FEB. 1937

HOW TO USE THE 913

RADIO WORLD

REG. U. S. PAT. OFF.

Quality with Tuner and P. A.

25c Per Copy

Power amplifier being checked by Charles J. Goss with Triplett instruments. At right is the superheterodyne tuner. See article, page 9.

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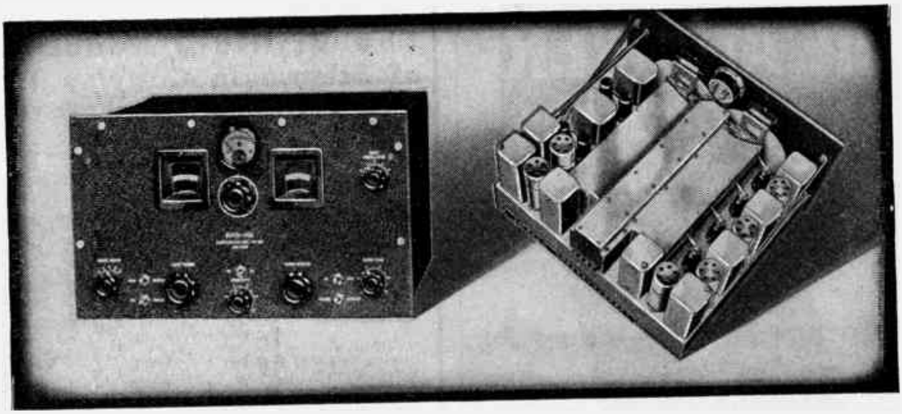

RADIO WORLD

Fifteenth Year

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A GLIMPSE AHEAD

Next month, in the March issue, constructional text and illustrations will be given for the de luxe tuner, diagram on page 25 of this issue, and a complete super, with 6L6 audio output, both using the voltage-doubling balanced detector. Another article will deal with the cathode-ray tube adaptation to television, considered from the viewpoint of the tubes used in service applications today. Circuits for making various measurements also will be featured.

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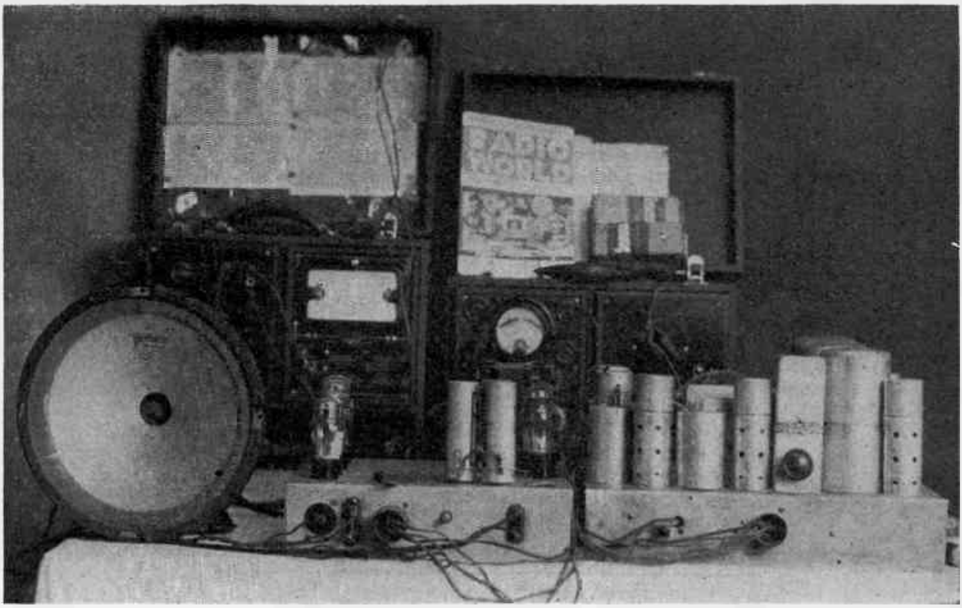


Both amplifier and power supply are shown on one chassis, immediately to the right of the speaker in the illustration. One of the two tuners is at extreme right. The other tuner is shown in similar position on the front cover illustration.

Segregation for Quality

Separate Tuners and Power Amplifier

By Einar Andrews

THE advanced radio experimenter who has ideas of his own and the ability to reduce them to practice often adopts the segregated method of construction. That is, he builds his tuner and intermediate-frequency amplifier on one chassis and his audio amplifier and power supply on another. Or he may go even farther in his division of the receiver. He may build the radio-frequency tuner and amplifier on one chassis, the intermediate frequency filter and amplifier on the second, his audio amplifier on a third, and his power supply on a fourth.

The advantages of such construction are many and considerable. First of all, the design lends itself readily to the "high boy" or skyscraper type of construction. This is of great advantage where floor space is at a premium. In the second place, the method is almost indispensable to the inveterate experimenter. When he gets a bright idea and wants to try it out forthwith, he does not have to design and build an entire receiver, for the idea in question relates to a particular part of the receiver. It may be in the tuner, in the intermediate filter, in the detector, in the audio amplifier, or in the power supply. He needs only to rebuild the pertinent component of the set. He saves not only money but a great deal of time.

For the same amount of money in the same time he can try out scores of ideas where he could only try one if he had to rebuild the entire receiver each time.

DEVICES BUILT BY GOSS

Even in custom-built receivers there is an advantage in the separate-unit type of construction. Most of these receivers are large and elaborate. To build them on one chassis would require an exceptionally heavy and sturdy frame, and the completed receiver would be unwieldy and cumbersome. When the set is constructed in separate units, each unit is easily handled. When a set like this breaks down and needs repair, it is not necessary to call in a gang of piano movers to transport it to the service shop. The service man who calls finds out in which section the defect has developed, and if he cannot effect repairs on the spot, he tucks the offending section under his arm and runs back to his shop with it.

Two receivers built in sections by Charles

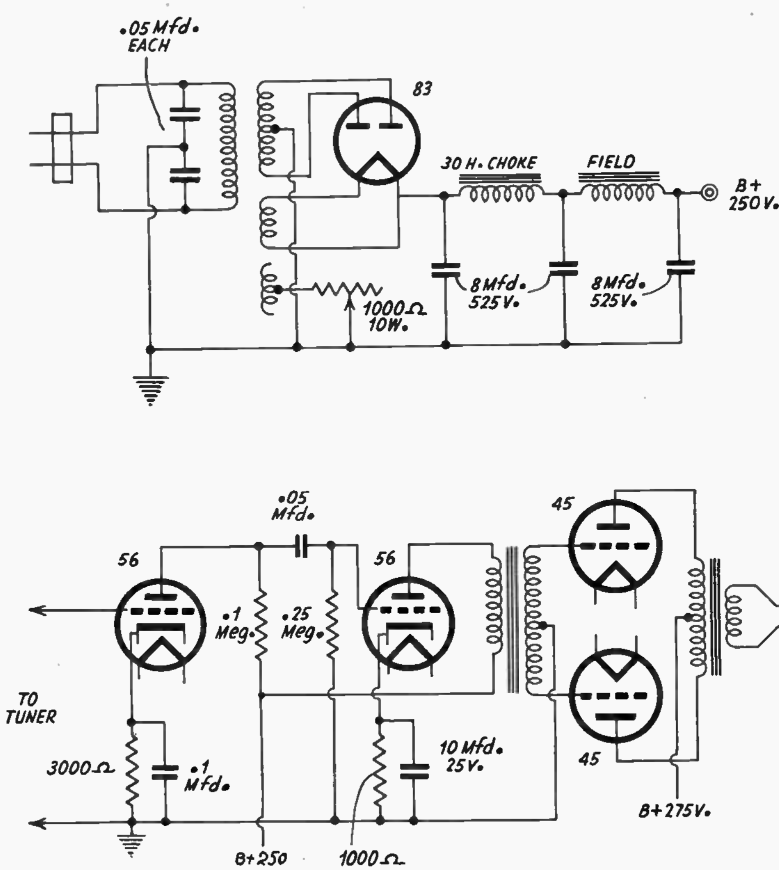
(Continued on following page)

(Continued from preceding page)

J. Goss, of 1730 Woodlawn, Terre Haute, Ind., are depicted. At the right in the first illustration is the radio and intermediate frequency tuner and amplifier, in the middle the audio amplifier and power supply, and at the left the loudspeaker. Behind the receiver are various test instruments with which the designer and builder adjusted the set to the highest accuracy.

each. Sometimes this filter does no appreciable good, but at other times it helps a great deal. It never does any harm.

The filter on the d.c. side consists of three 8 mfd. condensers. Condensers of 450-volt rating should be all right. As will be noticed, the field of the speaker is used as one of the chokes in the filter, as is now customary. The supply for the two output tubes, 45's, is taken from



Wiring circuit of the power amplifier and rectifier. The heater supply for a tuner would be included in the tuner as a separate filament transformer.

Let us glance first at the power supply and audio amplifier. The rectifier and filter are standard but an 83 tube is used in place of one of the more common rectifiers. Since this tube is of the mercury type, a couple of radio frequency chokes, one in each anode lead, might be used to advantage, or a single choke in the lead from ground to the centertap. The chokes may not be absolutely essential.

THE SUPPLY CIRCUITS

The customary filter in the primary of the power transformer is used. The values of the condensers are not critical and may be .05 mfd.

the juncture of the choke and the field, at which point the voltage is 275 volts, for the transformer used and the total current drawn. The drop in the field is 25 volts. The bias resistor for the two 45 power tubes is attached to the 2.5-volt winding on the power transformer. It is variable. For class A operation the normal value is 1,000 ohms, for two tubes, but for class AB it may be twice as great or more.

Two 56 tubes are used ahead of the power stage. Resistance-capacity coupling is used both between these two 56's and between the first 56 and the tuner ahead. Transformer coupling is used between the second 56 and the output stage, since this uses two 45's in push-pull. The two 56's are self-biased by means of separate resistors.

It is clear that this audio amplifier is capable of a large undistorted output and that the gain is high.

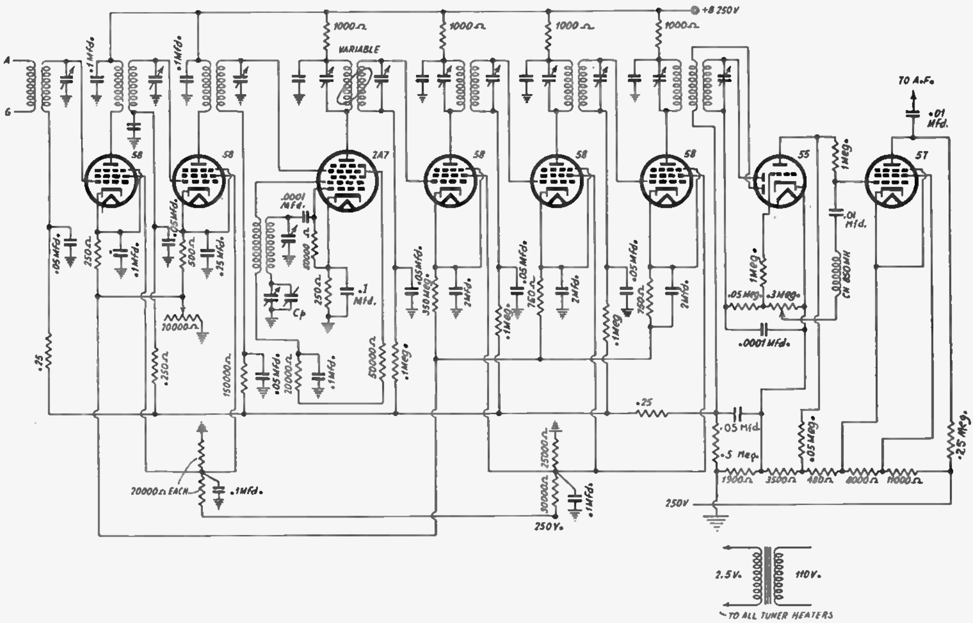
TWO TUNERS PROVIDED

The designer of this outfit offers two tuners between which those wishing to utilize the design may choose. The main difference between the two is that in one the oscillator is a 58 and in the other it is a 2A7. Each circuit has three radio frequency tuners and a frequency control, requiring four sections of a gang condenser.

Where the 58 is the oscillator, the detector is into the common lead to prevent grounding of the two elements to the high frequencies.

A feature of the intermediate-frequency amplifier is that the first doubly-tuned transformer has variable coupling. The details of this are shown in a constructional drawing. This feature appears in both circuits.

Another noteworthy feature, also appearing in both circuits, is the segregation of the audio and the a.v.c. rectifiers. In each case the last intermediate transformer has three windings. Two of these are tuned, the a.v.c. winding being the untuned one. This separation of the two functions in the rectifier provides flexibility of connections. One advantage is that the filter



The tuner that uses a four-gang condenser has a 2A7 pentagrid converter tube.

a 57. Where the 2A7 is the oscillator, it is also the detector. Different oscillators are used in the two cases. The tuned grid type is used with the 2A7 and a Hartley type with the 58. The tuned grid type has one advantage, in this case, and that is that both the tuning and the padding condensers are connected to ground on one side. Therefore there will be no body capacity effects while adjusting the padder. The Hartley has the advantage of simpler coil system. Of course the Hartley can be grounded the same way, by putting the leak from grid to ground and rotor, but the designer had two two-gang condensers, enabling isolation, one example being in the antenna circuit.

The coupling between two components of the mixer, the 58 oscillator and the 57 detector, is effected by tying the plate of the 58 to the screen of the 57. A 5,000 ohm resistor is put

condenser for the a.v.c. may be made ten times as large as that for the audio rectifier, thus allowing thorough filtering of the a.v.c. voltage without interfering with the high audio frequency resolving power of the sound rectifier.

NOISE SUPPRESSION

In both tuners a noise suppression circuit has been inserted between the rectifier and the audio amplifier. As is customary in circuits of this type, the squelcher tube is a 57, which is selected because it has a rapid cut-off. How does this part of the circuit work? When there is no signal, there is no bias on the grid of the 55, for there is no current through the .3 meg. section of the load resistance. Since there is no bias on the grid there is a high current through the plate load resistance, which is 50,000 ohms.

(Continued on following page)

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The drop in this resistance is added to the normal grid bias, 3 volts, of the 57. The drop in the plate resistance is much greater than 3 volts, and it is such that the negative bias on the grid of the 57 is increased. The 57 therefore is close to any signal because the grid bias is beyond the cut-off point. Any audio signal applied to the 57—and it would be only noise—cannot be amplified.

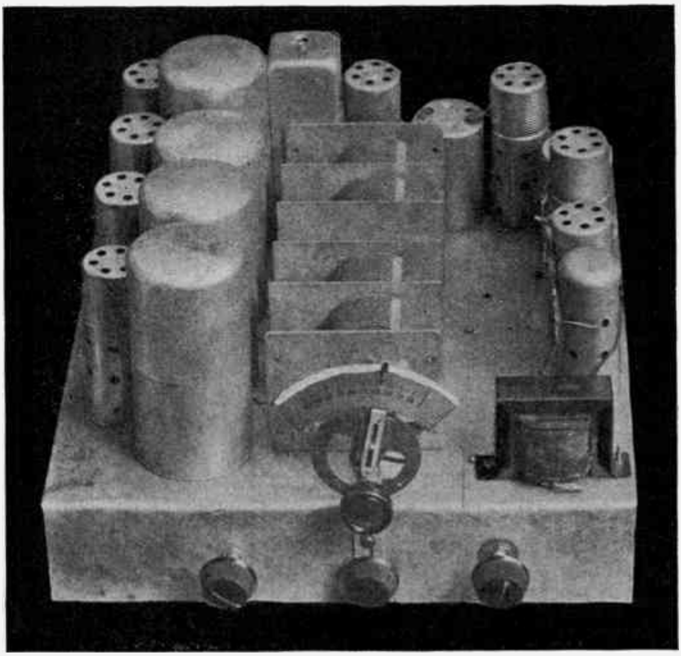
On the other hand, where there is a strong audio signal there is rectification in the 55 diode and a high bias is developed. No current, or at most very little, flows in the plate resistance of the 55 triode. Hence the normal bias on the 57 grid is about 3 volts, at which it is most effective as an amplifier. The audio signal, which is picked off the load resistance on the diode and is impressed on the grid through an 85 mh choke and a .01 mfd. condenser, is amplified to a high degree. The amount of input to the 57 grid is varied in the usual manner by means of a potentiometer.

If the noise is steady and considerable it might open the 57 tube to amplification just as an audio signal does. This might happen when the noise is about as strong as the signal and when it is sustained.

D.C. VOLTAGE PROVISIONS

Automatic volume control is applied to the first r-f 58 and to the three i.f. 58's. In addition to this a.v.c. there is a manual control for the two r-f 58s, a 10,000-ohm variable resistor being connected in the common cathode lead. Again, there is another 10,000-ohm resistor in the common cathode lead of the three r.f. 50's. Thus the gain in the two amplifiers can be controlled separately, and both independently of the a.v.c.

Attention is called to the coupling between the 55 triode and the 57 squelcher. The plate of the 57 is returned to the highest voltage available through a 20,000-ohm resistor and the screen is connected to a point 150 volts lower down on the voltage divider. Still lower down, 100 volts exactly, the cathode of the tube is connected. Thus the screen voltage is 100 volts and the plate voltage is 250 volts. To get a negative bias on the 57 it is necessary to connect the grid return to a still lower point, and the return is made to a point 3 volts below the cathode connection.



Tuner with four-gang condenser. This enables two stages of t.r.f., tuned input to the modulator at the r.f. level, and a section of the gang for the local oscillator. The three r.f. coils and the oscillator coil are in a row at left, between the condenser and the tubes served by the coils. The filament transformer, used to supply heaters of the tuner tubes, is at right front.

The triode of the 55 must also have a plate voltage. It is obtained by connecting the cathode and the plate return to points separated by 25 volts on the voltage divider. That is, the maximum plate voltage on the 55 triode is 25 volts. There is no stopping condenser between the plate of the 55 and the grid of the 57. The coupling is direct in the strictest sense of the word, and it is obtained by means of a 50,000-ohm resistor.

DELAY ON A.V.C.

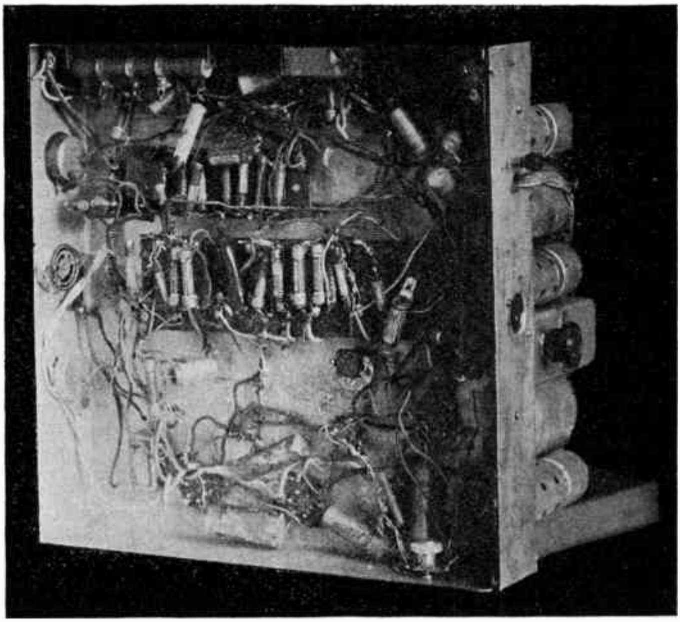
The point on the general voltage divider where this resistor is connected is the B plus point for the 55 triode and the C minus point for the 57. The function of the one megohm resistor between the grid and the plate is to prevent the audio signal voltage from shorting, in part, through the plate coupling resistor. Since there is no d-c through it, there is no drop and it does not, therefore, affect the grid bias on the 57. The operation of the arrangement in suppressing noise has already been discussed.

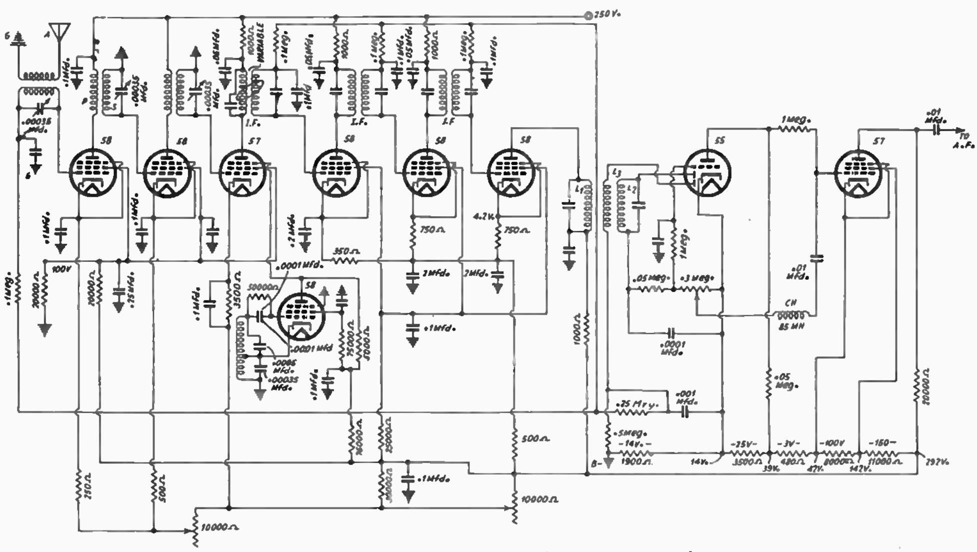
There is no delay voltage on the audio rectifier, for the load resistor is connected directly to the cathode of the tube. There is a delay voltage, however, on the a.v.c. rectifier, and it amounts to 14 volts. This is the drop in the 1,900-ohm resistor between ground and the cathode of the 55. The peak of the signal, as impressed by the untuned winding on the third i-f coil, must be 14 volts before there is any current through the a.v.c. rectifier circuit. Weak signals, therefore, are not affected by the a.v.c. This fact is an aid in making tuning adjustments for it is not necessary to short-circuit the a.v.c. while tuning up but only to reduce the signal impressed until it is less than 14 volts when rectified by the a.v.c. rectifier. Putting this 14-volt desirable handicap on the a.v.c. without putting any handicap on the audio rectifier is one of the advantages of using separate circuits for the two functions.

Attention is called to the fact that in the

(Continued on following page)

A glimpse underneath the chassis of the tuner that has the three-gang condenser. The rear of the tuner is at right and the knob plainly showing is the one used for permanent adjustment of the variable coupling of one of the i.f. coils. This adjustable arrangement was improvised, as detailed in a separate diagram. The controls at left are those used at front of panel.





This is the tuner that uses a three-gang condenser.

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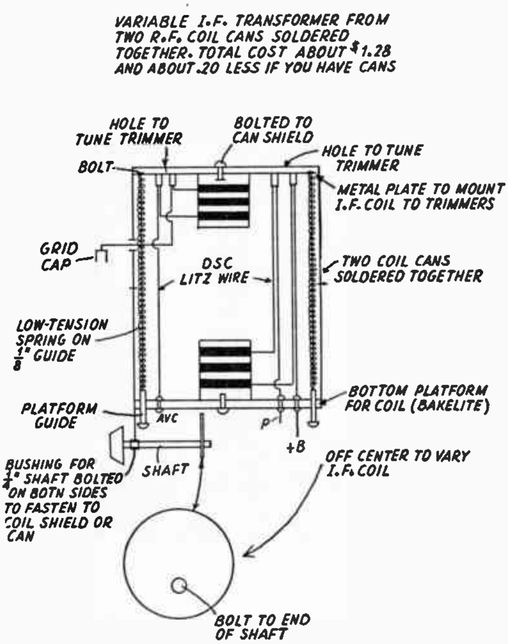
tuner with the 58 oscillator one of the tuning condensers, the first, is not grounded on either side. This suggests an isolated condenser section. It is possible, however, to avoid this, allowing the use of a regular four-gang condenser, by connecting the series resistor and the by-pass condenser in the same relative order as in the circuit with the 2A7 oscillator. The by-pass condenser, which has a capacity of .05 mfd. is then connected in series with the tuning condenser and the common point is grounded.

How the tuner chassis appears when viewed from the front and above is shown in the photograph on page 12. The first four tubes are shown at the extreme left and next to them the



How the variable coupling i.f. transformer was improvised.

four radio frequency coils. In the rear, immediately to the right of the fourth radio frequency condenser, may be seen the intermediate coil with the variable coupling. Directly behind the four-gang tuning condenser is the first i-f tube. Then follow three fixed coupling i-f coils and shielded tubes between, ending up at the front right corner with the filament transformer.

The four-gang condenser is split into two sections of two each. These two pairs are insulated from each other. It is not necessary, however, that they should be insulated, as has been pointed out.

On page 13 is a photograph depicting the under side of the chassis. The small parts are too crowded to identify any of them. It is noted, however, that resistors and condensers are placed in an orderly manner so that wiring is simplified and stray coupling minimized.

TUBES UP

11% Average Increase

After years of steadily declining prices, an increase in the prices of practically all types of radio receiving tubes is in effect.

The large number of different types of tubes, for many of which there is now only a limited demand because of the obsolescence of the radio sets in which they are used, and mounting material and labor costs, have made the increased prices necessary. An overall increase of 11 per cent over former tube prices is made.

