MODERN RADIO

EDITED BY ROBERT S. KRUSE

CONTENTS

July Number 13 20 cents

The Neglected Magnetron

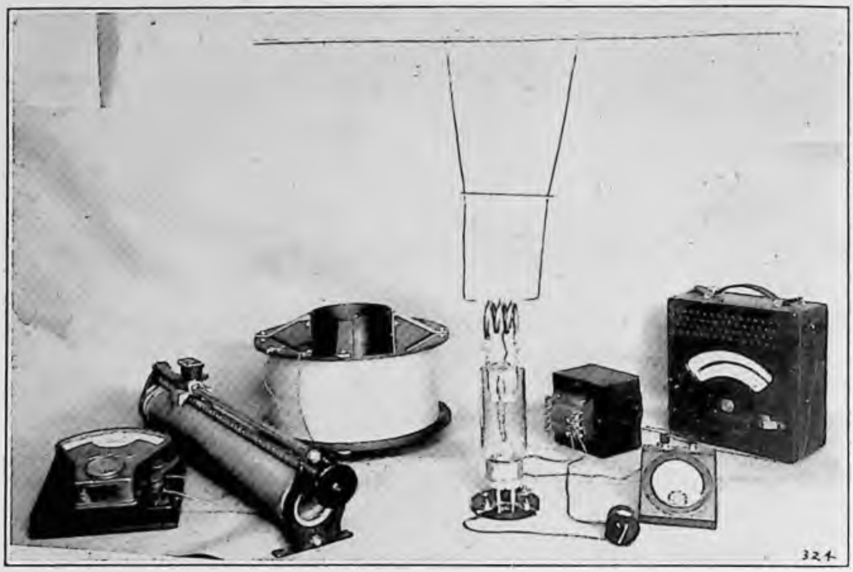


Illustration Courtesy "Below 10 Meters", National Co.

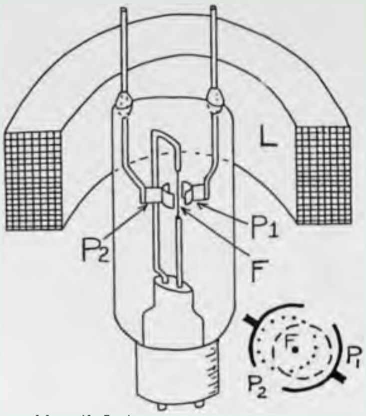
Experimental setup of a General Electric FH-11 magnetron with field coil set to one side. Field controls at left, filament and plate controls at right. The circuit is a modification of the second one of the diagram, except that feeders are led from the coil to a horizontal halfwave antenna as explained on page 22.

The field coil takes 5-6 amperes at 100 volts. It has 2,665 turns of 64 milliammeter enameled wire wound 74 turns per layer with 15 milliammeter paper between. Length of coil 5 inches, diameters—inside 5 inches, outside 11 inches. Field strength, 143 gauss per ampere.

At 1,500 volts and 45-60 Ma. the performance is as follows:

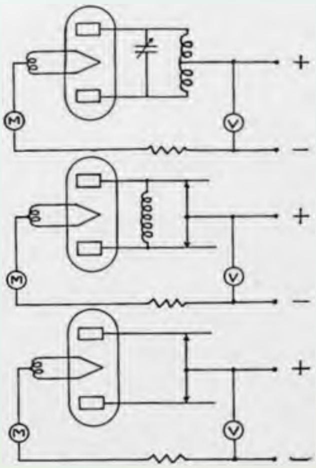
Wave Length in Meters	Output Watts	Tank Condenser Micro-Microfarads	Tank Inductance
0.75	5	0	Shorting strip 1" from seals
1.0	15	0	1 turn, 1½" dia.
2.0	25	0	3 turns, 1½" dia.
5.0	35	0	5 turns, 1½" dia.
25	45	50	2½ microhenry
50	50	100	7 microhenry

The magnetron oscillator seems to be receiving nothing like the attention it deserves. It is capable of oscillation at any wavelength at all from ¾ of a meter to 30,000,000 meters. There are no burnout difficulties as in the Barkhausen-Kurz ultra-short-wave oscillator, and much higher outputs are possible because the wasted heat does not center on a fragile grid, but a pair of sturdy plates. In operation the tube is surrounded by a large coil L carrying d.c. at such a level as will produce a magnetic field (at the filament) of 600-800 gauss. If the field is further strengthened the electrons from the filament never reach the plates but simply whirl in a circle as a space charge. Now, if the field current is slightly reduced an



The field coil L has been raised and cut across to expose plates P1 and P2, also filament F. Sketch in corner shows vibrations of one turn of the electron-spiral, which assumes first dotted and then dashed shape.

unstable condition ensues in which the electrons go from filament to plate through a long spiral of many turns. These turns vibrate as if made of rubber —see sketch. The RATE of these vibrations depends largely on the tuned circuit attached to P1 and P2 which operate in a sort of push-pull. The circuit



diagrams differ with the wavelength but (as seen as the other sketch) resemble familiar forms. Note in the table the rather high powers as compared to other oscillators working in the ultrashort wave region. More will be said later on this subject. The present information is from "Below Ten Meters", through courtesy of the National Company.

The Library of Congress needs back-copies Nos. 1 to 5 inclusive of "Modern Radio" to complete its files. "Modern Radio" will cheerfully exchange a year's subscription for the 5 copies.

The New York Public Library needs back-copies Nos. 1 to 8 of "Modern Radio" to complete its files. If a subscriber has these copies and no longer needs them the Library will greatly appreciate the courtesy if they are presented.

The "Ohio State Journal" suggests that a good way to squelch the wise youngster is to ask him what a whiffletree is.

"List me as a subscriber. I saw your magazine at the home of a friend and it looked good. It is brief and snappy and doesn't fill space with a lot of useless junk."

Harold C. Brooks,
Pleasant Lake, Ind.

"I borrowed a few 'Modern Radio' from a friend; I think it is the best radio magazine out."

W. T. Fouser,
Jobet, Ill.

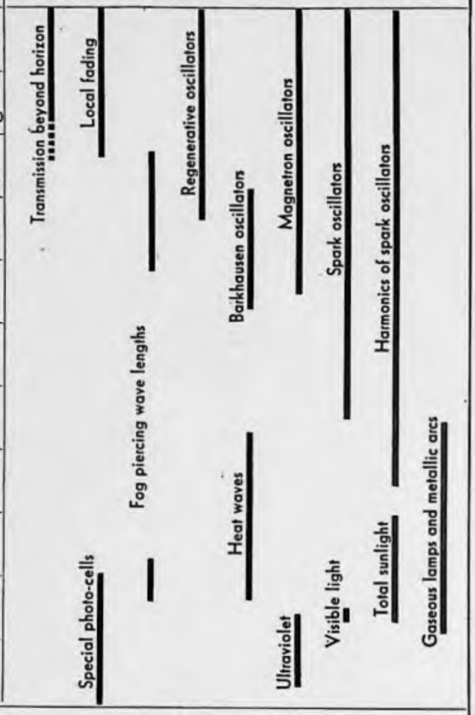
Gentlemen:

"Let me congratulate you upon the excellence of your 'Modern Radio' publication. It is the first American radio magazine that has soothed my ruffled feelings since 'Radio Broadcast' passed away some years ago."

F. Leslie Berger,
Danzig, Freie Stadt Danzig, Europe.

The Wavelength Ranges of Apparatus, Radiations, and Transmission Effects

Wave length			Generators and Detectors
Meters	Microns*	Angströms**	
10	10^7 or 1000000	10^{11} or 100000000000	
1	10^6 or 1000000	10^{10} or 10000000000	
.1	10^5 or 100000	10^9 or 1000000000	
.01	10^4 or 10000	10^8 or 100000000	
.001	1.000	10^7 or 10000000	
.0001	100	10^6 or 1000000	
.00001	10	10^5 or 100000	
.000001	1	10^4 or 10000	
.0000001	.1	10^3 or 1000	
	.01	10^2 or 100	



* A micron is a millionth of a meter.

** An Angstrom unit is a ten-millionth of a millimeter.

Courtesy "Below 10 Meters"; National Co.

