

157
Inductance Computation—By Edward M. Shiepe

RADIO

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WORLD

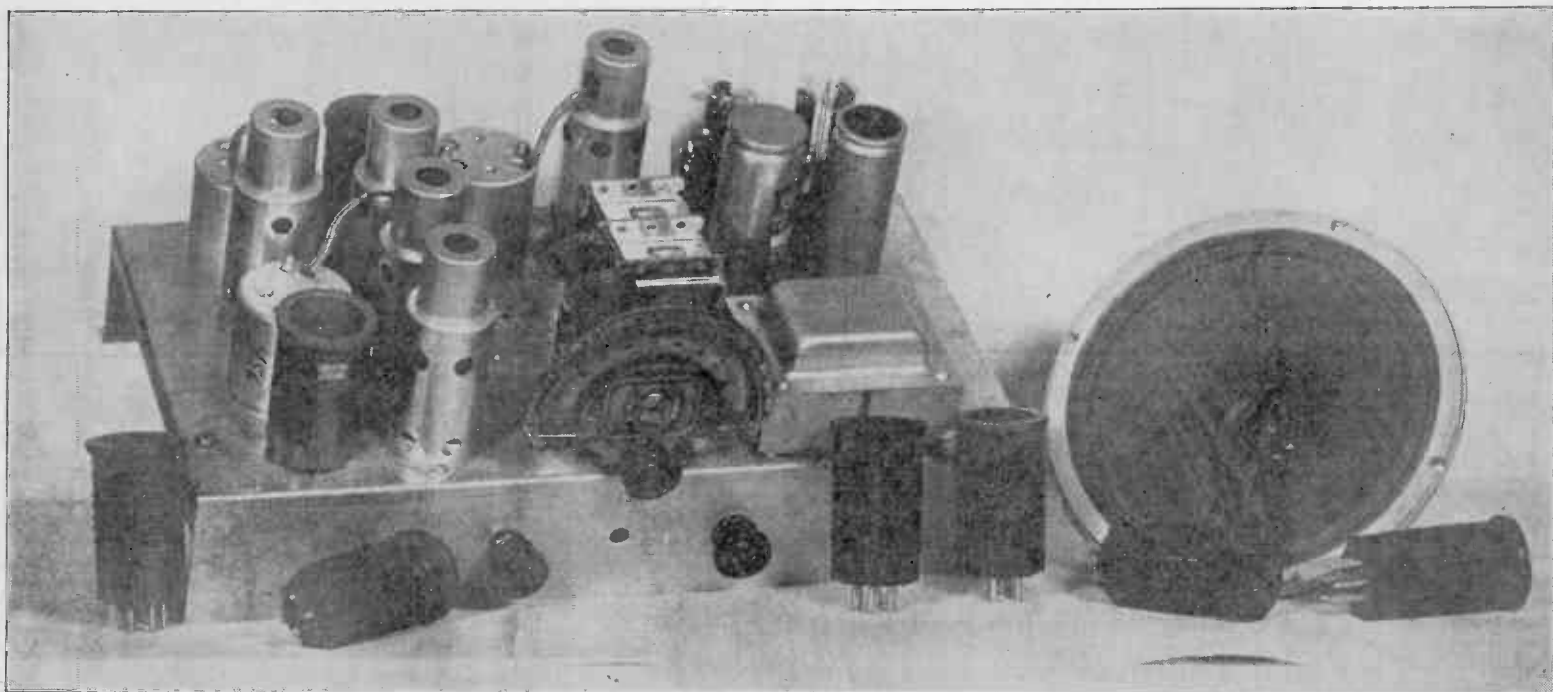
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JAN. 20th

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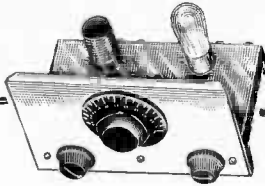
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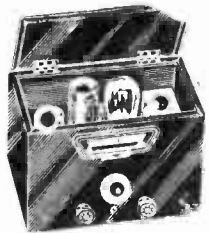
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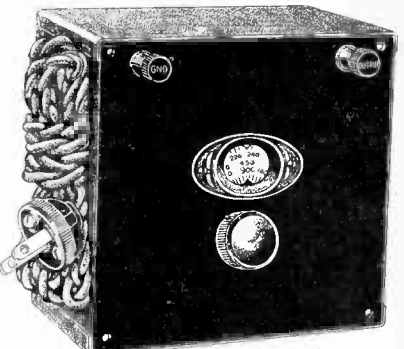
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"The Inductance Authority"

By EDWARD M. SHIEPE, B.S., M.E.E.

THE ONLY BOOK OF ITS KIND IN THE WORLD. "The Inductance Authority" entirely dispenses with any and all computation for the construction of solenoid coils for tuning with variable or fixed condensers of any capacity, covering from ultra frequencies to the borderline of audio frequencies. All one has to do is to read the charts. Accuracy to 1 per cent may be attained. It is the first time that any system dispensing with computation has achieved such very high accuracy and at the same time covered such a wide band of frequencies.
A condensed chart in the book itself gives the relationship between frequency, capacity and inductance, while a much larger chart, issued as a supplement with the book, at no extra charge, gives the same information, although covering a wider range, and the "curves" are straight lines. The condensed chart in the book so that when one has the book with him away from home or laboratory he still has sufficient information for everyday work, while the supplement, 18 x 20 inches, is preferable for the most exacting demands of accuracy and wide frequency coverage.
From the tri-relationship chart (either one), the required inductance value is read, since frequency and capacity are known by the consultant. The size and insulation of wire, as well as the diameter of the tubing on which the coil is to be wound, are selected by the user, and by referring to turns charts for such wires the number of turns on a particular diameter for the desired inductance is ascertained.
There are thirty-eight charts, of which thirty-six cover the numbers of turns and inductive results for the various wire sizes used in commercial practice (Nos. 14 to 32), as well as the different types of covering (single silk, double silk, single cotton, double cotton and enamel) and diameters of $\frac{1}{16}$, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, $1\frac{1}{4}$, $1\frac{1}{2}$, 2 , $2\frac{1}{2}$, 3 , $3\frac{1}{2}$, 4 inches.

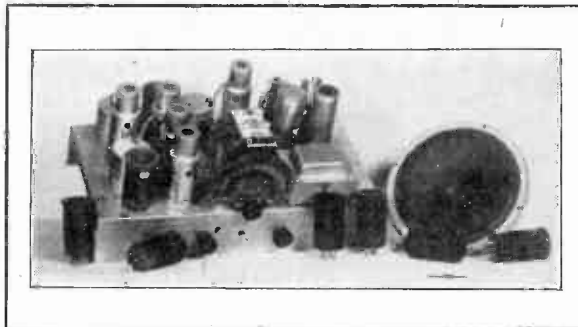
EACH turns chart for a given wire has a separate curve for each of the thirteen form diameters. The two other charts are the tri-relationship one and a frequency-ratio chart, which gives the frequency ratio of tuning with any inductance, when using any condenser the maximum and minimum capacities of which are known.
The book contains all the necessary information to give the final word on coil construction to service men engaged in replacement work, home experimenters, short-wave enthusiasts, amateurs, engineers, teachers, students, etc.
There are ten pages of textual discussion by Mr. Shiepe, graduate of the Massachusetts Institute of Technology and of the Polytechnic Institute of Brooklyn, in which the considerations for accuracy in attaining inductive values are set forth. These include original methods.
The curves are for close-wound inductances, but the text includes information for correction factors for use of spaced winding, as well as for inclusion of the coils in shields. The book therefore covers the field fully and surpasses in its accuracy any and all mechanical aids to obtaining inductance values.
The publisher considers this the most useful and practical book so far published in the radio field, in that it dispenses with the great amount of computation otherwise necessary for obtaining inductance values, and disposes of the problem with speed that sacrifices no accuracy.
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THE circuit is a seven-tube superheterodyne, using two plug-in coils for each band, total four bands, or eight coils.

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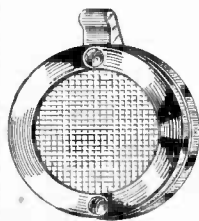
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INDUCTANCE COMPUTATION

THE MOST HIGHLY ACCURATE METHOD, AS COMPARED TO USUAL PROCEDURE THAT SOMETIMES DEVELOPS 20% ERROR

[The following masterful theoretical discussion of inductance computation is reprinted by special permission from "The Inductance Authority," a book consisting principally of curve sheets that dispense with all computation in determination of inductance. The highly accurate formulas were used for establishing the many points from which the curves were run.—Editor.]

By Edward M. Shiepe, B. S., M. E. E.

Massachusetts Institute of Technology and Brooklyn Polytechnic Institute

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THE radio engineer has found it troublesome getting his coil data. About the only way he could design a coil having a given inductance for his radio frequency circuits was to make several calculations until he hit upon the right value, or to cut-and-try. Now and again sporadic attempts were made to give coil information, but they were all limited in scope and accuracy.

It has been almost rule-of-thumb to use the "current-sheet" inductance formula, given later, and even authoritative writers, while pointing out the approximate nature of this formula for the usual radio coils, neglected to indicate how values of much greater precision could be obtained. For certain coils of round wire, this "current-sheet" inductance may be as much as 15 per cent. off from the true r-f inductance, and it is disconcerting to find writers innocently claiming for it accuracies of better than 1 per cent. Much of other published coil data suffers from this inaccuracy.

Method of Calculation

The method of calculation is outlined by the Bureau of Standards¹ and will be described here. The first step is to calculate the "current-sheet" inductance L_s by the formula

$$L_s = \frac{.0395 a^2 n^2 K}{b} \text{ microhenries} \quad (1)$$

1. "Circular 74," page 252.

where a = radius of coil to center of wire in cms.

n = total number of turns.

b = length of winding in cms.

K = a function of $2a/b$ and is given in Table I.

In this work we are dealing entirely with close winding in which case the coil length b is given by

$$b = \frac{n}{(\text{T. P. Cm.})}$$

where (T. P. Cm.) is the number of turns per cm. for the particular type of wire and is given on the curve sheets. Equation (1) now becomes

$$L_s = .0395 (\text{T. P. Cm.}) a^2 n K \quad (2)$$

We are dealing exclusively with round wire. For coils wound with this wire, (2) gives values which in some cases are as much as 10 or 12% too large. The inductance for round wire can be obtained much more precisely by means of correction terms. The corrected inductance is given by

$$L_s = L_s - .01257 na(A + B) \quad (3)$$

where L_s is obtained from (2),

A is a function of d/D (where d is the bare wire diameter and D is the distance between centers of turns) and is given in Table II.

B is given in Table III.

Formula (3) takes account of the space occupied by the insulation, and gives most precise values for the low-frequency inductance.

All curves in the book were calculated

from (3), each being determined by eleven or more well-spaced points.

High-Frequency Inductance

For a single-layer inductance coil of round wire the use of (3) gives a very accurate value on the basis of uniform current distribution over the cross section of the wire. At high frequencies, however, the current tends to flow on the surface of the wire and to concentrate itself on the inner side of the coil.² This decreases the effective radius of the winding and hence lowers the inductance. A decrease in radius, however, also increases the value of K , tending to keep the inductance constant, but not in fact doing so because for all but very short coils the variation in L due to a change in K is only about 10 or 20% of the variation in L due to the change in radius.

At very high frequencies most of the coil current would flow on the inner surface of the wires, making the coil function as if its radius were only greater than that of the winding-form by slightly more than the thickness of the insulation on the wire. On this basis, we can locate the r-f inductance of a coil as being somewhere between the low-frequency values corresponding to the coil-form diameter and to the coil diameter.

The direct calculation of the high-frequency inductance involves considerable labor and is of doubtful value for any but

2. Morecroft, Principles of Radio Communication, p' 156.

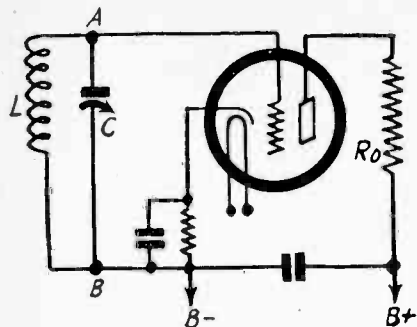


FIG. 1

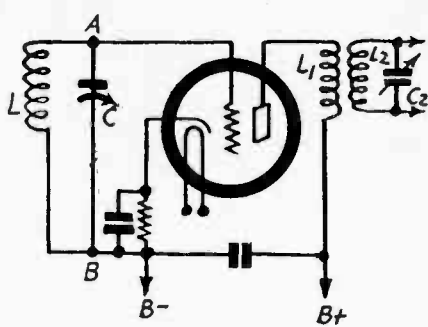


FIG. 2

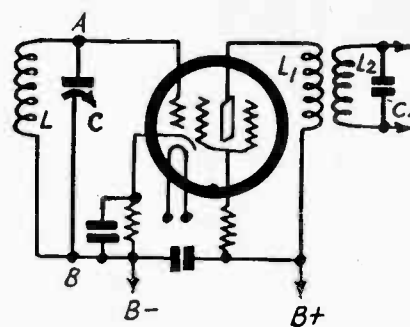


FIG. 3

Typical circuits referred to in the text in connection with inductance computation. Tuning condenser and stray capacities are considered.

the lower radio frequencies. The best work on the subject is necessarily very mathematical and may be found by reference to the publications of the bureau of Standards.³

Circuit Inductance

All r-f circuits are made up of various combinations of inductance, capacity and resistance. These factors alone, properly evaluated, determine the frequency response of such circuits. We shall discuss each of these factors separately and give some examples of their size and calculation.

The great majority of r-f circuits is used in conjunction with vacuum tubes. The presence of these tubes alters the values of inductance, capacity and resistance. As illustrations, take the grid and plate coils of

Figs. 1, 2 and 3. For all frequencies up to about 30,000 kc. the inductances of the leads inside the tube are small enough to be neglected, and the total inductance comprises that of the coil and of the wiring to the tube. In a well-designed circuit for broadcast frequencies, the lead inductances are negligible, leaving only the coil inductance for consideration.

How Much Inductance

Let us differentiate between the grid coil and the plate coil and first consider the grid coil L_2 in Figs. 1, 2 and 3. Neglecting the effect of resistance on frequency, we use curves from "The Inductance Authority" to ascertain what inductance is required for the capacity at hand. Assume that we wish to tune in a band from 500 to 1500 kc. and that the maximum capacity, including that of the

condenser, is 0.0005 mfd. How much inductance do we need and how low a minimum capacity must we have to make this possible? Follow the line for 0.0005 mfd. until it meets the 500 kc. line and read the corresponding inductance by going up to the intersection on the vertical scale. It is 203 microhenries. From this point, follow the 203 microhenry line horizontally to the left until it intersects the 1,500 kc. line, and at that point read the minimum capacity necessary. It is 0.000056 mfd. Should we want any frequency overlap, we would have to increase the inductance slightly and this would require an even smaller minimum capacity. A well-designed broadcast circuit will have a frequency ratio of about 3 to 1.

Now we go to the wire sheets to find the number of turns of wire for our secondary.

(Continued on next page)

3. See Hickman, Bureau of Standards, v. 19, 1923-4, for formulas.

TABLE I
Shape Factor K of Coil Depending on the Ratio of the Diameter to the Axial Length in any Units

Diameter		Diameter		Diameter	
Length	K	Length	K	Length	K
0.00	1.0000	2.00	0.5255	7.00	0.2584
.05	.9791	2.10	.5137	7.20	.2537
.10	.9588	2.20	.5025	7.40	.2491
.15	.9391	2.30	.4918	7.60	.2448
.20	.9201	2.40	.4816	7.80	.2406
0.25	0.9016	2.50	0.4719	8.00	0.2366
.30	.8838	2.60	.4626	8.50	.2272
.35	.8665	2.70	.4537	9.00	.2185
.40	.8499	2.80	.4452	9.50	.2106
.45	.8337	2.90	.4370	10.0	.2033
0.50	0.8181	3.00	0.4292	10.0	0.2033
.55	.8031	3.10	.4217	11.0	.1903
.60	.7885	3.20	.4145	12.0	.1790
.65	.7745	3.30	.4075	13.0	.1692
.70	.7609	3.40	.4008	14.0	.1605
0.75	0.7478	3.50	0.3944	15.0	0.1527
.80	.7351	3.60	.3882	16.0	.1457
.85	.7228	3.70	.3822	17.0	.1394
.90	.7110	3.80	.3764	18.0	.1336
.95	.6995	3.90	.3708	19.0	.1284
1.00	0.6884	4.00	0.3654	20.0	0.1236
1.05	.6777	4.10	.3602	22.0	.1151
1.10	.6673	4.20	.3551	24.0	.1078
1.15	.6573	4.30	.3502	26.0	.1015
1.20	.6475	4.40	.3455	28.0	.0959
1.25	0.6381	4.50	0.3409	30.0	0.0910
1.30	.6290	4.60	.3364	35.0	.0808
1.35	.6201	4.70	.3321	40.0	.0728
1.40	.6115	4.80	.3279	45.0	.0664
1.45	.6031	4.90	.3238	50.0	.0611
1.50	0.5950	5.00	0.3198	60.0	0.0528
1.55	.5871	5.20	.3122	70.0	.0467
1.60	.5795	5.40	.3050	80.0	.0419
1.65	.5721	5.60	.2981	90.0	.0381
1.70	.5649	5.80	.2916	100.0	.0350
1.75	0.5579	6.00	0.2854		
1.80	.5511	6.20	.2795		
1.85	.5444	6.40	.2739		
1.90	.5379	6.60	.2685		
1.95	.5316	6.80	.2633		

[The data in the foregoing table were compiled by the Bureau of Standards and are not part of the copyright.]

(Continued from preceding page)

Let us agree to use No. 28 enameled wire on a form of one inch diameter. Turning to the sheet for No. 28 enameled wire on page 41 and following the line for one inch diameter, we find that it intersects the 203 microhenry line at 137 turns. This is from the diameter of the coil form. The coil diameter is larger than that of the form by the diameter of one wire, which is 0.0137 inch in this instance. The over-all diameter of the coil is then about 1.014 inches. What fraction of the distance between 1 inch and 1 $\frac{1}{8}$ inches is 1.014 inches? An estimate shows that it is about one-tenth of the way over, and the corresponding number of turns for this new diameter is 135, or 2 turns fewer than before. The r-f inductance may be expected to be such that the number of turns required is between 137 and 135, or about 136. If the coil is properly shielded, the shield will decrease the inductance by about 2%. Noting from equation (2) that for small changes, the inductance is approximately proportional to the number of turns, we must increase this number by 2% to correct for the loss caused by the shield. This amounts to $.02(136) = 2.7$ or about 3 turns, so our coil finally becomes 139 turns of wire. For large changes in numbers of turns the inductance is proportional to the square of the number of turns, for then the variation in K becomes considerable and must be taken into account.