Attached is a list of the new list prices on all types of receiving tubes, compared to old net prices, as furnished by RCA Radiotron Co. Division of RCA Mfg. Co.:

STANDARD GLASS TYPES

Type	*Old Price*	*List Price*
00A	$1.25	$2.00
01A	.59	.70
1A4	1.50	1.75
1A6	1.25	1.50
1B4	1.75	2.00
1B5-25S	1.25	1.25
1C6	1.50	1.75
1F4	1.50	1.50
1F6	1.50	2.00
1v	.89	1.10
2A3	1.25	2.25
2A5	.99	1.20
2A6	.99	1.20
2A7	1.25	1.50
2B7	1.25	1.50
5Z3	.89	1.00
6A4-LA	1.25	1.50
6A6	1.25	1.50
6A7	1.25	1.35
6B7	1.25	1.50
6C6	.99	1.20
6D6	.89	1.20
6E5	1.50	1.50
6F7	1.50	1.75
6B5	1.50	1.50
10	2.00	2.25
11	1.25	2.00
12	1.25	2.00
12A7	....	2.00
12Z3	.99	1.10
15	2.00	2.00
19	.99	1.20
20	.99	2.00
22	1.25	1.50
24A	.89	1.00
25Z5	.99	1.20
26	.59	.70
27	.69	.80
30	.69	.80
31	.69	.90
32	1.25	1.50
33	.99	1.25
34	1.25	1.50

(Continued on following page)

(*Continued from preceding page*)

Type	*Old Price*	*List Price*
35	.89	1.00
36	.89	1.10
37	.69	.90
38	.89	1.10
39-44	.89	1.10
40	.69	1.00
41	.89	1.10
42	.99	1.20
43	.99	1.20
45	.69	.80
46	.99	1.35
47	.68	1.35
48	2.50	3.00
49	.99	1.20
50	2.50	2.25
53	1.25	1.50
55	.99	1.25
56	.69	.80
57	.89	1.10
58	.89	1.10
59	1.25	1.50
71A	.69	.80
75	.99	1.10
76	.69	.80
77	.99	1.20
78	.99	1.20
79	1.25	1.50
80	.59	.70
81	2.00	2.00
82	.89	1.10
83	.89	1.10
83v	1.50	2.00
84-6Z4	1.25	1.50
85	.99	1.20
89	.99	1.50
V99	.99	1.50
X99	.99	1.50
112A	.69	.90
874	4.90	4.00
876	6.70	6.00
886	6.75	8.00

* * *

ALL-METAL TYPES

Type	*Old Price*	*List Price*
5W4	$1.00	$1.00
5Z4	1.25	2.00
6A8	1.25	1.50
6B8	1.50	1.75
6C5	1.00	1.25
6F5	1.00	1.25
6F6	1.00	1.35
6H6	1.00	1.25
6J7	1.25	1.50
6K7	1.25	1.35
6L6	2.00	2.25
6L7	1.50	1.75
6N7	1.50	1.75
6Q7	1.25	1.35
6R7	1.25	1.35
6X5	1.25	1.50
25A6	1.50	1.50
25L6	...	2.25
25Z6	1.25	1.50

G SERIES TYPES

Type	*Old Price*	*List Price*
1C7G	$1.85	$2.00
1D5G	1.85	2.00
1D7G	1.60	1.75
1E5G	...	2.00
1E7G	2.35	2.75
1F5G	2.35	2.00
1F7G	1.85	2.00
1H4G	1.10	1.00
1H6G	1.60	1.75
1J6G	1.35	1.35
5U4G	...	1.50
5V4G	1.85	2.00
5X4G	1.35	1.50
5Y3G	1.10	1.00
5Y4G	1.10	1.00
6A8G	1.60	1.50
6C5G	1.10	1.25
6F5G	1.10	1.25
6F6G	1.35	1.35
6H6G	1.10	1.25
6J5G	...	1.20
6J7G	1.35	1.50
6K5G	1.35	1.35
6K6G	1.35	1.35
6K7G	1.35	1.35
6L6G	2.10	2.25
6L7G	1.60	1.75
6N7G	1.60	1.75
6Q7G	1.35	1.35
6R7G	1.35	1.35
6X5G	1.35	1.50
25A6G	1.35	1.50
25B6G	1.85	1.75
25Z6G	1.35	1.50

New Type Etched Foil Condensers Made by C-D

Cornell-Dubilier has brought out the Type KR Etcher Foil Dry Electrolytic condensers. This type is notable for its extreme compactness and for a patented exclusive etched foil process which assures a much better condenser than that made possible by less modern foil etching methods. An idea of the small size of the Type KR may be gained from the fact that the largest condenser in the series (24 mfd.) is approximately the same size as the average metal tube. This makes for convenient servicing of small receivers, greater symmetry of layout and contributes to the neatness of service jobs. Full details of this line of condensers are given in a special catalog No. 134A, which is now available and which may be obtained by addressing the manufacturer at South Plainfield, New Jersey.

BRUNO MOVES AND ENLARGES

The Bruno Laboratories, Inc., moved from 20 West Twenty-second Street to 30 West Fifteenth Steet, New York City, now occuping 10,000 square feet of additional space.

Remaking Power Transformers

For Higher Requirements, Using Old Cores

By M. N. Beitman

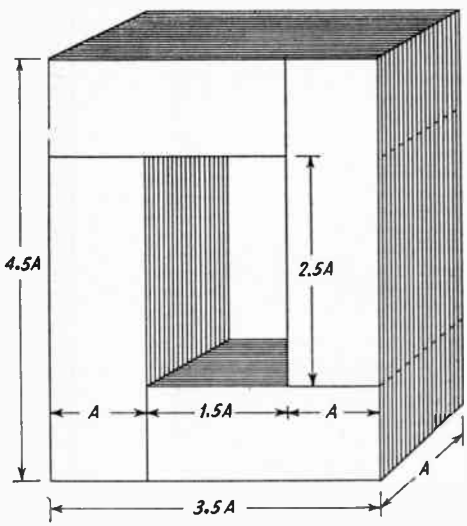


FIG. 1

Single opening for the window of the transformer, where windings are intended to be on separate cores. One winding could be slipped down on the left-hand upright, and the other up on the righ-hand upright. This is the L type.

THEORY and procedure in designing radio and amateur transmitter transformers are of especial value to any one intending to redesign and rebuild power transformers for more suitable characteristics. The present-day prices of power transformers are at such low figures that, except in the most unusual cases, it is cheaper to purchase power transformers that are commercially available than to build similar units.

Power transformers are used in radio receivers and transmitting equipment to step up or down the supply voltage which is commonly about 110 or 220 volts. In radio receiver power transformers all the secondaries are incorporated in a single unit, since the existing potential difference between the various secondary windings is relatively small. In an amateur transmitter a separate transformer is commonly employed for each secondary voltage required and, except in the very low power transmitter, the filament and plate transformers are never combined.

EFFECT OF TURNS RATIOS

Essentially a transformer consists of an iron core of suitable dimensions, a primary coil, and one or more secondary coils. The voltage induced in the secondary is in the same ratio to the primary supply voltage as the ratio of the secondary turns is to the primary turns.

The design for 60-cycle power transformers will be considered. However, any of these designs can be adapted for 25-cycle use by doubling the core cross-sectional area. The frequencies of 60 and 25 cycles are commonly used to supply power throughout the United States.

There is a great deal of flexibility in the design of power transformers. However, cores of certain shapes and a definite economical ratio of copper wire to iron core are generally used. Transformers are rated in watts, assuming unity power factor, or regardless of the

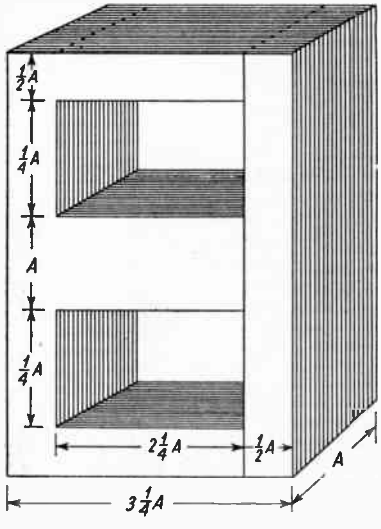


FIG. 2

Double opening used as the window, enabling putting all the windings on a single core, the cross-piece at center. This is the E type core.

power factor, in volt-amperes. The volt-ampere rating of a power transformer having more than one secondary is the sum of the volt-ampere ratings of the different secondaries.

WHAT COMPRISES CORE?

The core is made of silicon steel and consists of strips about 0.014 inch thick. The general shapes and the related dimensions of cores employed in radio transformers are shown in Figs. 1 and 2. The window space for the windings varies somewhat and in a well-designed unit the windings should just fill the window space.

The size of the copper wire used depends on the current. The primary current may be found by dividing the volt-ampere rating by the operating line voltage. For example, a 250-volt-ampere (watt) transformer for use on a 110-volt a.c. line will require a primary current of 2.27 (250/110) amperes at full load. The secondary maximum currents are usually considered in the initial design.

If no safety factor is required and the transformer is to be operated in comparatively open space, the wire size may be selected on the basis of 1,000 circular mills per ampere. The

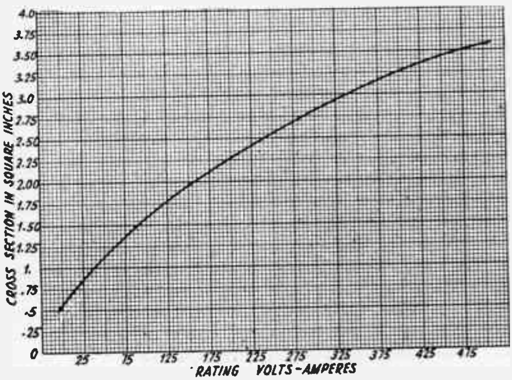


FIG. 3

The value of the cross-sectional area in square inches (read at left, bottom to top) is compared to the volt-ampere rating for 60-cycle transformers (read along the base). See Fig. 4 to get turns per volt.

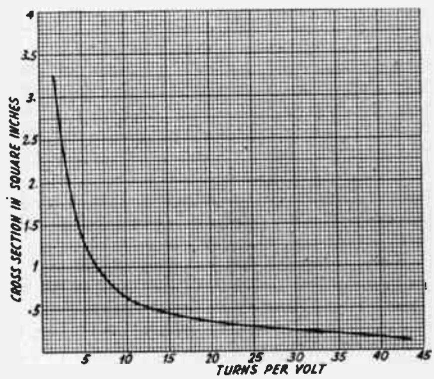


FIG. 4

Again the cross-section in square inches is considered, this time in comparison to the number of turns per volt. The number of square inches in the cross-sectional area is divided by 6.47 to obtain the turns per volt shown in the curve.

The cross-sectional area of the transformer leg is the determination of the unit's power handling capacity. The value of the cross-sectional area in square inches in relation to the volt-ampere rating is given for 60 cycle transformers in Graph 3. It is best to have the leg square in shape.

The turns per volt are found by dividing 6.47 by the cross-sectional area expressed in square inches. This may be found from Graph 4. The figure 6.47 is obtained mathematically from the fundamental equation for the voltage induced in the winding of a transformer. Fractional values of turns per volt may be rounded off by adding or subtracting as much as 20% of the value without any serious effect on the design.

SIZE OF COPPER WIRE

A transformer designed from purely theoretical consideration of the ratio of primary to the secondary will deliver the computed voltage at no load, but under load the secondary voltage will be lower because of the IR drop in the secondary winding. Generally it is best to allow about 5% extra turns for the secondary. While this figure is not correct for all cases, it will serve well in standard power transformer design and will eliminate much additional mathematical work.

correct wire size may be found from Graph 5. It is not very easy to handle wire thicker than No. 12, and if thicker wire is required two or more strands of thinner wire should be used in parallel. Many different types of insulation are used on wires, but for the amateur and experimenter double-cotton covered wire is recommended for the thicker wire requirements, single-silk enameled for sizes up to 32, and plain enamel wire for still thinner wires.

TURNS PER LAYER

It is much easier to place all the windings on a single core and the E type core, Fig. 2, is therefore recommended. The window dimensions may be modified to suit special requirements as they arise. For example, a 30-watt transformer to supply 2½-volt filament voltage will require a much smaller window than suggested. The primary is usually wound first, next to the core; the high-voltage secondary, if any, next; and low-voltage secondaries last. Correct insulation must be used between the different coils and insulation is advisable between layers. The complete coil assembly should be wound on a core of insulating material.

Having determined the number of turns required, and the type and size of wire to be

(Continued on following page)

FADING
Traced and Cured

MANY radio servicemen have confessed to the writer that they have spent many hours, and sometimes several days, in trying to find the cause of intermittent fading. I refer particularly to that type of trouble caused by coupling or by-pass condensers opening or changing capacity, flux joints affecting a.f. or r.f. voltages, etc. After questioning the complaining ones, it seems that almost invariably they all pursue the same course in attempting to locate the source of the trouble. After checking all tubes and voltages, and poking around here and there with no success, these fellows sit down, test prods in hand, and wait for the set to fade, or "pop out," and then check voltages again for a change.

Now comes a very annoying thing, indeed. Very often, when a fading receiver is touched nearly any place with a test prod, the signal immediately comes back again, and if the trouble should be due to a change in voltage of radio or audio frequency, especially r.f., the average repairman's equipment will not read it anyway.

In one of San Francisco's busiest repair shops, it is a common practice when a difficult job of this type is encountered to replace all by-pass condensers in the set. If this fails, they even start replacing r.f. chokes. This is supposed to be a time-saving system, but either the shop makes a very poor profit, if any, or the unsuspecting customer pays for a lot of parts he didn't need.

To some readers of this article, this haphazard way of going about a problem will seem very unprofessional.

When guesswork, intuition, and poking here and there have failed, start at either end of the set with the generator, and the process of elimination is a simple one. If you start at the antenna end, proceed stage by stage toward the output until you come to a point where the receiver ceases to fade. Conversely, if you begin with the final audio amplifier, then work backwards to the antenna circuit until a circuit is reached where fading *starts*. Either way will isolate the trouble for you, and *then* is the time to start inspecting parts and soldered joints, when there is just one small area to check.

ALAN C. KAYE.

Kaye's Radio Service,
3692 18th St., San Francisco, Cal.

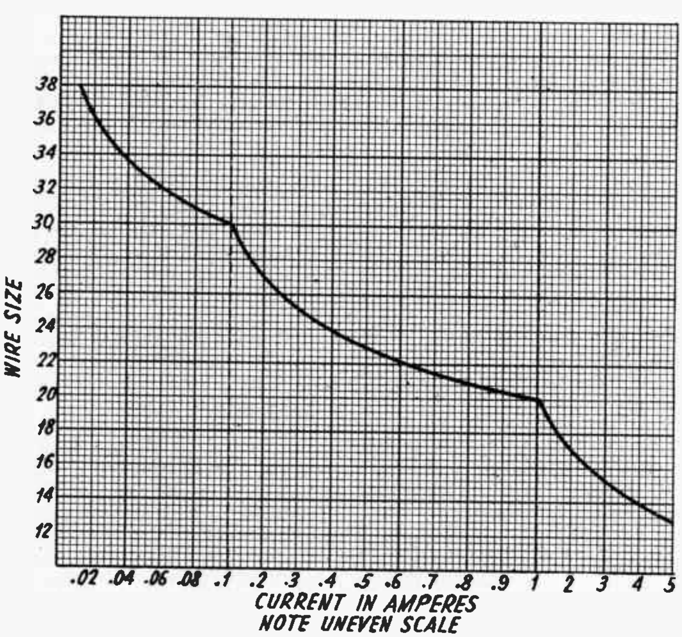


FIG. 5
One of the problems is to ascertain the correct wire size. This may be done by using the curve herewith, which relates wire size to current in amperes. The wire is selected on a basis of 1,000 circular mils per ampere, on the assumption the transformer is to be given plenty of ventilation.

(*Continued from preceding page*)

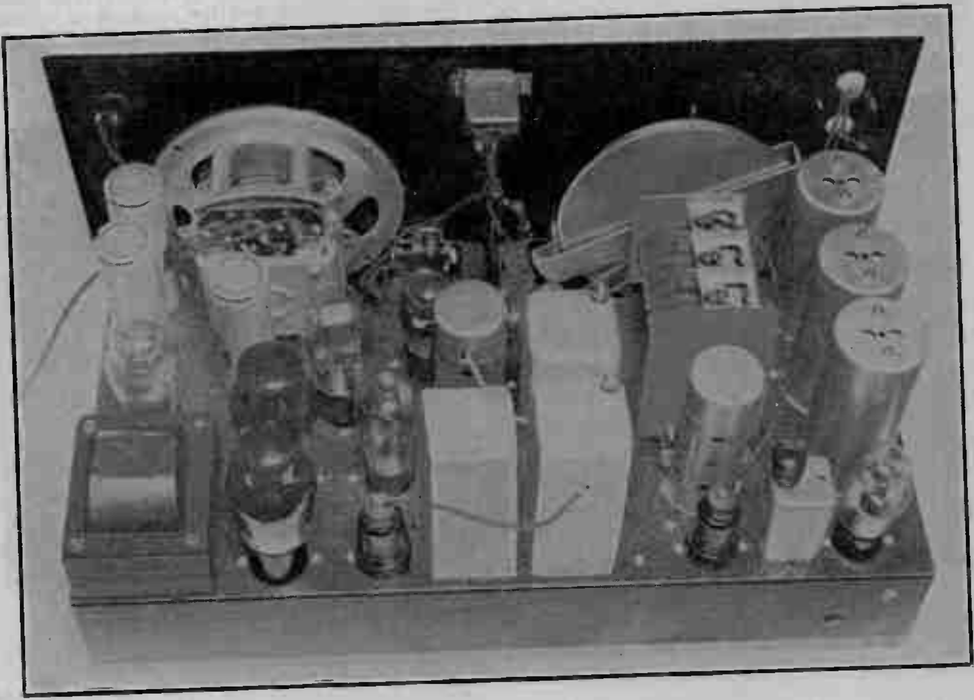
used, the number of turns per layer may be found from standard wire tables. From this information and the dimensions of the window the number of layers needed may be found. This process is repeated for all the different windings of the transformer. The thicknesses of all the layers are added, including the thickness of the insulating material used. The figure obtained should be about 80% of the space available.

Amateurs will find that cores of burnt-out power transformers or cores of units not having the required characteristics may be easily rebuilt for other applications. The primary need not be rewound unless it is at fault. An excellent power pack may be made inexpensively from a number of discarded transformer cores.

From 5 to 550 Meters

With Dual Type Personal Receiver

By Edwin K. Butler



View of the rear taken at an angle of 45 degrees.

AS a superheterodyne this twelve-tube receiver has four ranges, covering the waves from 20 meters up to and including the broadcast band. As a superregenerative receiver it extends the range from 20 meters to 5 meters. A beat frequency oscillator is also provided for receiving continuous code signals and for simplifying tuning in of broadcast signals.

The superheterodyne has two r.f. tuners and an oscillator frequency control. That is, a three-gang condenser is used for tuning the circuit. Each of the twelve tuned coils in the complex tuner is trimmed by an adjustable condenser marked Tr in the diagram. For switching in the various bands a six-circuit, four-position switch is employed. When the superegenerative feature is to be used, the gang switch is left on one of the four stops, thus making use of the primary as a radio-frequency choke coil, and the signal is tuned in with the 6J5-S tube. The superheterodyne is prevented from functioning when short waves are being received by switching the audio amplifier from the superheterodyne to the superregenerator by means of a D.P.D.T. switch. Since the switch throws out of the circuit the triode section of the 85, and as additional amplification is required, a stage of 42 is inserted in its place.

The switching out of the 85 triode also throws out the manual volume control, since this is placed in the grid circuit of the triode, and for that reason the manual volume control is duplicated in the grid circuit of the 42. In each case the control is a 1 meg. potentiometer.

The A.V.C. Features

Automatic volume control is employed in the superheterodyne, the grids of four tubes being returned to the negative end of the load resistance of the diode rectifier. Since there is no tube in the superregenerator that can or need be controlled automatically, the control in that circuit is done manually, first in the grid circuit of the 42, as mentioned above, and second

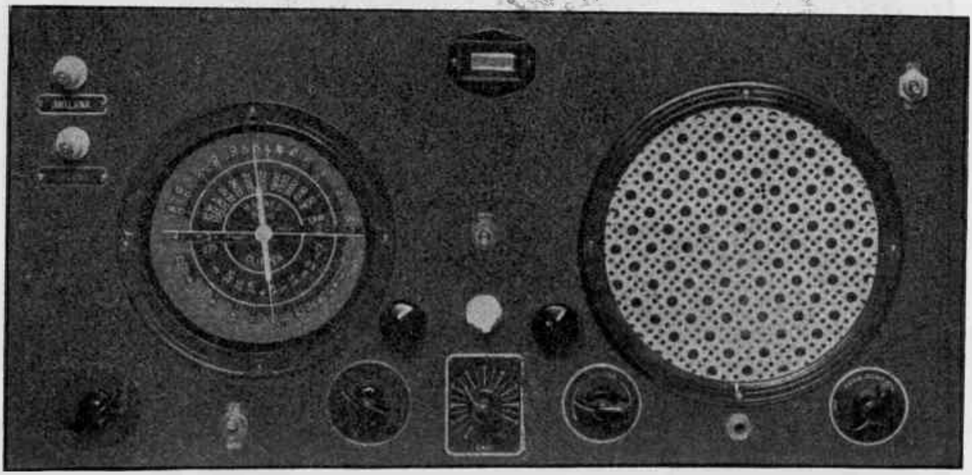
(*Continued on following page*)

(*Continued from preceding page*)

by control of the antenna condenser. Superregenerators, of themselves, when properly functioning, supply their own a.v.c.

The beat note oscillator appears, in the diagram, directly above the 6J5-S. It is a triode tube in a typical Hartley circuit. The grid of the oscillator is connected to the grid of the first i-f amplifier through a 15 mmfd. condenser. A small adjustable condenser across the oscillator coil allows making small changes on the local oscillator frequency, hence large changes in the beat frequency. While it is true that any beat frequency can be obtained by merely tuning the main oscillator control, it is desirable to adjust the beat oscillator so that the beat frequency is between 500 and 1,000 cycles when the signal is tuned in exactly. The 500-1,000 cycle note then is an indication that the circuit has been tuned in exactly "on the nose" for any given station. The note will be the same for every station, and it is easily recognizable. When the signal is voice or music modulated, the oscillator is stopped as soon as the tuning has been effected, and the stopping is effected by opening a single pole switch in the plate circuit of the beat oscillator.

(*Continued on page 22*)



Appearance of the front panel. Controls are identified below.

Where the Panel Controls are Located

The controls and posts on the front panel serve the following purposes:

At upper left is the antenna post, immediately beneath it is the ground post.

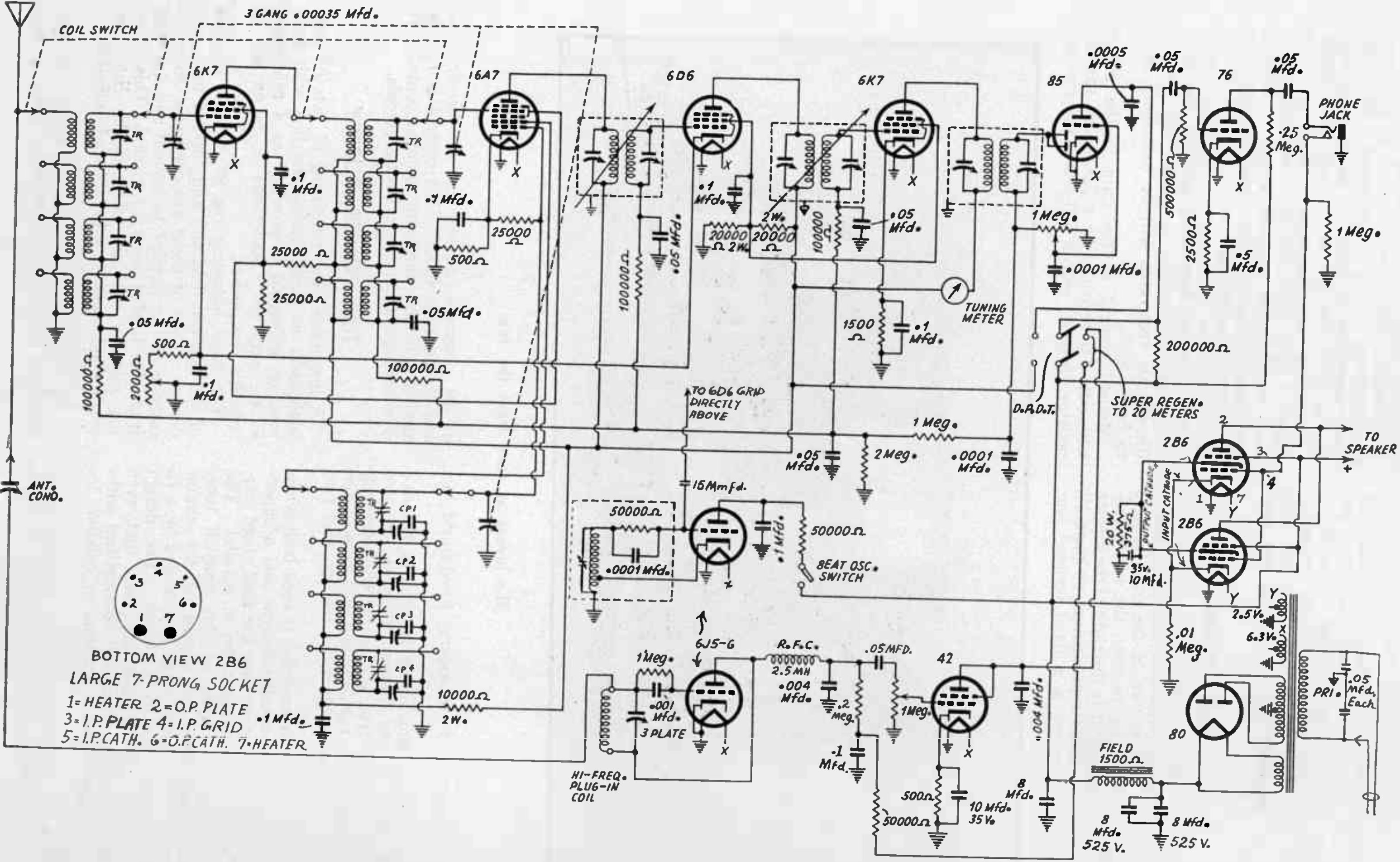
At lower left, positions marked 1, 2, 3 and 4, is the coil switch for the 15-550-meter bands.

The tuning dial is connected to the gang condenser and controls that, but by a pulley arrangement the separate high-frequency tuning condenser also is belted to the same dial, which therefore serves for all the tuning.

Immediately under the tuning dial is a double-pole, double-throw switch, for introducing super-regeneration for the 5 and 10 meter bands, and removing it for the higher wavelengths (lower frequencies).

Just to the lower right of the tuning dial is the knob that controls that dial, while to the right of the knob is a white object, controlling the antenna coupling condenser for the high frequencies (waves of 10 meters and lower). Just above that object is on-off switch for the beat frequency oscillator. The tuning meter, a Readrite 0-5 milliampere device, is at top center.

The oblong plate with the radial white lines at lower center is the volume control for the high frequencies only, while to its right is the attenuator for the 5 and 10 meter bands only. Between the two, elevated somewhat, is the control for gain in the tuner, applicable to 15-550 meters only. The earphone jack is just below the speaker grille, and the tone control bar handle is at lower right. At upper right is the master switch, controlling the a.c. line supply.



The 2B6 socket connections are particularized. I.P. = input and O.P. = output. I.P. cath. = .01 meg., O.P. cathode = 375 ohms.

(*Continued from page* 20)

The beat frequency oscillator coil is shielded and consists of a single tapped winding of intermediate frequency proportions. That is, it must oscillate near the intermediate frequency, which in this case is 465 kc. The coil may be seen in the front right corner of the rear view of the set on page 19.

Two I.F. Coils Adjustable

The intermediate frequency transformers are tuned to 465 kc with Hammarlund air dielectric condensers. The first two of the transformers have variable coupling between the two windings. These two appear to the right of the median line in the photograph reproduction on page 19. The third transformer is a fixed coupled one, with primary and secondary fixed-tuned as usual.