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How to Use Cathode Ray Tubes—Part 2

By R. R. Batcher*

In the May issue of "Modern Radio" the cathode ray tube was described and the general method of using it was indicated.* We will now take up the description of the associated equipment. Figure 1 shows a simple portable setup used by the author. This supplies all necessary voltages for anode, filament and bias. The circuit used is an adaption of the basic rectifier circuit in Figure 2. While the data given need not be followed exactly, it will be found convenient to do so. The transformer is any midget receiver power transformer of good design, such as Polymet. The proper filament rheostat depends on the particular cathode ray tube to be used. In the diagram shown, when the H-L switch is thrown to H approximately 1,000 volts is applied to the anode, and about 500 volts in the L position. Some tubes will be overloaded with the higher voltage—the Western Electric type 224B will burn out.

Manufacturer's instructions should always be followed, but the following may be of help. With the low anode voltage on and the bias resistance at

Fig. 1
The Author's Portable Cathode Ray Oscilloscope

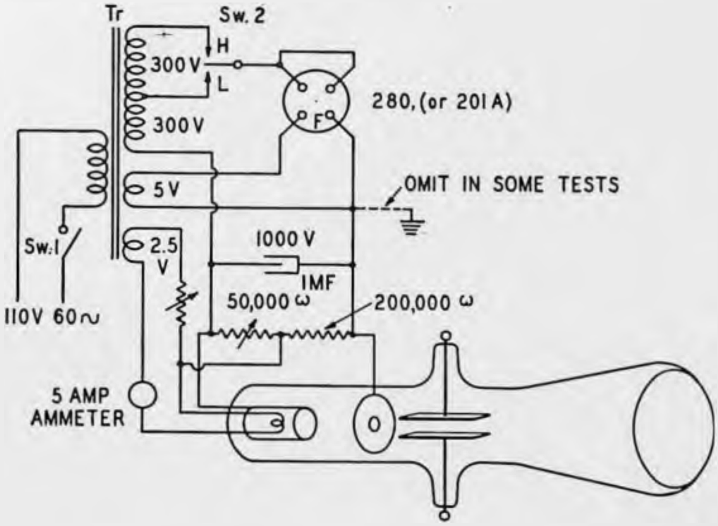


Fig. 2

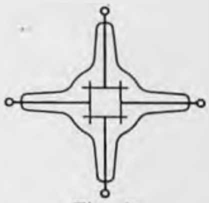


Fig. 3

* Consulting Engineer, 11335 198th St., St. Albans, Long Island, N. Y.

maximum the filament is brought up to a value specified for the tube. A filament ammeter gives better indications than a voltmeter. Reduce the filament current slowly until a fluorescent spot forms on the screen at the large end of the tube. Changing the bias will be necessary to get a fine focus—that is a small, brilliant spot. As a precaution, do not burn the filament at more than the rated current, also use as high a negative bias as possible—consistent with getting a good focus.

Having gotten the spot the next step is to try deflecting the spot in various ways. In Figure 2 the anode circuit is shown at ground potential. In some tests this connection is essential, but in case one deflecting plate of each pair is tied in to the anode lead, it will be necessary to remove the ground wire for some tests. For simplicity the deflection plates will be indicated in the rest of the diagrams and all other connections omitted. A cross section of the tube should, of course, show an appearance something like Figure 3 but for convenience this is reduced to the circle and straight lines seen in the remaining diagrams.

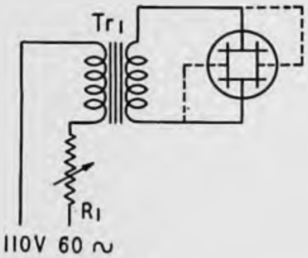


Fig. 4

Experiment No. 1

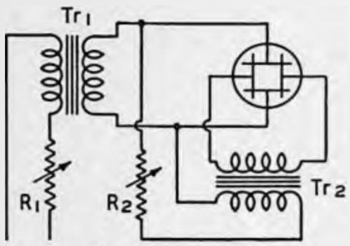
Connect an alternating potential across one pair of plates as in Figure 4, neglecting the dotted lines. No harm is done if too much voltage is applied and the spot swings off the screen. Swing a horseshoe magnet near the tube and observe how the spot momentarily expands into a somewhat distorted sine wave. Also, with the magnet held still, view the image of the line on the screen in a hand mirror and oscillate the latter rapidly meanwhile—or simply look at the line while shaking the head rapidly. In both cases the line spreads out into a curve, showing that it is being drawn by a moving spot.

Experiment No. 2

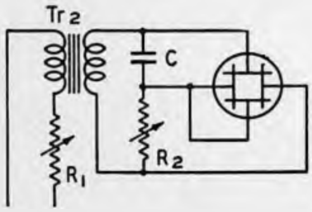
Connect the alternating current also to the other plate, as in Figure 4, USING the dotted lines. It will be found that the line has been rotated about 45 degrees. The rotation is seldom exactly 45 degrees as one pair of plates is almost always somewhat more sensitive.

Experiment No. 3

Two dimensional figures are obtained only when a difference in phase is obtained between the voltages applied to the two sets of plates. Simple ways of showing this are given in Figure 5. One method uses a second transformer, the other uses a simple phase-splitting circuit made of a condenser and a resistance. All sorts of circular and elliptical figures are obtained as shown in the left column of page 8 for May.



A



B

Fig. 5

Experiment No. 4

Figure 5B is useful in making audio frequency measurements, using the circuit of Figure 6. The unknown frequency is connected in series with one of the plates, producing a figure somewhat as shown in 6B. Here a 720 cycle frequency is superposed on the ellipse. (Count the bends and see.) With higher frequencies a somewhat more readable figure is obtained by connecting the unknown frequency in series with the anode, producing radial displacement—i. e., a sort of cogwheel effect.

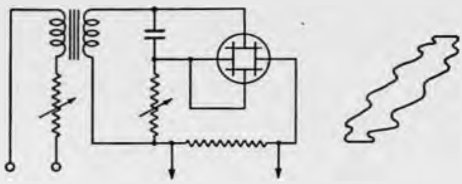


Fig. 6A and 6B

Experiment No. 5

With a 60 cycle wave on one pair of plates and the unknown frequency on the second pair, figures similar to those shown in Figure 2 of the May issue are obtained IF the two frequencies bear some definite relation to each other.

Experiment No. 6

Tests on the fidelity of audio amplifiers are easily made. Several methods are possible, of which that shown in Figure 7 is the simplest. An audio potential, preferably variable over the whole audio range, is applied to a potentiometer as shown. A portion is applied to the amplifier under test and the rest to the other pair of plates. A calibration line is first obtained by setting the slide so that a=b with the amplifier removed (see dotted line). The slope of this

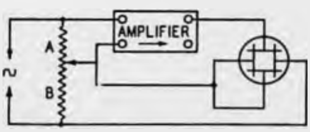


Fig. 7

straight line is duplicated by adjustment of the slider when an amplifier has been interposed and is being tested. This is done by adjusting the slider and the amplifier gain at any frequency is very evidently obtained from the ratio b/a. If harmonics are present they will distort the line.

Experiment No. 7

Radio frequencies up to about 5 megacycles may be used to deflect the ray, although some difficulty may be experienced in focussing the beam to a small spot. The tube may be used as a radio frequency voltmeter, ammeter, modulation meter, etc. In the last use the radio frequency is applied to one pair of plates, the modulation frequency to the other. It is often necessary to shunt the deflection plates with a one megohm resistor in these experiments. The amplitude of the deflection can be reduced with a series condenser or resistor.

This is to be regarded as a hasty first survey—in later issues we will show how these things can be done—also how radio transmitter tests can be made.

CANADA'S PLAN

In its issue for May 13, the "Christian Science Monitor" says editorially:

"Moved by public dissatisfaction with the so-called 'American plan', advertising-supported radio system, the Canadian House of Commons, after careful consideration of testimony from 53 different sources, has unanimously recommended a publicly owned national system of radiocasting for the Dominion. In so doing, it sets a pace for the rest of North America and heartens that vast field of United States listeners who in common with Canadian listeners have been chafing under too much advertising on the air.

An inflexible maximum of 5 per cent of any program period is established. The great majority of Canadian radio resources will be put into a great government owned and operated coast-to-coast chain of 50,000 watt stations. The income will be from three sources: transmitter fees, receiving set licenses and advertising of the limited type.

With the proposed Canadian system, more cleared channels will be needed for Canada. The Mexican side will have to be heard also. The Madrid conference scheduled for this fall, is a logical place to iron out these difficulties.

Servicing "A. V. C."