The above calculation is on the basis of 73 T. P. I. If we refer again to equation (2), we see that the inductance is also approximately proportional to the T. P. I. Should our coil have 72 instead of the specified 73, we shall be low by about 1 $\frac{1}{2}$ per cent.

Closer Reckoning

Now for the plate circuit inductance, as L_1 in Figs. 2 and 3. Once we have determined the value of L_1 , we proceed in the same manner for L_2 .

Before we can design L_1 we must obtain some more information about the tuned circuit L_2C_2 which we have already specified. This is the "selectivity factor" which tells us about how steep our resonance curve is. This factor is given by

$$\eta_2 = \frac{R_2}{2\pi f L_2} \quad (4)$$

and should be kept as small as possible by making the coil of low resistance. The condition for maximum voltage amplification calls for the following relation to be satisfied⁴

$$L_1 = \frac{\eta_2 r_p}{2\pi f k_2} \quad (5)$$

where r_p is the internal a-c plate resistance of the tube and k is the coefficient of the coupling between L_1 and L_2 , and depends almost entirely on the geometrical relationship of two coils. From considerations of selectivity it turns out that the effective selectivity factor η_2 of the secondary (including the effect of the presence of the primary) is

$$\eta_2' = \eta_2 + \frac{\eta_2}{k}$$

so the larger the value of k , the smaller the net selectivity factor of the tuned circuit. With $k = 0.5$, the factor is $3\eta_2$. For $k = 1$, it is $2\eta_2$. In the $\eta = 0.5$, example (a common one), the selectivity is 50% poorer. So we should make the coupling close between primary and secondary, and Browning has used values as high as 0.9.

Coil Size

For the screen-grid tube, the plate impedance should be large to match the tube impedance, so the inductance L_1 should be large. However, L_1 must be kept small enough so its natural frequency is higher than the highest frequency to be tuned in, if

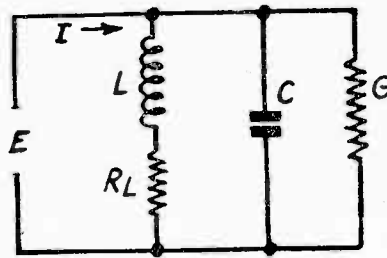


FIG. 4

Resistance has an effect on frequency not often considered. This circuit has formal parameters treated in the text in connection with resistance factors.

the circuit is to have a uniform amplification curve.

The electrical efficiency of a coil is greatest when it has the largest inductance for a given length of wire. For low frequencies this occurs when the diameter is 2.46 times the length. If we have a coil whose length is one inch, its diameter should be 2.46 inches to satisfy this relation. At radio frequencies the ratio is a little less. However, so long as we keep the same length of wire, the inductance is almost the same over rather wide values of this ratio. Thus, if the ratio is anywhere between 1.5 and 4.5, the decrease in inductance from the maximum value is only 3 per cent.

From the viewpoint of circuit or mechanical efficiency, the best coil need not be the one having the best electrical efficiency. The trend in receiver design is toward greater compactness and shielding and both of these factors have compressed coils to diameters often one inch or less and caused them to be wound with fine wire. The selectivity factors of such coils are high, although the circuit selectivity may be good. This is because several tuned circuits are used in a modern receiver, increasing to a sufficient degree the overall selectivity.

The prevention of oscillations in r-f amplifiers and the proper use of the screen-grid tube call for shielding of the radio coils. This shielding decreases the coil inductance and introduces additional capacity to the coil. By properly designing the shield, the additional capacity may be confined to a negligible value and the inductance will decrease only slightly. A good working rule is to make the diameter of the shield at least twice the coil diameter. Doing this, and centering the coil within the shield, reduces the capacity to a negligible value and reduces the inductance by only 1 or 2 per cent.

Coils With Spaced Windings

The coil charts in this book are all for close winding. For certain applications, especially in short-wave coils, it is sometimes found desirable to space the winding, and doing this alters the self-capacity, r-f resistance, as well as the inductance of the coil. In this section, we are interested in the inductance of such coils and we will see how to obtain it, and with what degree of accuracy.

Were the attempt made to give charts for all spacings, such as we have here for close winding, there would have to be a complete set of charts for each spacing. A large number of charts would be necessary. However, the charts which we now have can be used to give the inductance of spaced windings, although the accuracy will not be as great as for close-wound coils. In what follows examples of coils will be given, and it will be seen that the values obtained are two or three and generally less than five per cent off from the correct ones.

Given a winding form of a certain diameter, one usually knows how much space is available for the winding, or the length of the coil. These two parameters, diameter and length, determine the shape-factor K of the solenoid. In equation (1) on page

4 we note that if a , b , (and hence K) are held constant, the inductance is proportional to the square of the number of turns n . We can use this fact to obtain the inductance of our space-wound coil.

First, we choose the number wire we wish to use. Then we use the curves for enameled wire (because they approximate most nearly the "current-sheet" inductance) and find out from the T.P.I. how many close-wound turns may be gotten in the space available, and what the inductance of this reference coil is.

Call these n' and L' . If we propose to wind n spaced-turns, the inductance is

$$L = L' \left(\frac{n}{n'} \right)^2$$

Formula Transposed

If we do not know how many turns to wind, but do know the required inductance L , we use the same method except that we transpose the above formula to read

$$n = n' \left(\frac{L}{L'} \right)^{\frac{1}{2}}$$

We only have to remember that n' and L' are the reference coil, and n and L are the required coil. It is helpful to note that the ratios are always fractional, and that the required factor is always less than the corresponding reference factor.

Certain facts contribute to making this method approximate, however, close the values obtained may be to the correct ones. The first of these is that the curve sheets show values of inductance which already have a correction factor applied (as in equation 3) and so do not strictly show the "current-sheet" inductance of equation (1). Even though the curve sheets did show the "current-sheet" values, the correction factor of (3) would have to be applied, especially for large spacings, to get the corrected inductance. For more accurate work, this can easily be done. In the following examples, it was not applied, but the values are seen to be quite close to the true ones, and generally sufficient for most work.

Examples of Spaced-Windings

What is the inductance of a coil of 20 equally spaced turns of No. 22 wire on 2 inches diameter, the winding length to be 1.725 inches?

The reference coil has $29 \times 1.725 = 50$ turns whose inductance is 111.7 microhenries. The required coil then has an inductance of $111.7 (20/50)^2 = 111.7 \times 0.16 = 17.85$ microhenries. The precise inductance of this coil is 18.46 microhenries. The 17.85 microhenries value is 3.3% low.

Another Coil

What is the inductance of a coil of 10 equally-spaced turns of No. 14 wire on $\frac{3}{4}$ inch diameter, the winding length being 1 $\frac{1}{3}$ inches?

The reference coil has $15 \times 1.333 = 20$ turns whose inductance is 3.2 microhenries. The required coil then has an inductance of $3.20 \times (10/20)^2 = 3.20/4 = 0.80$ microhenries. The precise inductance of this coil is 0.84 microhenries, so the value obtained is less than 5% low of the true inductance.

Case of Known Inductance

It is required to wind a coil of 9.0 microhenries with equally spaced turns on $\frac{1}{4}$ inches diameter, the winding to be 1.72 inches long and of No. 20 wire. How many turns are required?

For a winding length of 1.72 inches of No. 20 wire, 50 turns of close wound enameled wire can be wound, as seen from the curves, and the inductance of this reference coil is 42.1 microhenries. The required number of turns is therefore $50 (9/42.1)^{\frac{1}{2}} = 50 \times 0.462$ or 23.2 turns. The precise inductance of

4. Glenn H. Browning, Radio News, June 1929.

these 23.2 turns is 9.23 microhenries and the variation is 2.5%.

Circuit Capacity

Besides the tuning capacity C there are three capacities which must be added to C to give the total circuit capacity. These are 1, capacity between wiring; 2, coil capacity and 3, capacity introduced by the presence of the tube.

Capacity Between Wiring

The capacity between wiring may amount to as much as 50 mmfd. when the circuit is shielded. It is customary to ground one side of the tuned circuit to the shield, as at B in Figs. 1, 2 and 3, the rotary plates of the condenser being grounded. The stationary plates then have a fixed capacity to any shielding or metallic parts in the vicinity. Care should be taken to keep this capacity low to increase as much as possible the capacity ratio of the condenser, maximum to minimum, for the frequency ratio is the square root of the capacity ratio.

Coil Capacity

Exact formulas for coil capacity are not known. An approximate value for single-layer solenoids, good to perhaps 25%, is to take this capacity in mmfd. as equal to the radius of the coil in centimeters.

For multiple layer coils the internal ca-

capacity is much larger and practical formulas have been developed for its calculation.⁵

Capacity Due to the Tube

Refer to the input circuits of Figs. 1, 2 and 3. The effective input capacity looking into the grid circuit of the tube depends upon the frequency. For frequencies below 160 kc. it is closely given by⁶

$$C = C_g + C_m + \mu C_m \left(\frac{R_o}{r_p + R_o} \right) \quad (6)$$

where C_g = capacity between grid and cathode.

C_m = capacity between grid and plate.

μ = amplification factor.

R_o = external plate-circuit resistance.

r_p = internal a.c. resistance of tube.

For frequencies greater than 160 kc. the input capacity is expressed by the inter-element capacities, as

$$C = \frac{C_g C_m + C_g C_p + C_m C_p}{C_m + C_p} \quad (7)$$

where C_p = capacity between plate and cathode.

In the screen-grid tube circuit of Fig. 3 the above expressions reduce to a simpler form, because this tube has negligible grid-to-plate capacity. If we put $C_m = 0$ in (6) and (7), both expressions become $C = C_g$.

5. Morecroft "Principles of Radio Communication," p. 230.

6. Van Der Bijl, "Thermionic Vacuum Tubes," 1st ed., p. 192.

Values of C_g , C_p and C_m for the various tubes are given in Table 4.

Unity Power-Factor Tuning

Whether f, L or C is made the variable, with the others fixed in value, the condition for unity power factor is satisfied when

$$f = \frac{1}{2\pi} \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} \quad (9)$$

Maximum-Impedance Tuning

This is the usual type of radio tuning and is called just the "resonance" condition. The relation between the factors depends on which of them is variable.

For variable frequency, with constant E, L, R, C and G the condition for current resonance or maximum-impedance requires that

$$f = \frac{1}{2\pi} \sqrt{\frac{1}{C^2 L^2 + \frac{2R^2}{CL^3}} - \frac{R^2}{L^2}} \quad (10)$$

For variable capacity, with constant f, E, L, R and G the same relation holds (equation 9) as for unity power-factor tuning. That is, with condenser tuning we have both unity power-factor and maximum impedance at the same setting of the condenser. A study of the vector diagram for this case very clearly shows this to be true.⁸

For variable inductance, with f, R, C, G and E constant?

Effect of Resistance on Frequency

The effect of resistance in a resonant circuit is to decrease the selectivity and generally lower the resonant frequency. In a well-designed circuit this resistance is kept as small as possible for good selectivity, and doing this decreases the resistance to a low enough value that its effect on the frequency is negligible. In a parallel circuit having negligible resistance, the frequency of resonance is the same as for a series circuit and is given by

$$f = \frac{1}{2\pi \sqrt{LC}} \quad (8)$$

TABLE IV

Tube Capacity Constants

Type of Tube	Inter-Electrode Capacities in Micro-Microfarads		
	C_m	C_g	C_p
112A	8.1	4.2	2.1
199	3.3	2.5	2.5
120	4.1	2.0	2.3
171A	7.4	3.7	2.1
200A	8.5	3.2	2.0
201A	8.1	3.1	2.2
210	8.0	5.0	4.0
222	0.025	3.2	12.0
Max.			
0.010	5.0	10.0	
Max.			
226	8.1	3.5	2.2
227	3.3	3.5	3.0
230	6.0	3.7	2.1
231	5.7	3.7	2.2
232	0.025	6.0	11.7
Max.			
0.9	8.9		11.1
0.020	6.4		12.8
0.010	5.0		10.0
Max.			
0.010	3.7		9.2
Max.			
2.0	3.5		2.2
0.3	4.1		8.5
0.007	4.0		10.0
Max.			
8.8	3.4		1.5
8.0	5.0		3.0
1.25	8.7		13.2
9.0	5.0		3.0
3.2	3.2		2.2
0.010	5.2		6.8
Max.			
0.010	5.2		6.8
Max.			

TABLE II

Correction Factor for Self-Inductance of the "Current Sheet" Inductance to Compensate for Insulation Between Adjacent Turns

$\frac{d}{D}$	$\frac{A}{D}$	$\frac{d}{D}$	$\frac{A}{D}$	$\frac{d}{D}$	$\frac{A}{D}$
1.00	0.557	0.40	-0.359	0.15	-1.340
0.95	.506	.38	.411	.14	1.409
.90	.452	.36	.465	.13	1.483
.85	.394	.34	.522	.12	1.563
.80	.334	.32	.583	.11	1.650
0.75	0.269	0.30	-0.647	0.10	-1.746
.70	.200	.28	.716	.09	1.851
.65	.126	.26	.790	.08	1.969
.60	.046	.24	.870	.07	2.102
.55	-.041	.22	.957	.06	2.256
0.50	-0.136	0.20	-1.053	0.05	-2.439
.48	.177	.19	1.104	.04	2.662
.46	.220	.18	1.158	.03	2.950
.44	.264	.17	1.215	.02	3.355
.42	.311	.16	1.276	.01	4.048

TABLE III

Correction Factor for the Mutual Inductance to Compensate for the Difference Between the Mutual Inductance of the Actual Coil and the Mutual Inductance of the "Current Sheet." The Mutual Inductance Meant is that Between the Individual Turns of the Same Coil

Number of turns, n	B	Number of turns, n	B
1	0.000	40	0.315
2	.114	45	.317
3	.166	50	.319
4	.197	60	.322
5	.218	70	.324
6	0.233	80	0.326
7	.244	90	.327
8	.253	100	.328
9	.260	150	.331
10	.266	200	.333
15	0.286	300	0.334
20	.297	400	.335
25	.304	500	.336
30	.308	700	.336
35	.312	1000	.336

(Continued from preceding page)

In general, radio circuits are designed so that the effect of resistance on frequency is negligible. This is done not so much to minimize the effect of resistance on frequency as to realize good selectivity in the circuit. In this section, however, we are interested in the effect of resistance on frequency, and we shall find that in some cases as well as for certain methods of tuning the effect of resistance is of great importance.

The usual radio circuit has parameters which may be closely represented by Fig. (4), in which E is the r-m-s value of the a-c electromotive force of frequency f, and G is the conductance in mhos of any leakage path across the condenser.

If we vary the frequency of E and measure the line current I with an ammeter we shall find that at some frequency f the current I becomes a minimum. At this frequency the tank circuit is said to be in current-resonance or maximum-impedance resonance. Holding the circuit in this resonant condition we investigate the phase relationship between E and I and we find that E and I are not quite in phase, so that the voltage and current maxima and minima occur just a little out of step. By continuing to vary the frequency we find such a frequency as will cause voltage and current to be in phase, but now we no longer have a minimum line current. In other words, the frequency for unity power factor is in this case different from that for maximum impedance. The equations which follow⁷ all refer to Fig. (4).

$$f = \frac{1}{2\pi} \sqrt{\frac{1+2RG}{2LC} + \left(\frac{R^4}{L^4} + \frac{R^2+2RG}{CL^3} + \frac{(1+2RG)^2}{4L^2C^2} \right)^{1/2}} \quad (n)$$

An excellent picture of the process of inductance tuning for the cases where R is a constant and where R is proportional to L, can be gained by reading Reuben Lee's article.⁸

It is thus seen that the frequency of resonance is not always simply a matter of inductance and capacity.

Example of Oscillator and Detector

Now see what the practical meaning of equations (9) and (10) is in an actual case. Suppose we have a calibrated oscillator of constant output and a detector circuit far enough away from it so that the mutual inductance in either one. We shall assume self-bias detection of the non-grid-current type such as may be had with a type 57 tube, negligible leakage across the condenser with no grid-current at maximum signal, making G zero in value. Take L = 200 microhenries (usual broadcast coil), C variable to about 0.0005 mfd. and let R be 400 ohms. The value for R is more than twice as much as it should be, but we are assuming that the coil is improperly designed and we want to see what the effect is upon the frequency response of the circuit.

First, we set our oscillator to 522 kc. Then we tune with the condenser of the detector and obtain current-resonance at 0.00035 mfd. This is maximum-impedance tuning with variable capacity and is given by equation (9). If, however, we had started with a fixed capacity of 0.00035 mfd. and varied the frequency of our oscillator for resonance we would have obtained the resonance peak at 593 kc. as given by equation (10). Had the coil no resistance, the resonance peak for either case would have been at 600 kc.