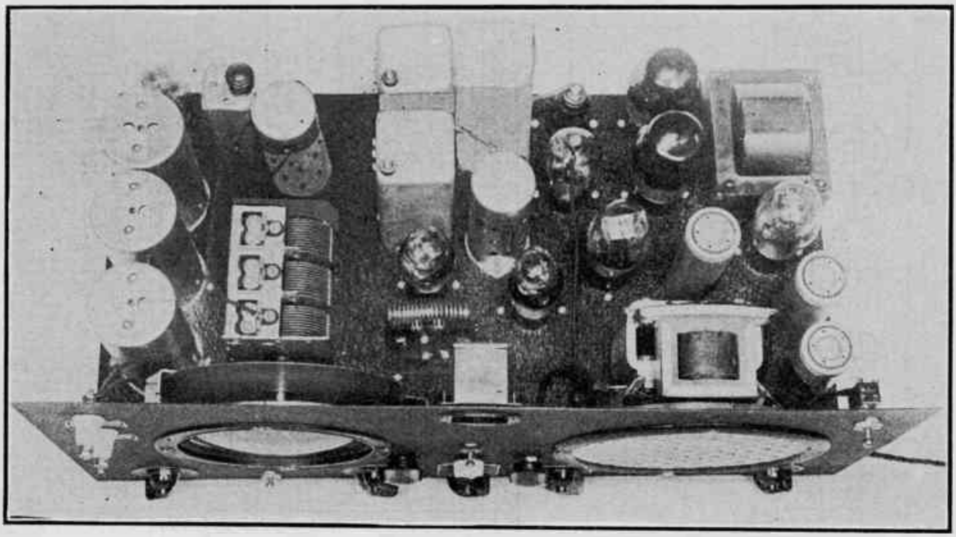
The r-f coils, which may be seen at the extreme right in the figure on page 19, are shielded, which is true also of the transformers, with trimmers, in each shield can. Two of the trimmers are accessible from the top and two from the bottom.

A first-rate audio amplifier is used both when the receiver is a superhetehodyne and a superregenerator. In either case the final stage consists of two 2B6 power tubes in parallel. The bottom view of socket of this unusual tube, which Triad makes, is shown on the circuit diagram. The output stage is preceded by a 76 and resistance-capacity coupling. The design constants in this coupler are such that even the lowest audible notes will be amplified without any appreciable reduction in relative intensity.

When the superheterodyne is used the triode of the 85 is the additional amplifier at aud'o frequency. This is coupled to the 76 by means of resistance-capacity values such as to insure good response on the lowest notes. When the superregenerator is used the 42 is substituted for the 85 triode, as has already been stated.

Since the superregenerative detector is in reality a grid leak detector, and therefore a diode rectifier plus an audio amplifier, there is much more audio amplification when ultra-short waves are received than when those of longer wavelength than 20 meters are received. Much more is needed because practically no radio frequency amplification is posible and many of the signals receivable will be extremely weak to begin with.

Manual control of the gain in the superheterodyne is provided by a 2,000-ohm variable resistor, in series with a 500-ohm fixed resistor, in the common cathode lead of the first r-f and the first i-f tubes. This control is merely auxiliary to the automatic volume control. It is advantageous on very strong signals.



The layout as seen from the top.

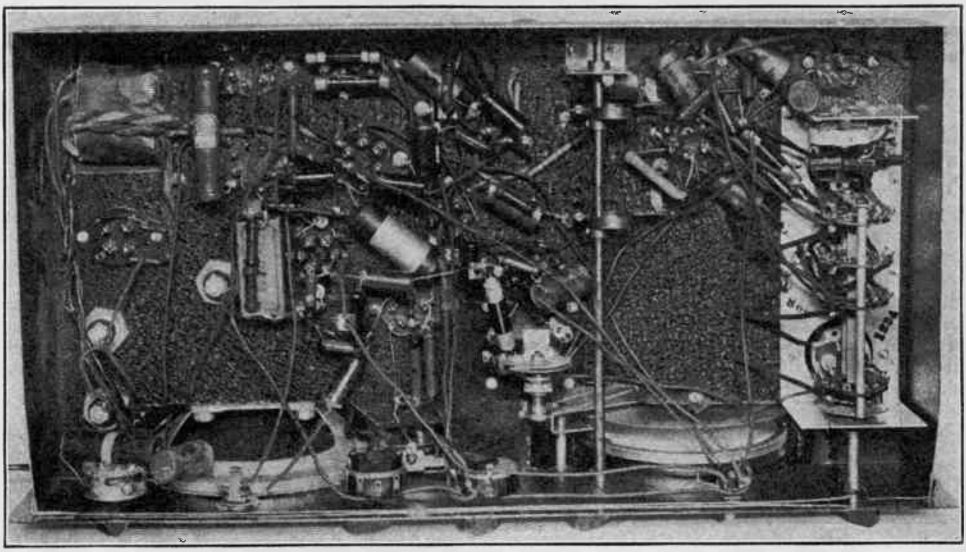
THE POWER SUPPLY

A line noise filter consisting of two .05 mfd. condensers in series across the line with their junction grounded is provided as a refinement in the receiver. Sometimes it is an aid in reducing line noises.

The filter following the 80 rectifier consists of the speaker field coil and three 8 mfd. condensers. Two of these are connected from the cathode of the rectifier to ground and the third from the B plus point to ground. This filtering, together with the effect of the distributed small condensers, has been found sufficient for this receiver.

The distributed filtering is quite thorough, but it is more to prevent stray coupling than

View of 5-550-Meter Set's Wiring



Bottom view, showing the wiring.

to eliminate hum. Hum elimination comes as a side line, for the filtering reduces regeneration and oscillation in the amplifiers. It is well known that either of these conditions will bring out hum when it is present in ever so small amount. All the cathodes are either grounded directly or through a comparatively large condenser. Thus there is neither direct or reverse feedback through the cathode circuits. Again, the plate supply is separately filtered by means of a condenser to ground and a resistor to the power supply. The screen circuits have been similarly treated, even to the extent of using separate voltage dividers for the r.f. and the i.f. circuits. The various grids that have been put on the automatic volume control have not only been filtered individually but also communally. There is slight chance, therefore, that any appreciable or troublesome feedback will occur.

LAYOUT OF RECEIVER

It is of interest to note that a close circuit jack has been inserted in the output of the No. 76 audio amplifier. Its primary purpose is to enable the observer to listen in to either code or broadcast with the phone in circumstances where the loudspeaker would cause interference with other listeners. Since the phone jack is in the output of the 76, which is common to both the superheterodyne and the superregenerator the solitary listening feature is available for both services.

With a loudspeaker properly matched to the two 2B6 tubes, an enormous amount of undistorted sound output is possible, for these power tubes are specially designed to be distortion free. The layout of the parts of the receiver may be seen from the pictures on pages 19, 20 and 22. Referring to the figure on page 22, the tuning condensers and the radio frequency amplifiers are seen at the extreme left. In the rear of the condenser may be seen the beat note oscillator coil and tube. Grouped in the middle background are the intermediate coils and tubes, and forward of this group is the ultra-high frequency coil, unshielded and all by itself. The three-plate condenser which tunes this little coil is near the bottom next to the speaker. It may be seen in the picture on page 19.

Back of the speaker on the right, in the picture on page 22, is the power supply, showing the three condensers and the rectifier, all grouped close to the speaker field coil. In the rear right corner are the power transformer and the audio amplifier. The two tubes to the left of the transformer are the 2B6s and the large tube to the left and forward is the 42.

The picture on this page shows the underside of the chassis. In this particular case it shows much more than in the usual case, for some of the principal features of the receiver are represented here. Thus at the extreme right of the figure the gang switch appears. This is directly under the row of three radio frequency coil shields which may be seen on the other two figures. Near the middle of the figure is a rod clear across the chassis. This is the rod that holds the cams by means of which the coupling in the first two intermediate transformers is varied. The cams are clearly seen on the top half of the rod. These cams are directly under the two transformers.

Special Fidelity Detectors

Quality New Goal, Succeeding Sensitivity

By A. J. M. Warren

SPECIAL detectors always have held high interest for those technically-minded in radio. In the beginning attention was concentrated on making the detectors as sensitive as possible, hence we had gassy detectors, of large ionization possibilities, and sodium detectors with a hiss louder than any screen villain ever deserved. Also we had a diode detector even then, but that was possibly premature, because tubes were expensive and an extra amplifier tube was required to compensate for the reduced sensitivity.

Nowadays interest in detectors is focused on

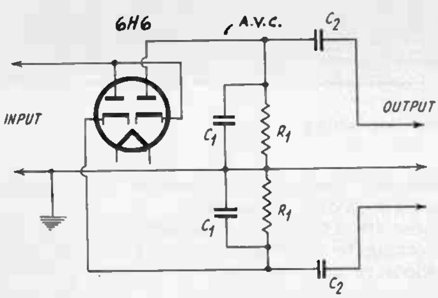


FIG. 1
The sensitive, high-fidelity detector, developed by Orval LaFrance, is of the balanced type, and enables feeding an audio channel that is also balanced, but can not be strictly classified as push-pull.

quality, and since tubes are cheap, and sensitivity is usually too high rather than too low in the rest of the receiver, it matters little whether the detector sensitivity is low or high.

VALUES SUGGESTED

One of these special quality detectors, given considerable attention in these columns since 1933, was devised by Orval LaFrance. It uses two diodes reversed in respect to each other, and working in voltage-doubling fashion. This is the most sensitive of the special quality detectors. It is one to which all persons seriously interested in quality radio reproduction should give close attention. Its basic circuit is given in Fig. 1, applied to a 6H6 tube because this has the two required diodes in one envelope.

The plate or anode of one diode is tied to the cathode of the other diode, while independent outputs are provided through separate load resistors R_1 for the remaining elements of the two effective tubes, i.e., one resistor goes from remaining cathode to ground and another equal resistor from remaining plate to ground. Across the resistors are put relatively small capacity condensers to bypass the radio or intermediate-frequency around the load resistors, while the stopping condensers leading to the next stage, which somewhat resembles push-pull, should be relatively large. Suggested values are $R_1 = .5$ meg, $C_1 = .0005$ mfd., $C_2 = .05$ mfd. Lowest possible leakage for C_2 should be strictly maintained.

AVOIDING A DIFFICULTY

The input is made between the joined plate-cathode circuit and ground. Usually an intermediate transformer's secondary is connected between those two points. Since one side is grounded, the system lends itself admirably to tuned-radio-frequency sets also, for there the condenser frame and rotor are grounded, and a usual difficulty, requiring isolating circuit, is avoided.

The output is taken from the two stopping condensers and ground.

The detector is of the balanced type, and is sometimes called a push-pull detector, although that is not strictly true. It is very difficult to conceive of any detector being push-pull, where push-pull represents equal and opposite phases of the voltages, in other words, a symmetrical circuit, and detectors perform by virtue of their assymetry.

Considering the total output, as from one stopping condenser to the other, the audio phase of the upper leg is always negative, and that of the lower leg is always positive, although the detector is working all the time, never idling, since when the left-hand plate is positive to a. c. lower R_1 carries conduction current and when that plate is negative, the cathode connected to it is negative, hence the companion plate of the second cathode is positive, and upper R_1 carries conduction current. But the cathodes are always positive to d. c., including pulsating d. c.

GOOD FOR 100% MODULATION

The circuit lends itself to automatic volume control, but the bus for the a. v. c. lead must be connected only to the side that develops the negative voltage, and that side is the upper one, and indicated in the Fig. 1. To apply a. v. c. a high resistance, minimum value 2 meg., should be connected to the a. v. c. source as shown in the diagram, the other side of this resistor being bypassed by some mica capacity, say, .006 mfd. to .01 mfd., and then the filter resistor-capacity networks set up for the returns of the circuits to be controlled. The reason for the high resistance preceding the usual filters is to uphold the impedance of the negative side of the detector to audio frequencies, thus protecting the audio characteristic, and indeed permitting both sides to perform excellently on 100 per cent modulated signals.

An eleven-tube standard broadcast band superheterodyne, using the LaFrance detector, was described last month in the January issue. The circuit was a superheterodyne with 6G5 ray indicator tube. A tuner, using National Company's four-gang pre-loaded worm-drive condenser, and the same company's intermediate-frequency coils, is shown in Fig. 2, a photograph of the underchassis being shown in Fig. 3. Another receiver, this one with full audio complement, has been completed and is in use in the home of Frank Simonds, and also will be described in constructional detail in a subsequent issue.

ALL ENCOURAGED TO TRY IT

The reason for giving so much attention to this detector is that it works so well, and with such high fidelity, that tone-conscious radio listeners, including symphonic orchestra leaders and choirmasters, acclaim its excellence. Any reader who has never given this detector a trial should do so without delay, and may resort to the present or last month's circuit diagram.

Another type of detector, also classed as a

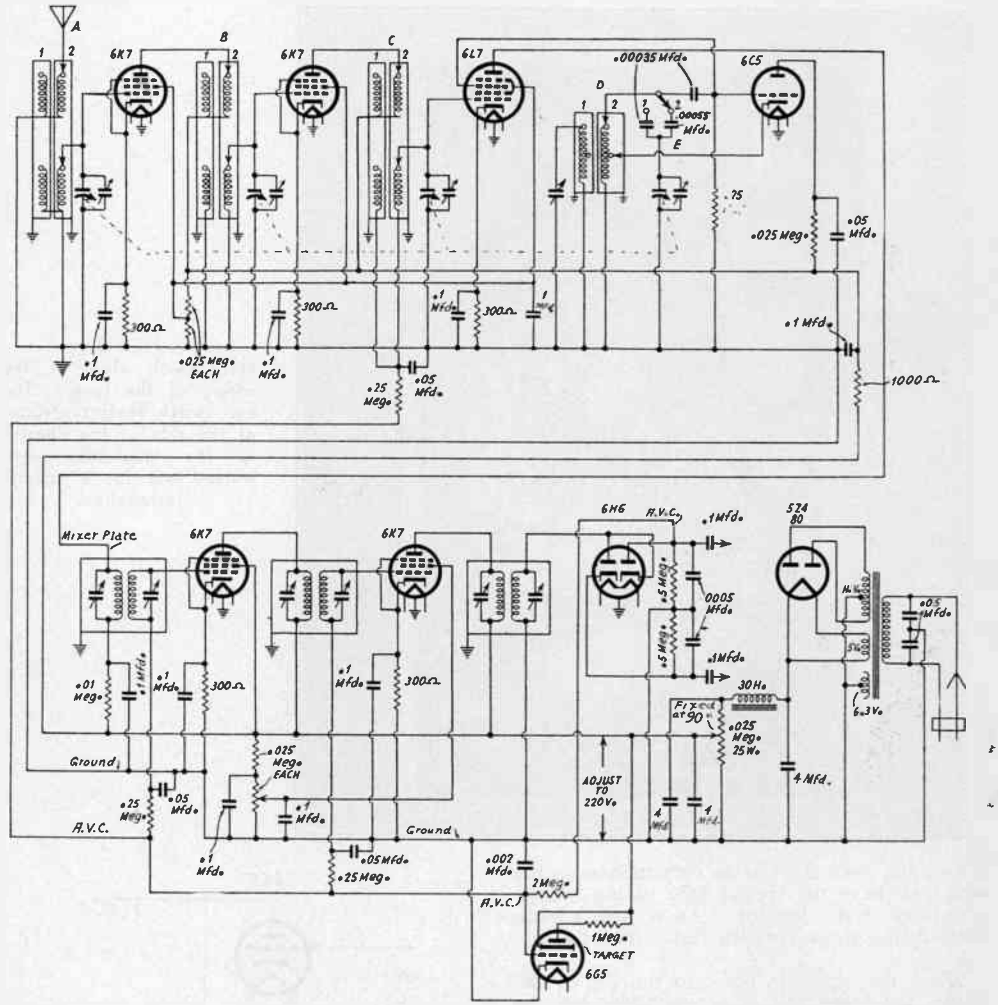


FIG. 2.

Wiring of the tuner, shown in two-band form, although covering 500-2,000 kc. The tuning condensers have a smaller capacity than usual, so that the inductance may be high and thus provide high Q tuner circuits, with practically uniform gain, as a given coupling is 2.25 times more nearly uniform for a 2-to-1 frequency ratio than for a 3-to-1 ratio. The 6C5 grid leak, Q5, is 25,000 ohms.

(Continued on following page)

(*Continued from preceding page*)

diode because of the linearity of its response, is really a triode with the plate circuit voltaged as usual but grounded to the signal. Fig. 4 shows the circuit. The normal plate current through the biasing resistor R_1 produces the potential difference that enables the grid to be maintained negative when the input circuit is

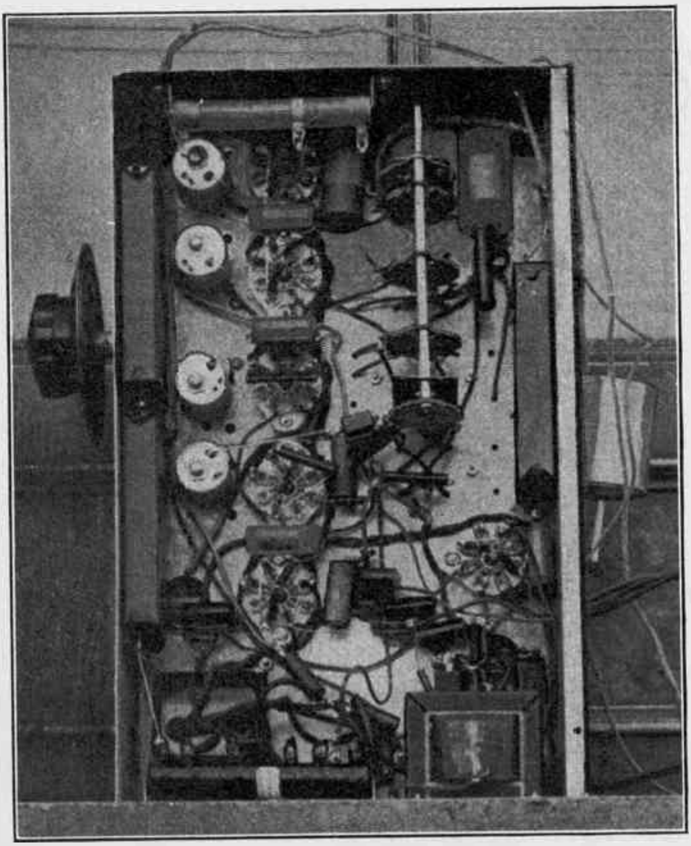


FIG. 3.
Underneath view of the wiring of the tuner. The coil switch shaft protrudes at the side of the chassis, as the mechanics were worked out for a special installation.

closed, and since there is no current flow in the input, we have the special case of the infinite impedance diode detector. As is well known, usual diodes draw current, hence load the circuit.

When the signal is put into the Fig. 4 detector, the selectivity is not reduced, but the plate current is changed according to the audio pattern, because a relatively small capacity condenser across the load resistor R_1 removes the radio frequency, leaving only the modulation envelope. We therefore develop audio frequencies across R_1, and have only to communicate them to the next circuit by the usual means of stopping condenser and grid leak, except that the circuit is somewhat critical as to resistive values, for maintenance of excellent response for deep modulation.

SOME FINDINGS BY SYLVANIA

Hygrade Sylvania Corporation, makers of Sylvania tubes, has considered this topic in its Engineering News Letter No. 31, entitled "Modulation Capabilities of Infinite Impedance Detectors."

Sylvania sets forth that the input impedance is nearly a pure capacitative reactance which becomes part of the tuned circuit without loading it, with resultant improvement in gain and selectivity. R_1 forms both an a. c. and a d. c.

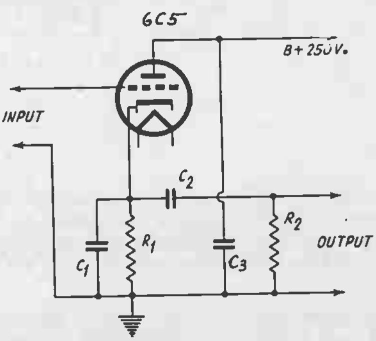


FIG. 4
A simple infinite impedance detector, circuited as a plate bend detector but having the linear characteristic of a diode, hence classified as a diode. Selectivity is maintained, also gain, due to absence of loading

load, while R_2 forms only an a. c. load in parallel with R_1, thus reducing the total a. c. load compared to the d. c. load as represented by R_1.

Information supplied by Sylvania, on the basis of tests the engineering department made, sets forth values for R compared to R_1 in terms of modulation handling capability in per cent., where R is equal to the a. c. load divided by the d. c. load, or R_2 divided by the sum of R_1 and R_2. These formulas mathematically are

$$R = \frac{\text{a. c. load}}{\text{d. c. load}} = \frac{R_2}{R_1 + R_2}$$

Since the best stations in the standard broadcast band utilize high percentage modulation, the stiffest requirement may be selected, that

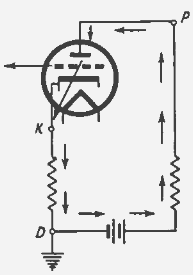


FIG. 5

The arrows indicate the path of the current. By taking D as the reference point, an examination will reveal that the voltage in the cathode leg is decreasing while it is increasing in the plate leg. This exemplifies 180-degree phase reversal.

of 100 per cent. modulated carrier, the detector so gaited as to produce minimum inherent distortion when there are different a. c. and d. c. loads as R_1 is varied.

VALUES FOR R_1 AND R_2

Neglecting the impedance of C_2, as very large compared to the effective parallel audio impedance, absolute values are given for R_1 and R_2 applicable to Fig. 4 for six combinations, one combination to a line:

R_1 (*ohms*)	R_2 (*ohms*)
50,000	80,000
100,000	140,000
150,000	210,000
200,000	290,000
250,000	360,000
400,000	640,000

If detector audio sensitivity is not of great moment, and as the rest of the receiver so allows, the higher percentages of modulation may be handled with still less inherent distortion, or capability of handling high percentages of modulation increased in the detector, if instead of taking off the full audio voltage, less is obtained, by using for R_1 a center-tapped resistor. Thus in Fig. 4 consider R_1 center-tapped and the stopping condenser C_2 connected to this tap. The values are for the full resistance of R_1:

R_1 (*ohms*)	R_2 (*ohms*)
100,000	20,000
250,000	40,000
500,000	70,000
1,000,000	150,000

USES FULL VOLTAGE

Since it is intended that there shall be no grid current flowing, requiring that the peak of the input signal shall not be sensibly near the steady d. c. bias voltage developed across R_1 the signal voltage applied to the detector is equal to the voltage across the secondary of

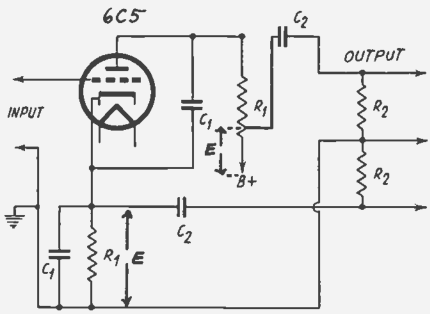


FIG. 6

Infinite impedance detector adapted to push-pull by utilizing the 180-degree phase shift exemplified in Fig. 5. It may not be necessary to find E for the plate leg between a tap and B plus, for the stopping condenser may have to go directly to plate. Experiment will reveal the requirement. The voltage E is understood to be a. c. The balancing is unconcerned with the d. c. value between the terminals.

the coil feeding the detector. This has been said in effect previously, the point being that the full generated voltage is utilized, and that there is no voltage loss due to loading of the generator. The secondary is considered as the generator. In the literal diode there is a division of the voltage between the two elements of the equivalent series circuit, consisting of the diode input impedance and the secondary impedance.

Though the 6C5 tube is indicated, other similar triodes of the glass series may be used, but high mu tubes should be avoided.

DEVELOPING PUSH-PULL

The circuit as shown in Fig. 4 is for single-sided output, but since there is a plate circuit that may well be loaded, it is practical to change the simple detector to one which develops the proper phases for push-pull, hence accomplish in one stroke both phase-inversion and infinite impedance detection with diode characteristics.

The possibility of developing push-pull may be analyzed with the aid of Fig. 5. Here we have the basic audio loads for plate and cathode legs, and we know there is a voltage drop across both equal resistors, and desire to ascertain if the phases are right for push-pull. This is done by including arrows that point in

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the direction of the current. It is assumed that the current flows from positive to negative in the tube and load, and from negative to positive in the d. c. supply. This is the conventional viewpoint and the one on which meters and formulas are based, although in reality the signs are exactly reversed, i. e., current flows from negative to positive in the work circuit.

Since the lower end of the cathode resistor is grounded, and since the B supply is grounded, the terminals of the cathode and plate load resistors are returned to the same a. c. potential. Were it not for the required intervention of the B supply, the two terminals might as well be interconnected for audio purposes.

THE PHASE REVERSAL

Now, considering the effective grounded point as being the same for plate and cathode load resistors, where P is plate, K is cathode, and D is ground, datum, or reference point, if we regard the descending arrows as representing falling a. c. potential and the ascending arrows as representing rising a. c. potential, we note that in respect to D, at any instant the voltage is falling in the cathode leg while it is rising in the plate leg. This is no more than saying in effect that the tube accomplishes a 180-degree phase reversal.

It is true that all the arrows seem to be pointing in the same general direction, in that they describe a continuous path, but it must be remembered in the interpretation of arrow symbols of this nature that some reference point must be selected, then an examination made as to whether the arrows are approaching or quitting that datum. So we find that the arrows when approaching D in the cathode branch are quitting D in the plate branch, and therefore we ascertain from inspection of the arrows that the voltages are 180 degrees out of phase.

Now, the push pull requirement is greater than that. Besides the adamant phase difference of 180 degrees there is a requirement that the potentials be equal. That is, equal voltages of opposite sign must be developed across the output. We know full well that the cathode load resistor escapes the amplification factor of the tube, but what about the plate load resistor? By vacuum tube voltmeter measurement, we may ascertain the a. c. voltage drop across the cathode load resistor and tap off on the equal plate resistor at an a. c. voltage above ground or B plus equal to the first voltage found elsewhere.

E MAY BE EQUAL

Since there is no formal input to the tube at audio frequencies, but only r. f. or i. f. applied between grid and ground, any audio developed across a diode load resistor should be equal to any audio voltage developed across an equal plate load resistor, both resistors identically bypassed for radio or intermediate frequencies by equal condensers. Therefore it need not prove surprising that the full value of the a. c. plate voltage drop should be taken off for equalization, and the reason for even suggesting that a tapped circuit would have to be utilized is that in practice a few examples of larger a. c. voltage across the plate load resistor have been met. If the datum of a vacuum tube is taken as the cathode, then the input circuit may be considered not merely as the grid-to-ground circuit, but as the grid-to-cathode circuit, and the ground-to-cathode circuit is therefore common to grid and plate circuits, because cathode-to-ground is in the plate circuit. That it is so in practice need not be disputed, otherwise how could degeneration arise in individually self-biased tubes, and why should there be need in formal audio circuits of large capacities across biasing resistors, or in radio-frequency or intermediate-frequency circuits, of any condensers across independent biasing resistors? By considering the audio drop across the cathode resistor as at least some input, a reason is established for finding there is more a. c. plate voltage than cathode voltage drop.

Fig. 5 shows the application of the push-pull principle to the infinite impedance detector.

Single Detector Feeding Push-Pull Unsolved

It had been pretty generally accepted that it was impossible to couple an unsplit detector directly to a push-pull amplifier without killing one side of the amplifier. Then came the La France circuit and apparently upset the accepted theory. Then what is the situation today? Exactly where it was before the La France circuit had come out.