Curing Ailments in Automatic Volume Controls

By L. W. Hatry, Assistant Editor

The first move in servicing an a.v.c. receiver is to make certain of the type of a.v.c. used, i. e., the basic circuit involved. This means that one finds out the important details leading to correct diagnosis of the kind and source of trouble. These important details are:

1. Is the a.v.c. tube independent of the receiving circuit, can it be removed as in Figure 4, without doing more than simply removing the a.v.c. bias? This found out, simple removal will give the performance of the receiver alone at full sensitivity. If something other than a.v.c. failure is affecting the set it can be located according to usual methods.

2. What type of a.v.c. tube circuit? In addition to the two triode circuits described in the May a.v.c. article* there is also the screen-grid tube a.v.c. and others shown herewith, Figures 7, 8, 9.

3. What sizes of resistors are involved in this a.v.c. circuit? A one megohm resistor subjected to accidental leakage current of 10 microamperes (.00001 Ma.) can subject the controlled tubes to 10 volts of undesired bias. With high resistors we may wisely look for insulation leakages, condensers with only 10 to 15 megohm resistance, etc.

4. Does the heater of the a.v.c. tube carry a potential different than the cathode? Is the heater at or near a.v.c. plate potential or what?

This information is to be read from the service diagram of the receiver or else it should be dug from the receiver itself.

If the receiver is one in which the a.v.c. tube may not be removed without crippling the circuit, several useful tests are possible, once one is certain that all tubes are O. K. In the event that a removable a.v.c. tube does not clear up performance these tests lead to the answer. Presumably you now have the information covered by 1 to 4.

The next step is to learn which tubes are under a.v.c. control: These are fairly certain to be the first r.f. amplifier and the first intermediate in the case of a super-het, the first two r.f. in the case of t.r.f. sets, or simply an intermediate in a super-het without t.r.f. These tubes may be checked with an analyzer or test kit like any other tubes and the effect of the control can be observed. To wit:

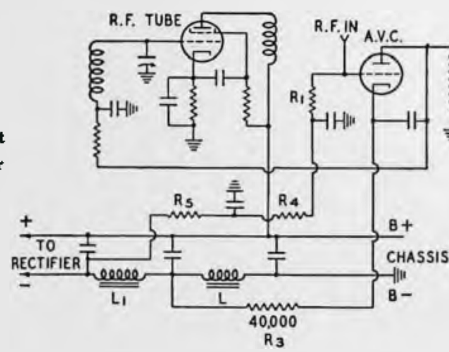


Fig. 4. A practical triode A.V.C. tube circuit showing wiring through to the r.f. tube under control. A.V.C. is a 227.

The probability is that the resistances "passing" the a.v.c. bias along will be too high to permit measuring a.v.c. bias with the analyzer voltmeters. Fortunately we don't need to measure this bias directly. We can SEE its effect on the plate-current of the tube under control. We check plate-voltage and

* Copies may be had at the regular price.

screen-voltage, and find the operating conditions of the 224 or 235 are normal knowing from experience that NORMAL control-grid bias will cause from 3 to 5 Ma. of plate-current. Consequently with only the plate-current meter in use we can tell if bias is normal PROVIDED NO STATION IS TUNED IN. If a station will not tune through the analyzer cable an oscillator on correct frequency may be used to place a good signal on the tubes FOLLOWING the one under check. If we are working on

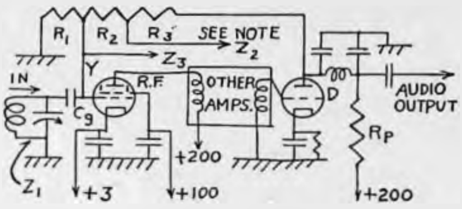


Fig. 7. A limited-range system easily added to existing receivers. If the tube to be controlled is a '24 and the detector is a '27 the voltages will be about as shown and the resistors will be about as follows: Rp—250,000 ohms, R1—1 meg., R2 and R3 each 2 megs. Change these resistors to adjust control action. The lead Y need not be connected as shown. If preferred, cut at Z1, transfer Cg to this gap and connect Y to lower end of tuned coil. If a second r.f. stage is to be controlled use lead Z2 in same manner. If an i.f. stage is to be controlled use lead Z3 through a ¼ meg. resistor to the i.f. grid. Many variations are possible.

so simple a receiver that neither scheme is practical, we may directly excite the a.v.c. tube with the oscillator. In any case, the r.f. getting to the a.v.c. tube will cause it NORMALLY to produce an increase of bias for the tube being controlled, (which we are analyzing) and cause a plate-current decrease. Of course, this same check may be made "on the air" by opening up the cathode, or plate-circuit, of the tube being checked and inserting in series a milliammeter (the well-known tuning-meter) to watch these plate-current changes as caused by reception.

If we find the controlled tube has no change of plate-current with (supposed) operation of the a.v.c. tube we must have found the plate-circuit resistor of the

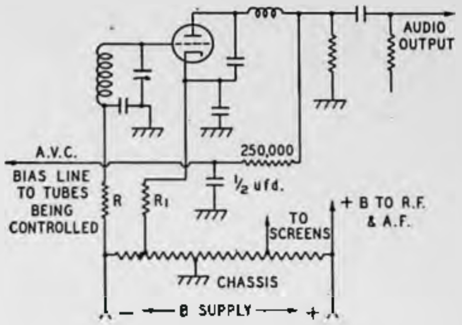


Fig. 8. The detector tube used as A.V.C. tube. The diagram is largely self-explanatory. R1 would be of the usual size, 25,000-40,000 ohms and R would be 100,000 to 500,000 ohms. R is purely an a.f. filter condenser and R1 is a part-bias resistor for the detector. Sizes of suitable by-passes are familiar from dozens of existing circuits. The layout of voltage divider is shown to make clear the obtaining of required detector voltages.

a.v.c. tube open, shorted, or else an open or short along the bias distributing network connected to the a.v.c. tube. Presuming we are feeding the a.v.c. tube r.f., from oscillator or antenna, and should be getting a bias from it, we may locate the exact point of trouble by disconnecting condensers and shorting resistors that seem doubtful. If, as in the case of some Stromberg-Carlson receivers, the control bias is passed through 5 megohm grid-leaks, we cannot conveniently short a resistor it may be temporarily shunted with another of suitable size: 5 megohms temporarily shorted by from .5 to 10 megohms, etc.

When two amplifier tubes are under control both, of course, should be checked if control appears to be missing from one, since if one is being controlled properly we have immediately isolated the portion of the circuit which is in trouble.

A large difficulty with a.v.c. systems as a class is the high-resistances used. Frequently they are cheap resistors shunted by cheap condensers: A combination CERTAIN to go bad. Sensible service is frequently going to call for complete replacement of a system started on the downward path.

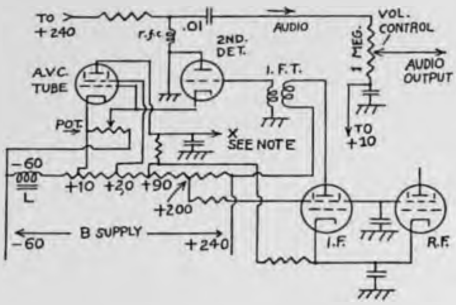


Fig. 9. The A.V.C. system of a typical superheterodyne. The a.c. and d.c. cathode voltages of the second detector are applied to the input grid of the type 24 A.V.C. tube whose rectified output is applied to the input grids of the i.f. and r.f. tubes from the lead X through the secondaries of the i.f. and r.f. input transformers feeding these tubes. These transformers are omitted for simplicity. The potentiometer permits adjustment of the point at which the A.V.C. action "takes hold", compensating for differences between '24 tubes. By-pass condensers, unless otherwise marked are either ½ or 1 ufd.

To be able to check the high resistors is evidently necessary. Indications up to 20 megohms for condenser leakage tests, and good readings in the range of 3 megohms to 30,000 ohms will be got with a 300 volt, 1,000 ohm-per-voltmeter AND 300 VOLTS from a B supply. Lack of resistance scale is no difficulty, as comparison with good resistors is easy and good resistors are cheap these days.

A.V.C. Tube Troubles

If the test previously described gives one a 224 operating at normal plate and screen voltages but without plate-current one knows that the control-grid voltage is too high for a normal tube. This control-grid bias is supplied in part normally and the rest by the a.v.c. We accordingly may short the control-grid to chassis in some sets, thereby cutting out the a.v.c. bias and putting normal bias on the tube, to get normal plate-current. Otherwise we may short the control-grid to cathode, have no bias whatever, and raise *abnormal* plate-current to learn that everything but bias is O. K. If changing the a.v.c. tube has no effect on this condition several troubles may exist as said before.