At radio frequencies the resistance of a solenoid is usually many times its resistance to direct current. As the frequency of the current is increased, the current concentrates nearer and nearer the inner surface of the coil, as explained in the section on r-f inductance. For the end turns on the coil this

Mexican Stations

Call Letters	Owner	Location	Watts	Kc
NEA	Alberto Palos Sauza	Juan Manuel 383, Guadalajara, Ja.	125	1,000
XEB	El Buen Tono, S. A.	El Buen Tono 6, México, D. F.	10,000	1,030
XEC	Jesús R. Benavides	Independencia 76, Toluca, Mex.	50	1,000
XED	Cia. Radiofonográfica, S. A.	16 de Septiembre 13, Guadalajara, Jal.	500	1,150
XEH	Constantino de Tárnava	Padre Mier 215, Monterrey, N. L.	250	1,130
XEI	Carlos Gutiérrez	Francisco I. Madero 545, Morelia, Mich.	125	550
XEJ	Juan G. Buttner	Avenida Lerdo 309, Ciudad Juárez, Chih.	250	1,010
XEK	Arturo Martínez	Jalapa 51, México, D. F.	100	990
XEL	Antonio Garza Castro	Aldama 59, Saltillo Coah.	10	1,000
XEN	Cerveceria Modelo S. A.	Motolinia 22, Edif. La Perla, México, D. F.	1,000	710
XEP	Ana María Rovalo de Pasalagua	Hotel Imperial, México, D. F.	500	780
XEQ	Francisco Conde Urdaneta	Insurgentes 539, México, D. F.	500	1,330
XER-XEF	Cia Radiodifusora de Villa Acuña, S. A.	Apartado Postal 30, Villa Acuña, Coah.	150,000	660
XES	Fernando Sada	Aduana Sur 4, altos, Tampico	250	1,020
XET	México Music Co. S. A.	Hidalgo 308, Oriente, Monterrey, N. L.	500	690
XEU	Fernando Pazos	Vicario 12, Veracruz, Ver.	100	1,010
XEW	Cadena Radiodifusora Mexicana, S. A.	16 de Septiembre 9 A., México, D. F.	5,000	910
XEY	Bartolomé García Correa	Calle 65,436, Mérida Yuc.	10	550
XEX	Luis F. Petit Jean	Aldama 932 Sur, Monterrey, N. L.	50	630
XEAB	Humberto García R.	Pino Suárez y Juárez, Nuevo Laredo, Tamps.	7.5	1,450
XEAC	Francisco de P. Cabrera	Jardin Hidalgo Sur, San Luis Potosí, S. L. P.	100	1,290
XEAE	Adolfo Labastida, Jr.	Ave. D. 542 (A. Postal 42), Tijuana, B. C.	800	1,000
XEAF	Manuel Mascareñas	Hotel Central, Nogales Son.	100	1,000
XEAI	Carlos González Caballero	Calz. del O. Mundial 21, México, D. F.	100	1,090
XEAW	Horacio Remes	Calle Canal 42, Veracruz, Ver.	250	1,100
XEAO	Luis L. Castro	C. Altamirano 156, Mexicali B. C.	7.5	560
XEAW	Cia. Int. Dif. de Reynosa S. A.	Reynosa, Tamps.	10,000	960
XEFA	Eduardo Limón Seguí	Mar Mediterráneo 236, Tacuba, D. F.	500	1,250
XEFB	Jesús Quintanilla	5 de Mayo Oriente 112, Monterrey, N. L.	100	1,310
XEFC	Julio Molina Font	Calle 59, 517, Mérida, Yuc.	100	1,050
XEFD	Carlos de la Sierra	Calle 5a. 312, Tijuana, B. C.	300	760
XEFE	Rafael T. Carranza	Km. 4, Carretera Laredo-Mont., N. Laredo, Tamps.	100	1,000
XEFG	Manuel Espinosa Tagle	Tepic y Lampazos, México, D. F.	250	1,080
XEFI	Feliciano López Islas	Ave. Hidalgo 73, Col. Industrial, Chihuahua, Chih.	250	1,000
XEFJ	Rodolfo Junco de la Vega	C. Morelos Oriente 759, Monterrey, N. L.	100	1,000
XEFO	Partido Nacional Revolucionario	Ave. Morelos 110, México, D. F.	5,000	940
XEFS	Salvador Sánchez	Calle Montes 23, Querétaro, Qro.	40	1,000
XEFV	José Onofre Meza	Tlaxcala 1013, Ciudad Juárez, Chih.	100	1,370
XEFW	José Expedito Martínez	C. Madero Poniente 19, Tampico, Tamps.	70	1,280
XEFZ	Manuel Zetina	Calzada Nonoalco 481, México, D. F.	100	1,370
XEPN	Cia. Radiodif. de Piedras Negras, S. A.	Piedras Negras, Coah.	50,000	585
XETB	José A. Berumen	R. Corona 317, Torreón, Coah.	125	1,380
XETE	Empresa Teléfonos Ericsson, S. A.	C. Central 3, Colonia del Valle, México, D. F.	250	9,550
XETH	Ramón Huerta	Calle 17 Oriente 6, Puebla, Puebla	100	860
XETR	Cia. Radiod. XETR de la Ciudad de México	Avenida Juárez 102, México, D. F.	1,000	610
XETU	Benito Castillo	ex-Hacienda de la Luz, Pachuca, Hgo.	100	890
XETW	Rafael M. Peña	Edif. "High Life", Gante 4, México, D. F.	500	830
XENT	Cia. Ind. Universal de México, D. F.	Apartado 47, Nuevo Laredo, Tamps.	150,000	1,115
XEYZ	Angel M. Díez	Ave. Juárez 48, altos, México, D. F.	10,000	760

Government Stations

XFC	Gobierno Estado Aguascalientes	Palacio de Gobierno, Aguascalientes, Ags.	350	805
XFO	Partido Nacional Revolucionario	Ave. Morelos 110, México, D. F.	5,000	940
XFX	Sría. Educación Pública	Argentina y L. G. Obregón, México, D. F.	500	840
XFA	Gobierno Aguascalientes	Apartado Postal 92, Aguascalientes, Ags.	5	550

a 1,500

Stations Preparing to Go on Air

XEE	Alejandro O. Stevenson	Aquiles Serdán 1001, Durango, Dgo.	50	1,010
XEZ	Bartolomé García Correa	Calle 65, 436, Mérida, Yuc.	500	630
XEM	Cia. Radiodifusora Mexicana, S. A.	Rio Rico D., Matamoros, Tamps.	500,000	660
XETN	Miguel Múzquiz	Matamoros, Tamps.	150,000	845
XEMC	Arturo Piña y Omar Osvaldo Ortiz	Calle 65, 695, Mérida, Yucatán.	250	...
XETZ	José Alvarez del Villar	9a. Londres 190, México, D. F.	500	...
XETX				

concentration is not the same as it is in the middle, and so the resistance varies over the ductance. For the end turns on the coil this eddy-current losses occur and serve to increase the effective resistance. This resistance is therefore seen to be a complex matter, best determined by measurement for specific coils. It may be calculated to about 300 kc. for various coils but the calculations are quite laborious.

Coils should have negligible values of r-f resistance. Now there are coils of many turns of wire and others of few turns, and although their resistances may be very different, they may be equally efficient (equally good selectivity). So we speak of the ratio of resistance to reactance when we wish to know whether or not a coil has a low enough resistance. This factor is usually designated by η . From experience we find that the reactance of a coil should be from 100 to 200 times the resistance at the highest frequency at which the coil is used.⁹ The reactance of the coil should be less than 2,000 ohms for broadcast frequencies and may vary from 1,000 to 2,000 depending on how the

coil is built. The resistance increases with the frequency, so that the selectivity factor η is almost constant over the frequency range.

A coil of 60 turns of No. 20 wire having an inductance of 370 microhenries has an r-f resistance of 3.3 ohms at 300 kc. At 900 kc. this coil has 16 ohms resistance. While the frequency tripled, the resistance more than tripled. Now let us take a similar coil of only 10 turns of No. 20 wire, having 22 microhenries inductance. At 1,200 kc. its r-f resistance is 1.3 ohms, while at 3,600 kc. it is only 2.6 ohms. Tripling the frequency for this coil only doubled the r-f resistance.

Usually for frequencies below 1,500 kc., multiple wire cable shows lower r-f resistance than solid wire, while at frequencies higher than this solid wire has lower resistance.¹⁰ Radio coils for the highest frequencies are built of solid wire, as the above shows they should be. Even at the lower frequencies, the use of solid wire usually gives values of resistance less than twice that for the corresponding cable of many strands.

7. Magnusson, "Electrical Transients," 2d ed., p. 192.

8. Reuben Lee. Proceedings, Institute of Radio Engineers, vol. 21, no. 2, February, 1933; p. 271.

9. Morecroft, "Elements of Radio Communication," p. 62.

10. Morecroft, "Principles of Radio Communication," p. 166.

NEON PEAK VOLTMETER

SIMPLE SLIDE-BACK DEVICE MEASURES
ANY A-C FREQUENCY'S POTENTIAL

By J. E. Anderson

A NEON tube can be used for measuring peak a-c voltages by a very simple arrangement. It is based on the fact that neon tube starts to glow at a definite voltage, and any voltage less than this can be measured. Referring to Fig. 1, let N be the neon tube, E a battery of adjustable voltage, P a potentiometer by means of which the voltage can be varied in small steps, and V a voltmeter by means of which the voltage applied across the neon tube is measured.

First short circuit the AC terminals and adjust the potentiometer and the battery until the neon tube just starts to glow. Note the voltage. Now reduce the voltage applied to the tube until the meter reads practically zero, and then connect the unknown a-c voltage across the AC terminals. If the peak of the a-c voltage is not very high the tube will not glow. Then increase the reading on the voltmeter until the tube just begins to glow. Note the reading on the voltmeter just before the glow started. The difference between this voltage and the original reading is equal to the peak value of the a-c voltage impressed.

Precautions

Just as the tube begins to glow the voltmeter reading drops because when the tube glows it draws current, and this current flows through a portion of the potentiometer. However, the tube does not stop glowing when the voltage has fallen below the starting voltage. It is of first importance to take the voltage reading at which the tube begins to glow. This must be done both when finding the glow point without the a-c and with it.

The voltage at which the tube glow ceases cannot be used because of the current that flows while it is glowing. The current will take power from the a-c source, and this would cause a large error in some instances. Thus there are two reasons why the striking voltage should be observed and not other.

Obviously, the arrangement is not suitable for the measurement of alternating voltages higher than the striking voltage of the neon tube, for if the voltage is higher, the tube will glow without the aid of the d-c voltage, and there would be no means of determining what the amplitude of the alternating voltage is.

If a neon tube having a negligible capacity could be obtained, the arrangement could be used for measuring radio frequency voltages as well as voltages of audio and commercial frequencies. As the ordinary neon tube comes it has too much capacity to make it useful at high frequencies. It is possible, however, to remove the base of the tube and use only the two leads. When that is done, and if the neon tube is of small dimensions, radio frequency voltages can be measured.

A Slide-back Method

It will be realized that this method of measuring voltage is closely similar to the slide-back method of measuring alternating peak voltages by the vacuum tube. In that a certain reference bias is established by noting the voltage on the grid that will yield a certain plate current. Then the a-c is applied in series with the bias and the bias

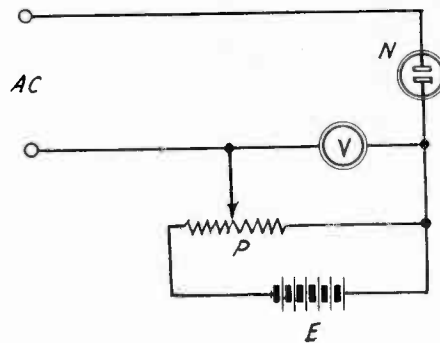


FIG. 1

This arrangement shows how a neon tube can be used as indicator in a slide-back type peak voltmeter.

is reduced until the same current appears in the plate circuit. The peak voltage is then equal to the difference between the two readings of the d-c voltmeter used for measuring the bias.

When the neon tube is used as indicator in the same arrangement, the glow point is used as the reference point. It is quite definite for a given tube, and once established it would not have to be measured again. It is then only necessary to subtract the reference or striking voltage from the reading of the voltmeter to get the value of the peak voltage of the a-c.

Since the peak voltage of a pure sinusoidal wave is 1.414 times the effective value of the measured voltage is 0.707 times the voltage obtained by the d-c meter.

Once more it is emphasized that the voltage should be observed just before the tube starts to glow. It is not necessary at all times to watch the neon tube for the appearance of the glow, for it can be more easily noticed on the voltmeter. The reading goes up gradually as the applied voltage is increased, and then it drops. Note where the meter needle is at the highest point. This does not always work, for whether or not the meter reading drops depends on how much of the potentiometer resistance is in the circuit. If the meter is across the whole battery there is no drop, but the tube begins to glow just the same. By adjusting the number of cells in the battery as well as the position of the slider on the potentiometer it is always possible to have a large resistance in the circuit when the glow begins, and hence to insure that there will be a drop in the meter as the glow begins.

Incidentally, the circuit can also be used to measure d-c voltages without drawing any current from the source. Thus it would be possible to measure the voltage drop in a megohm resistor in the plate circuit of a tube, where a current-drawing voltmeter would not give any appreciable voltage due to the high drop in the resistance.

When the tube is used for this purpose the arrangement is not limited to values less than the striking voltage of the tube, because the d-c voltage to be measured can be impressed in series with the battery, both so that it aids the battery and so that it opposes it. If the unknown voltage is higher

than the striking voltage, the unknown should be connected in opposition to the battery voltage.

The circuit is very inexpensive to hook up, simple to use, and fairly reliable. The voltmeter V can be any current-drawing instrument that happens to be handy.

40-110 Megacycle Band Asked for Television

Washington.

Recommendations regarding broadcast allocations for television have been made to the Federal Radio Commission by Radio Manufacturers Association. Following approval by the RMA Television Committee, of which D. E. Replogle is chairman, and also of a special RMA committee headed by Walter E. Holland, the Association has formally requested the Radio Commission to reserve for television service a continuous band of frequencies from 40 megacycles to at least the neighborhood of 110 megacycles. The RMA resolution also declared that from present indications the television requirements of the future will be such that assignments in television band should be at least four megacycles wide, to provide continuously entertainment and television service.

Additional recommendations to the Radio Commission regarding the use of frequencies between 1,500-1,600 kc, recently opened to use by the Mexico City International Conference, are under consideration. There has been much comment against such extension of the broadcast band for a mere increase in the number of broadcasting stations and engineering opinion also favors channel separation of 20 kilocycles in this part of the spectrum.

PERSONALITIES

"Radio is hard work but I like it," says Eddie Cantor. He spends an average of twenty hours supervising the preparation of the script for his Sunday night Chase & Sanborn broadcast. Once the continuity is okayed after many revisions, rehearsals are held. These consume anywhere from two to four hours before the performance is set.

* * *

Paul Whiteman, despite diet regulations, goes on occasional chocolate-cake sprees. . . . Likes gay neckties and flashy cars. . . . Doesn't like boats, airplanes or crowded elevators. . . . Only sports, swimming and golfing. . . . Is very proud of his friendship with the Prince of Wales, who calls him by his first name.

* * *

Four years Gertrude Berg has been recording the doings of the Goldbergs on NBC. Instead of experiencing a paucity of ideas, a common complaint with most authors after long association with one subject, Mrs. Berg finds thoughts crowd into her mind faster than she can develop them. To her, the Goldbergs have become so real that she just naturally can't help writing about them.

SIX USES FOR THE 6F7

TRIODE-PENTODE IN ONE ENVELOPE SERVES AS MIXER WITH EXTERNAL COUPLING, ALSO DETECTOR AND AMPLIFIER

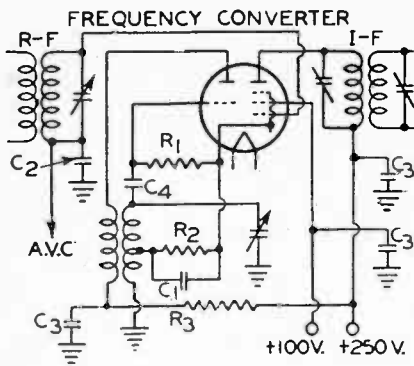


FIG. 1

In this mixer the coupling between oscillator and modulator, otherwise absent from the 6F7 tube because there is no electron coupling, is established by returning cathode to a point at one-quarter the number of secondary turns, measured from ground.

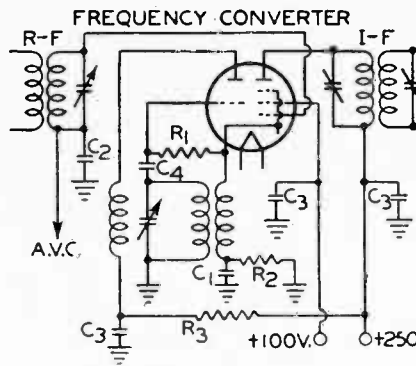


FIG. 2

This is considered a better coupling method for a mixer. The plate winding is next to it, while to the left, the grid winding is next to it, while to the right, above C1, is the pickup winding, in the cathode leg, above the biasing resistor.

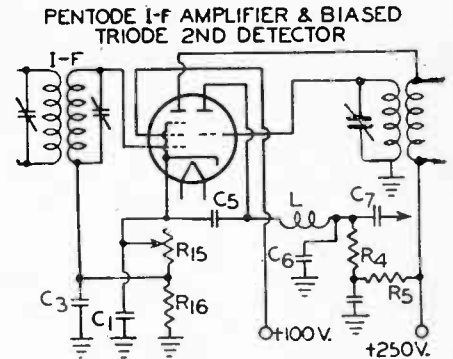


FIG. 3

If there is to be a substantial signal input to the second detector, the triode serves well, while the pentode is used as the preceding intermediate amplifier. Note that the biases are different. Worked thus, the detector is less sensitive, but load-handling is more important.

THE 6F7 is a vacuum tube consisting of two separate units, a triode unit and a pentode unit. Both units are contained within a single bulb and are constructed around a common cathode with the triode unit mounted below the

pentode unit. This tube has a standard seven-pin base, a cap connection to the pentode grid on the bulb top, and employs an ST-12 bulb.

The 6F7 is designed to be used as a combined oscillator and mixer (first detector) in the superheterodyne receivers. For this application, the triode is used as oscillator and the pentode, as mixer.

Other applications of the 6F7 in receiver design are: The use of the pentode as an immediate frequency amplifier with the triode unit connected either as a fixed-bias triode, grid-lead triode or as diode second detector; the use of the triode unit as second detector with the pentode unit as an audio-frequency amplifier; the use of other combinations in which the triode functions as an a. v. c. device or as an inter-channel noise suppressor with the pentode unit used as detector or amplifier.