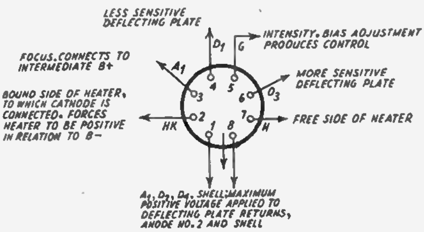
This circuit is not a single detector directly coupled to a push-pull amplifier, but two detectors in parallel connected to the push-pull amplifier so that they alternately feed the two sides. The same thing could be done with two crystals, if they could be made sufficiently equal to each other, or with any two rectifiers of equal detecting efficiency. In the La France circuit one side of the r.f. signal feeds one side of the double amplifier and the other side of the r.f. signal the other side of the amplifier. And the arrangement works very well.

Sylvania Issues Biggest Of Its Tube Volumes

The third and latest edition of Sylvania's "Technical Manual" has just been published. It is the most complete work of the editions, containing 184 pages of the latest and most essential tube data. It covers 193 types of radio receiving tubes, with latest characteristics of each type. The types of standard receiving tubes listed are glass, metal, "G" type, ballast and Sylvania tubes for Majestic receivers. The price is 15c.

PRECAUTIONS in the Use of the 913

By Herman Bernard



Bottom view of the octal socket used with the 913, with the pins numbered according to the standard order, and the indentities of the elements corresponding to those pin numbers disclosed. Also, the purpose or use of the electrode is revealed.

THERE are certain basic precautions that must be taken when using the 913 cathode-ray tube, which is the small, low-priced tube with about one inch viewing screen. Some other precautions are indirectly related to the 913 and apply particularly to the amplifier tubes that may be used in the oscilloscope. Except for some amateur and similar uses, it is conventional to include the amplifiers, one stage for each of the two deflecting pairs of plates, so that medium input voltages will provide a sizeable pattern on the viewing screen.

Perhaps the foremost consideration is the one attending the grounding of the oscilloscope. Suppose that the cabinet is metal, as it should be for the necessary shielding precautions, and that a hole is punched just large enough to pass some of the viewing end of the tube through the panel. Since this tube has a metal shell, and the shell is connected inside the tube to elements that take the maximum positive d.c. voltage, if the chassis is connected to B minus, the full B potential difference exists between chassis and shell. So if the shell contacted the chassis the B supply could be shorted, as the finish on neither can be relied on for insulation, and the rectifier tube could be destroyed, because of more current passed through it than it can stand. Also, the filter choke might be burned out for the same reason, and likewise the power transformer could go. In case of such a short not all are likely to go at the same time, for it is simply a case of one of them serving as a fuse for the other. But who wants to lose any of them?

INSULATION REQUIRED

Even if there is no short as described, it is certainly likely that at some time or other the operator, or some other person, will accidentally touch both chassis and tube shell at the same time, and thus get the full "benefit" of the B voltage, which may be 500 volts. With an adult operator of religious forgetfulness this usually results in a rapid flow of pointed language, but to minors, particularly in warm weather, such a shock may prove more than merely annoying. So if the tube is brought through chassis grounded to B minus, there should be insulation completely surrounding at least the exposed part of the tube, preferably extending forward, to accommodate a grommet that renders the tube shell completely inaccessible from the front panel. Another method is to "sink" the tube back a little, to make room for an insulating transparency, such as a small piece of acetate sheet as used as base in photographic films.

The heat generated is small enough to permit the use of a soft rubber grommet, and the acetate sheet is satisfactory for insulation, although inflammable.

It has been assumed that B minus is grounded. That is a safe method if only the cathode-ray tube is to be considered, if care is taken not to touch a lead carrying an unknown voltage to the chassis, to avoid a possible short to the grounded source of this voltage.

B PLUS GROUNDED

It is also practical to substitute grounding of B plus for grounding of B minus. Then the

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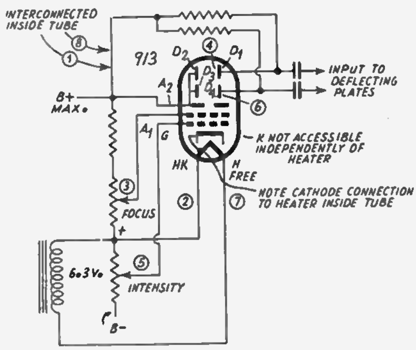
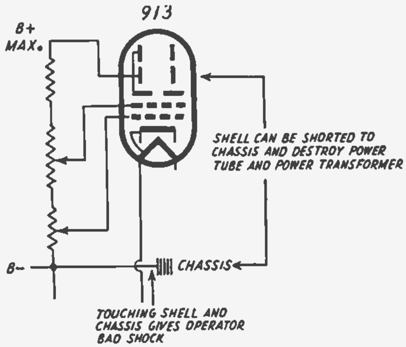


Diagram relating the numerical pin positions, identified by circles around the numbers, with the abbreviation for the electrodes, bleeder wiring, and emphasis of the cathode's d.c. potential.

(*Continued from preceding page*)
tube shell and the chassis and cabinet are at the same d.c. potential, so there can be no short circuit between them. When this is done the cathode is at a high negative potential in respect to ground, which reverses the process with which constructors of other types of apparatus are most familiar.

The reason for grounding B plus is that if any accidental contact is made with a grounded wire which is part of an external return circuit,



Here B minus and chassis are grounded. Power transformer, filter choke and rectifier tube are endangered by a short between chassis and shell, or, if these two are touched a person, a bad shock may result to the operator. Insulation is required as a precaution.

as where one side of the line or the heating system in a home or shop is grounded, the contact introduces no potential difference.

There are two other methods that are followed. One of them is to use a condenser between B minus and external ground, with chassis conductive to external ground, while the other is to ground the cathode. The cathode of the 913 tube is meant. As already intimated, the question also becomes important in connection with the built-in amplifiers.

If there is a separate power supply for the 913, the treatment may be made along any of the lines already discussed, so if there are amplifiers in the oscilloscope, if they too have their own single B supply, and own heater supply, the difficulties are practically nil. But for the sake of compactness and economy it is sometimes desired to use the same B supply for both purposes. This, while attended by some difficulties, can be accomplished. If, besides, the same 6.3-volt winding that serves the heater of the 913 is intended to be used for amplifiers, precautions of a rather elaborate nature have to be introduced, and in general accommodation to this singleness of heater service is not commercially attempted.

HK IS PIN NO. 2

The very nature of the construction of the 913 is such that the cathode is connected to one side of the heater inside the tube, and as the cathode is at a positive d.c. potential compared to B minus, heater is likewise so polarized. Care should be exercised in following instructions for the 913 socket connections so that common cathode and heater goes to the low positive voltage. This is Pin No. 2 in the standard order of enumeration and is designed generally HK.

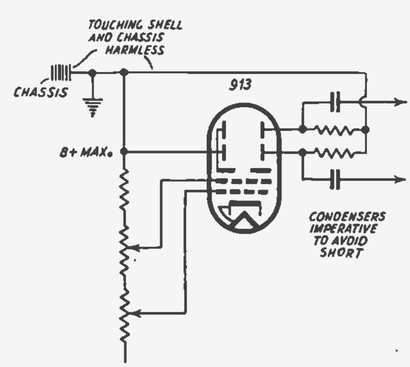
Because the cathode is tied to the heater this way it is impractical to use the series limiting resistance of the line cord type for the 913, in case any had that idea in mind, as the a.c. would have to flow through the direct-current or B bleeder circuit, rendering filtration practically impossible.

If no particular attention is paid to this limitation imposed by the restricted nature of the cathode-heater connection of the 913, and amplifier tubes are included, then any or all of several bad features may be introduced.

One of the complications is that if the cathodes of the amplifier tubes are tied to the cathode of the 913, and the amplifier tubes are returned to B minus, they get the same negative grid bias as does the 913 at maximum. It will be noted that the 913 bias is adjusted by controlling the d.c. potential of the grid return for intensity, but the potential drop across the potentiometer itself is practically steady, and so the bias on the amplifier tubes is also steady, and equals the full drop across the potentiometer, say, 50 volts for the minimum B voltage present, of 250 volts, and perhaps 90 volts if the B voltage is 500 volts total. In this sense the B and C voltages are cumulative and are referred to loosely as the B voltage. What is meant is that the total across the d.c. bleeder is 250 volts or 500 volts.

EFFECT OF COMMON RESISTOR

Of course, with such high negative bias on the amplifier tubes, particularly the pentodes commonly used, the plate current is cut off, there is practically no operation, or if there is any, it is badly distorted, of the detecting type, wiping out half of the wave anyway.



This represents the case of shell connected to external ground, rendering touching of both shell and chassis harmless, as chassis is likewise grounded. Condensers are imperative in the deflecting plate circuit to prevent signal shorting the B supply, but such condensers are normally included in practically all circuits, anyway.

Another factor is that the plate current of the amplifier tubes, when and if there is plate current, passes through the potentiometer used for 913 grid bias, hence the resistance of this potentiometer would have to be reduced accordingly, to make the intensity control of the 913 effective. If there is much variation of plate current in amplifier tubes there is much unsteadiness of the voltage present for biasing the 913, and the a.c. inputs to the amplifier circuits would contribute this unsteadiness, and this makes for erratic operation of the 913.

Meanwhile, the heater of the amplifier tubes is at the same potential as the cathode, which is favorable, for if there is to be any difference it should be small as possible in all instances, and the heater should be negative, not positive,

Now the heater is negative in respect to the cathodes of the amplifier tubes, the grid bias may be normal, likewise the plate current, but the common return through the B circuit bleeder again causes the cumulative amplifier current to pass through the potentiometer, the resistance of which must be reduced accordingly, lest the beam current for the 913 be cut off completely.

There would be some unsteadiness again, due to variations of the B current accumulated from the amplifiers, but a very large condenser could be put across the common biasing adjunct, which is the potentiometer, the power-handling capabilities of which would have to be sufficient for the possibly three-fold increase of current through this leg.

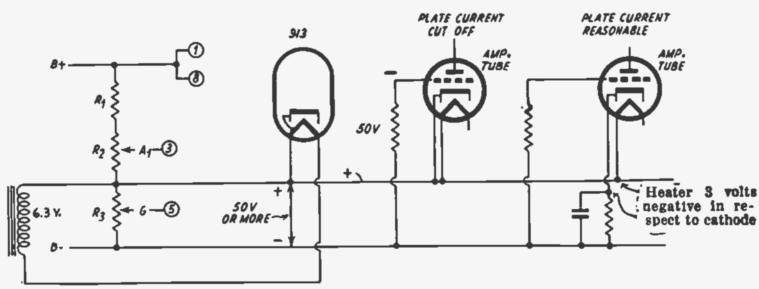


Diagram disclosing how grossly excessive negative bias may be unintentionally applied to the amplifier tubes, and at the same time the normal or intended maximum bias for the 913 increased because amplifier tube plate currents converge in R3. For reasonable plate current the drop across extreme right hand resistor may exceed by 3 volts that across R3.

so that the heater does not act as a functioning element and attract electrons.

To get around the heater d.c. potential difficulty, although meanwhile reducing the effective plate voltage by sacrificing the potential drop across the potentiometer just discussed, it is practical to put a biasing resistor between cathode and grid return, for each amplifier tube, the grid returns of the amplifier tubes being made to the potential that is applied to the 913 cathode. Or, amplifier returned to B minus, as at right in upper diagram, the cathode resistor may drop 3 volts more than R3.

The difficulties surrounding the d.c. potential of the cathode are avoided if a separate heater winding is used for the amplifier tubes, and since it is customary to use an 885 grid-controlled gas-discharge tube for the sweep oscillator, and as this tube requires 2.5 volts, the amplifier tubes also may be served from this winding, and may be 57's.

If one does not have a transformer that provides the extra winding of 2.5 volts, and if in addition one is to use a neon tube for sweep oscillator, then as a makeshift the two amplifier

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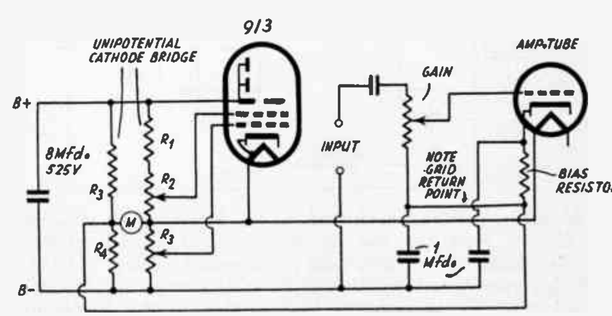
A method of establishing amplifier tube cathode and 913 cathode at the same potential, and avoiding amplifier tube current flow through the bleeder serving the 913. The meter is a high resistance voltmeter at high voltage range, and when the meter reads zero the two potentials are the same. This method is for use if there is only one heater winding, 6.3 volts, and the amplifier tubes are to be of the same heater voltage rating, fed from the same winding.



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tubes, of the 6.3-volt, .3 ampere type, may have their heaters fed from the line through a limiting resistor, the familiar line cord of adequate wattage rating, at least 30 watts.

Then the returns of the amplifier tubes automatically are made to one side of the line, and the return input posts for vertical and horizontal plates of the 913 would be to the line, a fact to be considered, since a short-circuit is possible, particularly by misconnection of some grounded unknown voltage. If a condenser is put in series with the input to avoid this difficulty to a major extent, the capacity would have to be very large, and although 1 mfd. is a compromise, realities, especially for sweeps, would require 8 mfd. minimum, and paper dielectric at that.

STILL MORE CAPACITY

Thus if the gain control is a high resistance potentiometer, with input to the full resistance, there could not be a short, although some conductive connection to the line through the high resistance remains possible, unobjectionable, however. Also, two condensers could be used, one between one high input post and potentiometer, other between low input post and line, but the same capacity requirements prevail, and, if anything, had better be doubled, as for two equal capacities the impedance is halved, compared to the single capacity.

There is bound to be some interaction in a common B supply for the 913 and amplifiers, even with the heaters maintained independent, either by the separate-winding method, or by the series limiting resistor method, but interaction is reduced by using large filter capacities. If these are electrolytics of 25 mfd. or so, their voltage rating must correspond to the voltage present, at least, not be lower than the true voltage at which they work, and if across sizeable resistors, the effect of the leakage resistance of the electrolytics has to be considered, for it reduces the effective resistance, sometimes considerably. The leakage resistance at the working voltage should be determined, and the effective resistance of the electrolytic and the fixed resistor as a parallel circuit should develop the correct and required resistance.

A method of avoiding interaction in the B

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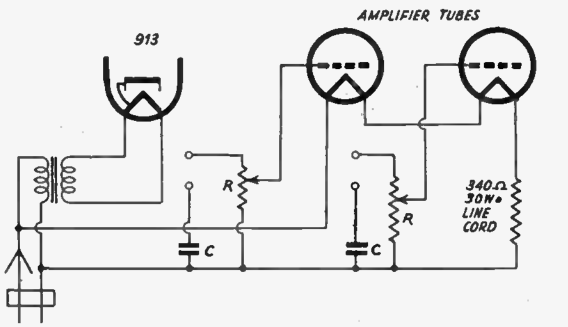
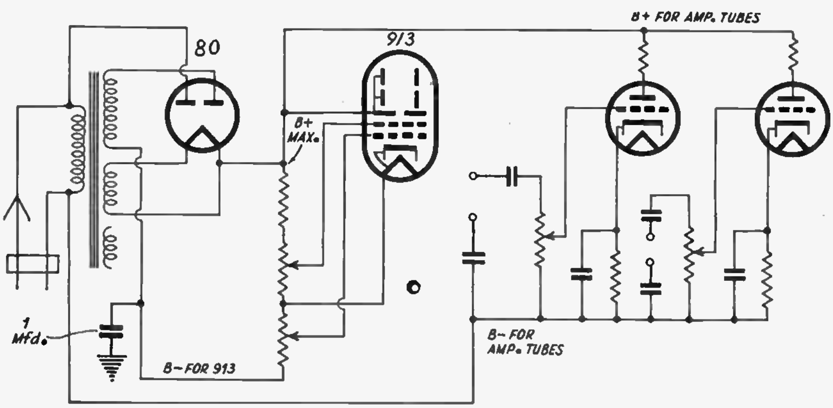


A limiting resistor of around 340 ohms, wattage rating 30 watts or more, is shown, enabling the heaters of the amplifier tubes to be freed from the d.c. potential of the 913. If the connection to low side of the input to the amplifiers is to be isolated from the line, large stopping condensers, C, must be used, and can not be electrolytics.



An 80 tube, with one plate fed by the high-voltage secondary of the power transformer, other plate fed directly from the line, to permit independence of B supply for the cathode-ray tube and the amplifier tubes. The B plus lead is common to both, but the returns are separate, in one case to the remaining terminal of the secondary, in the other to the line, hence the rectifiers are independent. Regard must be paid to the high voltage of the secondary. No B filter condensers are shown, but would be needed. from B plus to respective B minuses. Also, two stopping condensers at inputs to the vertical and horizontal amplifiers are shown.

FULL SERVICE FROM A 913 OSCILLOSCOPE

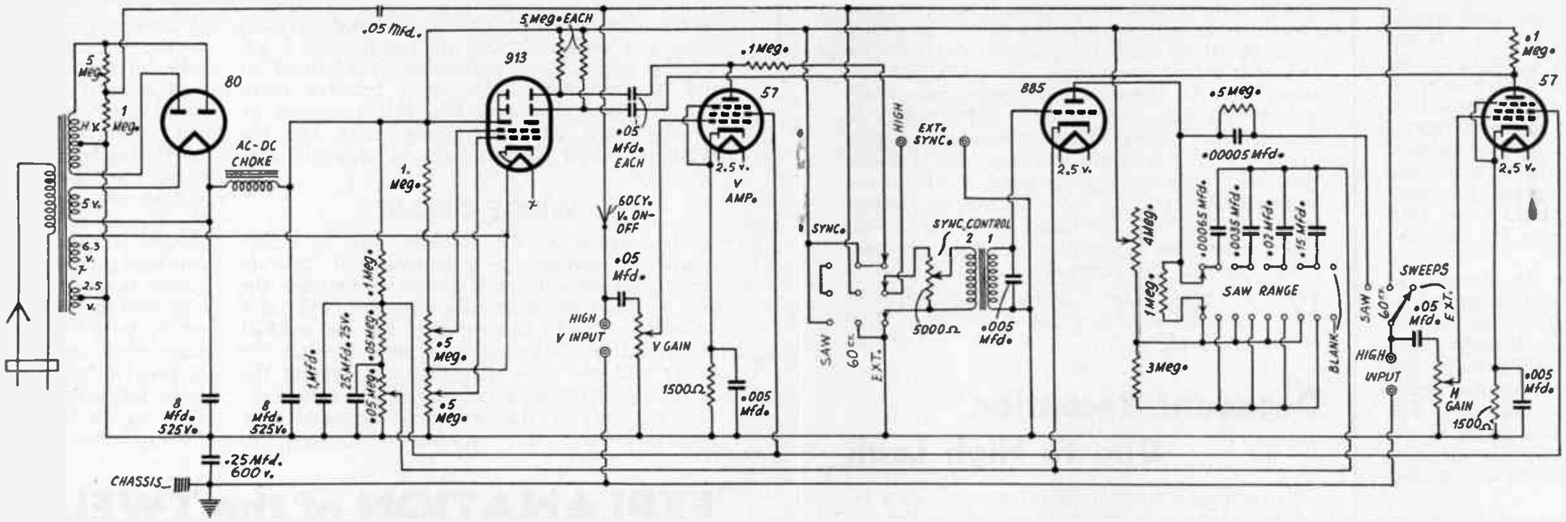


Diagram of an oscilloscope, using the 913, with common B supply, separate heater supply, with the 885 as sweep oscillator, and provision for external sweep, various synchronizations, and other features as found in larger oscilloscopes, and besides input from the line voltage from within the instrument, to enable wave comparisons to gain familiarity with patterns. Three synchronizing possibilities and three sweep possibilities are provided for. H input at right.

BECAUSE the 913 is a small tube is no reason to believe that it can not perform all the functions of a large tube. The difference between the 913, with its one-inch viewing screen, and the 906, with its 3-inch viewing screen, is principally expressed in the diameter comparisons of these screens. Incidentally, the 913 requires less voltage, so power transformers and filter condensers may be used of the same variety as are commonly included in small sets. The sensitivitv of the smaller tube is not as great. But anything that can be seen or done with the larger tube, or any other cathode-ray tube, can be seen and done with the smaller tube.

It is therefore advantageous to have an adequate circuit, and the one shown herewith is similar to one printed last month, also providing service of wide scope, but this time the switching has been simplified somewhat, also the 60-cycle voltage used for study purposes is subject to gain control. A few modifications have been introduced, principally as to values of constants, to bring performance more closely to that of the oscilloscopes using the larger tube. The circuit is about the same as that used for the larger models, as there is no point to sacrificing any service just because the tube is smaller. As stated, the service range is not limited by the size of the tube in any way. Observation and photography can be practiced, using the 913, and all other measurements and comparisons made.

It is needless to deny that there is an advantage in using the larger tube, as the pattern area will be greater, the luminosity somewhat higher, and the general "feel" of having a larger instrument is decidedly satisfactory. However, it must be realized the larger tube costs more than three times what the smaller one costs, and the equipment that goes with the 906 is more expensive on a probably comparable basis. The 913 is an excellent tube to begin with, and attain "familiarscopy."

FAMILIARITY with CONTROLS ESSENTIAL for 'SCOPE OPERATOR

(Continued from preceding page)

of voltages enables ready locking of the two frequencies in step, when there is an integral multiple frequency ratio, so that the sweep is preferably an integral submultiple of the vertical frequency. The internal sweep frequency has a wave form called saw tooth, and for short this is called saw synchronization. The middle position introduces 60 cycles from the high-voltage secondary, through a stopping condenser, while the right-hand position permits the introduction of any external synchronization voltage, which would be applicable, for instance, in transmitter testing, where the synchronization voltage is taken at reduced value from the transmitter's final. Independent posts are provided for connecting in the external synchronizing voltage. Since the object is to keep two frequencies in step, meaning the vertical frequency and the horizontal frequency, a third frequency may be used for this purpose, as was found when external synchronization was applied, and also when 60 cycles were applied. Always the internal sweep oscillator is going for use of any of the synchronizing pulses, also always the unknown a.c. to be studied and examined is injected, and the sole purpose of the synchronization is stabilization. Hence it is practical to synchronize by using part of the sweep oscillator frequency in the vertical circuit, as already explained, and the point should be remembered that synchronization may be internal in this manner, also external, hence there may be any one of three frequencies. At the extreme left-hand position the internal synchronization is complete, the sweep voltage being introduced in series with the vertical amplifier plate. At center and at right the vertical amplifier plate circuit is returned directly to B plus, there is no series tie-in as for saw tooth synchronization, but the external voltage or the 60 cycles, which may be considered external, though supplied handily, is injected into the 885.

8. The previous three-range switch controls synchronization selection, i.e., the type of synchronization used. There is a control for quantity of synchronization, and this is called the synchronization control. The amount of synchronizing voltage should not be too small, lest there be absence of effective synchronization, nor too large, lest there be defects such as broadness and irregularities in the resultant patterns.

9. Saw range. This is a nine-position, two-circuit switch, for the selection of capacity and to an extent the resistance values for production of the sweep frequencies within certain broad limits. There is no extra connection at one extreme position, to insure no sweep leakage in the B supply when the saw sweep is not wanted. Or, connect lower right blank to second lower tab from right, so that the circuit

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Requirements for Linear Time Axis

In vacuum tube oscilloscopy it is always desirable, and sometimes essential, to have a linear time axis. If the frequency involved is high, the time axis voltage must also be of high frequency, regularly repeating. Only one practical device has been brought out, and that is the constant-current saw-tooth oscillator, or linear saw-tooth oscillator. A condenser is charged to a given predetermined voltage in a given time and then discharged to make it ready for the next cycle.

The condenser cannot be charged at constant voltage through a fixed resistance, for then the voltage across the condenser does not rise linearly with time, but exponentially. To make the voltage rise linearly the condenser must be charged at constant current. The current may be maintained constant, regardless of the back voltage in the condenser, by passing it through a saturated diode or pentode.

The voltage across a condenser of capacity C is given by $V = Q/C$, where Q is the quantity of charge on the condenser. If I is the current flowing into the condenser, then the quantity on the condenser after a time T is $Q = IT$. That is, $V = IT/C$. Therefore if I is constant and C is fixed, the voltage across the condenser is directly proportional to the time, which is the necessary relation for a linear time axis.

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capacity across a relatively small resistance will result in production of the highest sweep frequencies of which the 885 is capable, at least in this circuit, and would be applicable to radio-frequency measurements. It must be remembered that the unknown radio frequency is to be higher than the sweep frequency at all times, and in fact an integral multiple of the sweep frequency (sweep times 2, 3, 4, etc.)

10. Besides the saw range, as obtained through the nine-position switch, a saw frequency fine adjustment is possible, by manipulating the 4 meg. potentiometer. This is augmented by a 3 meg. fixed series resistor, for certain positions of the nine-position switch, while a resistor of 1 meg. in parallel with the 3 meg. cuts down the total added resistance to enable greater frequency range without again changing condensers, though a new switch position is invoked. Hence this fine frequency adjuster, usually referred to as the "frequency" control, has alternate values of percentage resistance control, and affords that fulness of selection that adds to the value and service of the oscilloscope.

11. Sweep selector. Just as there is reason for picking out any one of three synchronizing voltages, so there is a purpose in selecting different sweeps. The saw tooth oscillator is the principal sweep and provides the returnless pattern, or the trace free of duplication or double exposure. This is selected with switch set at left. At middle position the switch picks up 60 cycles, not for synchronization this time, but for sweep voltage. Note that the saw sweep may be linear, the 60 cycles sweep will not be. At right any external voltage may be selected for sweep. The vertical input posts are used at this third position, but for the two other positions are not used, as the sweep voltages are obtained from within the instrument, saw in one instance, 60 cycles in the other, hence the H input serves only one purpose, external introduction.

12. H gain. This enables control of the amplitude of any one of the three types of sweeps used.

Decadent Reception Due to High Leak

Sometimes a peculiar defect develops in a receiver. After the switch is turned on the circuit begins to function in the usual manner, and plays all right for ten minutes to a couple of hours. Then it begins to die down gradually until the signals are entirely inaudible. If the power plug is pulled out and then inserted again, leaving the power off for only an instant, the volume comes back in full force suddenly. The same effect may take place by merely touching something in the set, set as the knob of a volume control. What causes this peculiar behavior?

The symptoms point to insufficient leakage through a grid leak or excessive leakage through a stopping condenser or a tube socket. A grid in the tube either goes positive or negative. If there is much distortion, the grid is probably positive; if the volume is completely cut off, the grid is probably negative. Restoration of the circuit to operating condition is brought about by discharging a grid condenser. The discharge may take place instantaneously or it may take a second. The remedy is usually to replace the grid leak or make certain that there is sufficient leakage from the grid to the cathode.

All Circuits We Print Can Be Readily Duplicated

ALL parts for circuits described in RADIO WORLD constructionally are obtainable. Most of them are stocked by supply sources. Address questions to Trade Editor, RADIO WORLD, 145 West Forty-fifth Street, New York.