In the R. C. A.-Stromberg triode rectifier a.v.c. tube circuit (see May issue), a.v.c. bias is caused by the plate-current of the a.v.c. tube. Watching our r.f. tube plate-current as before, we can short-circuit the plate resistor of the a.v.c. tube—which test will cause the plate-current of the r.f. tube to rise to normal since all a.v.c. bias is in that way eliminated. If the plate-current of the r.f. tube does not rise, trouble MUST be elsewhere.

Insufficient bias on the a.v.c. tube is the only thing that will allow it to have excessive plate-current to cause too much "idle" a.v.c. bias. Its grid-line, see Figure 4, accordingly must be gone over for shorts or opens which prevent or drop out the a.v.c. tube's grid-bias.

Of course, one of the basic problems of working on an a.v.c. set revolves around the effectiveness of the a.v.c. It is frequently desirable to hear the receiver work at actual full sensitivity in order to avoid guessing at normal performance since once the a.v.c. takes hold sensitivity is, of course, reduced. To get the a.v.c. action out of the picture in sets whose a.v.c. tube cannot be removed without stopping reception, use little or no aerial and the weakest signal that can be heard. For example, disconnecting the aerial may allow weak reception of a station, if another can be got at improved volume obviously the a.v.c. has reached its limit and the receiver is probably at full sensitivity. Small changes and a.v.c. performance can then be guaged with fair judgment. If the receiver will not pick up stations without an aerial, one to twelve feet of wire laid on the workbench will frequently serve as an aerial satisfactorily.

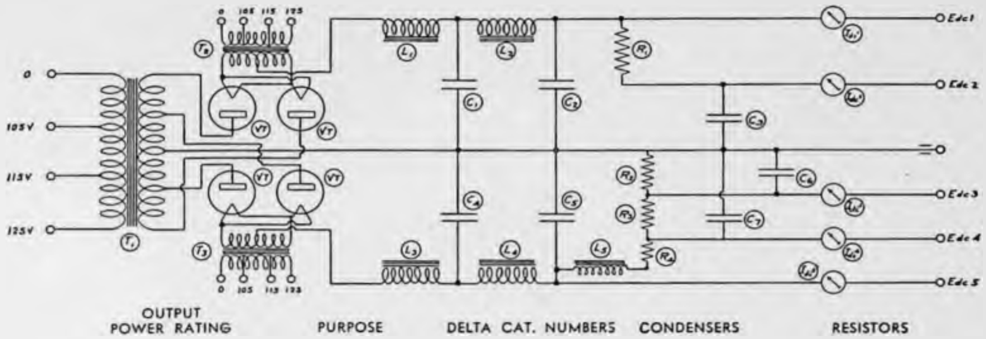
Improved Plate Supply for Radiophones

A Swinging Choke

Maybe this article ought to be labeled "advertisement". If so, get out your pencil and do it, for we propose to say frankly that the Delta Manufacturing Company of Cambridge, Mass., has made a very nice contribution to the plate-supply problem.

The occasion of the contribution is this:

In all transmitters, and in most pub-



Practical example of a duplex rectifier circuit. This is for a transmitter modulating in the next-to last stage—a bad case.

Tap	Rating	Purpose
1	180 Ma. 1,000 volts	One '03 tube, Class B.
2	180 Ma. 500 volts	One '10 or '65 Class C and two type '50 modulators.
3	10 Ma. 125 volts	Screen of the '65.
4	10 Ma. 180 volts	Voice amplifier type '27.
5	100 Ma. 350†-500 volts	Crystal oscillator and buffer.

The '66 rectifier tube is to be used. If '81 tubes are used in the low-power section the values marked † occur.

L1	6-30 Hy., swinging choke	C1	2 ufd.
L2	20 Hy., 350 Ma. choke	C2	4 ufd.
L3	6-30 Hy., swinging choke	C3	4 ufd.
L4	20 Hy., 175 Ma. choke	C4	2 ufd.
L5	15 Hy., 110 Ma. choke	C5	4 ufd.
R1	2,800 ohms, 100 watts	C6	1 ufd.
R2	12,500 ohms, 1.25 watts	C7	2 ufd.
R3	2,750 ohms, 1.1 watts	T2 and T3—See text.	
R4	10,650 ohms, 9:5 watts or 5,660† ohms, 5.1 watts		

lic address systems, we have an output tube or tubes which need high voltage d.c., but are not very fussy as to the purity of that d.c.—a bit of ripple does no harm. However, in the same system the earlier tubes want lower-voltage d.c. which must be very, very fine and pure. What to do? High voltage filters are costly and one does not like to think of enough chokes and condensers to make the whole supply "pure d.c." Of course, one can drain off a little current through a resistor and then filter it at a lower voltage—which is fine until someone takes the load off the low-voltage filters as so often happens in radio receivers when a tinkerer removes the small tubes. The chances for assorted feedbacks are a bit discouraging too. As an alternative one can provide two complete power supplies—and THAT isn't so good either because it costs money.

The Delta idea on this point is a simple one — provide a plate high-voltage transformer that is tapped. Simple?

In referring to the example shown in the diagram it will be seen that one of the chokes is special and is indicated as a "swinging" choke. This is a type of choke which changes its inductance with the current through it, in such a manner as to reduce the voltage variations which occur at the filter condensers (and at the load) when the current-drain is changed. With a current range of 10:1 the inductance of the choke changes about 5:1. This does a surprising lot of things, namely it reduces the peak current through the rectifier, allows one to use fewer microfarads of filter for the same effect and lessens greatly the voltage

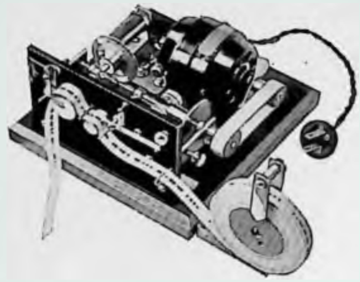
Although two filament transformers are shown in the diagram one of the multiple type shown here is used. It has 10,000 volt insulation between windings.

changes as the current-drain is changed —as for example, by keying a tube or by talking through a Class B amplifier (audio or radio). Thus the full current rating of the rectifier tubes may be used safely—at last. The fly in the ointment is that the choke must be made for the job, and the current drain must never drop below a certain value. This is because the choke must be matched to the apparent load resistance, which changes with voltage. A "bleeder" is accordingly necessary to keep the current at 10% load or better. The other thing to dodge is that the lowest inductance of the choke must not resonate with the first condenser at the line frequency. The Delta chokes are designed to avoid this with a two "mike" first condenser.

All hail to the chap (we forgot his name) who said he hoped the depression wouldn't be over soon because it's all some of us have left.

A REAL ADVANCE

Code practice devices have advanced slowly but the "Heterograph" seems to make up for the delays. It is completely socket-power operated, eliminating wavering buzzers, and requiring no batteries. The tone is generated by a built-in device, and the tape is driven through the contacter by a 110-volt motor under the



control of a phonograph-type governor. This permits an unvarying code speed which may be set at any value between 2 and 50 words per minute. Output terminals are provided for either headsets or speakers. The device is substantial and is used in a number of commercial radio schools, yet is not priced too high for the individual learner.

There is also offered a perforator for use in schools requiring considerable quantities of tape. With it fresh tapes of any makeup, spacing, or code, may be prepared. This device also is used at a number of prominent schools at Oakland, Seattle, Manila, Washington, D. C., and other cities.

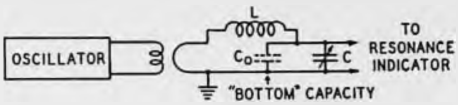
The Heterograph, with 75 feet of tape lists at $30, the Perforator at $250. They may be had from the manufacturer, Pacific Heterograph Co., 433 Call Building, San Francisco, or from the Western Representative, Mr. Don C. Wallace, 4214 Country Club Drive, Long Beach, California.

One of our hopes is that Bud and the Colonel will burlesque the 40 meter band.

Determining the "Bottom Capacity" of a Tuned Circuit

By A. W. Parkes, Jr.*

The "bottom capacity" may be only the distributed capacity of a coil plus the bottom capacity of a tuning condenser, or it may be that much plus other capacities due to wiring, sockets, or other equipment in parallel with the coil.



Reasonably loose coupling should be used.

