts at no output, the tube will need a bias of about 3 to 4 volts on the grid to reach cutoff of plate current. In general such tubes are run at similar voltages.

Likewise it is obvious from Philco resistor constants that the rectifier rig they use gives about the same general values for the resistor R. This simplifies thinking about the system and eases the problem of deciding on suitable R's and the like.

Time Constants

The "time constant" of an a.v.c. system is primarily the time constant of r.c. in the diagrams. This time constant determines the response to change of the system and to what degree it filters off a.f. ripples and smooths fading. A system has a low time constant if it immediately gives full background when the receiver is tuned off a station: likewise it has a relative high time constant if tuning off a station it lags sufficiently for background to increase slowly: a slow increase is advantageous in tuning from station to station without quick rises of noise between stations but it is disadvantageous in not being able to follow fairly quick fading of the station. The magnitude of the time constant may be altered at one place in the above diagrams by increasing the capacity of C since a time constant in seconds is got from the formula r.c., R in ohms and C in farads. In multiplying R times C we can use C in microfarads if we divide the result by 1,000,000. For instance, .5 mfd. times 200,000 ohms gives 100,000/1,000,000 or .1 second time constant for r.c. However, we aren't through with our time constant until we have also figured in the capacities and resistors affecting the automatic bias line. These in one receiver are .1 and 500,000 ohms on each tube controlled, and in series or additive for the first tube as in Fig. 6. What makes this lag or time constant is the discharge of the condensers through the resistors and likewise their charge.

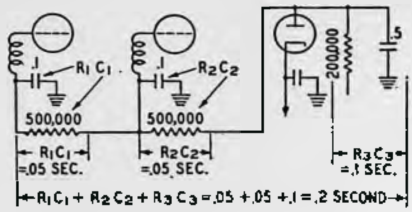

Fig. 6.

The time constant of the r.c. combination is usually defined as the time it takes C of r.c. to lose 63% of its charge. If the charge is made at 30 volts then when the total time constant is .2 second the receiver will go to 17 volts at the end of .2 seconds and about 10 volts in .2 more seconds. A long time constant may mean a full second of wait for return to level after leaving a strong local station so that the weaker one gradually builds up to normal volume. Likewise leaving a weak station to hit a strong one the a.v.c. will first allow too much volume and then the volume will drop to normal a.v.c. level. All these things must be compromised with to reach a suitable practical time constant. And we must also make certain that the time constant is great enough so that the condensers never get a charge from a rapidly changing audio ripple or else the ripple will modulate the r.f. tubes.

Part 3 will describe some very simple a.v.c. systems, easily added to existing sets, also will explain the servicing of a.v.c. sets.

P.S. The girl in the rocking chair—had to get the cut in some place!

Courtesy "Time"

Drs. Tuve, Dahl and Hafstad with their electron gun which produces effects equivalent to those of radium emissions.

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NOTES

1. Keep a copy of your letter, including diagrams, numbering questions 1, 2, 3, 4 and lettering diagrams a, b, c, d.

2. The right is reserved to return remittances for any questions which it is impossible to answer.

3. No attention will be paid to radiograms, telegrams or letters (other than those under class G) which are not accompanied by a remittance. Please use money order—loose cash may not arrive.

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Short Circuits

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We have on the one hand a harassed public looking to the automobile manufacturer to pull the world out of the mire and on the other, wasteful governmental agencies, always scheming to impose new and heavier taxes.

Henry Ford in "Christian Science Monitor".

Of course, marriage enlarges a man's capacities. No bachelor can carry over fourteen packages.—Hartford Times "Portico".

Why individual service-men so frequently go to work for someone else: charging $2.00 for material and labor in installing aerials.

It sounds radical, but one way to decrease the national deficit is to quit spending money.—Hartford Times "Portico".

We wish someone would invent a non-ambiguous label for folks that live in the U. S. A. At present the best thing we seem to have around is "Yankee", which looks like national property to someone on the outside but is actually held by New England under a quit-claim deed approved by all the other states—with cheers.

(Continued from Page 5)

Of such an antenna the optimum direction of response in the horizontal plane remains the same over a frequency range of two to one, although the directivity becomes somewhat less sharp as the frequency becomes less favorable. The vertical-plane directivity in the optimum horizontal direction is dependent on the length of each leg, the tilt angle of the component wires, and the height of the whole antenna above ground. Undesirable characteristics can to some extent be reduced by changing these factors. The low response to horizontally propagated waves discriminates against man-made interference originating near the ground.

NOTE—In our next issue the application of these antennas to amateur work will be discussed.

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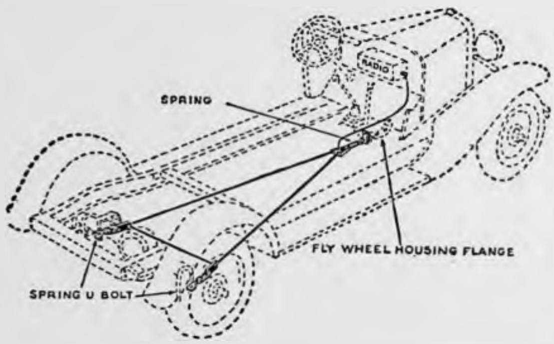

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