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supply is to set up a second bleeder circuit, the amplifier tube or tubes having cathode connected to a potential on this second network at least approximately equal to the potential of the 913 cathode. Suppose a very high resistance voltmeter is used for measuring the 913 cathode potential, between B minus and cathode. Then when the amplifier tubes are functioning, a tap on the second bleeder network is adjusted so that the potential is the same between there and B minus. In operation this sameness or identity may not continuously exist, but the relatively small changes are not of great consequence.

BRIDGE CIRCUIT

The identity of the voltages may be determined by setting up a unipotential cathode bridge, where a meter is connected between the two 913 and amplifier tube cathodes. This is a voltmeter, should be sensitive, and be worked at a relatively high voltage range, so that the meter will not have the effect of shorting the lower-leg resistors of the bleeders in the direction of unifying this intended segregation of resistance. In other words, the limiting resistor of the voltmeter should be very high compared to the smaller of the two resistors in the lower legs. The two cathode voltages are equal when the meter reads zero. The more common practice of measuring the amplifier cathode voltage or bias the same way that the 913 drop is usually measured may be followed, if the meter draws very little current compared to the bleeder as augmented by the amplifier tube current at zero signal input.

If a sacrifice of B voltage is to be permitted, which restricts the amplitude of the output signal that the amplifier tube can handle disportionlessly, then if an 80 or similar tube is used, one plate may be connected to the high-voltage secondary, the other plate directly to the line, a single lead serving for B plus, but the two B circuits being really independent, because of the separation of their returns. One return is to one end of the power transformer's high-voltage secondary for the 913, the other return is to the line for the amplifiers, and the same considerations about the line return apply as previously discussed. If two condensers are used for isolation, as shown in the diagram, they should be of double the capacity required for one alone.

EXPLANATION of the TWELVE CONTROLS

REFERRING to the diagram on the next page, representing a five-tube oscilloscope of considerable attainment, in fact on a par with the larger models, only using the small 913 tube, the working of the controls will now be discussed.

These controls are as follows, and in general are read from left to right in the diagram:

1. Line on-off. This, if desired, may be coupled to the intensity control, which then would be a .5 meg. potentiometer with switch attached.

2. Sweep oscillator bias control. The cathode is moved to different electrical positions along the .05 meg. potentiometer. This affects the amplitude of the sweep oscillations, also it governs to an extent the frequency of the sweep oscillator, and may serve therefore the dual purpose of limiting the quantity and changing the frequency. Quantity is largely affected, frequency less largely, but the frequency effect is sufficient to enable registration of exact submultiples of signal frequencies, necessary for perfect lock-in.

3. The intensity control. This is the potentiometer mentioned under 1, and is the lower of two equal potentiometers in the diagram. By sliding the arm of the potentiometer the grid of the tube, which is No. 5 on the pin arrangement, is brought nearer to or farther from cathode. If the arm is slid to exactly the cathode position there is no negative bias on the tube. Any bias present, by sliding from this position toward B minus, must therefore be negative. The intensity control governs the number of electrons that get by the gate, represented by Anode 2, on their way to the screens.

4. Focus. This function is performed by adjustment of the d.c. voltage on Anode No. 2, accounting for the second potentiometer of .5 meg. As the focus is sharpened the apparent intensity is reduced somewhat, but the intensity control, previously discussed, has a much larger effect on the degree of illumination, hence the standard nomenclature is justified. It should be remembered, however, that a certain degree of interdependence will prevail, and this must not be regarded as a defect.

5. V. gain. The unknown a.c. voltage is injected at the V posts for vertical deflection, across the total of the potentiometer resistance, so that moving the arm of this gain control will not have the effect of shorting the supply of the unknown voltage. Under certain exceptional conditions a slight shift in the phase of the unknown voltage may result when the gain control is manipulated.

6. If desired, 60 cycles may be put into the V plates, for which there is a SPST switch, and since 60 cycles also may be connected to the H plates, the same voltage would be introduced, and from the same point, but this is not a short circuit. The deflections will be in directions at right angles to each other. So phase patterns may exist. Also, by using saw sweep and 60 cycle V, the line's wave form may be examined, and will be found to be close to a sine wave.

7. A three-position three-circuit switch is used for synchronization selection. At extreme left position, taken from the diagram, part of the internal sweep oscillator voltage is fed to the vertical amplifier plate. This commingling

(*Continued on following page*)

RIGHT OR WRONG?

PROPOSITIONS

1 Direct current is flowing in a resistor in one direction. An equal amount of direct current is flowing in the opposite direction. There is a net current flowing through the resistor and the potential drop across the resistor is zero.

2 There is no highly accurate way of measuring the power radiated at ultra frequencies, and so plate current as found when the tube is not oscillating is compared to plate current at the same voltage when the tube is oscillating, and the power difference ascribed to radiation. Also equal lamps are lighted by the ultra-frequency current and d.c. and their brilliance compared for power comparison.

3 A saturated tube, one in which all the electrons are attracted to the plate from the cathode, prevents the increase and decrease of current through a circuit of which it is a series member.

4 Spot position of a cathode ray tube may be centered by proper selection of the amplitude of the signal voltage put into the vertical plates.

5 The power dissipated in a resistor is proportional to the voltage across the resistor, to the current through the resistor, but independent of the actual resistance of the resistor.

6 Cathode type tubes, when the grid bias is even a little bit negative, do not draw any grid current.

ANSWERS

1 Wrong. Since by net current is meant the difference between the two current values, since the currents are equal but the signs opposite, the net current is zero. However, it is true that the potential drop across the resistor is zero, because the net current is zero.

2 Right.

3 Wrong. The saturated tube is correctly described, the plate current cannot increase, as already all the electrons produced by the cathode are attracted by the plate, but the current through the tube may be reduced because of high resistance in the rest of the series circuit.

4 Wrong. Spot centering in both planes, i.e., right and left in one instance, up and down in the other, depends on the d.c. potentials and not to the signal or sweep a.c voltages. The return d.c. voltage of the deflecting plates may be adjusted across potentiometers to accomplish centering.

5 Wrong. While the power dissipated in a given resistor is proportionate to the voltage across the resistor, hence to the current through the resistor, if the resistance is changed the current is changed. With voltage or current constant the power also is proportionate to the resistance.

6 Wrong. There is usually grid current unless the grid bias is more than .8 volt negative

Generators, Both R.F. and A.F.

Including Beat Oscillators

By Henry Burr

VARIOUS components are commercially obtainable, including frequency-calibrated dials and the tuning condenser and coils to go with them, for construction of signal generators. The questions that arise are: What shall the circuit be? What is the method of insuring accuracy? How should the generator be used?

First, the circuit will depend largely on how the generator is to be powered. If batteries are to be the source, then a simple circuit, with 30 tubes, might be selected.

It is customary to have a C battery serve as A power, so that if one tube is used, a single cell suffices, or if two tubes are used, perhaps a 4.5-volt battery is included, and the filaments of the tubes connected in series, each tube getting 2.25 volts in the beginning.

It can be seen there is in both instances a departure from standard voltaging, as in one example we have 1.5 volts instead of 2 volts, and in the other 2.25 volts instead of 2 volts. It is quite all right for oscillators to use the lower voltage. Also, since the cells are overworked, the 2.25-volt condition in the second example does not long obtain, because of the rapid rise in battery resistance, so this is passable, too.

NO. 6 DRY CELL PREFERRED

But it is preferable to use a No. 6 dry cell, which has the necessary capacity, as that cell would stand even .25 ampere drain for reasonable life, and in the service of a single 30, or pair of 30's, should last for months, assuming average use.

So if a single tube is used, it is preferable to power it from a No. 6 cell, or if two tubes are used, to connect the filaments in parallel to the same cell, as the drain would be only .12 ampere for a pair of such tubes.

The bulky size of the No. 6 cell has to be considered. Familiar as a cell used for ignition purposes, it is excellent, but so is a more lately developed cell, to the same general purpose, but which takes less room, and is intended for portable use.

The circuit may be of any type that oscillates, and there is hardly much difference among the various circuits. Even the Hartley oscillator may be applied to the 30 tube, as shown in Fig. 1. The tuning condenser is put across the total coil, a tap about one-quarter the way up from the rotor terminal of the coil is connected to B plus, while rotor end of coil goes to plate. Instead, however, the conventional feedback circuit may be used, with a plate winding having from quarter to half the number of turns as the grid winding, whereupon the grid winding is tuned, the plate goes to coil switch, as does the grid condenser, and the attenuator remains in series with the B plus line.

The feedback type oscillator is illustrated in Fig. 2.

WATCH FOR NEGATIVE FILAMENT

In building any battery type oscillator, attention should be paid to the filament terminals. The one in line with the grid, when the filament prongs are held left to right, is the negative filament, and is the return connection for the grid circuit. Usually this return is made through a grid leak. For the feedback type ossillator the grid leak may be either across the grid condenser or, as in the Hartley circuit, in

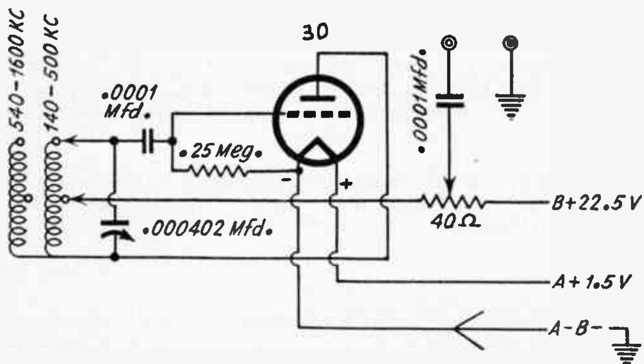

FIG. 1
The Hartley oscillator, applied to a battery type tube. Note that B plus is connected to the tap. The outside terminal of the universal wound coils goes to the grid condenser. Grid is returned to negative filament through the leak. Two bands are covered, as indicated. A double pole, double throw coil switch is required.

parallel with the grid-to-filament path. In the Hartley it is necessary to block the B potential, hence the leak in this instance can not be across the grid condenser. However, the operation is substantially the same, whichever leak connection is used, when there is any choice.

It will be noticed that all that one obtains is oscillation, although the quantity of output can be controlled. The device that permits such control is called the attenuator, because it enables reduction of the output.

So if one connects the generator to a receiver, making the generator take the place for the moment of a broadcasting station, since carrier alone is produced, no sound would be heard in the speaker, except perhaps a slight rushing noise, because the oscillator is unmodulated. The oscillator is said to be modulated when there is a tone impressed on it. The receiver's detector would eliminate the carrier in any instance, but with modulation present, the tone would remain, and therefore the modulating frequency would be heard in the speaker. So for aural basis of alignment it would be necessary to include modulation, although a receiver may be aligned very well, in fact aligned with greater precision, without resort to modulation. So an unmodulated generator has its uses.

MIXING THE TWO FREQUENCIES

If it is desired to include modulation, then another oscillator has to be set up, this one producing the audio tone. Instead of the radio-frequency type coil used in the r. f. oscillator we shall have to use a coil built for audio purposes, as a small audio transformer is selected. This had better not be a good one, otherwise the frequency of oscillation might be too low in pitch. A cheap transformer as used in a. c.-d. c. sets is entirely satisfactory.

The feedback type audio oscillator may be used, secondary S connected in the grid circuit, and primary P in the plate circuit. At audio frequencies the efficiency is much higher than at radio frequencies, therefore we may expect a very large oscillation voltage compared to the radio-frequency oscillation amplitude. It is clear we could not inject all the audio possible from the second oscillator into the first without running into trouble, called overmodulation. A small amount of the audio oscillation may be mixed with the radio-frequency oscillation by making the total resistance of the attenuator common to both circuits in the positive B leg.

With a small transformer there is considerable frequency range, depending much on the values of the grid leak and grid condenser, although finally only one frequency will be used. Those values are shown in Fig. 5 as .006 mfd. and .1 meg. If either or both are increased the frequency will be lowered, but losses may be incurred if the leak is made too low, whereby oscillation would stop. It was found that values below .05 meg. caused this trouble. Also, it may be necessary to use more than .1 meg, for the same reason, depending on the transformer.

Now we have a generator in which both radio-frequency and audio-frequency oscillations are producible, and so we may arrange to use the generator with or without modulation, by switching, and also shut off either one when the output of only the other is desired. We may want on occasion to take off the audio only, to test a public-address system or similar audio amplifier, without the presence of radio frequencies, which might go through the channel being tested and produce false results.

A master switch controls the entire device, while separate filament switches control the separate oscillators.

R. F. RANGE

The radio frequencies to be generated should be such as to permit at least alignment of intermediate channels. A frequency somewhere

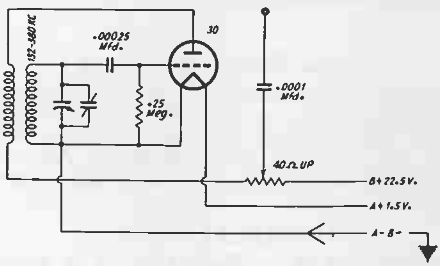

FIG. 2
Feedback type battery oscillator.

around 140 kc would be a low enough limit. With a condenser of .00035 mfd. or somewhat higher capacity it would then be possible to go to 500 kc, thus encompassing the entire span of intermediate frequencies as found nowadays in home receivers. If a single band is covered in this way, it is practical to make measurements of higher frequencies by resort to harmonics. There is some danger of confusion as to what the supposed frequency actually is, when using harmonics, but application of a simple formula will dispel this confusion.

Frequencies in the broadcast band may be taken from stations on the air, but there is usually some sacrifice of accuracy, or poor tracking, when this is done, because a tuner circuit is to be aligned at two points, say, at 1,450 kc and 600 kc, and stations of known frequencies that one may bring in perhaps are 1,400 kc and 570 kc, as being nearest to the tie-down points. Under such wide departure from the recommended tie-down frequencies poor tracking, and hence numerous squeals are certain.

It would be more accurate, therefore, to use harmonics of a single-hand generator, and handier to have the generator cover two bands, say, the intermediate frequency range, and the standard broadcast band. Then for still higher frequencies, harmonics of the broadcast-band oscillations may be used, for the intensity would be adequate for all-wave service within present-day requirements, say, to 20 mc, for even the thirteenth harmonic can yield a response.

It is practical to enlarge the range by using more coils, hence more switch positions, too, and cover, say, from 54 kc to 17,000 kc, although the B battery voltage has to be increased

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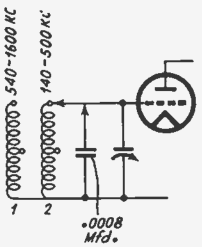

FIG. 3.
The fixed condenser across the other changes 140-500 kc to 83-99.9 kc.

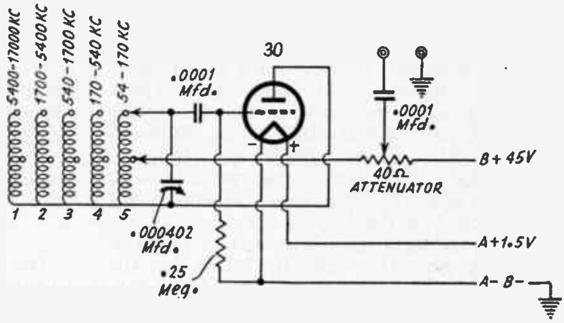

FIG. 4
All-wave coverage with B battery 45 volts.

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from 22.5 volts to the new level of 45 volts, to insure oscillation on the short waves. Fig. 4 shows such a circuit, without modulation, and Fig. 5 shows one with modulation. Also, in Fig. 5 the independent. a f. output may be attenuated.

UNIVERSAL TYPES

Getting out of the battery group of signal generators we find that the universal type, operating on either a. c. or d. c., is popular. The very simplest may have line connected to plate, whereupon there will be modulation present on a. c., due to the line frequency, or the output sound heard in a receiver will be the familiar line hum. While this type also works on d. c., naturally there is no modulation present, as the line frequency is zero, except that there might be a small ripple due to commutation, which, however, is not reliable for modulation purposes. So if, on d. c. use, there is to be modulation, it must be indepenently provided, and a small neon tube, preferably of the type without limiting resistor built in, will furnish this service. This handy tube is not useful for little battery generators, because requiring around 67 volts before igniting.

The d. c. line permits oscillation only when the plug is connected a given way. Reverse the plug in the convenience outlet if no oscillation is produced.

If the device is to be used always on a. c., then there is no need to include the modulating circuit. While it is true that an extra resistor and two posts will permit leakage tests, this service is available only for d. c., hence there would be no purpose in including the neon tube for any strictly a. c. application. Fig. 6 shows the circuit for intended a. c. application only, and Fig. 7 the circuit for a. c.-d. c. use, with neon tube included. The neon tube tests leakage and provides modulation only on d. c. use.

PRECAUTION AGAINST SHORT CIRCUITS

It should be noted that in all universal oscillators, the return circuit of the oscillator must be made to one side of the line, as that is B minus, and meets the need for conductive continuity. In other words, the coils, the rotor, one side of the heater, and the a. c. switch are "hot." They represent one potential, one side of the line. Therefore if the generator is to be put into a metal box, the tuning condenser frame must be insulated from the chassis, and with chassis thus floating, the metal box may be grounded externally, without danger. But the actual use of external ground is not imperative because the circuit is sufficiently grounded due to the return of the oscillator to the line.

By introducting a rectifier tube we always have d. c. on the oscillator, whether the line is a. c. or d. c., because even when a. c. is applied, the rectifier changes this to d. c. Now we may include the leakage test, applicable to a. c. and d. c. lines. The test is this: If there are flashes of more than one per second the condenser under test may be considered defective, strictly true in the case of paper condensers, but true with modifications in respect to electrolytics. The flash counting is not an infallible test of electrolytics, but only a good indication, because the d. c. resistance being tested in reality is not a measure of the formation of the plates, which is the real thing that counts, and also low-voltage rating electrolytics may produce flashes up to three a second and still could be excellent.

The leakage test applies generally, and not merely to electrolytics or other condensers. For instance, leakage of several megohms would be easily noticed, due to the glow, when test is made of a tube between grid and cathode. Besides, this is a continuity tester generally. But if any continuity tests are to be made on a receiver, be sure the set is turned off.

USE OF 80 RECTIFIER

With the same foundation unit for covering 54 to 17,000 kc an a. c.-operated signal generator may be built, with 80 rectifier. Fig. 9 shows the wiring diagram. The services are: r. f., with attenuation, over the bands specified, amplifier included; a. f., for modulation, also for separate audio output without r. f. oscillation present, attentuation of audio applicable to both purposes; leakage test and output meter. A ray indicator tube is to be connected to the output of the circuit being measured, either when audio alone is put into a channel, or r. f. with modulation into a receiver. When the unknown voltage is connected across the ray indicator tube's input, grid current will flow, the grid will be-come more negative the greater this current, and the angle will narrow down finally to a slit, at around 7 volts.

BEAT FREQUENCY OSCILLATORS

We come now to beat frequency oscillators, for producing audio tones. The advantage of this type of audio generator is the constancy of the amplitude. One oscillator is of fixed radio frequency, and the other is of variable frequency, though varied over only a small frequency span, both radio frequencies. When the frequency ratio of the variable oscillator is made small by putting a relatively large fixed condenser across the tuning condenser, the total capacity across the tuned circuit is always large, and this favors stability. For the same reason the total capacity across the fixed-frequency oscillator is made large, therefore we have stability in both directions, and whatever the audio note's frequency, the amplitude is the same. Thus when we come to measure an audio channel's gain we are not confronted with a defeating source that produces different amplitudes, but can compare the gain per stage and overall, for all audio frequencies, by the output meter readings, assuming a non-reactive meter, meaning one that does not change its sensitivity with frequency. The ray indicator, while not disclosing absolute values, is a good indicator of relative ones, and quite sensitive, besides being substantially non-reactive as circuited, except for the very lowest frequenies, with which public address systems and other power amplifiers are not concerned.

The beat frequency oscillator depends on a difference, and all measurements of absolute values, as in this case of absolute audio frequencies, where the basis is a difference, are attended with possibilities of large errors. We have found that the amplitude is constant, but the frequency may be far different than what we suppose, due to a small difference originally.

SMALL CHANGE, LARGE DIFFERENCE

Let us take an extreme example. Suppose the fixed frequency oscillator is made to produce 100 kc. Suppose the variable frequency oscillator is made to generate 99.9 to 83 kc. The resultant audio tones will be represented by differences, the range being — 99.9 = .1 kc = 100 cycles, to 100 — 83 = 17 kc = 17,000 cycles. If the variable frequency oscillator is calibrated for the radio frequencies it always produces, it is accurate in both directions, frequency and amplitude being constant, but suppose there is a small change in the fixed-frequency oscillator? Suppose when it is intended to generate 100 kc it generates 101 kc, an error of about 1 per cent? The audio note instead of being 100 — 99.9 for the extreme case, or 100 cycles, will be 101 — 99.9 or 1,100 cycles. an error of about 1,000 per cent. It is therefore advisable to set up the fixed-frequency generator with a fixed condenser across which is a variable at about half capacity setting, so that the required frequency is then produced at first, the small variable being panel-mounted, and thereby permitting a zero adjustment, if the range is to go below 100 cycles. Actually zero difference can scarcely be expected, but a frequency close to zero will be satisfactory, though even this can be attained only when the two oscillators are loosely coupled.

The diagram of the battery model beat-frequency oscillator, Fig. 10, permits connection of earphones to the output, or output may be connected to an amplifier, and the so-called zero adjustment made in reality so that a few cycles

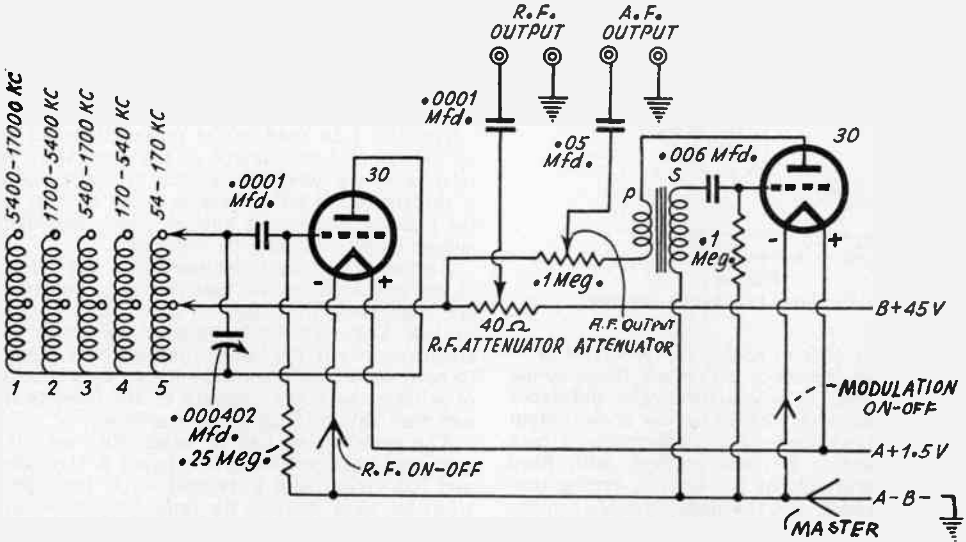

FIG. 5
All-wave radio frequencies, with separate audio oscillator.

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are produced. The 'phones may not be sensitive to such low frequencies, but the adjustment is made as closely as possible, say, until nothing is heard, as the frequency is reduced from some readily heard value. If the zero-adjusting condenser is moved beyond this point, continuing in the same direction, a note will appear again, due to a responsive frequency difference. Taking the first note sensibly heard, the knob attached to the small condenser may be turned until the same note is reproduced from the opposite direction, the no-signal area of the indicator observed, and zero taken as the center.

WHY 100 IS LOW LIMIT

These facts would apply for reduction to practically zero, where one is to calibrate his own dial. In the battery diagram the dial is

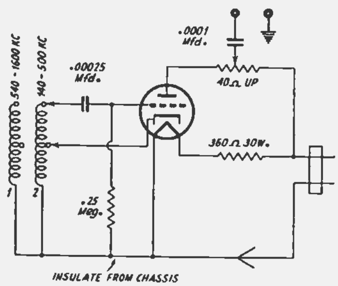

FIG. 6
A.C. on plate, two bands covered.

calibrated for 99.9 to 83 kc, so 100 cycles is to be the lowest frequency generated, the coupling being such that at below 100 cycles difference the two oscillators lock in, so no audio output is produced, as there is no difference. Hence when the setting is made at first, with fixed oscillator accurately at 100 kc, this setting prevails throughout, and the small variable condenser need not be brought out to the front panel, although frequencies lower than 100 cycles are not available. If the range is desired to extend below 100 kc it may be done by using 99.9 as the fixed frequency, yielding audio frequencies as tabulated herewith, but a zero adjuster and indicator is needed.

No particular coupling method seems apparent from a glance at the diagram, but the coupling is provided by the common impedance of the voltage supplies, both A and B, and the primary of the transformer. Since the primary may have an appreciable impedance to radio frequencies, there is a condenser across it, the value of which affects the degree of coupling of the radio frequencies. Smaller than the prescribed .002 mfd. will increase the coupling, but .002 mfd. usually will be found adequate for primary P of good transformers, and only good ones may be used, as a transformer that lacks practically flat characteristic will naturally affect the output, making it non-uniform in amplitude in respect to different frequencies. This effect is minimized by shunting the secondary with a resistance, and in this instance the volume control serves adequately as that resistance. So far as practical the output should be taken at maximum, to avoid any serious loading effect of the volume control, the resistance across the input circuit of the amplifier being reduced greatly at low settings of the control, and the impedance characteristic of the transformer altered likewise, also because of the loading. It will be necessary nearly always to use maximum output, as the quantity is very small at best from a beat oscillator that hasn't an amplifier built in. The reason for not including an amplifier is the difficulty of getting one that is itself non-reactive, in other words, has a flat characteristic from 100 cycles to 17,000 cycles.

A. C. MODEL B.F.O.

A five-tube a. c.-d. c. beat frequency oscillator is shown in Fig. 11. The same general remarks applied to the battery type are pertinent here, except that the coupling is not through any batteries, and is introduced by using the triodes unshielded for the fixed and variable oscillators, and having their envelopes close together, say ¼ inch between. In neither instance is the coil system of one inductively coupled to that of the other.

The 6E5 tube used in the universal model is an indicator of the output of the generator, in relative terms, when the switch at upper right is thrown to the left, where as when thrown to the right, it picks up a post to which amplifier output under test may be connected.

An amplifier tube is included, and the values of the grid load resistor and stopping condenser are high enough to permit good amplification of low and medium frequencies, although at frequencies near the upper limit there is bound to be reduction of amplitude due to the capacity of wiring, the ouput capacity of the tube itself, and the .0005 mfd. shunting condenser.

The commercial dial on which the two diagrammed beat oscillators are based is the same and has frequencies imprinted on it from 99.9 to 83 kc, so if desired, the radio-frequency output may be used separately, for fundamentals or harmonics, although both will be weak.