Method: Couple the tuned circuit as shown in Figure 1 to an oscillator. Set C at 0 on the scale. Adjust the oscillator frequency so that the tuned circuit resonates to the third harmonic of the oscillator. Increase C until the circuit resonates to the second harmonic. Note the reading of C. The bottom capacity is four-fifths of the difference in the capacity of C when tuned for the third and second harmonics. A calibrated condenser is required.

The result may be obtained for any combination of harmonics, providing the proper factor is used (see equation below). The second and third harmonics were chosen rather than the first and second so that it would not be necessary to reduce materially the coupling to the oscillator on changing from one harmonic to another. Almost any of the standard resonance indicating methods may be used. A vacuum tube voltmeter or a receiver coupled to L is preferred.

The derivation of the equation follows:

$\omega_3 = 2\pi \times 3f$ WHERE f = FUNDAMENTAL FREQUENCY; $\omega_2 = 2\pi \times 2f$.

(1) AT THE THIRD HARMONIC, $\omega_3^2 L C_0 = 1$.

(2) AT THE SECOND HARMONIC, $\omega_2^2 L(C_0 + \Delta C) = 1$, WHERE ΔC IS AN INCREASE IN CAPACITY OF THE MAIN CONDENSER FROM ITS MINIMUM VALUE AT 0 TO ITS VALUE WHEN TUNED TO THE SECOND HARMONIC.

(3) $\frac{\omega_3^2}{\omega_2^2} = \frac{9}{4}$ SINCE ω_3 IS 3 TIMES THE FUNDAMENTAL AND ω_2 IS TWICE THE FUNDAMENTAL.

(4) WHENCE $\frac{\omega_3^2}{\omega_2^2} = \frac{C_0 + \Delta C}{C_0} = \frac{9}{4}$, OBTAINED BY SETTING EQUATION (1) EQUAL TO (2).

WHENCE $1 + \frac{\Delta C}{C_0} = \frac{9}{4}$

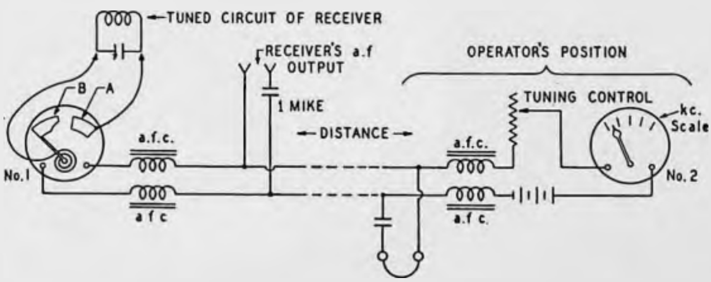
$$\frac{\Delta C}{C_0} = \frac{5}{4}$$

$$C_0 = \Delta C \, \frac{4}{5}$$

* Aircraft Radio Corporation, Boonton, N. J.

REMOTE TUNING

Here is a remote tuning stunt used in the northwest for several years, but which we have never seen published. The diagram is self explanatory. Two wires carry the control current AND the received signal. The device accomplishes very nice vernier tuning, or following an unsteady or drifting signal. The meters used are low range voltmeters or milliammeters. Those with heavy pointers, large faces, entirely covered by glass are best. The size of the foil on the outside of the glass can be adjusted to give the desired tuning range.



The Horizontal Diamond-Shaped Antenna

By E. Bruce—Part 2

Leibman Memorial Prize Winner

Member Technical Staff Bell Telephone Laboratories.

In the V-shaped combination of two wires shown in Figure 4, the added exposure of wire appreciably improves its directional characteristics and thus its signal output. Another advantage is its further extension of the breadth of the frequency range to which it is applicable. The tilt-angle errors, when the antenna is used at frequencies other than the optimum, are opposite for the two legs of the V, and thus cancel in the combination, leaving the optimum direction of response unaltered.

If the far end of any of these antennas were left open, there would have to be considered, in summing the elementary currents, not only those directly propagated to the receiver but also those propagated in the other direction and reflected back to the receiver from the open end. In practice, however, the far end of a tilted-wire antenna is terminated to ground through an impedance, equal to the characteristic impedance of the antenna, which absorbs all currents reaching that end.

It is this termination which achieves directional asymmetry, establishing a front and a back to the antenna so that it will respond strongly to signals from the front and inappreciably to signals from the back. Figure 5 shows that such an antenna can theoretically have an infinite front-to-back ratio, and indeed it is an experimental fact that the ratio is limited only by the physical rigidity of the antenna in space. It can be shown that an optimally tilted wire will have an infinite front-to-back ratio if its length is an odd integral multiple of one-quarter wavelength.

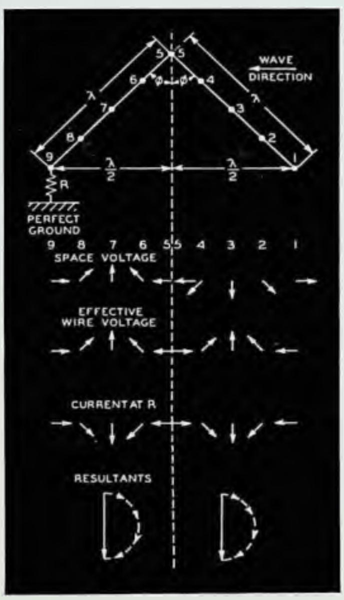


Fig. 4. The V-shaped antenna provides an array of two tilted wires which not only reinforce each other but leave the optimum direction of response unaltered over a considerable range of frequencies.

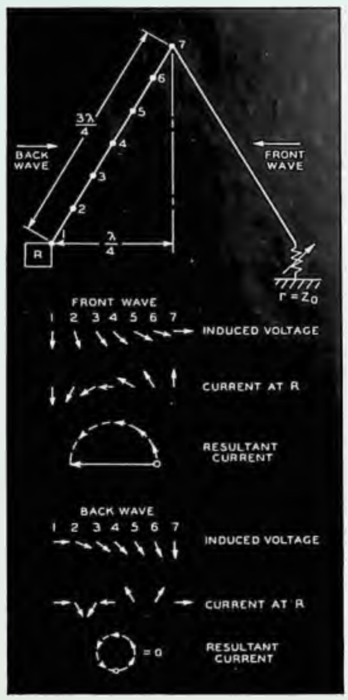


Fig. 5. A wave coming from the back of a V-shaped antenna whose legs are three-quarters of a wavelength long produces elementary currents whose phase at the receiver changes twice as rapidly as when the wave comes from the front, and which thus cancel there.

It might appear that this prescription of length would restrict the frequency range within which any particular antenna would exhibit an adequate front-to-back ratio. The frequencies for which the ratio is lowest are those for which the wire length is an even integral multiple of one-quarter wavelength. For a wire one wavelength long, for example, the resultant when the wave approaches from the back is found in Figure 6 to be as much as one-third the value of the resultant when the wave approaches from the front. The values of the ratio for optimally tilted wires of all lengths up to five wavelengths are shown in Figure 7, whence another advantage of long wires appears in the increase in the minimum ratio as the wire lengthens.

But even when a wave arriving from the back has one of these unfavorable frequencies, the signal it produces in an antenna can be cancelled by permitting an equal and opposite signal to be reflected from the antenna's far end. This can be accomplished by adjusting the terminating impedance so that it differs from the characteristic impedance of the antenna. It can be shown that the desired cancellation will occur for the most unfavorable frequencies when the termination equals the antenna's characteristic impedance times the cosine of the angle

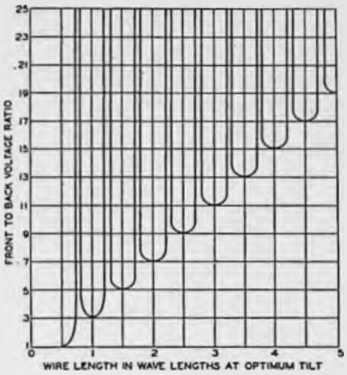


Fig. 7. V-shaped antennas the lengths of whose legs are even integral multiples of one-quarter wavelength have the lowest front-to-back ratios, but these minima become larger as the wire lengthens.