Typical operation conditions and characteristics for the 6F7 units in amplifier and converter service follow:

Maximum allowable plate voltages are: For the triode unit as an amplifier, 100 volts; for the triode unit as a biased detector, 250 volts; for the pentode unit as an amplifier or detector, 250 volts. Plate family and detection curves, curves of the pentode transfer characteristics, average characteristics of the pentode unit, operational characteristics of the pentode as a frequency converter, and pentode conver-

Values of Constants for the Diagrams

The approximate values of the constants cited in the six diagrams on this page and the next are:

- $C_1 = 5.0$ mfd. $R_2 =$ Pentode Self Biasing Resistor, 1,500 ohms
- $C_2 = 0.05$ mfd. $R_3 =$ Voltage Dropping Resistor, 50,000 ohms
- $C_3 = 0.1$ mfd. $R_4 =$ Plate Coupling Resistor, 170,000 ohms
- $C_4 = 0.0002$ mfd. $R_5 =$ Filter Resistor, 30,000 ohms
- $C_5 = 0.0024$ mfd. $R_6 =$ Plate Coupling Resistor, 300,000 ohms
- $C_6 = 0.00016$ mfd. $R_7 =$ Pentode Grid Leak, 0.5 Meg.
- $C_7 = 0.01$ mfd. $R_8 =$ Pentode Self-Biasing Resistor, 5,000 ohms
- $C_8 = 0.5$ mfd. $R_9 = 10,000$ ohms. $R_{10} + R_8 =$ Triode Biasing Resistor
- $C_9 = 0.0005$ to 0.001 mfd. $R_{11} =$ Filter Resistor, 1.0 meg.
- $C_{10} = 0.00025$ mfd. $R_{12} =$ Grid Resistor, 0.5 meg.
- $L =$ I-F Choke Coil, 1.0 meg. $R_{13} =$ Triode Grid Leak, 1.0 meg.
- $R_1 =$ Oscillator Grid Leak—0.1 megohm $R_{14} =$ A.V.C. Diode Load, 1.0 meg.
- $R_{15} =$ Pentode Self-Biasing Res., 4,000 ohms variable
- $R_{16} = 1,500$ ohms. $R_{16} + R_{15} =$ Triode Biasing Re-

TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

Heater		Amplifier Service (Class A)				
		Triode Unit		Pentode Unit		
Heater Voltage.....	6.3 Volts	100 max.	250* max.	100	250	Volts
Heater Current.....	0.3 Ampere	...	...	100 max.	250 max.	Volts
		...	...	-3 min.	-3 min.	Volts
		...	...	...	900	Ohms
		...	...	300,000	850,000	Micromhos
		...	...	1,050	1,100	Micromhos
		...	...	10	10	Micromhos
		...	...	6.4	6.5	Milliamperes
		...	...	1.6	1.5	Milliamperes

*This rating applies for biased detector use only.

†Grid voltage to be adjusted to give approximately 0.2 milliamperes plate current with no input signal.

sion curves are included in order that complete design information will be available.

Applications

Frequency-Converter

Fig. 1 is a circuit diagram showing the 6F7 used as a frequency-converter. In this diagram the oscillator coil has been tapped and mixing is effected by introducing oscillator voltage into the common cathode return to ground. Fig. 2 shows another circuit of frequency-converter application, generally preferable to that given in Fig. 1.

I-F Amplifier and Second Detector

Fig. 3 illustrates an arrangement whereby the pentode unit can be used as an i-f amplifier and the triode unit as a second detector. A biasing device consisting of a tapped cathode resistor is used to apply bias voltage to the grids of the two units. If desired, the biasing circuit may be arranged so as to include the cathode current of other tubes in the receiver such as the 6A7 or the 78. This makes possible, for purposes of volume control, the simultaneous adjustment of grid-bias voltages on all of the controlled tubes. The method is practical because cut-off voltages for the 6F7 pentode unit, the 6A7 pentode unit, and the 78 are approximately the same for the same plate voltages.

As a detector for small signal inputs, the pentode unit is more suitable than the triode because of its greater sensitivity. For this reason, the pentode rather than the triode, is generally used as mixer or first detector. Either unit may be used as a second detector, the unit chosen depending upon the level of the input signal. As a second detector, the triode unit can deliver sufficient output voltage to excite a power tube, if the signal input voltage to the detector is sufficiently high. This arrangement (in Fig. 3) provides not only an i-f stage and second detector but also adequate input to the power output stage without intermediate audio amplification.

If automatic volume control is desired, it is most easily obtained by using the 6B7 (a duplex-diode pentode).

Detector

Although either unit of the 6F7 can be used as a second detector, the characteristics of the tube are such that the triode is the preferable unit for this purpose.

When the 6F7 is used as a combination intermediate, or radio-frequency amplifier, the pentode, as previously indicated, is used as the amplifier unit and the triode as the detector. To interchange these functions would result in great loss in the overall gain obtained. Of the two units, the pentode is the better amplifier at either radio or audio frequencies. Hence, the most efficient application of the tube as combined detector and audio amplifier is that wherein the triode functions as detector (second) and the pentode, as audio amplifier. When so employed, the

triode can be connected for grid-leak or fixed-bias detection.

A limitation imposed by the common cathode makes it impossible to obtain true self-bias detection for the triode because the pentode plate and screen current greatly exceeds the triode detector plate current in the common cathode. As a result of this limitation when a tapped biasing resistor is used in the cathode return (as in Fig. 4) the bias obtained for both the pentode and triode units is virtually a fixed bias.

Calculations to determine the size of biasing resistor should take into consideration this fact. As a grid-leak detector, the triode unit will handle small signals to give small audio output voltages. As a fixed-bias detector, the amount of signal that the triode unit will handle, and also its sensitivity, are determined by the applied grid-bias voltage.

Second Detector and Audio Amplifier

Figs. 4, 5 and 6 clearly show how the 6F7 is used as a detector and audio amplifier. Fig. 4 shows the pentode connected as audio amplifier following the triode unit as a fixed-bias detector and Fig. 6 shows the same arrangement except that the triode is connected as a grid-leak detector. Fig. 5 shows the triode connected as a diode followed by the pentode unit connected as an audio amplifier. This arrangement provides diode detection with delayed automatic volume control and is accomplished by connecting the triode grid and plate separately for direct current but together for r-f input. The grid acts as the diode anode for detection and the plate with its associated circuit provides the delay bias. Where the series-cathode resistor R_{17} is made adjustable, the amount of delay can be varied.

Operating Characteristics

I-F Amplifier and Second Detector

For operation of the 6F7 as a combination i-f amplifier and fixed-bias second detector in the circuit shown in Fig. 3, plate and screen voltage supplies are 250 and 100 volts respectively. The grid-bias voltage for the pentode unit is obtained from the drop across R_{16} and that for the triode unit from the drop across R_{15} and R_{16} . Grid-bias voltage for maximum volume-control setting, should be approximately 20 volts for the detector and 3 volts minimum for the pentode. The variable resistor R_{16} provides manual volume control by variation of the grid bias on the i-f amplifier.

Fixed-Bias Detector

Fig. 7 shows curves of fixed-bias detector operation for the 250- and 100-volt conditions. The radio-frequency input voltage as well as the corresponding grid-bias voltage required for a given audio-frequency output voltage are shown. These curves were taken with the radio-frequency input modulated 20%. Within the upper limits of these curves, the de-

tor output will be relatively free from distortion.

In choosing the value of grid-bias voltage, one should be guided by the detector operating conditions. From the shape of the curves it is noted that detection sensitivity decreases for the higher values of output. It is best, therefore, to operate the detector at the lowest bias voltage commensurate with the audio-output voltage required. For example, if the triode detector is to be followed by a power output tube requiring 14 volts peak or 10 volts rms, to excite it, the triode should be biased to approximately 21 volts for the 250-volt supply condition. If, however, the tube following the detector requires only a very small input voltage, such as that required by the 6F7 pentode unit, i.e. 3 volts peak or 2.1 volts rms, detector sensitivity would be at its best if a bias voltage of 14.8 volts were supplied to its grid.

The self-bias voltage can be obtained from a series-cathode resistance and is essentially fixed because of the smallness of the detector plate current as compared to the pentode plate current, say RCA Radiotron Co., Inc., and E. T. Cunningham, Inc.

Grid-Leak Detector

Curves for operation as a grid-leak detector were taken with a 1.0-meg. grid leak and a 0.00025 mfd. condenser and with other values as indicated on the curve sheets. The grid-leak detector is more sensitive than the bias detector. It is better used as a detector where sensitivity and small output voltage are required. Where larger output voltages are necessary fixed-bias detection should be employed.

The following tabulation of the output voltages obtainable with 30 per cent. modulation of the input radio-frequency signal is representative of the maximum detector output voltages obtainable under the given conditions:

	Triode	Pentode	Pentode	Pentode
Plate-Supply Volts	100	250	100	250
Input Volts (RMS)	2.1	3.0	0.7	0.7
Output Volts (RMS)	2.0	3.85	5.5	8.6

For the triode, these values are at saturation beyond which the output voltage will not increase with increased input voltage. For the pentode, the above values represent the points where appreciable distortion commences.

Comparison of the above tabulated values for the triode portion of the 6F7 with the corresponding values shown in Fig. 7 shows quite clearly the differences in operating levels of the two types of detectors, their relative sensitivities, and the gain obtainable with each type.

Fig. 8 shows the screen grid voltage necessary to obtain maximum audio output at different signal levels for the pentode unit operated with 250 volts total d-c supply, 20 per cent. modulation of the input voltage, and optimum circuit values. The setting of screen voltage is quite critical. The accompanying screen cur-

(Continued on next page)

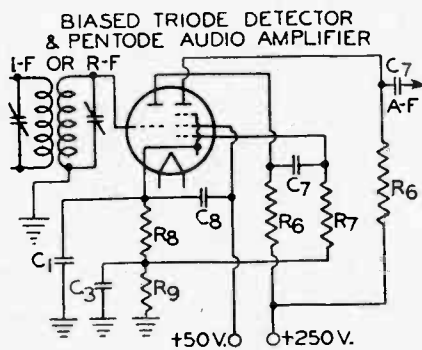


FIG. 4

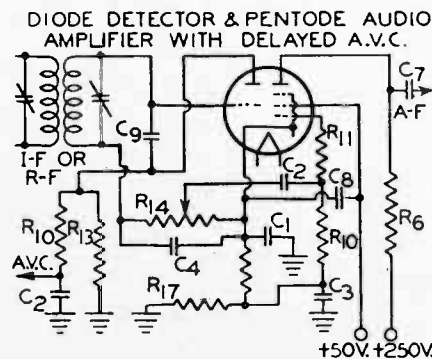


FIG. 5

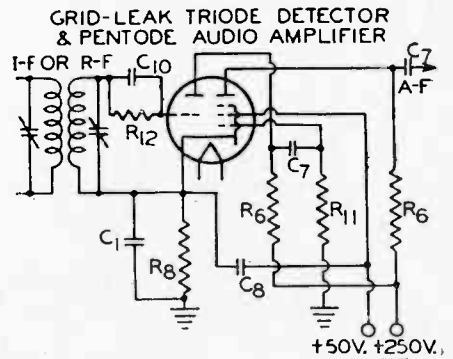


FIG. 6

THIS SHORT-WAVE SET

European and Pacific Countries Ro

By Herma

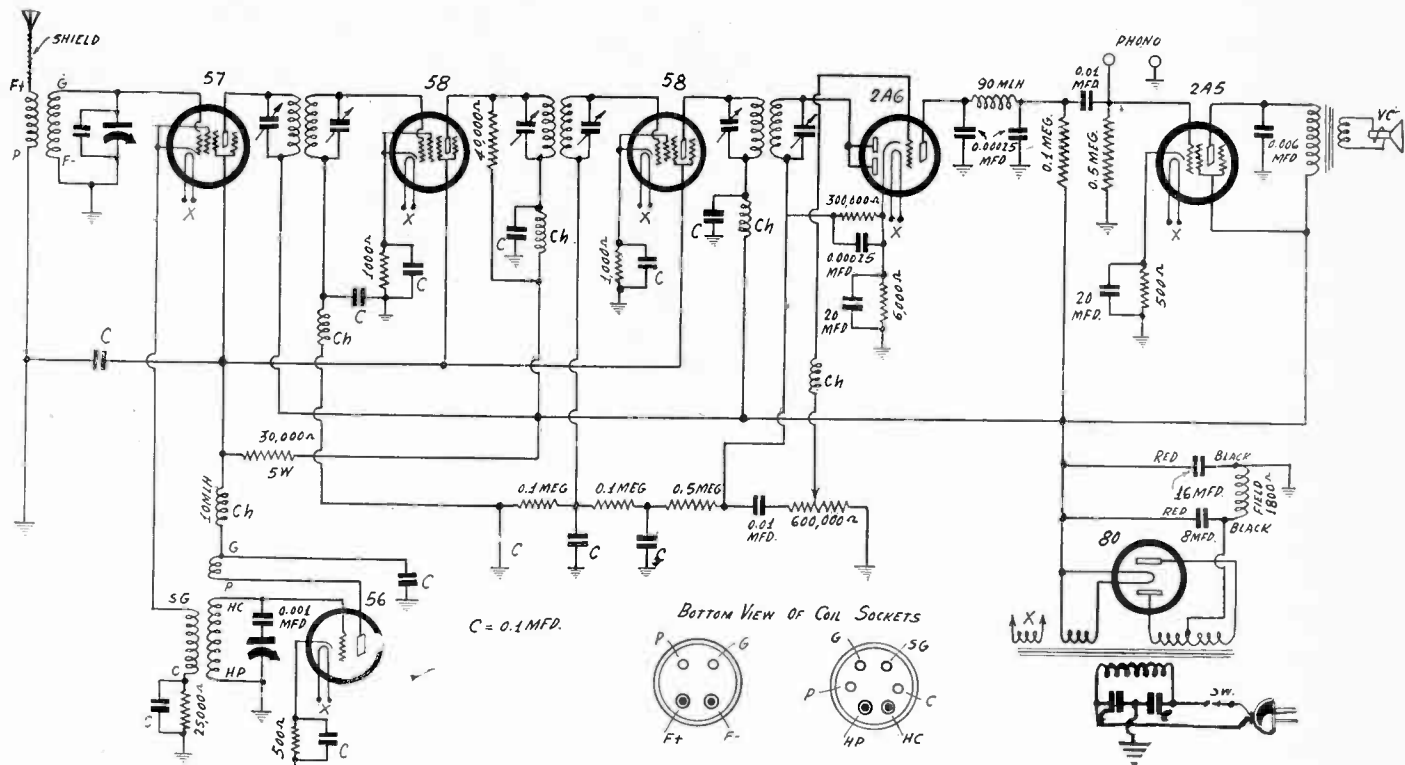


FIG. 1

The circuit of the Superba, a short-wave set that does splendidly on foreign-country programs. Automatic volume control is included. Standard plug-in coils are used.

NOW, practically for the first time, a high-performance a-c short-wave receiver can be constructed at exceedingly low cost, and yet will give speaker results entirely satisfactory, with practically no fading, and with humless a-c operation.

Such a receiver is the one diagrammed, the developmental work on which is due to Edwin Stannard, of Supertone Products Corporation, and on which he was engaged for nine months.

It was found that there would be considerable fading unless automatic volume control were included. And when such control was selected of a degree that did not reduce the sensitivity unbearably, and filtration was properly introduced, even notorious fading stations stopped their bad behavior, not as a complete eradication by metered test, but at least to a degree that rendered meter-readable variations of intensity scarcely up to the level of discernment by the aural test. You could listen but could not notice the fading. So Mr. Stannard remarked: "You hear a set with your ears, and not with a meter, so the automatic volume control feature is highly desirable."

2A6 Detector-Amplifier

After sensitivity had been developed to a degree that seemed satisfactory, but before it was decided that the set should be marketed as completely worth-while in every aspect, a new tube came out, and it was

tried in many ways. In almost every connection used there was greater sensitivity than with the tube it replaced. So the 2A6 is used as the duplex-diode detector, with a practically linear detecting characteristic, which means freedom from distortion, and was resistance-capacity coupled to the high-mu triode it contains.

Six-fold Increase

If the receiver were to be used for broadcasts perhaps the 2A6 would not be so acceptable in such a receiver, because the amplitude of the wave front from broadcasting stations in the 1,600-540 kc band is far greater than that of short-wave stations from overseas. But taking conditions as they are, and adopting methods that pertain particularly to short waves, the sensitivity was increased six times by the proper inclusion, circuiting and voltaging of the new tube, and stations brought in at a poor loca-

(Continued from preceding page) rent, plate current, and average d-c bias voltage are also shown in this figure.

Pentode as Audio Amplifier

When used as an audio amplifier, the pentode may be resistance-capacity coupled to the preceding detector stage as illustrated by Figs. 4, 5 and 6. A plate-coupling resistance of approximately 300,-

Curves On t

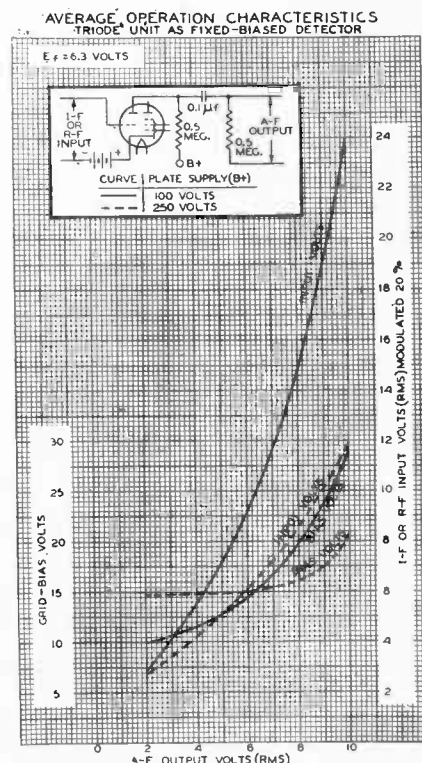


FIG. 7

SURE DOES BRING 'EM IN

ll In, If Only They Are On the Air

n Bernard

tion with satisfactory volume and comforting regularity from Europe, Asia and other remote points.

The set was designed primarily for those interested in hearing programs from over the seas. As every one knows, their number is legion right now, for we are in the midst of a short-wave boom. Perhaps persons who grew somewhat tired of regular broadcast programs as a steady diet for ear and mind found radio's nascent fascination in hearing a station in the foreign land of their birth, or where their wife was born, or their fathers and mothers. And besides the thrill of distance is never dead, only dormant sometimes.

No Loss of Personality

Just for the program type of listener the receiver, called the Superba, was developed, and much common sense was applied to the design. The circuit is a superheterodyne, with tuned modulator input and tuned oscillator, the oscillator being a separate tube (56), while the modulator is a 57. Thus in the coil construction the coupling is made different for each band, locking of the two circuits is prevented, hence r-f selectivity renders some benefit even on the highest frequencies, and there are peppy results even at 20,000 kc (15 meters), a region where many short-wave receivers lose their personality.