The differences would have to be struck mentally for the audio values. The calibration is in .1 kc steps, hence 100 cycles, from 99.9 to 99, representing frequencies from 100 to 1,000 cycles in steps of 100 cycles, well spread out on the dial, the rest of the scale in steps of 500 cycles. One quickly becomes familiar with the equivalent audio values without having to repeat the subtraction.

ADJUSTMENT OF CIRCUITS

Any frequency-calibrated dial is based on a particular tuning condenser. In the circuits shown always the same condenser is considered. Its capacity at maximum is 402 mmfd. and at minimum is 15 mmfd. These values may be written .000402 and .000015 mfd. respectively.

The coils have to be accurately matched to the condenser, and the inductance can be held to an accuracy of 1 per cent. in manufacture of commercial coils. Even so, for low frequencies sometimes the coils are purposely of too high inductances, because for greatest operating accuracy the inductance may be selected by experiment to better than 25 per cent. accurate. If turns are to be taken off, a method selected because far easier than putting turns on, the manufacturer advises the procedure.

Applying the adjustment of inductance to the cases of the radio-frequency oscillators that do not call for a trimmer condenser, and these are all save one so far discussed, the dial is affixed to the condenser so that the lowest frequency is read when the condenser plates are fully meshed. This does not necessarily mean that the condenser shaft is turned to the extreme direction in all instances, for the condenser begins to disengage a bit before such extreme position is reached. Therefore a flat surface is laid across the condenser so that the plates are stopped from coming out more than they should, when the movement is from extreme right-hand displacement in the direction of what ordinarily is lessened capacity. For the calibrated dials used, these terminal frequencies in two instances are 54 kc and 140 kc. For the other, 138 kc, the same holds true, but there is a trimmer, and that special case will be given individual treatment.

CONDENSERS WITHOUT TRIMMER

Considering now the circuits that require no trimmer, and for generation of radio frequencies only, after the dial is affixed to the condenser shaft as described, and coils are given any adjustment recommended by the manufacturer, which is a tentative adjustment anyway, a receiver is set going in the standard broadcast band, and harmonics of the generator are used for low generator frequencies, fundamentals and harmonics for the broadcast band. Short waves are checked on fundamentals on an all-wave set.

Take the case of the dial reading 54 to 170 kc. Some station is tuned in that produces a frequency that is an integral multiple of 54, or of some frequency just higher than 54, but not higher than 60. Suppose the station frequency is 660 kc. Then 660/12 = 55, and a response should be heard at 55 kc, the twelfth harmonic of which is beating with 660 kc. The generator of course is coupled to the receiver. The other responses is consecutive order should be equal to 660 divided by consequentively higher whole numbers than 12, e.g., by 11, 10, 9, etc. So the frequencies at which responses are heard would be 660/11 = 60 kc, 660/10 = 66 kc, 660/9 = 73.3, until a frequency equal to twice the lowest test frequency is reached, e.g., 110 kc, the sixth harmonic of which beats with 660 kc. The test is to see that the responses come in at the indicated frequencies as read on the dial.

If for the first or lowest frequency the reading is higher than it should be, which will be the only direction of error for oversized inductance, remove a turn at a time, until at or near the selected low frequency setting the required frequency registers. Then the other responses will be according to the division of the station frequency by higher numbers, as explained.

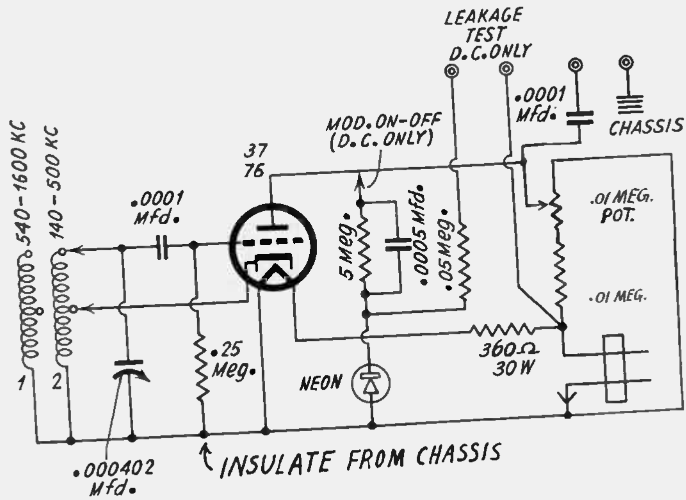

FIG. 7. Leakage test included for d.c. line.

USING TWO STATIONS

In general, the same procedure applies to low-frequency bands, including the intermediate frequencies, for all signal generators, the test being made without introduction of modulation, and the generator being tuned each time to zero beat, that is, no frequency difference between the station frequency and the harmonic of the generator.

When the frequencies are not as low as those at first considered, say, when the second band of the five-band generator is used, 170-540 kc, or when the lower frequency of the two-band generator is checked, 140-500 kc, one station may be used for one station of low broadcast frequency, say, 540-710 kc, may be used for inductance setting, at or near maximum capacity of tuning condenser in circuit, and a station about in the middle of the broadcast band for

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some higher frequency checks. Thus 1,000 kc could be used as station when 500 kc is generated, second harmonic beating with station. Although one such station at about the middle of the band may be used for all purposes, a lower lower frequency station reduces the possibility of error.

When the inductance is right, as determined by the low-frequency setting, the only other adjustment would be for capacity. If the frequency reads too high at or near the high-frequency end, after the inductance has been made correct as determined at the low-frequency end, less capacity is needed. If the frequency reads too low more capacity is needed. In general, no adjustment of capacity will be required, as all factors were considered, including the coil capacity, in calibrating the dial for trimmerless condenser. But to reduce capacity shorten leads, and, if there is a leak, use a larger value leak. The small capacity change will have no significant effect on the low-frequency end.

GETTING RATIO RIGHT AT FIRST

Aside from the selection of proper inductance, any inductance approximately right, even 25 per cent. off, may be used as a check of the capacity relationship. It has been stated the calibration depends on the condenser's capacity, or rather, it is that capacity plus other capacities in circuit. The frequencies imprinted are related to the inductance, when the capacity already has been the most important basis of calibration. So any inductance even roughly near the required value, and of about the same distributed capacity, may be used as check by setting the generator dial as prescribed, inserting the coil, picking up a station with which the generator beats when set at or near lowest frequency, paying no regard to true frequencies, then multiplying the generator dial-read frequency by 2 and 3, and seeing that responses come in at these points, also, receiver not molested, only the generator turned to higher frequencies. For instance, no matter what the true frequency that is generated, suppose there is a response at 54, then there should be a response at 2 x 54 or 108 and another at 3 x 54 or 162. Really only the first and third readings need be considered. If the reading is 169 instead of 162 it is too high, and the capacity is too high, while if it is 158 instead of 162 there is not enough capacity, so add a little, until the 3-to-1 frequency ratio is established, for oscillators that tune to a frequency ratio of at least 3 to 1. All do, as shown in the diagrams, except the beat frequency oscillators, and the single-band 132-380 kc oscillator, which has a frequency ratio of 2.933. But even the 132-380 kc oscillator may be adjusted on a 3-to-1 basis, also, because it has a trimmer which, if of insufficient capacity, permits the 3-to-1 ratio. Hence established 3-to-1, then turn down the trimmer (using more capacity) until the beat is made of a frequency just highes than audibility, e.g., the sound disappears.

SAME RATIO RETAINED

It is not good practice first to establish the correct capacity ratio by this method, using the coil as you find it, for then the turns may be taken off with full safety at a low-frequency setting, to get the inductance just right. Only one turn at a time may be taken from low-frequency coils already approximately correct. For standard broadcast band the same advice may be good. But for short waves if any inductance adjustment is to be made it had better be by pressing the turns closer together for increased inductance, or spreading them out a bit for reducing the inductance, using binder to keep them in place when once correctly established.

The establishment of the correct capacity ratio, when once made for one band, is applicable to all bands, and need not be altered therefore after once set correctly. Where there is some overlap provided on the dial, and there is at least a little on two of the three dials considered in this article, if the exactly correct frequency ratio is a little awkward to establish, using either an approximate or accuate coil, the dial may be slightly shifted on the condenser shaft, to render the 2-to-1 and 3-to-1 ratios exactly applicable.

The standard broadcast band coverage of the generator may be checked on fundamentals throughout, or second harmonics of the generator may be used for the higher frequencies of the band, always, however, beating with stations of known frequency.

In the case of the beat frequency oscillator, since the inductance is the same as for the 140-

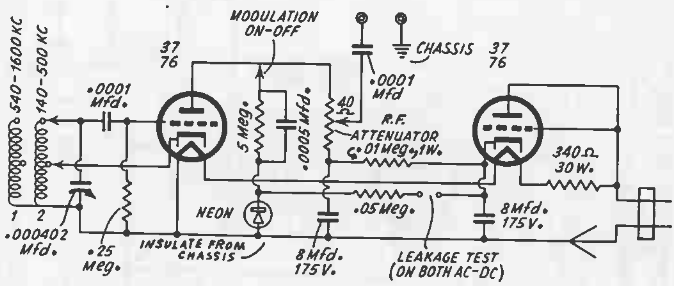


FIG. 8.
Rectifier included makes neon tube operation always optional.

500 kc band of one r. f. oscillator, and the frequencies are lowered by puting a fixed condenser of .0008 mfd. across the tuning condenser, the first check should be to established the radio frequencies, 140-500 kc. This may be done by ratio, using the 3-to-1 reading method without regard to frequencies, dial displaced a little from original setting to establish the ratio if it proves elusive, then the inductance adjusted for a reading of 140 to 145 kc for some station the frequency of which divided by 4 or more, always whole numbers, equals between 140 and 145.

EASIER TO DO THAN TO READ

Turns are adjusted to coincide generator reading with station frequency divided by first number. Then dividing by successively higher numbers, the frequencies of the generator, the dial of which is moved while station is kept intact in the receiver, will be equal to station freqency divided by numbers successively one higher than the first. Actual application of the rule is easier than its comprehension at first reading.

The next beat frequency problem is to get the right capacity. This is composed of the tuning condenser capacity, now correctly established at the ratio for coincidence with dial on its 140-500 kc scaling, and the added parallel capacity of .0008 mfd. The use of fixed condensers in parallel is recommended to build up the capacity to half the maximum of the small variable. Say that 100 mmfd. small variable is used. Set the variable at half that, or 50 mmfd. approximately (if it is straight capacity line), and use three .00025 mfd. in parallel for .00075 mfd., or one .0005 mfd. and one .00025 mfd. These are run-of-factory values and may not be accurate. However, include enough capacity so that tenth harmonics of the new low frequencies beat with stations, and any station may be used in the range 99 x 10 to 83 x 10 in steps of 10 kc, e.g., 990, 980, 970, 960, 950, 940, 930, 920, 910, 900, 890, 880, 870, 860, 850, 840, or 830 kc. The trimmer is set to zero-beat with the selected station, but the response will be very weak, and one should listen carefully. It is possible that earphones will be required even on a big receiver, or at all hazards a listening check is necessary, as the beat is not strong enough to influence most meters one has on hand. When the correct adjustment is made, the only remaining problem is to establish 100 kc.

This is easily done by duplicating the .0004 mfd. maximum of the variable by building up parallel fixed capacities, until substitution of these for the variable restores the station beat used previously, and then, restoring the variable and removing the new fixed values, new fixed ones are built up to equal the first bank of "fixtures." Now the two recently fabricated fixed values are combined with a small variable, and that variable is adjusted independently in the fixed-frequency oscillator until a beat is heard with any station on a frequency equal to an integral multiple of 100 kc, e.g., 600 to 1,600 kc in 100 kc steps. An extra check is provided in that every such station produces a beat, also the total number of modulation responses less one, stations unnecessary, when multipled by a hundred, equals the frequency difference on the receiver, handily checked if the receiver itself is accurately frequency calibrated.

(*Continued on following page*)

Table Converting R.F. Calibration to A.F.

The beat frequency oscillators shown in the two diagrams, Figs. 10 and 11, have the same dial, calibrated from 83 to 99.9 kc. If 100 kc is the fixed frequency oscillation, the lowest audio frequency due to mixing is 100 cycles, the highest 17,000 cycles. But 99.9 kc may be used so the fixed oscillator zero beats with the adjusted other, requiring a zero indicator, shown as a meter, the needle of which is to be made nearly to stand still, after oscillating. The range then is 0-16,900 cycles. The dial readings for the two examples are tabulated.

Dial Reads Kc	*A.F. Cycles for 100 Kc Fixed*	*A.F. Cycles for 99.9 Kc Fixed*
99.9	100	0
99.8	200	100
99.7	300	200
99.6	400	300
99.5	500	400
99.4	600	500
99.3	700	600
99.2	800	700
99.1	900	800
99.0	1,000	900
98.5	1,500	1,400
98.0	2,000	1,900
97.5	2,500	2,400
97.0	3,000	2,900
96.5	3,500	3,400
96.0	4,000	3,900
95.5	4,500	4,400
95.0	5,000	4,900
94.5	5,500	5,400
94.0	6,000	5,900
93.5	6,500	6,400
93.0	7,000	6,900
92.5	7,500	7,400
92.0	8,000	7,900
91.5	8,500	8,400
91.0	9,000	8,900
90.5	9,500	9,400
90.0	10,000	9,900
89.5	10,500	10,400
89.0	11,000	10,900
88.5	11,500	11,400
88.0	12,000	11,900
87.5	12,500	12,400
87.0	13,000	12,900
86.5	13,500	13,400
86.0	14,000	13,900
85.5	14,500	14,400
85.0	15,000	14,900
84.5	15,500	15,400
84.0	16,000	15,900
83.5	16,500	16,400
83.0	17,000	16,900

(*Continued from preceding page*)

The total capacity to generate 100 kc, using the same type coil in the fixed-frequency oscillator as in the variable-frequency oscillator, is .0012 mfd. The combination of the two frequencies now will result in audio tones equal to the difference between the dial readings and 100, as already explained.

Directions for Alignment with Generators

The procedure for alignment of superheterodynes, using a signal generator, may be briefly summarized as follows:

1 Turn on the set, turn on the generator, short the set's antenna-ground posts, and connect generator output to the r.f. control grid of the modulator or pentagrid converter tube. Sometimes a series resistance of 10,000 to 25,000 ohms is required between generator and the tube under discussion, to enable proper response.

2 Tune the plate and grid circuits of each i.f. transformer, for maximum response, be it aural response as heard in a speaker when signal generator is modulated, or visual response, as noted on a series current meter or indicating tube, without modulation. Tune the first r.f. transformer first, then the others, as it causes the biggest change in sets having diode second detectors. Now decrease the generator output to a level barely discernible, retune the plate circuits of all i.f. transformers, identified because of the high voltage between them and coil shield, and then tune the grid circuits of the transformers. Having nicely tuned the plate condensers, do not molest them once the grid condensers have been set properly. They are interdependent with the grid condensers, and to change one is to change both.

3 For the broadcast band, select the tiedown points recommended by the manufacturer, otherwise use 600 kc and 1,450 kc. With 60 kc injected into normal antenna post the series padding condenser is first adjusted, while the condenser gang is rocked at about three-quarters of full capacity, until maximum response is obtained. Then the 600 kc injection is removed from the antenna post, and 1,450 kc substituted. The oscillator parallel trimmer is adjusted for maximum responses, there being two possible, but the one requiring the less trimmer capacity is used, or, if only one response is obtained, it is almost certainly the correct one. It it is incorrect this will show up by numerous squeals accompanying stations, though not all stations. If there is a squeal for every station the i.f. channel is oscillating. Now turn the antenna parallel trimming condenser, across the secondary of the first coil, and then the trimmer condenser of the next stage, unless that stage is the one feeding the modulator (three-gang condenser set). If it is, then usually no adjustment causes any improvement, as in most sets the modulator and oscillator are so closely coupled that the capacity setting for the oscil-

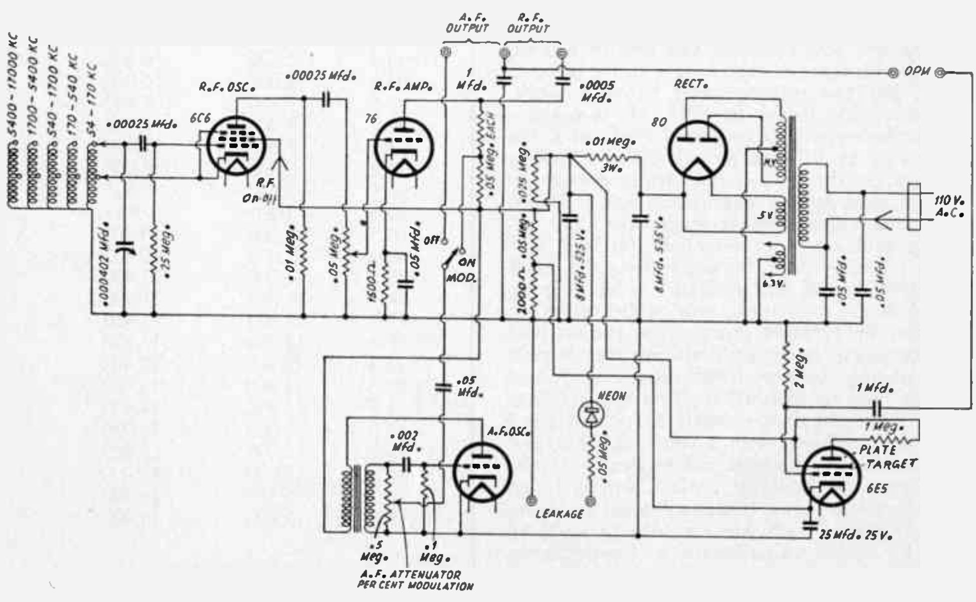


FIG. 9
A.C. operated signal generator, with ray indicator tube.

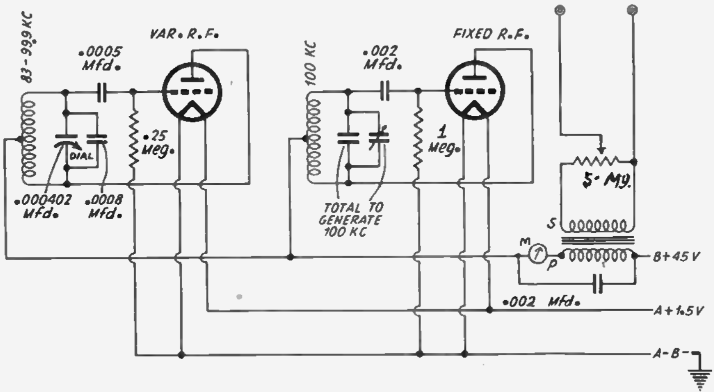


FIG. 10
Battery-operated beat-note oscillator.

lator trimmer suffices also for the modulator, and any further adjustment, by resort to the modulator trimmer, is in the direction of upsetting the balance. If a tracking section is used, adjust parallel trimmers only, all at 1,000 kc.

The directions for an audio beat frequency oscillator are: Feed the output of the oscillator directly into the device to be tested, which is assumed to be high impedance. If there is to be a low impedance feed a matching transformer is preferred, with impedance matched to the output tube of the generator, on the primary side, and various secondary impedances obtainable from taps, e.g., 8 to 500 ohms. For overall tests, the beat frequency oscillator may be made to modulate a radio frequency oscillator and the radio frequency injected at the receiver's antenna-ground posts at any desired r.f., to which the set is tuned.

Coming Back to Earth

When Marconi received the letter S across the Atlantic, at Grace Bay, Nova Scotia, from Poldhu, Eng., he refuted those who had argued it could not be done because radio waves would go off into space and not follow the curvature of the earth. Today we know that because of much higher radio frequencies used, not only do ground waves follow the earth's curvature, but also sky waves shoot off into space. But the high frequencies are often reflected back by the Heaviside layer.

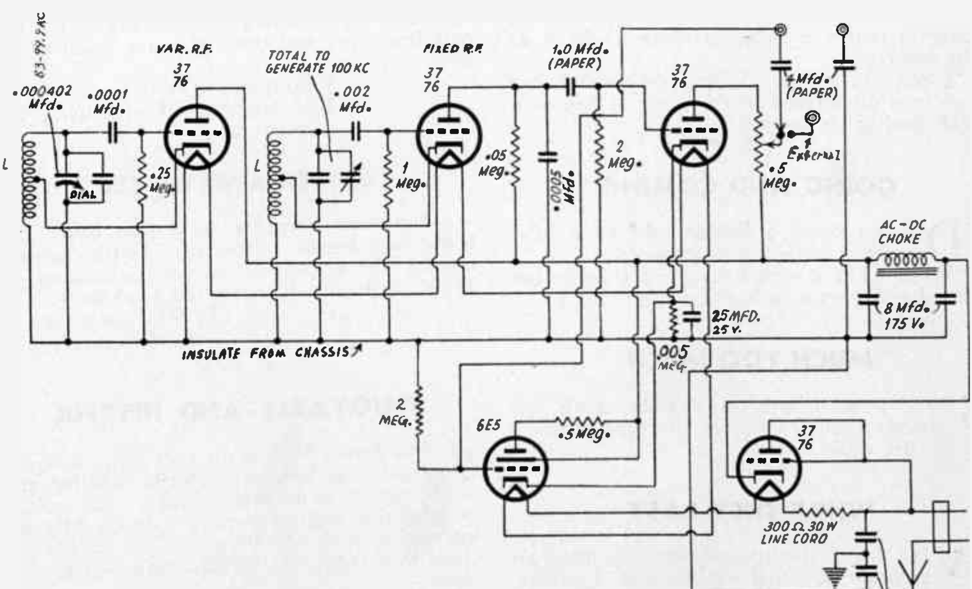


FIG. 11
.05 Mfd. EACH
Universal-operated beat note oscillator with ray indicator tube.

GRIN And Bear It

KNOWS HIS RIGHTS

A SERVICE man walked up to the stamp window in the Post Office and asked for 100 one-cent stamps, laying 60 cents on the counter.

"Forty cents more," said the Post Office clerk.

"What for?" demanded the service man. "You'll have to give me the usual discount if you want me to handle your line."

* * *

MY OWN IS BEST

"I GET full rated power out of my final now," said one ham.

"Fine," said his fellow worker in the amateur field. "But, say, old man, you ought to do something about improving your modulation. Isn't it a bit rough? I've got a 100 per cent. modulator that's more linear than a ruled edge, and not so hard on the ears."

"I noticed a change in your modulation. It sounded to me like an open grid."

* * *

HOME TO ROOST

"I CAN'T get any programs on my set any more," telephoned a customer. "Can you tell what's the matter with it?"

"No," replied the service man, "but it's going to cost you twice as much to fix it as you expected."

"I don't mind that. When you fixed it last week you guaranteed you'd repair it free if it went dead in six months."

* * *

GOING AND COMING

"DO you count a ballast tube as a tube, since it is only a resistance?"

"When I buy a set a ballast is a resistor, but when I sell a set a ballast is a tube."

* * *

MUCH TOO MUCH

SOME persons have encyclopedic minds, but nobody could remember the type numbers of all the radio tubes.

* * *

WHILE THEY LAST

WHEN an experimenter wants to make an accurate measurement he uses a bridge, when he's after amplification and detection he uses a tube, when he wants a strong wire he uses a bus, and when he needs an aerial for his 'plane he uses a trailer. But when he wants to transport his parts that became obsolescent in the past twenty-four hours he uses a five-ton truck.

* * *

MULTIPLICATION MYSTERY

ALL coils have inductance, all condensers have capacity, all resitors have resistance, and all sets have only all three. That's why it's hard to understand how a composition of three simple ingredients turns out to be a thirty-three tube set.

FORUM

"FINE! GREAT HELP!"

I like your magazine fine and it's a great help to me.

PVT. THOMAS C. MABRY,
Bat. G.B.D.A.,
Marine Base, San Diego, Calif.

* * *

MEAT PACKERS

I look forward to the meaty articles with which RADIO WORLD is packed.

ARTHUR W. BEALS,
P.O. Box 442, Christchurch, New Zealand

* * *

"I THINK IT FINEST"

I have been reading your magazine for the past few years and think it is the finest of its kind.

JOSEPH BUCKLEY,
3461 Jasper St., Philadelphia, Pa.

* * *

"BETTER AND BETTER"

I find your magazine is getting better and better each month. Especially liked in January number the article on an audio oscillator by M. N. Beitman. Keep up the good work.

L. S. WASSERMAN
S. Milwaukee, Wis.

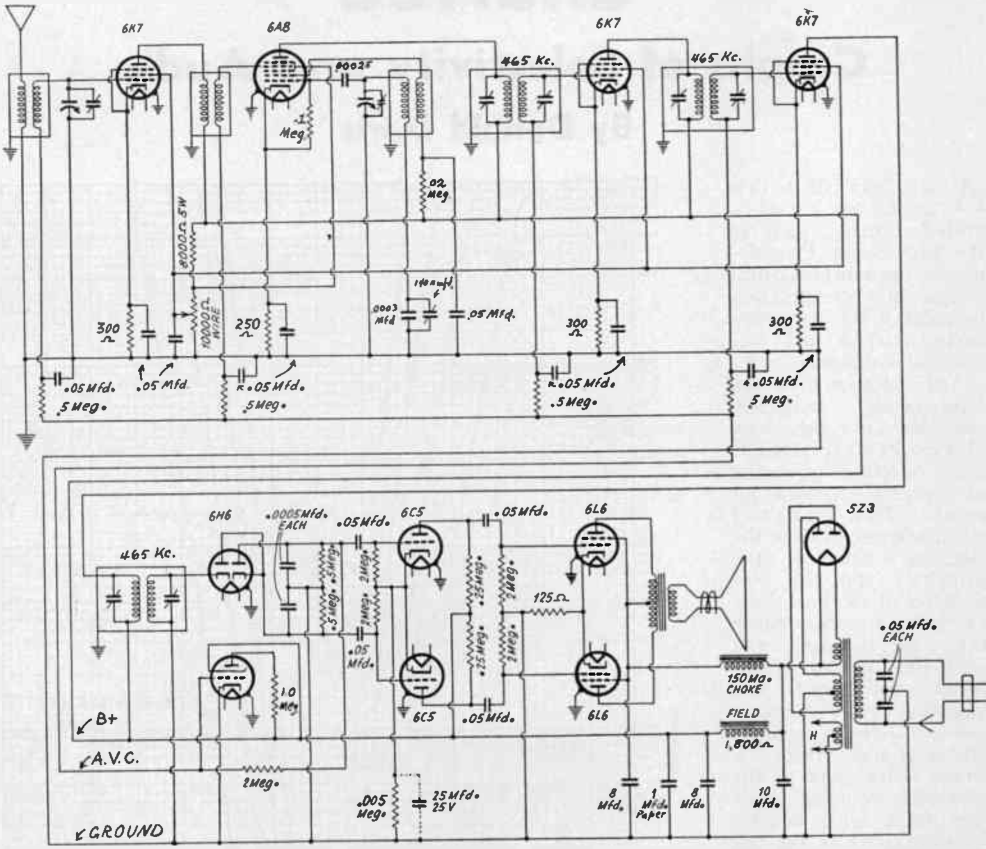
* * *

ENJOYABLE AND HELPFUL

I find RADIO WORLD an excellent magazine. It not only has been enjoyable to read but also has helped me in my service work. The articles on television and the new cathode-ray tube are interesting and educational. You should include more receiver diagrams using glass type tubes.