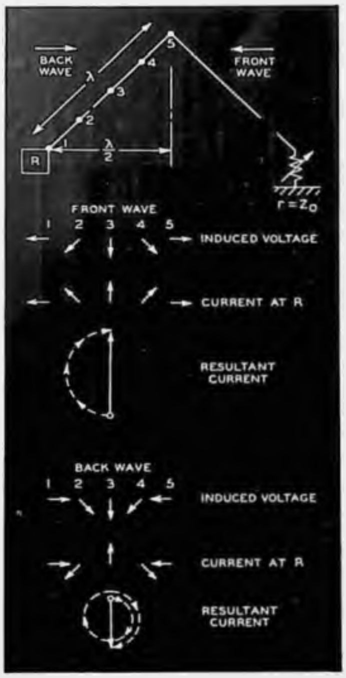


Fig. 6. A V-shaped antenna whose legs are a full wavelength long responds to waves from the back one-third as strongly as to waves from the front.

between wave direction and wire. Since this cosine approaches unity as the wire lengthens (Figure 3), the necessary adjustment of the terminating impedance for long wires is quite small. By making the terminating impedance a compromise between the ideals for the most favorable and the most unfavorable frequencies, large front-to-back ratios can be secured for a long optimally tilted wire over its entire useful range of frequencies.

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

THE LOST PI

In the article "Improved Cathode Biasing" which appeared in our last issue, there appeared a defective equation on page 9.

It should have read:

"All condensers have a certain capacity reactance which is equal to

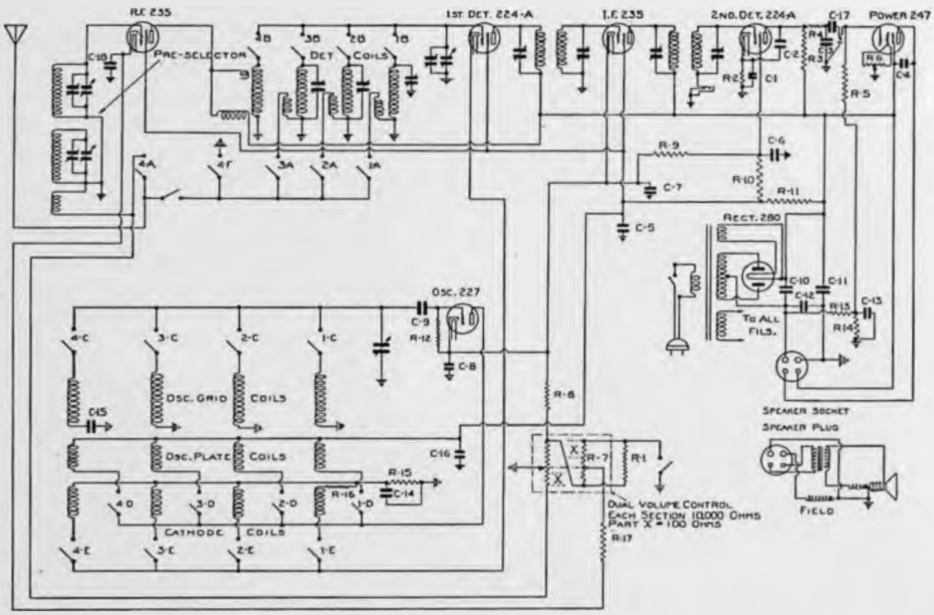
$$\frac{1}{2 \pi f C}\text{"}$$

Unfortunately the pi was lost.

The Pilot "Dragon"

In the Pilot "Dragon" we have a multiple-range receiver with some unique advantages. Fundamentally it is a 6-tube superheterodyne (plus rectifier) receiver which has been given 4 tuning ranges by means of a gang-switch. In the broadcast range the circuit is normal, consisting of a double-tuned preselector circuit feeding an r.f. amplifier tube which in turn feeds the usual superheterodyne system, namely a first detector, an i.f. stage, a second detector and a pentode output tube. The oscillator is of the '27 type and its output is fed into the cathode circuit of the first detector in the usual way. This can be seen from the diagram, the switches 4-A, 4-B, etc., being closed in this range. Actually these are parts of one drum switch with double-wiper silver contacts. In this range the volume control employs both sections, one being shunted across the antenna coil by the action of switch 4-A. The other section operates in the usual way to control tube-voltages though the circuit is out of the ordinary.

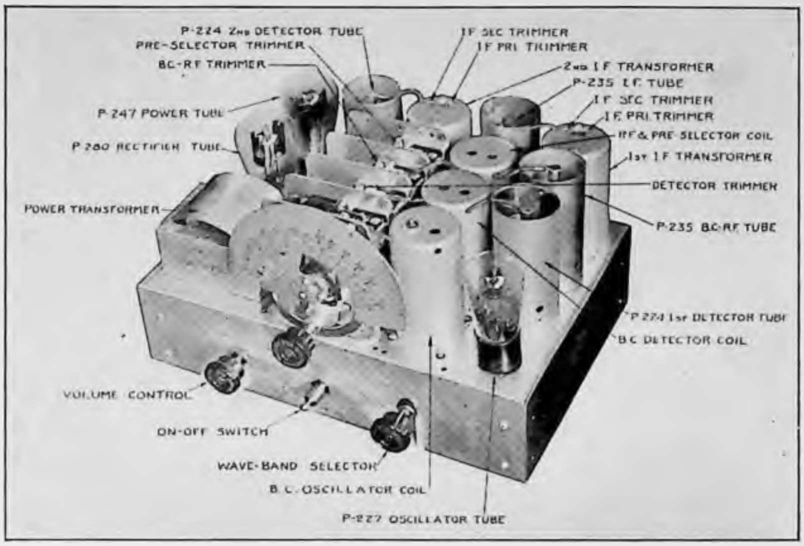
In the shortwave ranges the unusual features multiply. For simplicity the dual-preselector and r.f. tube are (properly) switched out when leaving the broadcast range. However, inductive coupling to the antenna is retained (by switches 3-A, 2-A and 1-A), which materially decreases noise and local interference. The tuning system, is unusual. Each of the detector input coils



Condensers
C1 — .25 mfd.
C2 — .0005
C3 — .0005
C4 — .01
C5 — .25
C6 — .25
C7 — .25
C8 — .1
C9 — .0001
C10 — 8
C11 — 8
C12 — .035
C13 — .25
C14 — .1
C15 — .001400
C16 — .1
C17 — .01
C18 — .1

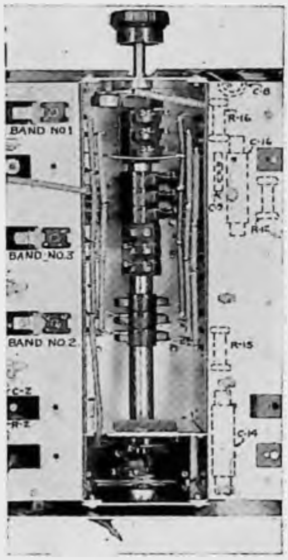
Resistors
R1 — 10000 ohms ½ w
R2 — 40000 " "
R3 — 250000 " "
R4 — 50000 " "
R5 — 500000 " "
R6 — Center Tap Resistor
R7 — 10000 ohms V.C.
R8 — 250 " ½ w
R9 — 10000 ohms ½ w
R10 — 10000 " "
R11 — 14000 " 3 w
R12 — 40000 " ½ w
R13 — 500000 " "
R14 — 120000 " "
R15 — 10000 " "
R16 — 500 " "
R17 — 300 " "

SCHEMATIC DIAGRAM
DRAGON MODEL 10 SUPER HET



carries its own trimmer so that both the range and the tuning-spread can be properly located with the same tuning condenser which is used in the broadcast band of 550-1,500 kc. Since the oscillator must shift range similarly the oscillator condenser is special, and in the broadcasting range the oscillator tuned coil (grid) is provided with a series condenser, C-15. It will be seen that all switching is so done as to leave no unused coils in circuit. The system may at first appear to be quite complex, but the mechanical arrangement is such that each coil is close to its switch contacts, and the switch in turn is close to the tuning-gang-condenser. The switch-and-coil assembly is a unit and may be wired before it is placed in the chassis—also may be removed as a unit if this becomes necessary. The arrangement of the parts is so well shown by the illustrations that little more need be said.

The tuning ranges are 18-40 meters, 33-82 meters, 80-200 meters and 200-550 meters, which includes everything but amateur 5 meter phone! The set tunes nicely in all ranges and seems free from the queer yodels and yowls so often met in the sets of firms with less previous shortwave experience. For the sake of the "fan" who wishes to use the receiver in "hunting distance" a headset jack is



The Selector Switch seen from below.

provided after the second detector. A second jack is provided for a phonograph pickup.

Since much of Pilot's business is export a variety of chasses is manufactured, differing only in the power transformer. The 50-60 cycle types are available for 110-115 volts, 125 volts, 220 volts and 240 volts. The 25 cycle types are for use at 110-115 volts and at 125 volts.