To attain sufficient sensitivity two stages of intermediate-frequency amplification (three coils) were used, and with proper filtration and adjustment of the impedance

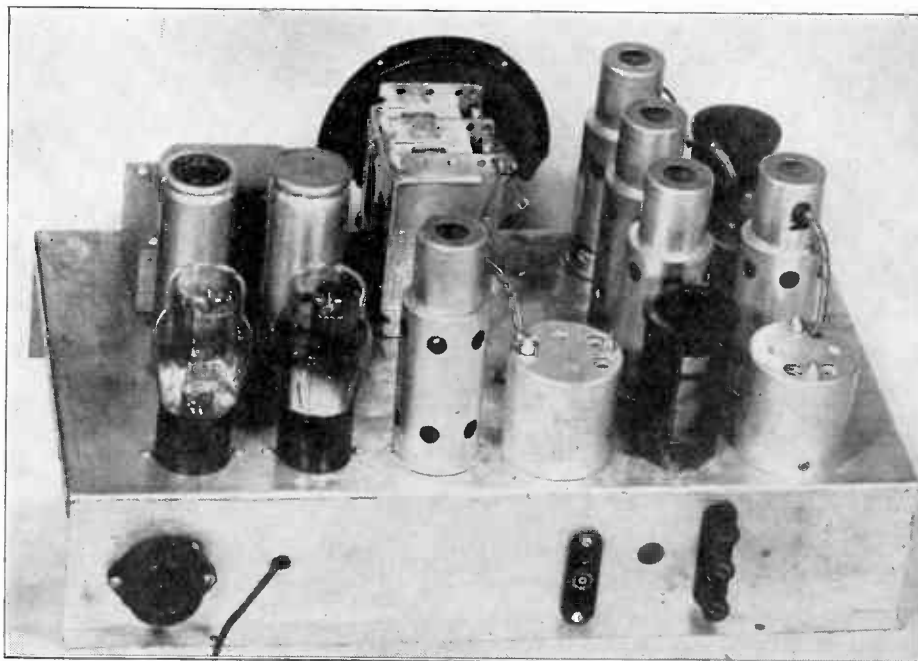


FIG. 2

Rear view of the finished receiver. The parts are compactly arranged on a metal chassis. Plug-in coil sockets are easily accessible.

load by a parallel resistance across the primary of the first coil, stability was unflinchingly achieved. Hence the set does not pop into i-f oscillation, as many sets do, and reception is fairly quiet.

There is bound to be some noise on occasion when one works a sensitive short-wave set, because the noise is "in the air," rather than in the set, and if the receiver is extremely sensitive, as it should be, and as this one is, the noise will be heard. But it isn't present every day or every night. Many a time the reception is so clear that one scarcely can distinguish the result from that attained from the nearest broadcasting station.

Use a Short Aerial

When a receiver is so sensitive a short aerial, even only a few feet of wire indoors, may be used. This improves the selectivity greatly, so that foreign stations close to one another in frequency, do not interfere. It seems preferable on nearly all the short-wave sets that are highly-sensitive to use a short aerial for that reason, and also because there is less noise than of the type caused by heterodynes, as these interferences are trapped out.

In line with the argument in favor of

sensitivity one may notice that virtually all the short-wave sets have pentode output, as has the Superba, which uses a 2A5. This tube is favorable indeed to the designer or a short-wave set, as it has been noticed that in a-c designs the hum tends to be higher than in broadcast sets, perhaps even through the rectifier. Therefore it is well to have an indirectly heated cathode type output tube.

The circuit has a manual trimmer for the secondary of the antenna coil, a volume control and besides may be equipped with a switch to short out the a.v.c. for appeasing the preference of "hams." This switch (not shown) would ground the filtered returns of the i-f grids, with a high resistance left between ground and the high side of the second detector.

PERSONS OF MOMENT

Rudy Vallee fears the day when he may become fat and bald . . . Favorite dish is buckwheat cakes with plenty of butter . . . Always carries at least three toothbrushes while traveling . . . Pinches the lobe of his ear when nervous . . . Detests the odor of a pipe and asks pipe smokers to kindly refrain from smoking in his presence.

* * *

"A singer is really an athlete. Get out of condition and blooey goes the voice. It is an accurate and sensitive barometer of your physical condition. Plenty of exercise and lots of sleep are first essentials for a vocalist."—Frank Luther, tenor.

he 6F7 Tube

TYPICAL GRID-LEAK DETECTOR CHARACTERISTICS

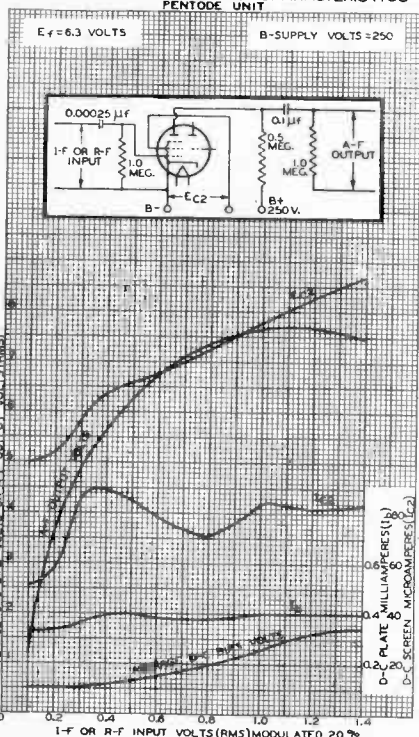


FIG. 8

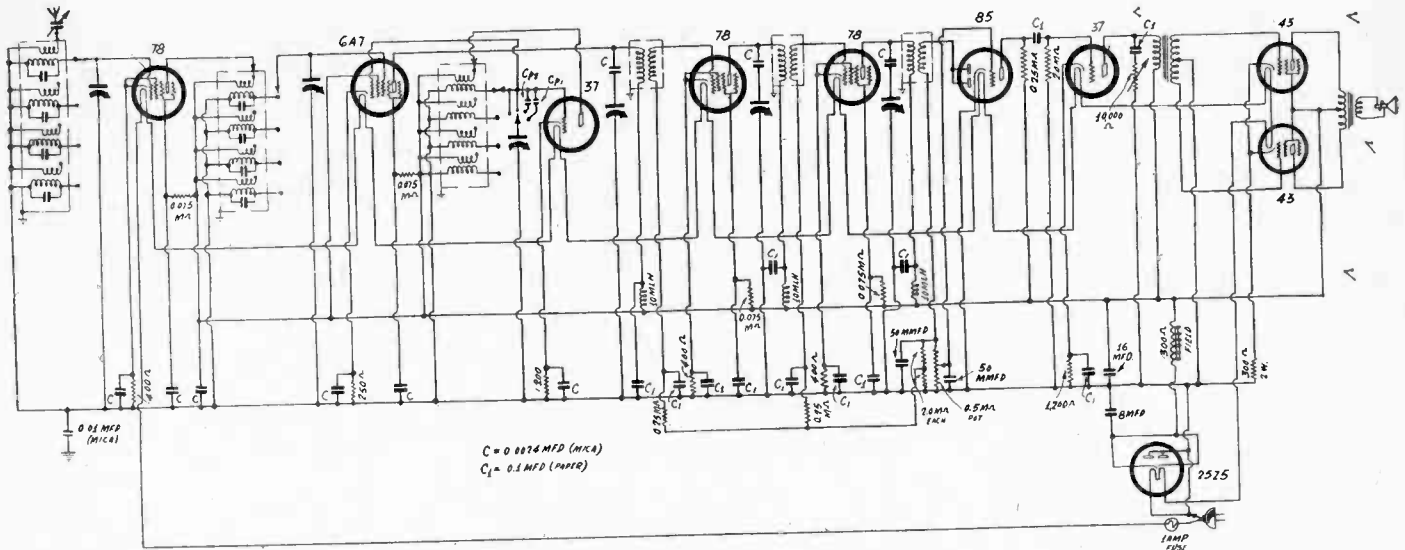
000 ohms, with a plate-voltage supply of 250 volts and a screen-grid supply of 50 volts should be used. The resistor in the grid circuit of the following tube should be 1.0 meg., if possible. For some tubes, where 1.0 meg. may be too large a value, the maximum recommended value should be used.

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COIL-SWITCH UNIT

for "All Waves" is on the Way

By Herman Bernard



THE all-wave coil-switch assembly, properly padded, aligned and adjusted, is one of the products that may be confidently expected for next season. The fashion of using plug-in coils no doubt will wane sufficiently by that time, due to the style impulse arising from inclusion of the switching devices in commercial all-wave sets made now by the larger manufacturers. There will be a retained interest in plug-in coils by professionals and experimenters, but for the general run of users the coil-switch arrangement is "in the bag."

The difficulties have surrounded the switch. The requirements are that the switch should have extremely low contact resistance, that is, no higher than the equivalent resistance resulting from the use of plug-in coils; that the capacity introduced by the switch be small, so that the frequency of tuning range of the condensers with any coil will not be reduced much; and that the switch have a definitive position denoting infallible contact. All of these problems have been solved already, so it is up to the coil manufacturers or specialists to unite the switch with the coil system and produce the much-desired unit.

Design Work Going Forward

It has been said that this will be done. The reason for saying it is that the design work in several factories is going forward and production will follow as soon as the laboratories give their O.K. In present-day radio, products are not rushed into production and the purchasers left to find out whether the gadgets work properly. That may have been all right in boom days, though this writer thinks it always was all wrong, nevertheless today the products are right before they are put on the market. In other days they may have been right or wrong when produced, or made right later, if it was possible to rectify a manufacturing or design mistake.

The coil-switch assemblies probably will be made for two or more intermediate frequencies. It is certain that provision will be made for 175 kc, which is still popular, and for 465 kc, which is growing in popularity.

There is not much difference in performance between the two, except that in the

An interesting circuit, especially from the viewpoint of total absolute bandsread at any carrier frequency.

broadcast band the inter-channel selectivity is higher with 175 kc. For all-wave coverage, however, a higher intermediate frequency is practically always selected, because it gives a bit of an edge in the matter of the carrier frequency and the local oscillator frequency not pulling together, due to the greater difference between the two.

Tracking Section

Besides these two intermediate frequencies, 175 and 465 kc, there is small need for any others, unless a tracking condenser is to be used, as there are such condensers that require 456 and similar odd intermediate frequencies. However, tracking condensers were intended only for broadcast-band use. The tracking section could not possibly be used for higher frequencies, unless the intermediate frequency were changed for each step, a practical impossibility due to the enormous changes required, band for band. The amount of change is equal to the frequency span at the carrier level for the band. Thus, for 456 kc i.f., broadcast band, assuming 3 to 1 frequency ratio, the highest frequency might be 1,600 kc, so for the next band the i. f. would have to be 1,516 kc for the second band and for the third 3,200 kc, etc., a ridiculous requirement. The only possibility would be to use, say, a three-gang condenser for the broadcast band and arrange the switching so that for the higher frequencies the tracking section would not be used, and a stage thus omitted.

Constructional Hint

The coil-switch assembly can be made by the handy home constructor along these general lines: Since three tuned circuits are used, a shield box, of aluminum or copper, is constructed, and two walls soldered in place, to constitute three effective shields. In each of the three compartments the total number of coils is put. For the circuit shown there would be four coils. By using 3/4-inch diameter tubing the four coils can be

accommodated. Each compartment could be 3 x 3 x 3 inches.

The coils are mounted to the bottom, leads being brought out to the sides, which are pierced for an insulating strip on which lugs or spades are put, for soldering to outside connections. The open top of the total shield may be used at bottom in mounting the assembly to the chassis, as the chassis completes the shielding, if metal. If broadcasts are to be covered, whole band by one switch setting, meaning 0.00035 mfd. condensers or thereabouts, the first short-wave band should be padded as well as the broadcast band. If 0.00015 mfd. condensers are used, there would be padding for both parts of the broadcast band as well as for the first short-wave band.

Variably-Tuned Intermediates

There is another idea in the diagram that might look like an error. The intermediate tuning condensers are variable, a regular three-gang. The object of that is to give a total absolute bandsread. Should broadcasts be desired, the i-f condenser would be turned to a marked position, representing the i. f. intended (465 kc). No bandsread is needed or desired. For short waves first tuning is done at the same i-f setting, but if the i. f. is to beat other than the geometric mean of the i-f range, then the bandsread is in both directions. Usually all that can be done is to lower the frequency. Here it may be lowered or increased. Let us take a numerical example.

Suppose the regular i. f. is 465 kc. If this is to be the geometric mean of the intermediate range then the coils are selected so that the total tuning range is 806 to 269 kc. This can be achieved for practical purposes simply by winding a primary (which is tuned here) to strike 270 kc at maximum condenser capacity. The condenser is assumed to be 0.00035 mfd. or larger, and the frequency ratio 3, which is common.

536 kc Span

Thus, take the total frequency span, 806 to 270 kc, the difference is 536 kc. Starting at 465 kc, the frequency may be increased to 806 kc, a difference of 341 kc, and to 270 (Continued on next page)

FOR BATTERY DEVOTEES—

A SIX-TUBE SUPERHETERODYNE WITH PUSH-PULL OUTPUT

By Brunsten Brunn

MANY radio set builders who live in the country, away from power lines, request sensitive receivers that can be operated from small batteries. These sets must be comparable in sensitivity with a-c operated receivers, and as far as possible, they should also be comparable with them in respect to output power. We might as well state at the outset that there are no battery-operated tubes that will give as much output as the power tubes ordinarily employed in a-c operated sets. The most suitable tube is the 33, and two of these can be used in push-pull to give a fairly large output. Somewhat more can be obtained with a single 19 in a Class B amplifier, but this tube imposes certain restrictions on the design.

In Fig. 1 is a six-tube battery operated superheterodyne using two 33 tubes in the output stage, a 1A6 as oscillator and mixer, a 34 as intermediate amplifier, a 32 as a grid biased detector, and a 30 as intermediate audio amplifier. If more output power is required than this will give, it is possible to add two more 33s, putting two of them on each side of the symmetrical amplifier. This would double the output power without requiring any higher input voltage. The added tubes, would, however, increase very much the drain from the A and B batteries.

The Oscillator

For oscillator the inner elements of the 1A6 tube are used and the circuit employed is of the tuned grid type. The 350 mmfd. tuning condenser and the series padding condenser are placed so that both are grounded on one side. Since the padding condenser is in series with the tuned winding it also serves as a grid stopping condenser and for that reason no condenser is put in the grid lead. A leak of 50,000 ohms is connected

between grid and the negative end of the filament to provide a path across the padding condenser.

The oscillator coil has only two windings, since no pick-up winding is required when electron coupling is used. Suitable coils for this purpose are standard and are available for all the common intermediate frequencies employed in superheterodynes. Padding condensers also are available for any of the usual intermediate frequencies, provided that the tuner covers the broadcast band.

The choke L1 in the plate return lead of the oscillator should have an inductance of about 10 millihenries, and may be one of the 800-turn chokes used in 175 kc intermediate tuners. A 0.1 mfd. condenser is connected between ground and the junction of the choke and the tickler. This filter combination is desirable, although it is not absolutely necessary.

The Mixer

There is one radio frequency tuner between the antenna and the grid of the mixer tube. The inductance of the secondary of the transformer should be such that it fits the 350 mmfd. tuning condenser. Shielded coils of this kind are standard. A word might be said about the primary on this transformer. Since there is only one r-f tuner, radio frequency selection will not be great if a large primary is used. Hence the coil selected should have a small one, especially if the antenna employed is high and long. Of course, the circuit is intended to be used in the country remote from power supplies. This means that it will also be remote from broadcast stations, and therefore an extremely high selectivity is not needed. This is fortunate in one sense because, the location of the receiver being remote from broadcast stations, a high sensitivity is required.

Therefore it might be necessary to use both a first rate antenna and a good size primary on the input transformer.

The Intermediate Amplifier

Following the 1A6 mixer tube is a doubly tuned intermediate frequency transformer, after which there is a 34 super-control radio frequency amplifier. Then there is another doubly tuned intermediate transformer, which feeds into the grid of the 32 detector.

The intermediate frequency is optional. Transformers are available for 175 kc, 456 kc, and 465 kc. Right now, perhaps, the 456 kc frequency is the most popular as many commercial receivers employ it. This is particularly true when the mixer-oscillator is of the pentagrid type. When this frequency is chosen there is no difficulty getting the oscillator coil that matches and the padding condenser.

The Detector Circuit

For detector a 32 is used with grid bias. In its plate circuit is a filter consisting of a 10 millihenry choke L2 and two 250 mmfd. condensers. The grid has fixed bias, which is obtained from a voltage divider to be discussed later. The screen voltage on the detector must be rather low, and for that reason a 0.25-megohm resistor is put in the screen lead and it is returned to a point on the battery where the voltage is 67.5 volts above the filament.

The coupling between the detector and the first amplifier is of the usual resistance-capacity type, the stopping condenser being 0.01 mfd., the plate resistor 0.25 megohm, and the grid leak 0.5 megohm.

The Audio Amplifier

The 30 audio amplifier is coupled to the
(Continued on next page)

Constant Bandspread by I-F Tuning

(Continued from preceding page)

kc, a difference of 195 kc. There has been no terminology for this method, since the revelation is being made now for the first time, but it is safe to say, I think, that the system yields a total bandspread of 436 kc for the frequencies specified, and that this bandspread is constant for all carrier frequencies, hence gives most relative spread-out at the higher carrier frequencies, where it is most needed.

Calibrated Dials

Frequency-Calibrated dials are growing in their popularity and will be increasingly used. The question then arises whether the calibration is upset by the total constant bandspread method. Yes and no, mostly no. Again it is a matter of definition, and, as stated, the definitions have to be developed. Since the dial of the i-f circuit, or knob used, has a reference to the exact point equalling 465 kc, when that point is used the dial calibration for the tuner holds. If the i. f. is calibrated also, particularly this and that side of the geometric mean, say, plus 0 to plus 341 kc and minus 0 to minus 195 kc, the total change of 536 kc in the i-f level would be divided in two equal parts, and the change from the calibration could

be added or subtracted mentally, using the 341-0-195 reading as taken from the i-f dial.

Of course the radio-frequency tuning would not be changed, but for the higher frequencies the resultant effective r-f resistance is such a damper that the heavy burden for selectivity falls on the i-f level, and is represented manually by the oscillator frequency dial. If the i. f. is altered it is to the same effect as turning the oscillator dial a bit, therefore the tracking for higher frequencies will not be disturbed, within the practical meaning of the word "disturbed" as applied to a tuned circuit or two that tend to become broad at the frequencies where bandspread is most desired.

Credit to Anderson

The total constant bandspread method is due to J. E. Anderson and represents an idea that ought to be carried into practice, many of the advanced experimenters having received enough information from the present article to enable them to produce an experimental receiver that affords the distinguished benefits that the system contributes.