RUDOLPH F. WEINRICH
311 Van Winkle Avenue, Hawthorne, N. J.

17 Minutes Allowed to Find Mistakes



There are two mistakes in this diagram. Try finding them in seventeen minutes. The only clue given is that you should look for series conductivity and parallel completeness.

A GOOD test of one's radio knowledge is to find the mistakes in diagrams. So here is a circuit with two errors purposely introduced, and as solving the riddle requires some thought, seventeen minutes are allowed.

If you find the mistakes in that time you may consider yourself good. If you can't, don't be discouraged, but try the next time to beat the gun.

The circuit may be briefly described as an eleven-tube super, counting the ray indicator tube. It is intended there be a stage of t.r.f., a tuned input to the modulator, a tuned oscillator, which is in the pentagrid converter circuit, two stages of i.f. amplification, a balanced detector, a push-pull output power stage, a rectifier and a tuning indicator tube.

If you will read the foregoing carefully you will get some assistance in the direction of the solution, and the specific advice is: Look for series conductivity and parallel completeness. That advice is not much help, we admit, but any aid should be welcome.

A good way to go about the problem is to see that the A, B and C voltages are proper, that resonance is established as and where it should be, and that tubes performing functions related to large change be examined for possibility of failure.

After you have decided that you have obtained the correct answer, turn to page 56 and ascertain how you made out.

Super Pro Responses Charted

Graphs of Selectivity and Audio

By Donald Lewis

A RECEIVER with laboratory - calibrated controls, such as the new Super Pro, demands extremely skillful design and construction to achieve the necessary perfect circuit and mechanical synchrony.

The selectivity of the intermediate frequency amplifier of the new "Super Pro" is continuously variable by means of a control in the front panel. This control simultaneously varies the coupling between the primaries and the secondaries of the first three i.f. transformers. Since both the primary and secondary of each transformer are tuned, this variation of coupling changes the response characteristic from a single sharp peak in the minimum coupling position to a wide double-humped curve in the position of the maximum coupling. The total range of the coupling provided by this panel control is from approximately one-third optimum in the narrow position to about three times optimum in the wide position. The control being continuously variable, any intermediate value between these two extremes is readily obtainable.

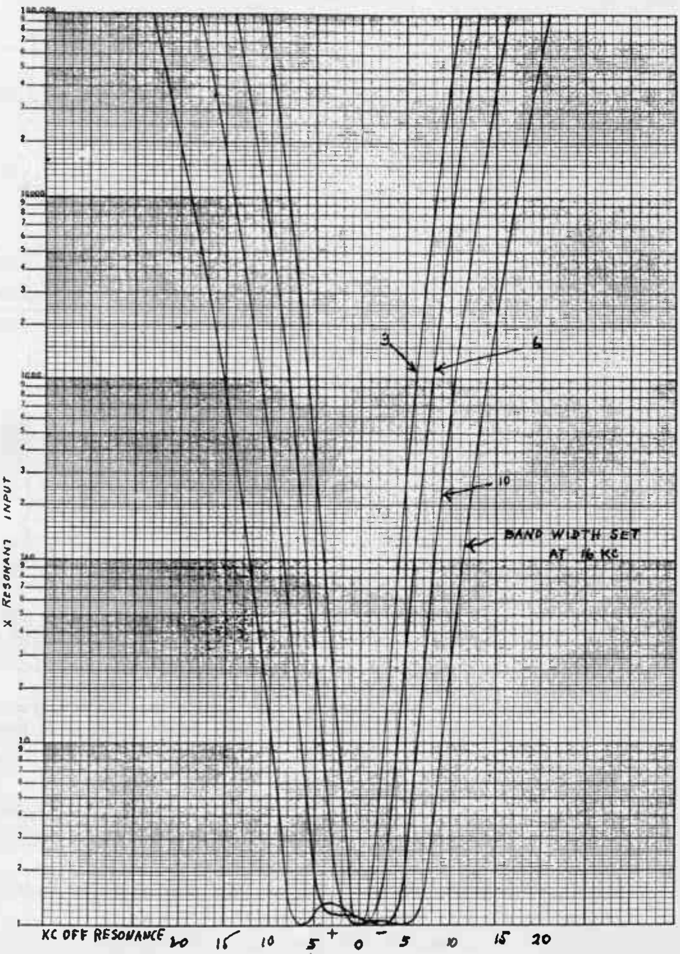


FIG. 1
Selectivity curve of the new Super Pro, made at 6,000 kc. The band width was adjusted at the intermediate level by varying the coupling. Widths are shown for 3, 6, 10 and 16 kc, with 30% modulation at 400 cycles.

Thus with the aid of a carefully engineered group of transformers and a special measuring instrument, the selectivity or band widths were both calibrated and the calibrations noted directly on the panel as 3, 4, 6, 10, 16 kc.

Fig. 1 was made with the input at resonance one micro-volt, 30% modulated with 400 cycles, a 50-ohm resistor being in series with each A post. The sensitivity was adjusted to produce a 6 milliwatt output with one microvolt input at resonance. The band width control was set as indicated on the curve. The signal frequency was set at 6 megacycles, and the a.f. gain at 10. Since the major portion of the receiver's selectivity is in the i.f. amplifier, there is but little variation throughout its entire tuning range.

Two stages of radio-frequency amplification using 6K7 tubes are used in this model to afford a high input with maximum image suppression.

The a.v.c. system used is of the amplified and delayed type, using the 6B7 as both amplifier and rectifier. A single tuned circuit link coupled to the primary circuit of the fourth i.f. transformer feeds it to the control grid. The double or twin tuned output transformer feeds the amplified signal voltage from its plate circuit back to its diode plates.

The a.v.c. output transformer is an exact duplicate of the second detector output transformer with its coupling similarly adjusted and locked in position at the laboratory. The delayed action is accomplished by normally maintaining a no-signal bias on the diode plates of the 6B7 of approximately minus 40 volts.

The audio component of the 6B7 second detector diode circuit is capacitively coupled to the a.f. gain control. This first a.f. stage is resistance-capacity coupled to the grid of the driver stage which uses a 6F6 in Class A. The audio output stage is transformer-coupled from the driver and consists of two 6F6's operated as triodes, class AB. A special curve was made for the fidelity of this receiver with the results shown in Fig. 3. The test was made with the input at 100 microvolts, modulated 30%, audio from 30 to 10,000 cycles, with a 50-ohm resistor in series with each A post. The sensitivity was adjusted to produce two watts (4 volts across 8-ohm load) at a modulation frequency of 500 cycles. The a.f. gain was set at 10, and the radio frequency was 1,000 kc.

Taking the 6 db loss as the cut-off point, it is seen that the fidelity follows closely the settings of the band width control with settings of 3, 4, 6, 10 and 16.

SUCCESS WITH CIRCUITS

I have read RADIO WORLD since it was a weekly magazine and have tried many of the novel circuits published in it, all with great success.

STANLEY G. FISCHER,
26 President St.,
New Rochelle, N. Y.

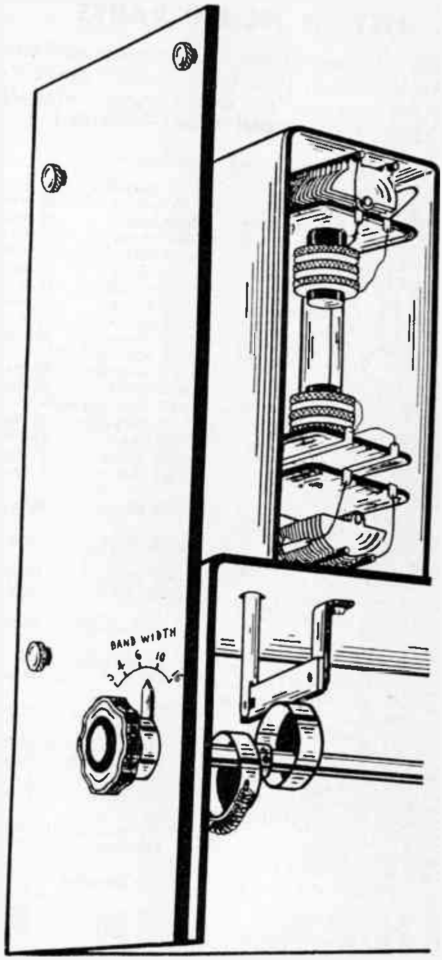


FIG. 2

Mechanism for varying the band width. One transformer is illustrated. In the set three transformers are controlled. The band width is dial calibrated. The shaft from the transformer has a downward pressure, due to internal spring. Eccentric cams communicate the movement.

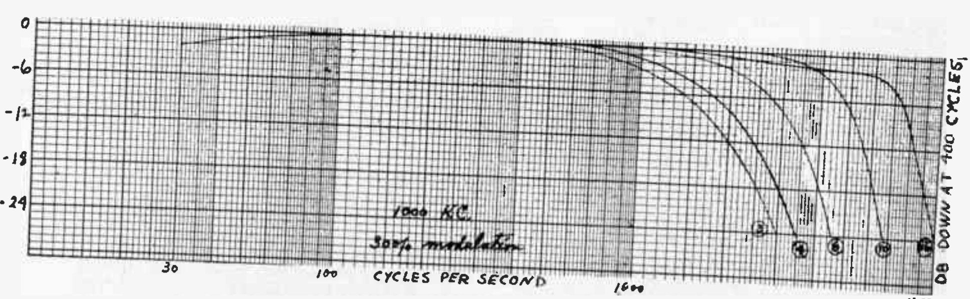


FIG. 3

Audio response characteristic, at 30% modulation.

LIST OF NC-100 PARTS

[The diagram of the receiver was published in the November, 1936, issue, and had constants identified by symbols. The list below correlates the symbols and actual values.—EDITOR.]

(Resistors and Condensers)

R_1	R.F. Grid Filter	.5 megohm	½ watt
R_2	R.F. Cathode Bias	350 ohms	½ watt
R_3	1st Det. Cathode Bias	5000 ohms	½ watt
R_4	H.F. Circuit B + Filter	2000 ohms	½ watt
R_5	1st I.F. Grid Filter	.5 megohm	½ watt
R_6	1st I.F. Cathode Bias	350 ohms	½ watt
R_7	2nd I.F. Grid Filter	.5 megohm	½ watt
R_8	2nd I.F. Cathode Bias	500 ohms	½ watt
R_9	2nd I.F. Screen Filter	2000 ohms	½ watt
R_{10}	2nd Det. Cathode Bias	20,000 ohms	½ watt
R_{11}	Audio Volume Control	50,000 ohm potentiometer	
R_{12}	AVC Plate	.5 megohm	½ watt
R_{13}	I.F. B + Filter	2000 ohms	½ watt
R_{14}	R.F. Gain Control	10,000 ohm variable	
R_{15}	Common Grid Filter	.5 megohm	½ watt
R_{16}	Gain Control Bleeder	50,000 ohms	½ watt
R_{17}	Voltage Divider	20,000 ohms	2 watt
R_{18}	Voltage Divider	20,000 ohms	2 watt
R_{19}	H.F. Oscillator Grid Leak	20,000 ohms	½ watt
R_{20}	H.F. Oscillator Voltage Divider	50,000 ohms	½ watt
R_{21}	H.F. Oscillator Voltage Divider	100,000 ohms	½ watt
R_{22}	1st Det. Screen Filter	100,000 ohms	½ watt
R_{23}	Tuning Indicator Grid Filter	.5 megohm	½ watt
R_{24}	Tunning Indicator Target	.1 megohm	½ watt
R_{25}	C.W. Oscillator Grid Leak	50,000 ohms	½ watt
R_{26}	C.W. Oscillator Voltage Divider	100,000 ohms	½ watt
R_{27}	C.W. Oscillator Voltage Divider	100,000 ohms	½ watt
R_{28}	AVC Grid Return	.5 megohm	½ watt
R_{29}	AVC Voltage Divider	350 ohms	1 watt
R_{30}	AVC Voltage Divider	1000 ohms	2 watt
R_{31}	AVC Voltage Divider	1000 ohms	2 watt
R_{32}	Tone Control	500,000 ohm potentiometer	
R_{33}	Output Cathode Bias	250 ohms	2 watt
R_{34}	C.W. Oscillator Plate Filter	.25 megohm	½ watt

C_1	R.F. Grid Filter	.01 mfd.	400 volt
C_2	R.F. Cathode Bypass	.1 mfd.	200 volt
C_3	R.F. and 1st I.F. Screen Bypass	.1 mfd.	200 volt
C_4	R.F. and H.F. Osc. Plate Bypass	.1 mfd.	400 volt
C_5	1st Det. Cathode Bypass	.1 mfd.	200 volt
C_6	1st Det. Plate Filter	.1 mfd.	400 volt
C_7	1st I.F. Grid Filter	.01 mfd.	400 volt
C_8	1st I.F. Cathode Bypass	.1 mfd.	200 volt
C_9	1st and 2nd I.F. Plate Filter	.1 mfd.	400 volt
C_{10}	2nd I.F. Grid Filter	.01 mfd.	400 volt
C_{11}	2nd I.F. Cathode Bypass	.1 mfd.	200 volt
C_{12}	2nd I.F. Screen Filter	.1 mfd.	200 volt
C_{13}	2nd Det. Cathode Bypass	10. mfd.	50 volt
C_{14}	2nd Det. Plate Bypass	.001 mfd.	Mica
C_{15}	Phone Coupling	.1 mfd.	400 volt
C_{16}	AVC Plate Bypas	.1 mfd.	200 volt
C_{17}	AVC Grid Coupling	.0001 mfd.	Mica
C_{18}	C.W. Oscillator Coupling	2 mmf.	Special
C_{19}	C.W. Oscillator Grid	.001 mfd.	Mica
C_{20}	H.F. Oscillator Grid	.0001 mfd.	Mica
C_{21}	H.F. Oscillator Series Padding--Different for each range		
C_{22}	H.F. Oscillator Heater Bypass	.01 mfd.	400 volt
C_{23}	H.F. Oscillator Screen Bypass	.1 mfd.	200 volt
C_{24}	H.F. Oscillator Coupling	.01 mfd.	400 volt
C_{25}	Tuning Indicator Grid Filter	.01 mfd.	400 volt
C_{26}	C.W. Oscillator Heater Bypass	.1 mfd.	200 volt
C_{27}	C.W. Oscillator Screen Bypass	.1 mfd.	200 volt
C_{28}	AVC Cathode Bypass	.1 mfd.	200 volt
C_{29}	Tone Control	.01 mfd.	400 volt
C_{30}	B-Supply Filter	8 mfd.	450 volt
C_{31}	B-Supply Filter	8 mfd.	450 volt
C_{32}	B-Supply Filter	8 mfd.	450 volt
C_{33}	Crystal Filter Bridge	.0001 mfd.	Mica
C_{34}	Crystal Filter Bridge	.0001 mfd.	Mica
C_{35}	Crystal Filter Coupling	35 mmf.	Variable

X_1	B + (stand-by) Switch
X_2	AC On-Off Switch
X_3	C.W. Oscillator Switch
X_4	AVC On-Off Switch

L_1	2nd Det. I.F. Choke	7. mh.
L_2	Tone Filter Choke	18. Henry
L_3	B-Supply Filter Choke	20. Henry
T_1	Push-Pull Input Audio Tranformer	
T_2	Power Transformer	4:1 Ratio
T_3	Output Transformer	Mounted on Speaker

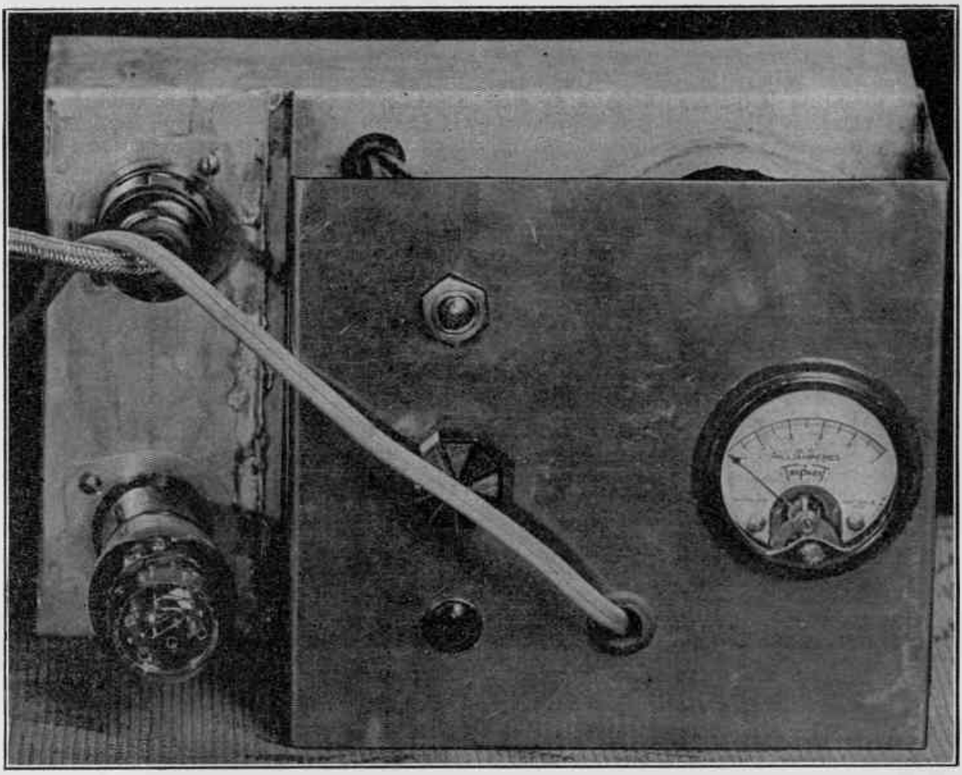
Possible to Avoid Corner Screw Use

The generator on page 42 fits into a metal box that accommodates a metal panel that should be 4⅞ inches square. The four holes at corners are for self-tapping screws, for which openings are provided in corner lips that the box contains. However, these corner holes on the panel are not strictly necessary, as the fit is tight.

In fact, overlapping of two planes of the metal of which the box is made causes the width to be a trifle less than 4⅞ inches. So the method of adhering the panel to the box without screws will be detailed. It is presumed those following this method will omit the four panel corner holes.

Turn the box so that the hole on one side, where the volume control or attenuator is to be placed, is at right rear. Then hold the panel at both sides, near the top, where the large hole is, and insert the bottom of the panel a little through the box near the bottom of the box opening. Now push the panel into place, over the two bottom lips, using considerable force, until the panel is aligned with the front of the box. It will be found that the top of the panel can not be forced into place because of the extra width, some 1/16 inch narrower panel being required for about ½ inch. With a pencil mark these two locations. Remove the entire panel, file the top sides of panel a bit until the clearance is provided, then repeat the previous insertion operation, finally forcing the top also into place, for now there should be a snug and permanent fit.

The panel thickness may be up to 3/16 inch, and when it is that, the top of the panel, when in place, will be flush with the top of the box. Otherwise the panel will be "sunk" the difference.



The top view of the vacuum tube voltmeter shows the Triplett Model 223 meter, 0-1 milliampere range, and the two switches, one for the a.c. line, the other for the meter. Between the switches is the knob of the zero-adjusting bridge rheostat. At left is the rectifier tube. A connector plug is used for the shielded cable, shown at upper left.

A Balancer Type VTVM

Range 0-2 Volts, Using Two Tubes

By Frank G. Simonds

IT is generally conceded that a vacuum tube voltmeter is the only practical device for measuring radio-frequency voltages where no power must be taken from the source of the voltage to be measured. While it is true that a static voltmeter can be used for unidirectional voltages and low frequency voltages, it is of no use where voltages of the order of one volt or less are to be measured. It is in this range where the vacuum tube voltmeter holds sway. Not only is it capable of measuring low voltages accurately, but it can measure voltages of practically all frequencies regardless of how high.

For a vacuum tube voltmeter to be practical it must have its own plate voltage supply. This may be provided by a battery. As a rule, however, a battery is not satisfactory because it deteriorates rapidly and must be replaced frequently.

HOW IT LOOKS

The other alternative is to build in a rectifier. In the long run this is the cheaper and it is also the more satisfactory at all times. There are two possibilities. The rectifier may be of the universal type or it may be adaptable to a.c. only. An instrument built so that it can be used on either an a.c. or a d.c. line has many limitations. It may cause short circuits. These might be both dangerous and destructive. Therefore the best power supply is one having a transformer and therefore usable only on a.c.

An a.c. powered vacuum tube voltmeter is de-

(Continued on following page)

(*Continued from preceding page*)
picted in top view. The O-1 milliammeter at the right is the unbalance indicator and, by calibration, the voltage indicator. The knob opposite the meter is the zero adjuster, or the no-signal balancer. Two switches are shown on the panel, one below and one above the rheostat. One is for the power and the other for variable arm of the circuit.

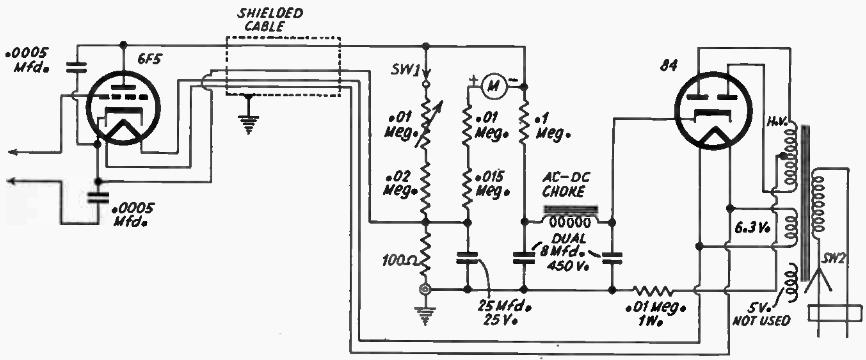
The rubber-covered lead entering the panel is the a.c. line and the shielded lead that may be seen a short distance at the left is the supply cable for the vacuum tube. As can be seen from the circuit diagram, the hook-up is composed of two parts, namely, the power supply and the indicator circuit. The shielded cable contains four leads, two for the heater of the 6F5 and two for the balancer circuit.

PLENTY OF PROTECTION

The test leads, indicated by arrows at the left of the 6F5, are terminated in convenient test clips. One of them connects to the grid cap of the 6F5 and the other to ground. The lower side of the bottom .0005 mfd. condenser should be grounded (not shown so in diagram). This is done at the sheath of the shielded cable. Since there is a 100-ohm resistor in the voltage divider between the cathode and the grid return, there is a minimum negative bias on the grid. In order to return the a.c. component directly to the cathode for high frequencies, a .0005 mfd. condenser is connected from ground to the cathode.

The meter is well protected, for there is a total resistance of more than .11 megohm in series with it in the common leads and another resistance of .025 megohm in series with the meter itself. Besides these series resistors there is the adjustable shunt, having a minimum resistance of .02 meg. The tube resistance is also in shunt. The value of this resistance varies with the unknown voltage, and for that reason there is a relation between the current through the meter and the voltage impressed on the grid of the 6F5.

The reason the 6F5, the test leads and the by-pass condenser are placed apart is that in this manner distributed capacity and losses are kept at a minimum. The function of the small condenser connected between the plate of the tube and the cathode is to lower the effective



Wiring diagram of the balancer type vacuum tube voltmeter, using a heater rectifier tube, and also a heater detector tube, 6F5, for the VTVM proper. The 6F5 is put at the far end of the cable, and the input to this tube is made to leads that are terminated in clips. The lower input prod is grounded to the cable sheath.

LIST OF PARTS

Coils

One small power transformer for 6.3 volt tubes and full-wave rectification.
One a.c.-d.c. choke.

Condensers

One dual 8 mfd., 450 volt electrolytic condenser.
One 25 mfd., 25 volt electrolytic condenser.
Two .0005 mfd., mica condensers.

Resistors

Two .01 megohm.
One .01 rheostat, with knob.
One 100 ohms.
One .015 megohm.
One .02 megohm.
One .1 megohm.

Other Requirements

One line cord.
One line toggle switch.
One single pole switch.
Two test clips and leads.
One grid cap.
Two sockets.
One O-1 milliammeter.
One 84 rectifier tube.
One 6F5 amplifier tube.
One four-lead shielded cable.
One insulating panel.
One metal chassis.

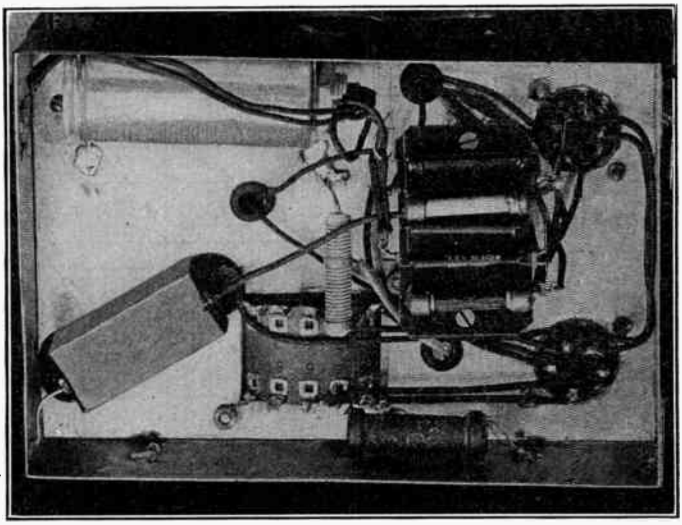
denser the effective input capacity of a high mu tube working into a high resistance would be very large—possibly of the order of .0005 mfd.—while with the condenser it will be only slightly more than the static input capacity, which is about 6 mmfd. This condenser is of importance only on high frequencies.

CALIBRATION

The figure on page 55 shows the under side of the chassis of the vacuum tube voltmeter. The various resistors and condensers are easily recognized.

the instrument is calibrated to read in volts on the plate current milliammeter.

This calibration may be in terms of peak volts or in terms of root mean square, or effective values. Different curves will be obtained in the two cases. Still another curve is obtained when the instrument is calibrated to read direct voltages. The curve for direct voltages is simply a grid voltage-plate current characteristic for the tube and circuit. The other curves are modifications of this curve. In the particular instrument described in this article the curves are not typical because of the way the meter is con-



The dual 8 mfd. filter condenser is shown at lower right, while the 25 mfd., 25-volt bypass condenser is directly above it. The connector plug that provides one terminal of the shielded cable is at lower left, and the rectifier tube socket is at upper left. Five small resistors are mounted on an insulating shelf. The leads passing through the chassis bottom are protected by rubber grommets.

An idea of the performance of the arrangement may be had by referring to the graph on page 56. The curve gives the relation between the current through the milliammeter for difference values of r.m.s. grid volts. The total range of the milliammeter is one milliampere and this enitre range is utilized. The voltage range is from .1 volt to 2 volts. The variation is very nearly linear. Hence for moderately accurate work it is not necessary to refer to the calibration curve but only to double the current readings and call the result volts. Of course, for another tube and another set of resistors, there would be a different curve. Therefore in every instance the circuit must be calibrated against known alternating voltages. For most accurate work the calibration curve should be used for every reading.