Another Type of Amplifier

By McMurdo Silver*

Today three types of audio power-output stages are available. To simplify a comparison between them let us consider the audio output stages as they appear in high-quality receivers designed for home use. The usual form of the three systems is then:

1. **A pair of '45 triodes in push-pull.**

2. **A pair of '47 pentodes in push-pull or parallel.**

3. **A pair of '46 tubes in Class B push-pull ("push-push"!).**

It is usually assumed that No. 1 is "Class A" amplification, but actually no set has in the past employed what may be properly called "true Class A" amplification. Class A audio amplification may be described as that condition under which the fixed grid bias is so located that the a.c. signal voltage causes the grid to swing between the limits set by the bends in the grid voltage plate-current curve—that is to say, along the entire straight part of this curve. Now this curve is partly in a region of positive grid voltages, therefore, small grid currents are to be expected and provided for if the curve is fully used. This is NOT the type of triode amplification utilized in the past, for that has been predicated upon setting the fixed grid bias at a point substantially midway between zero bias (above which grid current will be drawn) and the bend at the negative end of the curve. The intention is to draw no grid current at all.

It is now seen that we must make four classifications, and add to the table.

Four full-range Class A push-pull with a pair of '45 tubes.

This type of operation, in turn, is not to be confused with Class B operation, merely because some grid current is drawn. In the first place, the current is very small (¼ Ma. as compared to 50 Ma. or more) and in the second place, both tubes are working at all times while in Class B operation the two work alternately for their bias is initially set essentially at the lower bend (highly negative or else a high-mu tube with zero bias as in the '46 type) so that even a small swing carries one tube into the positive-grid region for a considerable distance, but at the same time entirely cuts off the other tube by carrying it into the highly-negative, or cut-off region so that it has no plate-current at all.

Comparison of Audio Output Systems

		Maximum Watts Out	% Harmonics at 1/5 Watt Output	% Harmonics at 2 Watts Output
1	**Normal '45 push-pull**	3.2	.5	1
2	**'47 push-pull**	5.0	2.0	2.5
3	**'46 push-pull, Class B**	16.0	6.2	1.3
4	**'45 push-pull, "True Class A"**	8.0	0.4	0.6

Distortion

Distortion—most conveniently expressed in percentage of the harmonics introduced by the amplifier—is present in all amplifiers. When the audio pentode was first introduced in 1931 there was a story current in Chicago that an engineer looked closely at a '47 and said, "Absolutely wonderful—here we have 30% distortion in a bottle". This was an exaggeration, of course. The writer has found that the allowable harmonic distortion differs with pitch, with level, with the presence of other notes, and, of course, may be masked by speaker dis-

* President, Silver-Marshall, Inc.

tortions. He has reached the conclusion that for home entertainment the I. R. E. standard allowance of 5% is altogether too high. Not over 1½% should be permitted. The writer bases this statement on a careful analysis of the reactions of a large number of people to demonstrations of the systems of the table. The demonstrations were made to small groups. As they listened to push-pull pentodes at 2.0 watts output the quality

at first seemed acceptable, as did that of the '46 tubes in Class B, though most of them remarked that it was "not as clear" as they would desire. But, as soon as they heard the '45 Class A stage they definitely condemned the pentodes and the '46 tubes. In this case the comparison was (see table) between about ½% harmonics for the '45 and about 2% for the pentodes. The conclusion was that even 1½% harmonic was "too much".

Cost

The '47 pentode and the '45 (push-pull) require about the same power supply, whereas the '46 (drawing up to 70 Ma. of grid current) must be driven by an additional power stage through a relatively expensive coupling transformer with enlarged core and windings. The output transformer is also of increased cost since it must have high inductance as compared to triode coils. The extra power stage also adds to the filtering problem.

The Choice

In choosing between the various types which have been discussed, an important consideration is the power level that is NEEDED. For home entertainment there is no use for the 16 watt output of a pair of '46 Class B tubes, two watts meeting all ordinary needs. Even for dancing 4 to 6 watts are ample. Conventional speakers begin to introduce harmonic distortion in themselves when more than 5 watts are supplied to them. On the other hand, if the level of the Class B stage is lowered to the "armchair level" of 200 milliwatts, the harmonic distortion rises because a relatively large part of the entire performance then takes place in the lower-bend region.

It appears that the best audio system would use the '45 in push-pull—but would provide less than four watts, even at a 5% harmonic distortion.

For these reasons work has been going on in our laboratories along the line of increasing the power output and further lowering the harmonic content of '45 push-pull stages. At present it is possible to obtain about 8 watts of audio output at 5% harmonic distortion and about 5 watts at 1%, using a "true" Class A system, as in item 4 of the table.

The circuit is that of the conventional push-pull amplifier and the modifications are in the constants. The plate-voltage has been increased to 300, which is perfectly safe for the '45 tube if the plate dissipation is kept down, which is done by a 68 volt negative bias. This gives a Class A amplifier, but the input or excitation, necessary is greater than can

be obtained from a '27 "power" detector, particularly as small grid currents (¼ Ma.) are drawn on large swings of the '45 grids and the coupling transformer must accordingly have a step-down ratio of 1.28/1. Consequently a coupling or driving audio stage is provided ahead of the Class A stage. It uses the '56 tube (descendant of the '27—see page 2 "Modern Radio" for May) as a voltage amplifier. The normal filtering of our receivers has been found sufficient for this system. From a fidelity standpoint such a system is believed to be superior to anything now offered. Side by side with any pentode system, the latter sounds—at any level—like the 1922 battery set with a horn speaker. The comparison with the '46 type of Class B stage is also most favorable to the new system.

Where Class B Fits In

In battery sets it is true that a pair of Class B tubes permit useful audio outputs with extreme battery economy and so justify themselves. But for the a.c. household set, where the power cost is only a cent or two an hour, Class B amplification would appear to have small justification. This, of course, is not intended to be an all-inclusive statement—there are occasions in transmission and other high-power work where an absolute necessity for many audio watts justifies Class B audio.

As for pentodes—one year of "30% distortion in a bottle" was quite enough.

The only broadcasting station in Roumania, "Radio-Bucuresti", operating with a power of 16 kw. at 394 meters. The station is at Bucarest as the station-call indicates, and the photograph comes to us from Mr. Cezar Bratescu, via Don C. Wallace.

GOOD NEWS FOR THE PHONE MAN

If you are pretty well fed up with vacuum tube voltmeters you'll help us cheer about the very clever schemes of E. A. LaPort (Westinghouse) for checking up radiophone transmitter modulation percentage and fidelity with very little besides a wavemeter. It's all in the March issue of "Electronics". Those who have never checked these things can now tackle the transmitter with some confidence.

Will someone suggest a good reason why modulated transmission is forbidden on the 75 cm. amateur transmission band?

Practical Tone Control *

An amplifier and speaker may give perfect tonal reproduction according to all engineering standards but still not appeal to many people, while other amplifiers having very poor response curves may be called good. Since radio is sold to please the individual purchaser rather than to establish a standard tone quality, it is just as logical to adjust tone as to adjust volume. Dealers should make certain every receiver they sell is tone control equipped, and service men will

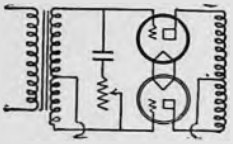


Fig. 1

find this a profitable and easily installed accessory on the older sets having sufficient high frequency response to insure a variable effect.

To avoid misunderstanding, explain to your customer that any good modern receiver is designed to give uniform output at all audible frequencies when the tone control is adjusted at the brilliant or high frequency position. This may be apparent to the era, however, only when the output volume is loud. A low frequency sound must have far greater

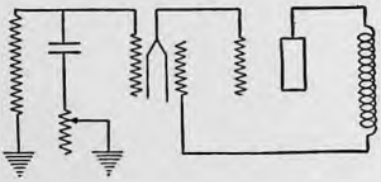


Fig. 2

energy than a high frequency sound to make the same impression on the ear. Consequently, as the volume level is reduced, the ratio between the low and high frequency changes as apparent to the ear, with the high frequencies predominating. Tone control compensation is then required by adjusting out the "highs" until the desired ratio is again restored. The general rule of operation,

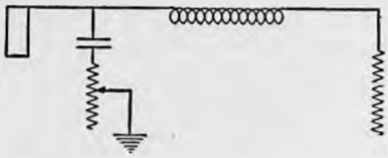


Fig. 3

therefore, is to adjust at the "high" position when the set is adjusted at loud volume as for dancing, or in large rooms, and toward the "low" position as the volume is reduced or the set used in a small room.