The local oscillator is a separate tube in the circuit diagrammed, while the 6A7 is used as a pentode modulator, the triode ele-

ment being not used, except to pick up the oscillation voltage and afford electron coupling in the modulator. It is just an idea, and works, but it is not within the intention of the present writer to state that electron coupling as pretendedly afforded by such a tube really exists in the desired exclusive state at higher than broadcast frequencies. The inter-element tube capacities account for much more of the coupling than does the naked electron stream or space charge, and that is also true as to broadcast frequencies, and results in such strong coupling because the two methods (capacitive and electronic) are combined. There is less harmonic intensity by the method diagrammed because the capacity coupling is reduced. That was the only reason for showing a separate oscillator.

The circuit as shown is arranged for universal operation (a. c. or d. c.), 120 volts estimated, without any limiting resistor being required. All the voltage is dropped in the tubes, but a 6-volt pilot lamp, shunted by a 40-ohm 5-watt resistor, may be added to the series chain, or one of the new 60-milliampere pilot lamps put in series with the biasing resistor of the power tubes. It will light sufficiently for the purpose of making the dial scale legible.

A ONE-TUBE CONVERTER

Short-Wave Device Uses 2A7 Tube

By Einar Andrews

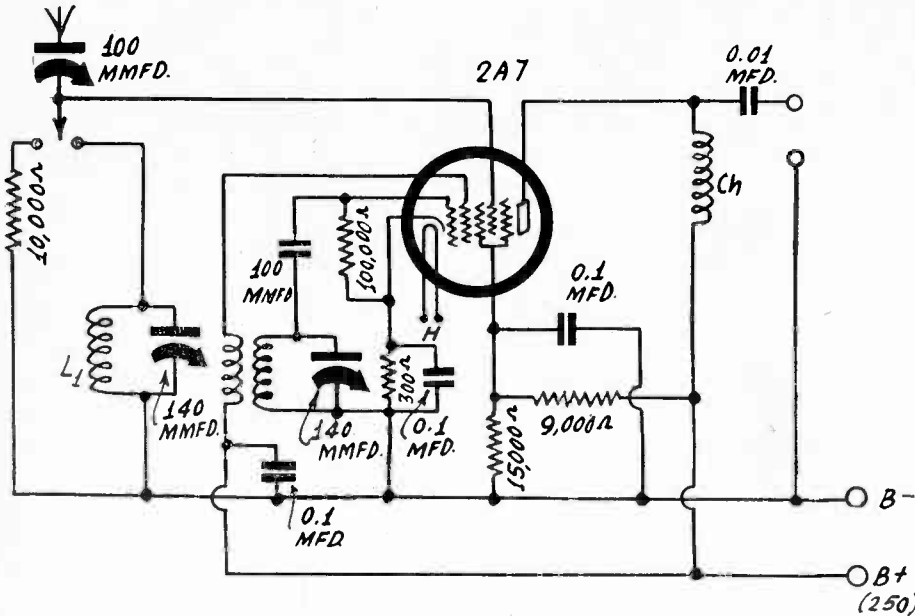


FIG. 1

The circuit of a one-tube short wave converter utilizing the 2A7 pentagrid (6A7). It is intended for attachment to a broadcast receiver and to take the power therefrom.

A SHORT-WAVE converter with a single tube can now do the work of two tubes, and do it much better, because of the greater efficiency of the new tubes and also because of the multiplicity of grids and anodes in some of these tubes. The 2A7 is especially suitable for a short wave converter, for it can function both as an oscillator and as a mixer, and a circuit

for this tube is shown in Fig. 1. This converter has been designed for attachment to an existent broadcast receiver utilizing 2.5-volt tubes. The heater current is supposed to be taken from the 2.5-volt circuit in the receiver, which is done by connecting the heater terminals, H, across the heater winding in the set. This can be done at any convenient point. The plate voltage for the

tube is also supposed to be taken from a convenient point in the receiver. Only two connections are required for the plate voltage, the negative to the chassis and the positive. Two other leads, of course, are needed for the heater, and these should be a twisted pair.

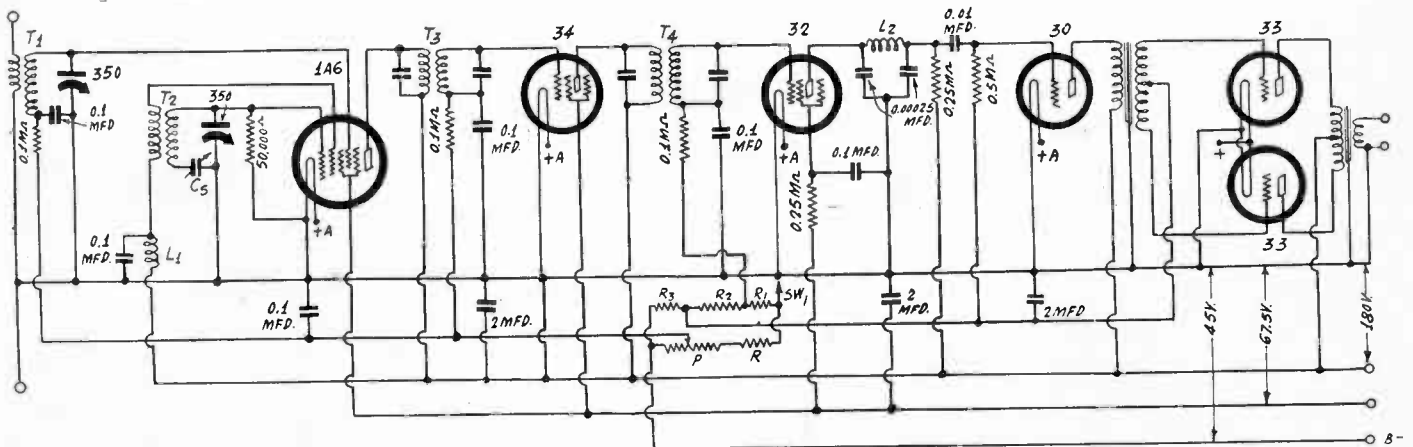
While the converter is supposed to take its power from the receiver, a filament transformer can be used as well to supply the heater current of 0.8 ampere and the plate voltage may be taken from any other convenient source.

Use of Six-Volt Tube

In case it is more convenient to get a 6.3-volt supply for the heater, the tube can be a 6A7, and it is not necessary to make any other change in the circuit. That is, if a 6A7 is to be used in place of the 2A7, a voltage of 6.3 volts is applied to the H terminals, everything else remaining the same. The plate voltage, however, may be reduced to 135 volts if desired.

Some prefer to have a resistance coupler between the antenna and the first tube, while others would rather have a tuned circuit. Both methods are provided for, and the constructor can take his choice. The reason some prefer a resistance coupler is that it requires only one tuned circuit, and hence obviates the need for tracking the two tuned circuits. Those who prefer a tuned circuit in the input of the mixer know that more sensitivity can be obtained with it and that the greater reach of the circuit well repays for the extra trouble in tuning and adjustments.

Those who want only one tuned circuit should put a 10,000-ohm resistor between the antenna and ground as indicated and those who want the tuned circuit should replace the resistance with a parallel resonant circuit. In either case the antenna condenser of 100 mmfd. should be used, although



(Continued from preceding page)

output stage by means of a push-pull input transformer. The highest permissible voltage is applied to the plate of the tube in order to insure adequate input to the 33s. This is quite safe provided that the bias on the 30 is not too low.

A push-pull output transformer is used between the 33s and the speaker, and this may be an integral part of the speaker. Since there is no means of energizing an electromagnetic speaker field, the speaker must either be a magnetic or a permanent field dynamic. There is such a speaker available especially designed for the 33 tubes.

The addition of two more 33 tubes in the output stage would require a different speak-

er, or possibly two speakers in parallel. The simplest way, perhaps, to add two tubes would be to have two separate amplifiers, with two separate speakers, but with the grids connected in parallel.

Biasing is done by a 45-volt biasing battery and voltage dividers. The negative of this battery is connected to the terminal marked B minus and the positive to the filament. Across this battery are two voltage dividers. One consists of a 500,000-ohm potentiometer, P, and a limiting resistor, R, of 7,500 ohms. This divider is used for biasing the grid of the mixer and also the grid of the intermediate frequency amplifier. The purpose of the limiting resistor is to insure that the bias shall not be less than three

volts. The maximum is 45 volts, which is sufficient to squelch both the mixer and the intermediate amplifier.

The other divider consists of three resistors in series. R1 next to the filament has a value of 600 ohms and gives a bias of 6 volts to the detector grid. R2 has a value of 750 ohms, the drop in which is 7.5 volts. Therefore the bias on grids of the power tube and on the first audio amplifier is 13.5 volts. R3 is used only to limit the current and to drop the voltage not needed by the amplifiers. Its value should be 3,150 ohms.

Since the current through the voltage dividers would quickly drain the 45 volt battery if continuous, a switch is put in the circuit so that it can shut off B current simultaneously

LIST OF PARTS

Coils

- One set of four plug-in oscillator coils for 140 mmfd. condenser.
- One set of four plug-in r-f coils for 140 mmfd. condenser.
- One 800-turn radio frequency choke.

Condensers

- Two 140 mmfd. tuning condensers.
- One 100 mmfd. variable condenser.
- One 100 mmfd. fixed condenser.
- One 0.01 mfd. fixed condenser.
- Three 0.1 mfd. by-pass condensers.

Resistors

- One 100,000-ohm grid leak leak (or 50,000).
- One 9,000-ohm resistor.
- One 15,000-ohm resistor.
- One 300-ohm bias resistor.

Other Requirements

- Two vernier dials.
- One small seven-contact socket.
- Two four-contact sockets.
- Five binding posts.
- One grid clip.
- One knob for antenna condenser.
- One small chassis.

it is not of prime importance when the resistance coupler is employed. When the tuned circuit is used the antenna series condenser is very valuable in making adjustments for highest sensitivity.

The Oscillator

The oscillator is of the tuned grid type. It has a 100,000-ohm grid leak connected between the grid and the cathode and a 100 mmfd. stopping condenser. It is important that the grid leak go to the cathode and not to ground, and it is for this reason the shunt connection is used, for if the leak were across the stopping condenser the grid of the oscillator would be biased, and this does not work invariably.

The innermost grid of the tube is used as control grid of the oscillator, and the next grid as the plate or anode. The oscillator is tuned with a 140 mmfd. condenser and the coil is of the plug-in type.

In case blocking should occur in the oscillator, the grid leak should be reduced to about 50,000 ohms, or even less if necessary. However, in short wave circuits the higher resistance can usually be used safely. It is also advisable to try different anode voltages on the oscillator, but it is not necessary to apply different voltages on the plate of the mixer and the anode of the oscillator.

The Mixer

The mixer is the tetrode part of the tube and the control grid is at top of the tube. This is connected to the top of the resistor in the antenna circuit or to the stator of the mixer variable condenser, whichever input method is used.

A bias resistor of 300 ohms is used in the cathode lead of the tube to give a bias of about 3 volts to the control grid, and this resistor is shunted by a condenser of 0.1 mfd.

The screen is given a lower positive potential than the plate, the voltage being divided by a 9,000-ohm resistor in the lead to the screen and a 15,000-ohm resistor between the screen and ground. A by-pass condenser of 0.1 mfd. connects the screen

to ground to insure freedom from signal fluctuations of the screen potential.

In the output circuit of the mixer is a radio frequency choke coil Ch to effect coupling between the converter and the broadcast receiver. A 10-millihenry choke will do here, one of those 800-turn chokes employed in 175 kc intermediate frequency transformers. A condenser of 0.01 mfd. is connected between this choke and the output binding post to make it safe to connect the converter to any broadcast receiver.

Coils Used

The simplest way to get satisfactory coils is to use plug-in coils of standard make for the specified condensers. This obviates the need of making any special adjustments and it also eliminates troublesome switches. Coils that fit these condensers are made by nearly every coil manufacturer. The r-f coils need only one winding but if the coils employed have two windings, that is all right, for only the secondary need be used. The oscillator coil requires two windings and a four prong form. The r-f coil will also need a four prong base, because we have no form with fewer prongs.

The entire short wave band will be covered with four coils, provided they have no wider overlap than necessary, and those made usually have the correct coverage.

The Intermediate frequency

The coverage of a given pair of coils will depend on the intermediate frequency employed, that is, the frequency to which the broadcast set is tuned. Most coils are made for an intermediate frequency of 465 kc. Therefore, the broadcast set should be tuned to the lowest frequency—to 530 kc if it will tune as low as that. However, the sensitivity of the converter will depend on the sensitivity of the broadcast set, and since this is usually least on the low frequencies, it will be advantageous to employ a higher intermediate frequency at times.

In order to make the converter as flexible

as possible in respect to coverage, the two tuning condensers, that is, the one in the oscillator and that in the r-f, should be on separate controls. This permits the use of any intermediate frequency within the tuning range of the broadcast receiver. The fact that both these controls must be set in a particular way to receive most strongly a given short wave signal makes tuning a bit difficult. With a little familiarity with the circuit, the difficulty soon disappears, however. There is no difficulty at all if the resistance input is used for then there is only one control. When the tuned r-f circuit is employed tuning will be greatly facilitated if the r-f condenser is set at minimum while the station is located by the oscillator control. Many stations can be received in this manner, that is, by setting the r-f tuner at zero and tuning the circuit with the oscillator condenser alone. When a station has been located, the volume may be increased by tuning the r-f circuit.

The First Band

Most divergence will occur between the oscillator and r-f condensers when the signal frequency is immediately above the broadcast band, and it will be greater the higher the intermediate frequency. Therefore, in order to track approximately, a low intermediate frequency should be used on the longer of the short waves. At times better results are obtained when the second oscillator coil and the largest r-f coil are used simultaneously. This works quite well when the intermediate frequency is high, say near the upper limit of the broadcast band.

As the signal frequency increases, the two coils are about of the same inductance and the two condensers track closely. The tracking, of course, is closer the lower the intermediate frequency, but when the signal frequency is very high, it does not matter what the intermediate frequency is, for even if it is 1,500 kc it is small compared with the signal frequency, so small as to be scarcely noticed.

Notes on Permeability Tuning

Last week we discussed permeability tuning and showed the construction of a coil, the use of a coil in a Colpitts oscillator, and the application of permeability tuned circuits to a radio frequency amplifier. We did not show the complete six-circuit tuner to which we referred, nor the selectivity possible with the arrangement.

The six-circuit tuner, four tube amplifier-detector, to which we referred is shown in Fig. 4. It will be noticed that there is a permeability tuned resonator in each grid circuit and also in each plate circuit. Two of the grid coils are returned to an automatic volume control device, whereas the others are not returned to any point. It is understood that the three plate coils are to be connected to a positive source of voltage in the usual manner and that the third grid should be connected to a suitable negative bias. The tubes in the circuit are shown to be of the filament type. This is hardly consistent with any tubes available, considering the functions of the various tubes. Hence we must assume that the cathodes have been omitted. There is no difficulty putting them in. The circuit was not drawn to show the detailed connections of all the

elements but only to show the placement of the coils.

The detector circuit shown is a type that is frequently used in broadcast sets. One of the diodes is employed for signal rectification and the other for automatic voltage control. The high potential side of last coil is connected to the diodes through a condenser, one directly and the other through a second condenser.

The selectivity attainable with the six-circuit tuner using permeability has been found to be greater for the lower signal frequencies but the difference is not great. When the signal frequency is 600 kc, it requires a signal about 100 times as strong at 10 kc off resonance as at resonance to put out the standard output. At 1,400 kc the signal required is only about 30 times that required at resonance. When the detuning is 20 kc it requires a signal about 1,000 times as strong as at resonance. At 30 kc off resonance the signal required is about 10,000 times. If all the circuits have the same selectivity and if they are lined up exactly, the Q-factor of each circuit is approximately 150, which is a very good Q indeed.

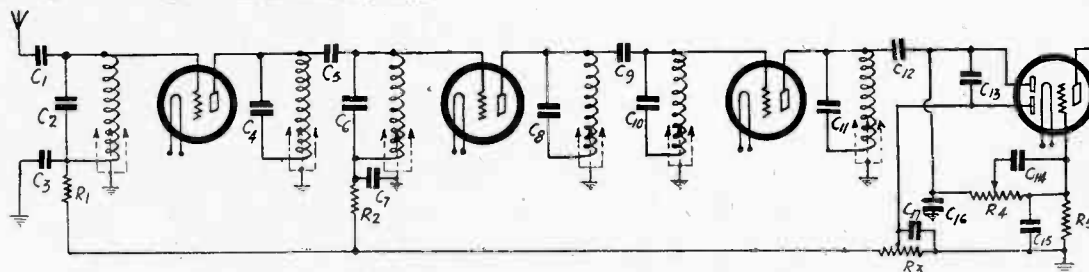


FIG. 4

This sketch shows how six ferro-inductors can be used in a tuned radio frequency receiver of high gain and high selectivity.

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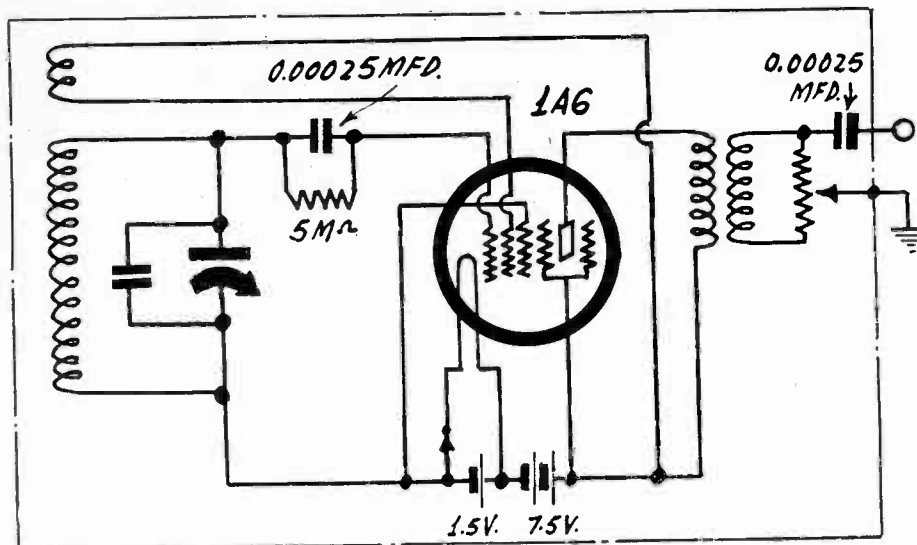


Diagram of an intended oscillator that one reader could not get to oscillate on low filament and B voltages, but the method to gain oscillation despite the voltage handicaps is revealed in the answer to his question on this page

How to Achieve Oscillation

HAVING TRIED the 1A6 in a hookup of my own, patterned somewhat after a diagram you published two weeks ago, but using batteries instead of universal method, I have been unable to make the oscillator oscillate. Enclosed is a diagram. Can you suggest remedies?—I. L.