From this explanation, it is obvious there is no disadvantage in the simple tone control circuits that seem to change the volume as well as the tone. The

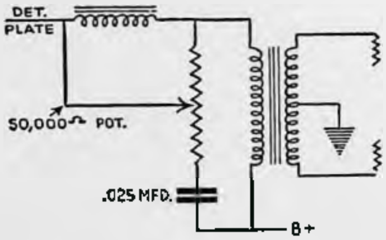


Fig. 4

better the high response of the amplifier, the greater will be the volume control effect, since tone is controlled by reducing the "highs" until the desired balance with the "lows" is obtained, and not by boosting the "lows". Actually boosting the "lows" is a difficult problem requiring careful engineering in the original design of the amplifier, and can seldom be accomplished with satisfaction by any attachment made later. Even when in-

* From the Centralab Volume Control Guide.

corporated in the original design, it can have no practical advantage over a simple tone control on a full range amplifier when the tone and volume control knobs are properly adjusted.

The most widely used and simple circuit is (shown in Figure 1. A one megohm uniform-taper rheostat) is shunted, in series with a fixed condenser, from grid to grid of the push-pull output tubes. The condenser capacity commonly used is .01 ufd. If greater high frequency cut off is desired, use a larger capacity, such as .02 ufd., while less cut off results from a smaller capacity, such as .005 ufd.

While Figure 1 illustrates a '45 output, the same parts and connections are used with a pentode push-pull, except that the condenser capacity should be about .004 ufd. The proper connection for a single pentode is shown as circuit 24, and the same connection is used with a single '45 or '50. All of these grid circuit applications, which we recommend as best, use the same one megohm control with a condenser capacity of about .01 ufd. for the '45 and about .004 ufd. for the pentode.

Some receivers locate the tone control in the detector plate per Figure 2. The rheostat should have a maximum resistance of 500,000 ohms. The condenser capacity is about .05 ufd. The arrangement of Figure 4, also located in the detector plate, is designed to boost the "lows" as well as cut the "highs". The inductances and capacities are part of the receiver design. The control is a 50,000 ohm, uniform-taper potentiometer.

Some tone controls have been located in the plate circuit of the output tubes, either pentode or '45. This circuit is not recommended because the high voltage and possible surges in this location may break down the condenser or the control. Where such trouble requires replacement parts, substitute the arrangement of Figure 1 or Figure 2.

The other evening we heard a radio singer who did NOT say "Love sends a lit-tul gift of roh-zuz".

Radio Fire Fighting

About 1921 Chief John C. Moran of the Hartford Fire Department initiated some experiments to determine the possibility of radio communication with fire apparatus and also with the cars of the Deputy Chiefs while these were on the road. The first experiments were made in conjunction with a radio transmitter owned by Mr. C. D. Tuska now connected with the Atwater-Kent Mfg. Co. of Philadelphia. This transmitter was operated by Mr. J. F. Furey. No attempt was made to use code signals although it was recognized that firemen have the advantage over the ordinary citizen in that they are trained to read such signals if voice communication should fail and the superior range of radio-telegraphy become necessary. Encouraging results were obtained although the vacuum tubes then available made maintenance of an automobile receiver difficult and costly, also the present sensitivity was then not possible. Putting it differently the idea was sound, but until the screen-grid tube came along a proper receiver was not available. Similar experiments by the Detroit Police Department and other organizations at about this same time gave similar results.

During the following years communication with moving motor cars on a one-way basis was developed in various places, outstandingly by the Detroit Police Department. The sending equipment was ahead of the receivers, and I believe this is the case today—we still do not have wholly satisfactory motor-car receivers, for such a set must combine all difficult things at once, compactness, lightweight, ruggedness and will continue to be the case—it is hard to devise a receiver to be small, light, rugged, weatherproof—and yet highly sensitive and reliable without the attendance given a transmitter. However, police departments find that with systematic service it can be done, and fire departments are fortunate in having signal services thoroughly grounded in the art of vigilant inspection and test.

A radio transmitter at Fire Department headquarters presents no new features, save that code signalling will almost certainly be retained in this new medium and used to reinforce voice. Like the entertainment station (broadcasting) and the police station, we may expect the fire department station to be faced with a fight for space in the ether. It requires far less time on the air than a police station and fewer channels will serve accordingly. If the complex problems of administration can be solved the two services may even use the same municipal station—in which case the fireman uses the police messages as tests and must have his own messages preceded by a loud signal of "ATTENTION FIREMEN". Probably one had best use his thoroughly established habits by giving him this signal in his standard bell-tap-code—reproduced AS a bell by the loudspeakers in the houses, Deputies' Cars and on the major apparatus.

"Answer Back"

This is not all that a fire department needs. As Mr. E. A. Sullivan of the Hartford department has repeatedly pointed out, it would be most advantageous to know that an order has been heard and understood; there should be an "answer back" from the moving vehicle. Now it is harder to equip a motor car with a transmitter than with a receiver, but the thing is not hopeless. This statement is not purely "blue sky". During the summer of 1931 Mr. Sullivan suggested that the more advanced state of the art warranted another look at the present possibilities. The station-to-car work was obviously possible but as a matter of interest was set up with an amateur radiofone in the "top amateur band", and a Bosch-Detroit police receiver working in an automobile equipped with various queer antennas, supposed to simulate the odd sky-wires necessary on such things as ladder-wagons, towers, etc. Though the transmitter worked with 50 watts in an inferior antenna, and the receiver was not of a late type, there was obtained a consistent 3 mile range (including railroad underpasses and streets between steel buildings), which was enough for the immediate purpose. The "answer back" problem could, of course, be properly attacked only with a mobile license but by carrying the station transmitter downstairs with a lampcord trailing behind, and setting it into the car on the driveway, it was possible to manufacture some data by using a variety of receiving points. The lampcord was then eliminated in favor of a device which manufactures a. c. from the 6 volt storage battery of the car. Limited by the requirements of an amateur license, and a 10-year-old desire to avoid interference, this work was necessarily done in amateur bands and in the chilly pre-breakfast hours when others were abed (at last, or yet). Cold feet, frosted ears and encouraging data resulted. Some such equipment, refined electrically and mechanically seems to offer a decent chance of bringing about the original thought of the Hartford Department—two-way radio contact with the Chief, his Deputies, and the major apparatus—the other in voice or tap-code and the instant "answer back" in the tap-code.

The main need appears to be for someone to foot the bill for development as Detroit footed the bill for Police Radio.

R. S. K.

"DUO DIODE"

Maybe after a while the dust will settle and we will have a common understanding of what the term "duo diode" is supposed to mean.

At this moment there appear to be diverse meanings, about as follows:

1—A push-pull type of diode rectifier. That sounds like a description of a 280, but what is meant is a push-pull detector.

2—A triode used simultaneously as a detector and as an automatic volume control tube, some of the elements being used in both circuits.

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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.

4. Address letters, "Modern Radio", 101 Allyn Street, Hartford, Connecticut.

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Short Circuits

The pendulum respects gravity without having it.

It is now spring in Hartford; summer comes on the 15th and 16th of August.

Someone has figured out that railroad telegraph operating is pretty dangerous business because you run the risk of becoming a railroad president. All right —what happens to radio operators when their wrists get stiff?

Folly of 1929—paying twice as much as necessary and regretting it. Folly of 1932—paying half as much as necessary and regretting it.

Brother Clifford thinks there is little novelty in railroad radio as he has owned many sets which whistled at every station.

Capone is supposed to have boasted that no law existed that money couldn't forget. Now what do you suppose he'd do with Ohm's law?

It is very difficult now to determine a person's social class unless you take time to observe which laws he breaks.—Hartford Times "Portico".

A nationally known radioman near New York has his program reception down to the simplest form. The family receiver was tuned to WEAF, plugged into an attic light socket and connected to a speaker downstairs. The family can listen to WEAF or can go up and snap the switch on the attic stairs—and stop listening to WEAF.

One of our neighbors believes it is possible to fry an egg with the output of the recent Class B audio systems. Why not tune the set to a night club orchestra and get it scrambled at the same time?

JUSTIFIED APPREHENSION

Feelings of cartoonist Don Hoffman of QRX (Fifth Naval District Communication Reserve publication) on hearing that amateur radio may be turned entirely over to the Federal Radio Confusion.