There are two conditions that tend to prevent oscillation in your intended oscillator, and both may be readily overcome. First, the use of the triode as the oscillator. This is absolutely out, if you are to use such low plate voltage. The mutual conductance of the triode is far too low. Second, the grid leak acts as a damper. If you will increase the plate voltage to 45 to 67 volts you will get oscillation with the hookup as shown, but if you want to retain the low filament and plate voltages (1.5 and 7.5 volts respectively), then you should alter the circuit as follows. Omit the grid leak and condenser. Leave the tuned coil where it is. Connect the feedback winding in the screen circuit instead of in the plate circuit of the triode unit. Leave the control grid of the pentode unconnected anywhere. This will afford some modulation due to floating grid effect, if you want modulation. If not, ground the control grid of the pentode or connect it to the control grid of the triode. Whichever way you do it, calibrate the oscillator only when the circuit is in its selected formation, and do not switch from modulation to non-modulation, as the resultant frequencies are quite different when the pentode grid floats and when it is connected somewhere. The oscillator plate current (screen circuit) will be around 0.2 milliamperes, the filament current almost exactly 50 milliamperes. The B current through the primary of the output transformer (pentode plate) is virtually too small to measure with usual instruments.

Output of Oscillator

IN A HARTLEY oscillator I have built I get as high as 300 volts peak on the grid when the voltage applied on the plate is

only 250 volts. Where does the voltage come from? It does not seem reasonable to me.—W. H. C.

If you have a transformer with many turns on the secondary and a few turns on the primary, you get a higher voltage across the secondary than on the primary. It may not be reasonable but it is a fact. Also, when you impress a certain voltage on a tuned circuit, the voltage across either the condenser or the inductance may be many times greater than the impressed voltage. This may be unreasonable but it is a fact. If the plate winding of the Hartley is smaller than the grid winding there is a step-up of voltage as in any other transformer. Moreover, there is a tuned circuit which steps up the voltage. A voltage of 300 volts is by no means the limit obtainable in the Hartley or any other thermionic oscillator

Beat-Note Oscillator

IN A BEAT-NOTE oscillator I have constructed it is impossible to get low audio frequencies because the two high frequency oscillators interlock around 100 cycles per second. Nothing I have done has succeeded in preventing this. Can you suggest a way of preventing it so that I can get as low frequencies as 5 per second?—R.E.J.

The reason for the interlocking is that you have too close coupling between the oscillators. This may be mostly stray coupling through the air or through the power supply. Or the coupling may be through the oscillator tubes themselves. It is necessary to shield the two oscillators from each other and also from the rest of the circuit. Moreover, the intentional coupling should be loose. If the two oscillator coils are coupled inductively to a common coil which is in the input of the detector, it is very difficult to get loose enough coupling. The two oscillators should be coupled to grids, preferably of two independent tubes, before the mixer tube. All supply leads should be well filtered. The supply leads to each oscillator should pref-

erably be filtered separately. These extreme precautions are not necessary unless the beat is to approach zero.

Sensitivity of Meters

WHAT DETERMINES the sensitivity of a current and voltage meter? I have noticed that most sensitive meters have high internal resistances. Is this necessary?—B. M. S.

There are several things that affect the sensitivity of a meter. First, it is the strength of the magnetic field; second, the number of turns on the moving coil; third, the type of movement, or the restoring force used on the movement. Suppose the field has been made as strong as is consistent with the purpose of the meter, by using a large magnet with a field concentrated on the spot where the armature coil is to swing. Then one way of increasing the sensitivity is to increase the number of turns on the armature, or moving coil. Increasing the turns increases the length of wire and that in turn increases resistance. Moreover, as the number of turns is increased, the wire must be finer in order to get the coil into the concentrated field. This increases the resistance some more. The other way of increasing the sensitivity is to reduce the restoring force, which is done in many different ways. It can be done by decreasing the strength of the counterspring, or by suspending the movement from a single pivot, or by suspending the movement by a very fine phosphor bronze spring. The unipivot method is employed in some portable microammeters and galvanometers. The phosphor bronze suspension is employed in wall type galvanometers, and other instruments not intended to be portable.

A Sweep Oscillator

WHAT IS MEANT by a sweep oscillator as used in connection with a cathode ray tube? What does it sweep?—R. T. M.

When a cathode ray tube is employed for studying wave forms and various characteristics of tubes, the cathode ray must be moved in two directions at once. That is, it must move vertically and horizontally. The sweep oscillator is used for moving it horizontally, that is, to draw a straight line across the screen. This line is equivalent to the X-axis in Cartesian co-ordinates. The signal to be studied is used to cause deflections in the opposite direction, that is, at right angles to the sweep. This is equivalent to the Y-axis. When the two are impressed simultaneously, the ray traces a curve on the screen and gives the wave shape of the signal or the characteristic curve, depending on what is being examined. The latest sweep oscillators are constructed so that the sweep line is linear in respect to time, which means that the cathode ray moves equal distances in equal times across the screen. These are produced by means of a neon tube or other gaseous discharge tube. The linear time scale is produced by charging the condenser in the neon oscillator through a thermionic tube in which the plate current has saturation value.

Low Resistance Contacts

IN MANY SWITCHES sold for selecting different coils in an all-wave receiver the contacts often are very poor and sometimes are not made at all. Can you suggest any way of making contacts that will insure positive, low resistance every time?—E. L.

The resistance at contact points depends on several factors, namely, the pressure exerted by the springs, the surface area making contact, and the state of the surface. To increase the pressure we must have stiff springs. To increase the area we may have several contact points. Contacts are often better after they have been worn a while, just as a gasoline engine is better after it has been worked in. Perhaps the most important point is the nature of the contact area. If there is oxide or other

dirt, the resistance at the joint may be extremely high, even infinite. For this reason there should be a wiping movement so that the contact surfaces, or points, are wiped clean every time the switch is turned. It is especially important while soldering to the lugs on the switch to see to it that no flux flows over the contact surfaces. If the flux is corrosive, oxide will form which will make contact impossible. If the flux is rosin, this will harden and again there will be no contact. Many failures of switches are due to this. Of course, it is a defect in the design of the switch when flux can reach the points, but it is also carelessness to allow it to happen. In good relays and other switches the contact points are made of silver, for silver has a low resistance, does not oxidize readily, and the oxide is partly conductive.

Questions on Divers Subjects

1.—If the neutralizing condenser used to balance the plate to grid capacity in a radio frequency tube is too large, what will be the effect?

2.—If the maximum current is a sine wave is 40 milliamperes, what is the r.m.s. value of the current?

3.—What is the greatest advantage of a band-pass system over all other systems?

4.—Supposing that we have a five-tube radio receiver operating from batteries and that this set used 0.25-ampere tubes at five volts and we wish to install resistance so that the set can be operated from a 110 volts d-c line instead of a 6-volt storage battery, what size resistance is necessary in the circuit to make the voltage across terminals where the batter was six volts?—S. M. S.

1.—Since the circuit was regenerative before neutralization, it will be degenerative after the neutralizing condenser has been put in and made too large. In other words, the amplification will be less than it would be if there were no plate to grid capacity to neutralize.

2.—If the maximum current of a sign wave is 40 milliamperes, the r.m.s. value of the current is 0.707×40 milliamperes, or 28.28 milliamperes. The factor 0.707 is obtained by taking the square root of the mean square of the instantaneous values of the current for a quarter period. The mean square is obtained by integration and is $I^2/2$, that is, it is one-half the square of the maximum current. The mean square for one-quarter period is the same as the mean square for any number of whole periods.

3.—Some band-pass filters do not have any advantages over ordinary tuned circuits. A band-pass filter, however, may be superior in that the transmission inside the band is more uniform and is less outside the band than it is in ordinary tuned circuits.

4.—If the voltage drop in the circuit is 6 volts, which it will be if it has been adjusted for a storage battery, and if the line voltage is 110 volts, the voltage to be dropped in the added ballast resistor is 104 volts. Now, there are 5 quarter-ampere tubes, so the total current is 1.25 amperes. If the current through a resistance is 1.25 amperes and the voltage across it is 104 volts, the resistance must necessarily be $104/1.25$, or 83.2 ohms. The wattage dissipation in this ballast resistor will be $(1.25)^2 \times 83.2$, or 130 watts, which means that the ballast will be a little furnace.

Line Voltage Frequencies

IF A transformer has been designed to operate on 25 cycles per second is it safe to use it when the frequency is 40 cycles? If the filters in the B supply have been designed for 25 cycles will the filtering be as good on 40 cycles, or will it be better?—J. M. B.

It is quite safe to operate the transformer on 40 cycles, or on 60, but it would not be safe to operate a transformer designed for a given frequency on a much lower frequency. The filtering will be better when you use the filter on a higher frequency.

Television Scanning

WILL you kindly outline the different methods used for scanning scenes to be transmitted by radio? I have heard of the flying spot and the direct methods, but don't know just what they are?—R. N.

When the flying spot pickup is used, an intense beam of light is made to illuminate the scene in the proper sequence by sweeping the beam in horizontal lines from left to right and from top to bottom. Different amounts of light are reflected from the scene according to the nature of that scene. Photoelectric cells are placed in front of the scene, but toward the sides so that they do not interfere with the beam. These pick up a portion of the reflected light. This method is the most effective but it gives rise to unnatural pictures. In the direct method of pick-up the only light is that on the scene. Since the maximum possible illumination is quite limited, this method is not very effective. It requires more sensitive photoelectric cells. Sometimes the image formed on a screen by a high class lens is scanned rather than the scene itself. This is applicable to either method, that is, either flood illumination or flying spot. It has the advantage that the area scanned always has the same dimensions. Moreover, it takes advantage of the high state of the development of lenses.

* * *

Linear Time Base

WHAT is meant by a linear base in connection with scanning in television or in connection with the use of cathode ray oscillographs?—B. E. Y.

It has to do with the rate at which the cathode ray moves across the screen horizontally. If the time base is linear, the ray moves equal angles in equal times from one extreme to the other. Or the spot on the screen moves equal distances in equal times. Sometimes a sinusoidal time base is used, because that is the easiest to obtain. In this case the spot moves very rapidly near the center of the screen and slowly at the extremes. This makes the line produced brighter at the ends because the light lingers longer there. The linear time base is used in television scanning and it is produced by the output of a neon tube oscillator in which the condenser is charged through a saturated vacuum tube.

* * *

The Meissner Oscillator

THE Meissner oscillator is seldom used in superheterodynes, yet it seems to me that it has many advantages that would recommend it. There is no need of a stopping condenser and choke in the plate circuit, since there is a winding there that may go direct between the plate and the voltage

source. There is also a winding in the grid circuit and there may be a grid condenser and leak or bias. Again the tuned circuit is not connected conductively to anything, which is often an advantage? Does the oscillator have any serious disadvantages which makes it impractical? Is it possible to stabilize it?—W. B. N.

The Meissner has all the advantages you say, it can be stabilized just as any other oscillator, and it has no serious disadvantages. If you place the three windings on the same form and adjust the coupling between the plate and the grid coils so that the coefficient of coupling is the reciprocal of the amplification factor of the tube, then if there is no grid current, the oscillator will be stabilized. This is perhaps the easiest way of all to stabilize an oscillator, provided that the circuit can be adjusted so that no grid current flows. And that is not very difficult in the Meissner if the plate voltage is right and the grid is biased properly. The circuit is often used in commercial superheterodynes, but not particularly in the stabilized form, which is not necessary. To get the coupling loose enough to satisfy the condition that the coefficient should be the reciprocal of the amplification factor the tuned circuit should be put in the middle of the form and the grid and plate windings at the ends.

* * *

Oscillators on Low Voltage

IS IT possible to make a vacuum tube oscillator with as low voltage as 7.5 volts on the plate and about one-half the rated voltage on the filament?—W. E. C.

It is possible to make a tube oscillate even on lower voltages, but it depends on the tuned circuit employed and also on the bias used on the grid. First of all, the tuned circuit should have a high L/C ratio, or better, a high L/RC ratio, for the circuit will oscillate more easily the higher the inductance, the smaller the capacity, and the smaller the resistance in the tuned circuit. A small tube with a normal filament current of 60 milliamperes will operate on one-half that, or even on one-third. The plate voltage need not be more than 7.5 volts, and oscillation is possible even with 3 volts on the plate. An oscillator like this does not put out much power, of course, but in many instances it will be enough for the purpose.

* * *

Loss of High Notes in Resistance Amplifier

WHAT is the main cause of the loss of amplification on the high audio frequencies in a resistor-capacity coupled amplifier? I have made some measurements and the loss is much more than the tube capacities (Continued on next page)

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DOUBLE VALUE!

Station Sparks

By Alice Remsen

NEW SPONSORED PROGRAM FOR WABC

Quite a few new programs started over WABC and the Columbia network with the New Year. "Charm Secrets," with Jean Merrill, sponsored by the manufacturers of Lavis and originating in the Columbia Chicago studios, is the title of a new bi-weekly series heard each Tuesday and Thursday at 11:15 a.m. EST. Miss Merrill is an international beauty consultant, and she has promised to divulge secrets of charm and beauty which have heretofore been available for just a privileged few; so listen in all, ye plain young ladies, and learn the secret of charm, which always predominates over mere beauty of form and face. . . . Tony Wons, the hardly perennial of radio philosophers, begins a new Coast-to-Coast series on January 23rd; Peggy Keenan and Sandra Phillips, the popular red-headed pianists, will provide the musical background for excerpts from Tony's "Scrapbook"—read in his inimitable manner; the makers of Johnson's Floor Wax are responsible for this "philo-musi-phy" program which you may hear each Tuesday at 11:30 a.m. EST.; over the Columbia network. . . . Housewives will probably garner a lot of useful information and some new recipes from Jane Ellison, who features brief dramatizations of the housewife's problems along with her famous "Magic Recipes"; Miss Ellison will be assisted by Billy Bradley; program sponsored by Borden's Eagle Brand Condensed Milk, Each Wednesday, 11:45 a.m. . . . Tito Guizar's fans will be glad to hear that his Mid-day Serenade, with the Brillo Harp Ensemble, returns to WABC and the CBS network, each Sunday at 12:30 p.m. . . . Fred Waring's opening date for Ford is February 4th; Fred and his Pennsylvanians will be heard twice weekly, Sundays at 8:30 p.m. EST., and Thursdays at 9:30 p.m. EST. Guest artists will be used. . . . Frederic William Wile, whose discussions of "The Political Situation in Washington Tonight" have been a WABC-Columbia feature for more than ten years, now has a new schedule—Saturdays at 6:30 p.m.; the schedule change coincides with the renewal of Congressional activity in the Capitol City; Wile started his discussion of Washington events in 1923 and since then has been before the microphone every week during the life of Congress; he began his current series in September, more than three months before the Senators and Congressmen returned to their desks on Capitol Hill, because of the unusual interest in the activities of the administration. . . .

IF YOU LIKE IT

If you like an Argentine flavor to your dance music, tune in on Pancho and his orchestra, broadcasting from the Ambassador Hotel in New York, every Saturday at 5:00 p.m. and each Tuesday at 12:30 a.m. EST. WABC and network. This South American maestro previously played at the Casino, the Ritz-Carlton and the Embassy Club in New York, and at the Arrowhead Inn, Saratoga Springs; Pancho is famous for his tangos, composed by himself, and his wonderful rhumba rhythms. . . . The Mills Brothers, originally engaged for three guest appearances with Bing Crosby, will continue on the program until Bing leaves the Coast in February. Gus Arnheim and his orchestra have also been signed for that period. Gus is well-known as a conductor, pianist, composer and arranger. A tall slender, serious sort of chan. He and Bing have worked together before, and made many of the phonograph records which helped to

bring the singer to the attention of CBS. . . . Ford Rush, "Ye Happy Minstrel," and His Tiny Band, will be heard for another sixteen weeks over WABC and network. Wheatena has renewed his contract; five times a week—Mondays, Wednesdays and Saturdays at 6:45 p.m. EST, and Tuesdays and Thursdays at 4:45 p.m., EST. . . . The "March of Time," popular program of news dramatization, and in my humble opinion, the most interesting program on the air today, has been renewed and will continue to be heard over a nation-wide WABC-Columbia network Fridays at 8:30 p.m., EST, under the sponsorship of Remington-Rand. Arthur Pryor, Jr., son of the famous bandmaster, will continue his able directorship of the presentation, and Howard Barlow has been retained to take charge of the musical end; the editors of Time, the weekly news magazine, as heretofore, will prepare the scripts; six to eight of the outstanding current events of the week will be re-enacted in each dramatic edition, employing more than seventy-five actors and impersonators. . . . Gertrude Bates, Esther Ott, and Florence Creagh are the Rhythm Girls who are introduced by Paul Whiteman each Thursday night at 10:00 p.m. over WEA, and their pianist and arranger is Charlie Bates; yes, he is the husband of the cute little Gertrude. . . . Connie Gates is not the only shy radio singer; Shirley Howard and Francis Langford are shy, too! . . . Peter Dixon, in his Saturday radio column for the *New York Sun*, extols three CBS orchestras as being perfectly grand, and I hereby agree with him; the names are Freddie Rich, Mark Warnow and Andre Kostelanetz. . . . And Peter, dear, why a Jentucky major? Why not go the whole hog and be at least a Colonel? Or maybe a General? . . . I'll salute you, anyhow! . . .

GRACE DONALDSON IN A FLURRY

Ran into Grace Donaldson of the Don Hall Trio one afternoon last week; she was frantically trying to corral an orchestration in a hurry of a Feist song; none available; Grace wanted it immediately as the trio was opening in vaudeville the next day; believe she finally got one from the NBC Music Library. . . . Basil Ruysdael is still doing that beautiful program, "Red Lacquer and Jade," over WOR every Sunday at 6:00 p.m. EST.; there is nothing quite like it on any other station. . . . Another very interesting program on the Bamberger station is that of Allan Broms, the noted astronomer and science lecturer; I remember Mr. Broms very well; his broadcast preceded mine a few years ago; I always found his talks quite fascinating; if you are interested in the stars and planets, tune in on WOR, Saturday afternoons at 3:30 p.m. EST. . . . "Back Stage With Boris Morros," the program which comes from the Paramount Theatre over WOR, has a new schedule now—Saturdays at 8:30 p.m. EST.; tune in and you'll find this excellent entertainment. . . . Paul Whiteman is back on WOR, Monday evenings, 11:30 p.m. EST, from the Biltmore. . . . Alfred J. McCosker, President of the Bamberger Broadcasting Service, was among the many distinguished people who broadcast their greetings to the new 25,000 watt transmitter of Station KVOO, Tulsa, Oklahoma on January 7th. . . . Mary L. Roberts, who conducts the "Around the Wheel of Events" program every Wednesday morning at 11:15 on WOR, is still in her early thirties, but packed into those few years of her life is a varied experience; Miss Roberts has been associated with the U. S. Department of Justice, the British Government, Emma Gold-

A THOUGHT FOR THE WEEK

WE'LL admit that for a long time we didn't like Alexander Woollcott and The Town Crier air program. Mr. Woollcott seemed to us to be too whimsical, too full of painful nuances—in fact, altogether too-too. However, again, we listened in the other night—prepared to be a little bored and somewhat resentful; but we listened in. Then Mr. Woollcott told us about that wonderful system, "The Seeing Eye"—and forthwith we took off our mental hat to the narrator of the story of a remarkable plan by which highly trained dogs lead and take care of human beings who, blind and hitherto helpless, and often hopeless, are able to go about and find new safety and happiness in an active pursuit of life. It was an amazingly human story, beautifully and compassionately recounted. It was no longer the whimsical Woollcott who spoke—it was the human, feeling, understanding Woollcott who stood revealed.

We salute you, Alexander Woollcott, and we're going to listen again—for we now know you as you really are!

man, the Welfare Committee of Pittsburgh, the New York State Joint Legislative Committee; U. S. Senatorial elections, and she has made addresses on world problems and Americanization work; other activities include secretaryship to a U. S. Senator; she's a good housewife and cook, too; I'll say she's a pretty versatile sort of person. . . . Priscilla Parker, NBC soprano, is a second cousin to Richard Wagner, the composer.

MUSIC AND SCIENCE

And now engineers are writing music, too; Hunter Reynolds, Chicago NBC engineer, has composed a waltz, "Isn't Love Wonderful." Sure is, Hunter! . . . Margaret Ackerman, soprano, who broadcasts over WSM, Nashville, Tennessee, is soloist and a member of the quartet at the McKendree Methodist Church of that city. . . . Ann Greenway is making quite a hit over in London, with her beauty and charming way of putting over a song. . . . Cab Calloway has bidden New York a long farewell; he and his band are at present on a vaudeville tour; when that is ended Europe will beckon to these dusky troubadors. . . . Irving Mills has signed another colored orchestra—Jimmy Lunceford and his boys from the upper part of New York state; they promise to be as sensational as other finds of the astute Irving Mills. . . . A new dramatic series has begun on WEA, each Sunday at 7:00 p.m. EST; called "The Court of Human Relations"; well worth a listen!

Postal Radio Corp., 135 Liberty Street, New York City, has a new illustrated descriptive circular on their International Short Wave Receiver for free distribution.

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BYRD ICE PACK STATION KFZ GETS LICENSE

Washington.

The Federal Radio Commission has granted a license for the operation of KFZ, Antarctic unit of the Columbia Broadcasting System. This station, the most remote unit of a network in the world, will be located on the bleak ice pack at Little America and will start operating when the Byrd Antarctic Expedition sets up quarters at that location.

KFZ will be used to transmit the regular Saturday night programs of the expedition to the United States and also will be called into service for descriptions of any significant events in connection with the expedition's work. With KFZ's inauguration, KJTY, the present "floating" CBS unit aboard the Byrd flagship, Jacob Ruppert, will cease operating.

Will Use Ship's Transmitter

KFZ will use the same transmitter, of 1,000 watts power, now operating on the Ruppert, but it will have the added advantage of a directional antenna which will shoot short-wave signals direct to Buenos Aires for relay to the RCA receiving station near New York.

A second directional antenna, pointed toward New York, should make it possible at times to pick up the signals from the Antarctic direct. Transmission of Byrd Expedition programs, which, to date, has been considered remarkable in view of the limitations of ship's equipment, is expected to improve considerably when the transmitter gets its stationary location on the ice.

Coincident with the granting of the license for KFZ, the Commission also licensed KFZY, which will be the 200-watt broadcasting unit at the forward base of the expedition within the shadow of the Queen Maude Mountains.

400 Miles from Pole

At this base, which is only 400 miles from the South Pole, two men will be stationed throughout the long winter night with equipment to be used in case of any emergency during Admiral Byrd's proposed flight to the South Pole. The station will be used to keep the men in touch with the main camp at Little America and a description of their experience in this exceedingly cold encampment is expected to be relayed by short wave to American listeners some time during their exile.

The Byrd program is broadcast over the CBS chain Saturdays at 10 p.m. EST. The frequencies assigned to the Byrd stations, in case any short-wave fans want to try picking him up direct, are between 3 and 22 megacycles, and the actual frequency used is selected each time on the basis of testing.

Corporate Activities

REPORTS

RKO Midwest Corporation (Controlled by Radio-Keith-Orpheum Corporation, which in turn is controlled by Radio Corporation of America)—Net loss for the three months ended March 31, \$19,486. The total net loss for 1932 was \$41,545, compared with a net income for 1931 of \$285,745.

Crown Record Co., Inc., phonograph records, 10 West 20th Street, New York, N. Y., has assigned to New York Credit Men's Association, 470 Fourth Ave., New York, N. Y.

BANKRUPTCY PROCEEDINGS

Mary Olds, 353 W. 57th St., New York, N. Y., radio advertising. Assets: \$100; liabilities, \$1,679.

TRADIOGRAMS

By J. Murray Barron

Nussbaum's radio store, 61 Cortlandt Street, New York City, one of the best known of the Cortlandt Street stores, has moved to Rockefeller Center, Sixth Avenue between 49th and 50th Streets, and will be known as Rockefeller Center Radio Shop.

* * *

Postal Radio Corp., 135 Liberty Street, New York City, reports orders from many foreign lands, as well as from all points in the United States for its short-wave set. The drawer-type coil assembly is gaining and hams are likewise interested in the special beat-note oscillator. There is some interesting descriptive free literature.

* * *

At times some of us forget the viewpoint of the younger fellow, even though we may have been of the experimental type when growing-up. To-day many of the boys and youths are even more alert to mechanical things than some of us older fellows were, so those of us who get our kick from radio experimenting should not forget the smaller brethren.

* * *

Frank Hanus, formerly operating under the name of General Fabricating Company, 37 East 18th Street, New York City, is now doing business under the name of Insulating Fabricators, Inc., at 10-14 East 12th Street. The company does fabricating as well as engraving and machine work. Stock of merchandise includes bakelite, lamicoide, fibre, pressboard and varnished sleeving in sheets, rods and tubes.

* * *

Radio Manufacturers Association, Inc., opposed before a Congressional committee the continuance of the 5 per cent. excise tax on manufacture and said its removal would increase employment by at least 10 per cent., perhaps 15 per cent. A general sales tax was favored for increase of Federal revenue.

* * *

Arcturus now makes the 25Z5 rectifier operate in 17 seconds. Many of this year's sets, particularly the a.c.-d.c. models, use the 25Z5 as well as the 43, both indirectly heated tubes which have required 60 seconds or longer to operate. The Arcturus 43 is an equally quick heater.

* * *

A new and distinctive console type radio cabinet designed by Lewis Winner, of Hammarlund Mfg. Co., New York City, has made its debut. Its lines are somewhat modified moderne, getting away from the straight up and down flat cabinet and yet not theatrical, but in all a very pleasing effect. This will house the latest model Comet Pro.

* * *

To those, and there are some no doubt, who feel that the parts business is a thing of the past, we would suggest a visit to the bargain basement of the Try-Mo Radio Co., Inc., 179 Greenwich Street, New York City. Marcus Lager reports good business, and on last Saturday showed a capacity crowd, that reminded one of the very earlier days when most folks built all their radio receivers. Here one may find as fine a stock of small and replacement parts as can be found anywhere in the country. Servicemen, amateurs and experimenters are particularly catered to. There is a complete staff to aid and assist on radio problems.

* * *

The new edition of the Servicemen's Handy Manual as issued by the Try-Mo Radio Co., 85 Cortlandt Street, is in reality more than just what its name might imply. The experimenter or others who desire short wave circuits and general information and suggestions with regard to various radio apparatus should find it quite helpful.

Literature Wanted

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

Grover K. Martin, 4328 34th St., San Diego, Calif.
George Martin, 369 Northridge Road, Columbus, Ohio.
S. M. Skovran, 826 Vista St., N. S., Pittsburgh, Penna.
Stanley J. Pearson, 5700 Hamlet Ave., Cleveland, Ohio.
David Knopf, 1135 Forest Ave., Bronx, N. Y.
John F. Gallant, c/o J. W. Dole, Rowley, Mass.
George Carass, 418 York St., Jersey City, N. J.
Jos. Belick, 65 Front St., Box 133, Coplay, Penna.
C. D. Cannon, 2820 Franklin St., Denver, Colo.
E. W. McCullough, Box 17, c/o Postmaster, U.S.S. Texas, San Pedro, Calif.
B. & M. Radio Service, 258 Delaware Ave., Dayton, Ohio.
Dr. J. H. Robinett, 612 First Huntington Nat'l Bank Bldg., Huntington, West Va.
Joseph S. Maksym, 84 Hope Ave., Passaic, N. J.
Gustave Simmons, Radio Service, 228 Wyoming Ave., Billings, Mont.
Michael Malast, 17 Reservation St., Buffalo, N. Y.
Lester Stein, 528 W. Mishawaka Ave., Mishawaka, Indiana.
B. H. Cooke, Box 293, Selma, No. Car.
C. A. Lauster, 12 Ampere Parkway, East Orange, N. J.
Roy P. Johnston, 4177 Canton Ave., Detroit, Mich.
W. H. West, Lake Wales, Fla.
Ernest H. Smith, 613 12th Ave., Sterling, Ill.
Lange Radio Exchange, 4115 No. Thomas Ave., Minneapolis, Minn.
Harold E. Boutillier, 58 Alexandra St., Sydney, N. S., Canada.
John W. Auer, 1 Grosvenor Road, Kew Gardens, N. Y.

Ultra Frequencies Get Attention for Police

To further the development of police radio a special Radio Manufacturers Association committee on police radio recently arranged in New York City to compile not only specifications and standards for construction and performance of police radio, but additional basic information and data essential to efficient installation.

The information being gathered by the committee is designed to assist officials of states, counties and municipalities in their adoption and development of police radio. Dr. Alfred N. Goldsmith, consulting engineer, with Chairman L. F. Curtis of the RMA Police Radio Committee, and E. L. Nelson of the Bell Telephone Laboratories will cooperate in preparing data. Among the problems which will be studied will be two-way communication, the ultra-high frequencies as compared with present police frequencies, single transmitter systems and multi-systems, single receiving point versus multiple receivers (two-way systems) and coordination of individual cities into groups by radio and teletype.

Also to be considered is drafting of requirements on performance of well-designed police radio receivers and for incorporation in purchasing specifications. The problem of installing police radio in automobiles, in cooperation with motorcar manufacturers, also is involved.

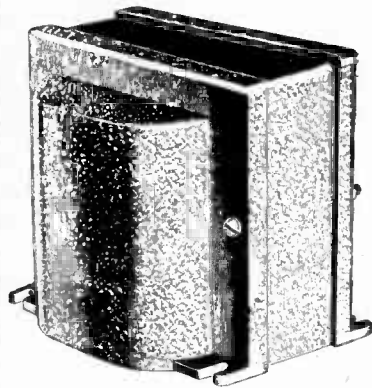
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Power Transformer for a BIG SET



INSTEAD of using undersized, overheating, inefficient power transformers for a big set, why not use a cool-running, efficient transformer and pay the little extra? The Reliable transformer, Model 104-SP, will work an 18-tube set. Provides for C bias supply through 25Z5 rectifier, for quality Class C or Class A.

Primary = 115 v., 60 cycles
 Secondary X = 14 amp., 2½ v., ct.
 Secondary Y = 6 amp., 2½ v., ct.
 Secondary R = 5 v., ct.
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FOR STANDARD SPEAKERS

Outside diameter of cones is given, also d-c resistance of field coils. If tapped field is desired, state ohmage of tap.

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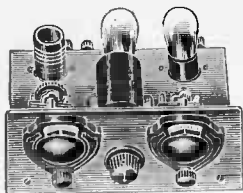
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NEW 1934 DIAMOND of the AIR

A-C OPERATED SHORT-WAVE RECEIVERS

12,500-Mile Reception

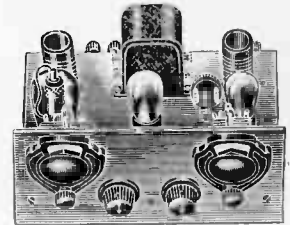


2-TUBE

Introducing the latest in short-wave receivers. The "Diamond of the Air" 2- and 3-tube battery receivers for many months have been acclaimed by owners to be the most remarkable short-wave receivers in their class. Now, for the first time, Reliable Radio Company introduces the 1934 A-C SHORT-WAVE "DIAMOND"—incorporating all the features of the battery-operated sets plus the convenience of a-c operation. The receivers have to be powered additionally and the power pack quotations will be found on this page.

IMPROVED RECEPTIVE QUALITIES

All 1934 features have been incorporated in the new "Diamond of the Air" a-c short-wave receiver and, besides, the popular battery-operated models have been improved in a new 1934 design. The lowest in price, yet these sets will log stations from all parts of the world regularly.



3-TUBE

The A-C "Diamond of the Air" Receivers

The a-c receivers have been developed for those who have the benefit of electric service. They use the latest type triple-grid tubes, resulting in more selective and sensitive reception.

The 2-tube model employs a 57 tube, resistance coupled to a 56 type output tube. For those desiring to use this receiver on batteries, simply replace the 57 type tube with a 77 and the 56 tube with a 37, for heater excitation from a 6-volt storage battery and use B batteries for plates. Loudspeaker reception on all local and many distant stations.

The 3-tube a-c receiver uses a 58 as an r-f amplifier, followed by a 57 detector and a 56 as an output tube. This receiver can be used on batteries by using 77, 78 and 37 tubes as detailed above. Capable of logging stations from all parts of the world.

Employs the Highest-Grade Materials

A receiver is only as good as the parts used in its construction. Only the finest parts are included. Hammarlund condensers, representing the finest, are used. The metal panel eliminates body capacity.

DIAMOND OF THE AIR

Battery-Operated Short-Wave Receivers

The battery-operated receivers employ the 2-volt low-current tubes, saving considerable expense to those living in districts where no a-c is available. The two-tube model uses two 30 tubes. Especially designed for headphone reception, although loudspeaker reception may be obtained at ordinary room volume.

The 3-tube two-volt model employs one 34 and two 30 tubes. It will receive short-wave stations from all parts of the globe on a loudspeaker.

Electric Models

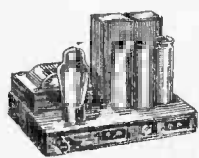
- Cat. No. 5025-D. Two-tube A-C kit, with blueprint. Shipping weight, 5 lbs. \$8.45
- Cat. No. 5026-D. Above, wired and tested. Shipping weight, 5 lbs. 9.45
- Cat. No. 5027-D. Complete set of tubes for above, either one 57 and one 56 for a-c operation or one 77 and one 37 for battery operation. Specify which. Shipping weight, 2 lbs. 1.45
- Cat. No. 5028-D. Three-tube a-c kit, with blueprint. Shipping weight, 7 lbs. 11.45

- Cat. No. 5029-D. Above, wired and tested. Shipping weight, 7 lbs. 13.45
- Cat. No. 5030-D. Complete set of tubes, either one 58, one 57 and one 56 for a-c operation or one 78, one 77 and one 37 for battery operation. Specify which 2.45

Two-Volt Battery Models

- Cat. 5019-D. Two-tube kit, with blueprint, less accessories listed below. Shipping weight, 5 lbs. \$7.75
- Cat. No. 5020-D. Above, wired and tested, less accessories listed below. Shipping weight, 5 lbs. 8.75
- Cat. No. 5021-D. Complete accessories including two 230 tubes, one set of standard headphones, two No. 6 dry cells, two standard 45-volt B batteries. Shipping weight, 22 lbs. 4.50
- Cat. No. 5022-D. Three-tube kit, with blueprint, less accessories listed below. Shipping weight, 7 lbs. 9.95
- Cat. No. 5023-D. Above, wired and tested, less accessories listed below. Shipping weight, 7 lbs. 10.95
- Cat. No. 5024-D. Complete accessories, including two 30 tubes and one 34 tube, one set of standard headphones, two No. 6 dry cells, three standard 45-volt B batteries, one 6-inch magnetic speaker. Shipping weight, 32 lbs. 8.95

DIAMOND of the AIR SHORT-WAVE POWER PACK



Supplies clear hum-free power regardless of circuit sensitivity. Especially designed for use with the "Diamond of the Air" Short-Wave receivers, but can be used on any short-wave battery-operated receiver for B supply.

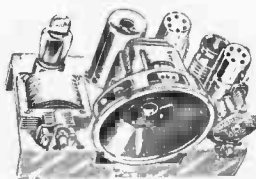
Contains a brute-force filter, employing two heavy-duty 30-henry chokes, specially-designed power transformer, and three electrolytic condensers. These factors assure pure d.c.

Will deliver 180 volts. Supply your own taps, 135, 90 and 45 volts. Supplies 2½ volts at 10 amperes for filament drain. All taps terminate at binding posts on the side of the pack. Employs an 80 rectifier. Will stand up to 75 ma. drain for B current.

All parts are mounted on a sturdy metal base finished in silver.

Cat. DAPP. Price, including 80 tube\$5.95

Shipping Weight, 20 Lbs.



Four-Tube A-C Short-Wave Receiver with Built-In Speaker

Will tune in short-wave stations from all parts of the world with ease. Uses four plug-in coils to cover the entire short-wave band from 15 to 200 meters. The built-in power supply is entirely free from hum or disturbing line noises. Uses an ultra-sensitive dynamic speaker which aids in tuning in the weaker signals.

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For A-C and D-C Operation

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With headphones the entire world is at your finger-tips. Chassis is completely encased in a beautiful crystal finished cabinet. Covers the short wave, band from 15-200 meters. Uses one 78, one 25Z5 and one 43 tube.

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WITH EACH PURCHASE OF A SHORT-WAVE RECEIVER



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