Calibration may be made on the basis of line voltage, using a step-down transformer, with 30-ohm potentiometer across the 2.5-volt winding, and connecting an a.c. voltmeter in parallel with the VTVM prods, which go to one end of the potentiometer and ground.

While a vacuum tube voltmeter is primarily intended for measuring alternating voltages, it may also be used for measuring direct. As a matter of fact, it is the direct current effect that is used for measuring alternating voltages. The instrument is primarily a plate bend detector, or transrectifier. When alternating voltages are measured, they are evaluated in terms of the detecting efficiency of the tube. In most cases

nected. The departure of the usual type was intentional, for it was desired to obtain a nearly linear relationship between the plate current and the root mean square value of the grid voltage input.

The vacuum tube voltmeter draws no power from the source, provided the input is not greater than a predetermined amount, because the grid of the tube is to be always negative. There is a small input capacity, of course, but the current through this does not require any power. If it is the voltage across a tuned circuit that is measured, this small capacity becomes part of the tuning capacity and it can be easily compensated for, if it causes any appreciable detuning.

One of the useful applications of this device to direct voltages is for measurement of actual grid voltages. For example, it is possible to measure accurately the voltage between the grid of a tube and its cathode even though there may be millions of ohms between. No current-drawing instrument will give anywhere near the correct voltage. A meter, for example, that requires one milliampere for full scale may indicate a voltage of .1 volt whereas in reality the voltage is 10 volts. In other words, the error may be 100 to 1.

To make the vacuum tube voltmeter most accurate a first-class socket should be used for the tube. A poor socket will draw a little cur-

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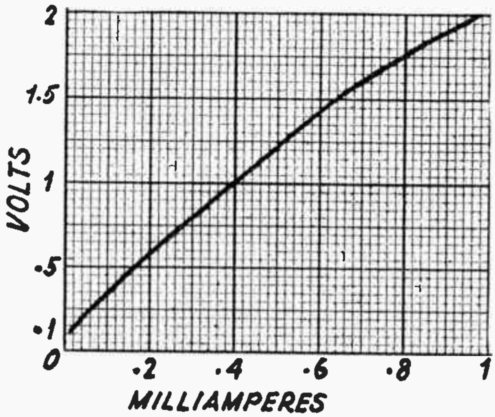
rent and will for that reason partly vitiate the observations. It is also clear that in making observations with an instrument like this the test prods should not be held by the bare hands. The body is conductive and will carry a current if the test prods are held by the hands during a reading. Large errors may creep in as a result of this current. The precaution should be taken both when making direct current and alternating current measurements. In high-frequency measurements there will also be capacity effects if the test prods are touched during a reading.

Because of possible losses and capacity effects between the test leads, they should be kept as short as practical because the longer the leads



Curve obtained for the vacuum tube voltmater for the 0-2 volt r.m.s. range. The a.c. meter used for making the calibration at the input was of the 0-10 volt range, and possibly more closely accurate points could be registered if a meter of lower voltage range were used for this purpose. The curve compares the a.c. input to the plate current as read through the 0-1 milliammeter.

the greater will be both the losses and the capacity effects. If it is necessary to make measurements at some distance from the power supply and the milliammeter, it is the shielded cable that should be increased in length. Of course, in most instances it is possible to more then entire assembly to do the work.

It will be noticed that the sleeve of the shielded cable is grounded and also that the negative side of the B supply is grounded. Though not shown in the diagram, the lower of the two test prods should be connected to ground also. Grounding stabilizes the circuit and insures that the meter reads the same every time a given voltage is impressed on the grid. The instrument should be grounded as indicated when it is calibrated and thereafter every time it is used. It is only in that way that precise readings are insured.

The Two Mistakes Revealed

The two mistakes in the diagram on page 49 are: the tuning condenser is omitted at the r.f. input to the modulator, and the second detector has a dead diode on the right-hand side, with no input to this section. Only one side of the second detector works. The secondary of the last i.f. coil should connect to the joined reversed elements, opposite plate and cathode, and the freed left-hand cathode should go to the lower terminal of the lower .5 meg. resistor.

Literature Wanted

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

Lewis Beach, 647 So. 17th St., Newark, N. J., on tube data.
Herbert Schidlio, 15 Bradford St., Brooklyn, N. Y., on radio servicing.
Douglas Warth, 192 Gilbert Ave., Memphis, Tenn.
John W. Clark, 28-24 Utopia Pky., Bayside, Queens, N. Y.—suitable to servicing business. Jas. A. Warwas, Lock Box 444, Buffalo, Minn.
General Radio Service, Berendrechtskaab 9A, Batavia-C, N. O. I.
W. G. Garnahan, Jr., S. L. I., Box 312, Lafayette, Ind.
John A. Trant, 2707 So. 24, St. Joseph, Mo.
Richard Hougton, 36 Woodlawn St., New Bedford, Mass. (Amateur set builder, student and experimenter, and would appreciate experiments about electricity or radio by other readers.)
Roy Goodyear, 705 Trenton Ave., Wilkinsburg, Penna.
W8LXN, Ralph Haartje, Box 72, Stow, Ohio. (Amateur station operator and serviceman.)
Henri Raffn, 14, Rue Klock, Clichy, Seine, France.
W. W. Bradeenm, Frenchylen, Ore.
Ralph H. Cain, 3323 West St., Holliday's Cove, West Va.
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Joseph Buckley, 3461 Jasper St., Philadelphia, Penna.
Charles J. Albertoni, Box 274, Ellet, Ohio.
Eugene P. Hanafin, Box 1086, Pensacola, Florida. (Used meters and test equipment and general radio parts).
Marvin Godsey, Appomattox, Virginia.
O. C. Rheinford, 3702 W. Cloverdale, Seattle, Wash.
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James Sweet, 1298 Rodgers Avenue, Brooklyn, N. Y.
R. S. Bonner, 1314 W. Washington Ave., Madison, Wisc.
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John Sulesk, 2324 Frankford Ave., Philadelphia, Penna.
United Sales Ltd., P. O. Box 4029 Arsenal Station, Pittsburgh, Penna.
Clem the Radio Man, Spalding, Nebr.
Radio Sales & Service, Box 204, Mt. Airy, Md.

The Beginner's Special

A Universal T.R.F. Receiver

By Jack Goldstein

HERE is a broadcast receiver for beginners to build. It is a standard circuit that works on a. c. or d. c., 90-130 volts. If the set is used on a. c. the line frequency may be any commercial frequency, only for frequencies of 40 cycles or lower the filter capacity next to the rectifier has to be doubled. That is, use 32 mfd. instead of 16 mfd.

The receiver is of the tuned radio-frequency type, using a two-gang condenser. Two radio-frequency transformers are used. Because there are few stages, and since there must be a certain amount of gain, the difference is made up by the use of high-gain coils. These are in general about the same, with large inductance primary winding, say, a universal wound coil, and the usual solenoid secondary, but with a turn or two of extra wire brought from the primary and wound around the secondary, for the capacity effect.

WHEN THERE'S A DIFFERENCE

Usually the primary is not inductively related to the secondary, but is at right angles to the secondary, and the capacity effect alone is relied on, being all-sufficient. However, if two coils that are somewhat different are used, the one that permits some inductive coupling is to be used in the input circuit. That is, the large winding is the antenna winding. Commercial coils are used, and these are obtainable from supply houses.

Any who want to try preparing their own coils may wind equal secondaries on separate forms 1 inch in diameter, about 3 inches long,

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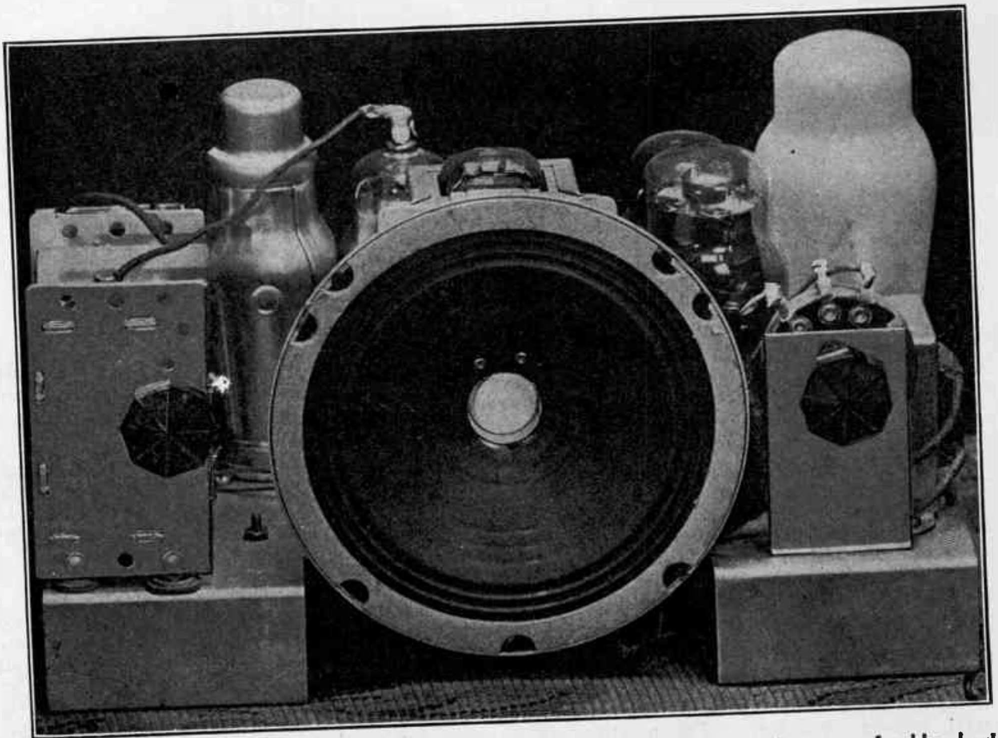
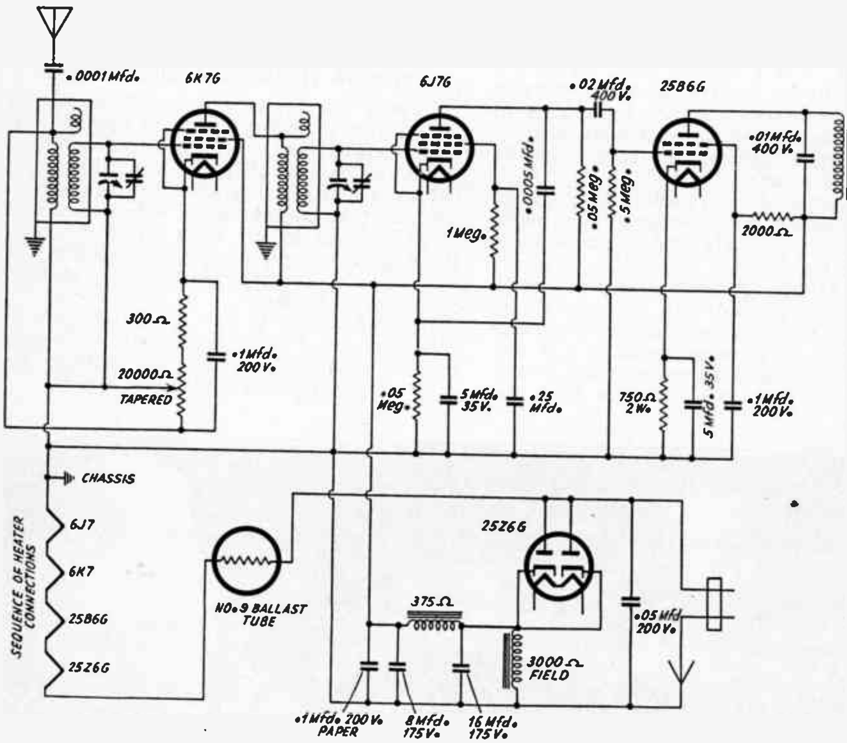


The two controls are for tuning (left) and volume (right). The tuning condenser preferably shoul[d] be isolated from the chassis, and the fiber spacers, shown under the condenser frame, provide thi[s] safety, so long as the screw heads on the under side of the chassis, attached to the frame, are sim[ilarly] insulated.

(*Continued from preceding page*)

putting thereon tight-wound 127 turns of No. 32 enamel wire. Two universal-wound coils, looking like small honeycomb coils, are fitted inside the secondary form, so that the windings of these small-sized but high-inductance coils are right angles to the direction of the secondary winding. Then an extra insulated wire, rather thick, is soldered to one side of the primary, brought up the side of the secondary, and put around the secondary for two turns, near the which the plate current changes a great deal for small changes of station carrier amplitude, and that requirement is of the essence of such detection. The power tube is a 25B6-G, a new glass tube, with more power output, at the same voltages, than the 43. The 25Z6-G is the rectifier, and a No. 9 ballast tube from the Sylvania list completes the tubes, all glass.

When a.c. line is used, the rectifier performs its intended service, changing the a.c. to d.c., although the resultant d.c. has some hum left



This receiver is so simple to build that a novice may attempt it with full confidence. The clear photographic views give all the necessary information about the layout, and the wiring diagram above reproduces exactly the connections made by the author who built the set.

top, being adhered by looking through a hole in the coil form top, and by using coil dope.

The two-gang condenser usually has a maximum capacity of .000365 mfd., also written as 365 mmfd., the first abbreviation being for micromicrofarads, or billionths of a farad. The unit of capacity is the farad, named for Michael Faraday, English electrical genius of another generation.

THE TUBES USED

A glass tube with octal base is used as radio-frequency amplifier and a similar, but not identical, tube as detector. The amplifier is a 6K7-G, which is of the type permitting volume control by grid bias variation without introducing distortion. The detector is a 6J7-G, in in it, known as residual hum, or ripple voltage. A filter is a device for removing this. The filter consists of a 16 mfd. condenser next to the rectifier, a B choke, and an 8 mfd. condenser after the choke.

USE OF SPEAKER FIELD

Note that the d.c. resistance of the choke should be low. The value of 375 ohms was used, the inductance was truly 15 henries, but may be larger without harm, and also the d.c. resistance need not be critically just what is specified—say 450 ohms down would be passable, but the lower the resistance the better, as then the B voltage to the power tube is not reduced much.

The speaker is of the dynamic type, and has

LIST OF PARTS

Coils

Two unshielded radio-frequency transformers. (The placement of the coils above and below metal chassis results in shielding that the wiring diagram symbolizes).
One 6" dynamic speaker for pentode output tube, 3,000-ohm field.
One 15 henry choke coil, d.c. resistance about 375 ohms.

Condensers

One two-gang .000365 mfd. condenser with trimmer built in.
One .0001 mfd. One .01 mfd. 400 v. up. Three .1 mfd. 200 v. (paper).
One 5 mfd., 35v. One .25 mfd. 200 v.
One .05 mfd. 200 v. One 16 mfd. and one 8 mfd,, with 175 v., in one container.
One .0005 mfd. One .02 mfd. 400 v.
[Fixed condensers products of Cornell-Dubilier]

Resistors

One 300 ohm. One 20,000 ohm. tapered potentiometer with switch.
One 750 ohm., 2 watts. One 2,000 ohm. Two .05 meg. One .5 meg.

Other Requirements

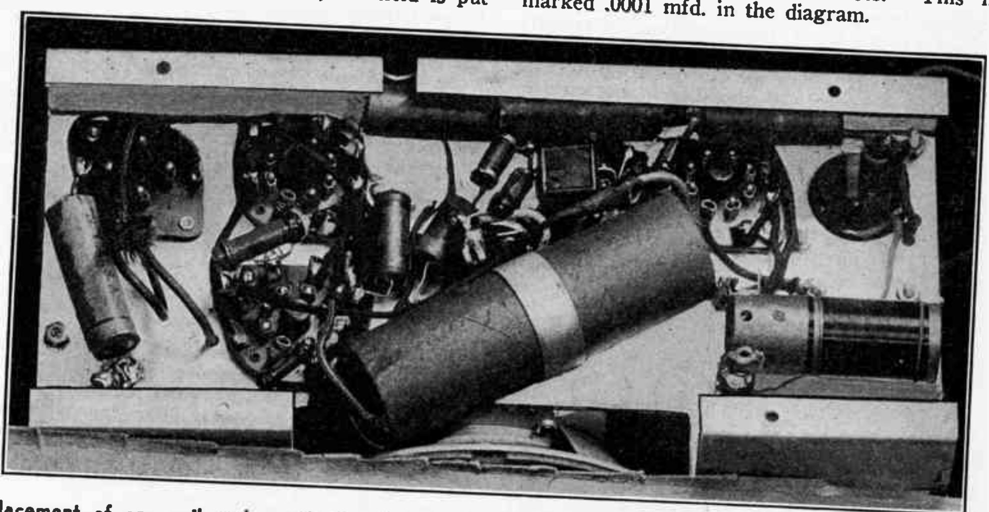
Four octal sockets and one four-hole socket.
One a.c. cable and plugs. Two grid clips.
Two knobs. One dial scale, one volume plate.
One tube shield (for r.f. amplifier).
Sylvania tubes: One 6K7-G, one 6J7-G, one 25B6-G, one 25Z6-G, one No. 9 ballast.

a field coil, which is one form of choke, but not used for that purpose now, as the resistance of the field is too high, a few thousand ohms normally. Passing the set's current through all that resistance would drop more voltage than the law allows, therefore, the field is put across the rectifier output, and results in considerable drain, though only from the rectifier tube, which can stand it, and not affecting the set.

The tubes have their heaters connected in series. That means that the same current must flow through all heaters. Such is in fact the case. The voltage drop across the individaul heaters may be different, in fact is, but the same identical current passes through all, close to .3 ampere. Late tube manual give full information on socket connections for the tubes. The diagram shows the preferred order of connecting the heaters for absence of modulation hum. Note that one side of the detector heater is grounded to chassis. This does not mean an external ground is to be connected to the chassis. Indeed, no such connection should be made, as there would be danger of short-circuiting the line, i.e., blowing a fuse. No ground should be used with universal sets, as the a.c.-d.c. receivers are called, unless the chassis is "floated."

The chassis may be "floated," if desired, by connecting putting insulating spacers between the tuning condenser frame and chassis, and duplicating these spacers below the chassis, to prevent the screws for fastening the condenser down, from engaging the chassis proper. Then the condenser frame is tested with prods between it and chassis on any continuity tester, including ohmmeter, so that there is no deflection.

Now the point marked with ground symbol in the diagram represents the condenser frame and the line, but the chassis is not connected to the line. Also a condenser of .0005 mfd. or similar capacity, mica dielectric, may be connected between condenser frame and chassis, and the chassis may be connected in this special instance to external ground. The fixed antenna series condenser is advisable as a protecting device in all instances. This is marked .0001 mfd. in the diagram.



lacement of one coil underneath the chassis, while the other one is above, provides all the shielding necessary to prevent undesirable interaction, so long as there is a shield on the r.f. tube. The large tubular object contains the filter capacities.

RADIO CONSTRUCTION UNIVERSITY

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

HIGH-POWERED RECTIFIER

AS I desire to use 50 watts output power in a special amplifier, please show the use of appropriate rectifier tubes, preferably two in parallel.—P. L.

The diagram herewith shows the circuit for the use of two tubes of the 81 type. Extra care must be taken to have a power transformer that will stand the large current, also chokes that will maintain considerable inductance under this load, and filter condensers both of adequate capacity and safe voltage rating. The requirements for a high-power rig such as you mention are severe on the rectifier.

* * *

METAL BEAM TUBES

SOMETHING may go wrong, or there may be a misconnection, in the power tube circuit, and if 6L6 tubes are use, e.g., in push-pull, it would be hard to see right off the reel that there is trouble, because of the metal shell, and the tubes get hot when nothing is wrong. These beam tubes handle considerable current, therefore the danger is heightened. With glass tubes, if the screen overheats, for instance, the visibility reveals this at once.—L. W.

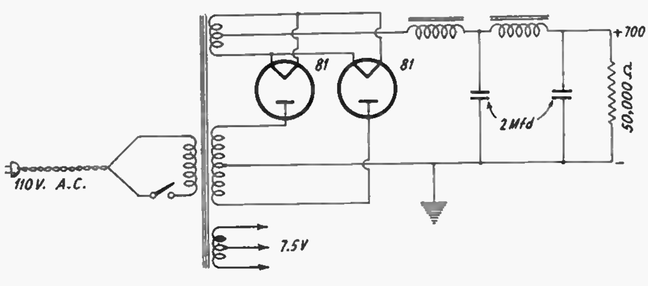
If the metal tubes have the proper voltages there should be no trouble, and the fact that you can see through glass hardly should be relied on as an excuse for a misconnection. Carefully check all the connections before turning the line voltage on. It is true the current drain is large with the beam power amplifiers. Be sure to limit the screen voltage to recommended values, or have the total voltage according to rated level if both screen and plate are to receive the same voltage. If you have any objection to the metal envelope you may use the 6L6-G tubes, which are practically the same, only have husky glass envelopes. By the way, there is a beam power amplifier of the 25-volt type newly announced for the .3 ampere class of tubes (heater current). In using the beam tubes suitable choice of a rectifier tube to afford the required current is necessary, and quite a few circuits have been shown, using the 5Z4, where this metal type rectifier may not afford adequate current for push-pull, for instance, the maximum rectifier current is 125 milliamperes, whereas the 6L6 push-pull plate current alone under certain operating conditions may reach that value, and besides there is the screen to accommodate with its small current, not to mention the rest of the receiver, which combination may require 25 milliamperes more. The 5Z3, a glass tube, will stand the drain, being rated at 250 milliamperes. It is of the four-hole socket series. A glass octal rectifier of high current service is the 5X4-G. This is equivalent to the 5Z3, except for the base, which for the 5Z3 is four-prong.

* * *

CATHODE-RAY SENSITIVITY

IN your article on the 913 cathode-ray tube in the January, 1937, issue, you state that as the Anode No. 2 voltage is increased, the deflection sensitivity is decreased. It has always been my experience with vacuum tubes that as the plate potential is increased the sensitivity is increased, until saturation is reached. Also please explain whether the horizontal deflection is the result of the horizontal plates acting on the beam.—K. W. C.

As the Anode No. 2 voltage is increased on this tube, or the equivalent voltage on practically any other cathode-ray tube, the electron velocity is increased, the Anode No. 2 current is increased and there is a brighter fluorescence. But the deflection sensitivity is decreased, as was set forth in the article, because the deflecting force is constant, while that which is to be deflected becomes more strongly influenced to



Rectifier and filter for serving an amplifier with 50 watts output. The 2 mfd. filter capacities are bare minima, and much larger capacity is therefore preferred.

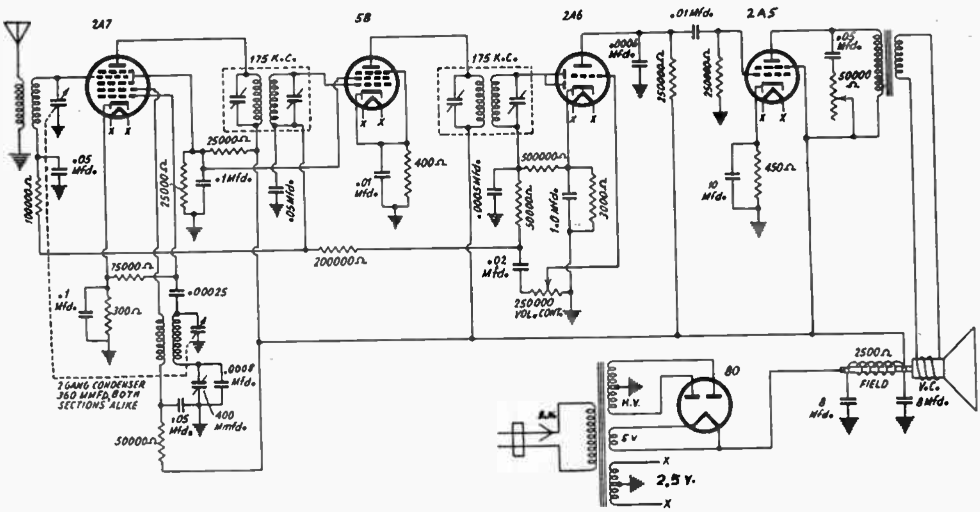
maintain its undeflected spot position. Suppose a car was going at a certain speed and a certain deflecting force was exerted on it, say, a push in an off-road direction. Suppose the speed of the car was doubled, and the deflecting force remained unchanged. Would the car be deflected as much? No, because as the speed of the car is increased greater deflecting force is needed to obtain the same deflection as existed when the speed was at its first and lower value. As for the second part of your question, the horizontal plates in the tube are the ones that cause the vertical deflection, because the plates act upon the beam at right angles.

* * *

CORRECTION OF DIAGRAM

REGARDING the five-tube superheterodyne on page 46 of the January, 1937, issue, is the diagram correct as to B voltage on the output tube, and what tube should be used?—I. D.

There is an omission in the diagram, resulting in the absence of any B voltage applied to the power tube, which may be a 47 or a 2A5. If a 2A5 is used the biasing resistor is connected between cathode and B minus. If a 47 tube is used, the biasing resistor goes from heater center to B minus. We are printing the corrected diagram herewith for use of the 2A5 tube and showing the B voltage properly connected to this tube.



A five-tube a.c. superheterodyne.

* * *

TESTING CONDENSERS

WHEN a condenser is being tested for leakage, if a.c. is applied, does not the current depend on the capacity of the condenser (assuming a fixed frequency for testing), and if so how would leakage be tested? Can you suggest some method of voltage rating for a filter condenser, so that one may establish the voltage rating himself? What procedure is followed in testing for intermittents?—W. D. S.

The condenser leakage test is made when d.c. is applied, not a.c., for the resistance then is the current-limiting factor, and the capacity effect is negligible, except for the first flick. The reading is taken when the meter needle subsides. Thus, the leakage test may be made in ohmmeter fashion, where a meter has in series with it a high resistance and a relatively high voltage, say, for a 0-1 milliammeter, a minimum of 90 volts and 90,000 ohms. Higher voltage and higher limiting resistor are preferred, 1,000 ohms for each volt, because enabling closer readings of higher leakage resistance. Ordinarily a 20 meg. ohmmeter would be used. Thus the leakage could be determined directly in ohms. When a.c. is applied the meter must be able to read a.c., and the impedance of the circuit may be determined, also the condenser's capacity, when the condenser resistance is known, or is the resistance very large due to circuit conditions, compared to the impedance. The filter condenser voltage rating may be undertaken by assigning some certain leakage current to be tolerated, say, 2 milliamperes, and increasing the applied d.c. voltage until 2 ma flow. Then that voltage may be considered the rating. If the test is made on d.c. then the d.c. "sudden" voltage is considered, but if the condenser is left a considerable period at this voltage, without increase of current flowing, then the continuous working voltage at d.c. is the factor. Intermittent reception due to poor condensers may be checked by applying considerable heat to a suspected condenser when checking, as by using a reflecting electric heater, and for impact by using an impact generator, which is a device that shakes the condenser considerably and thus shows up poor electrical connections.

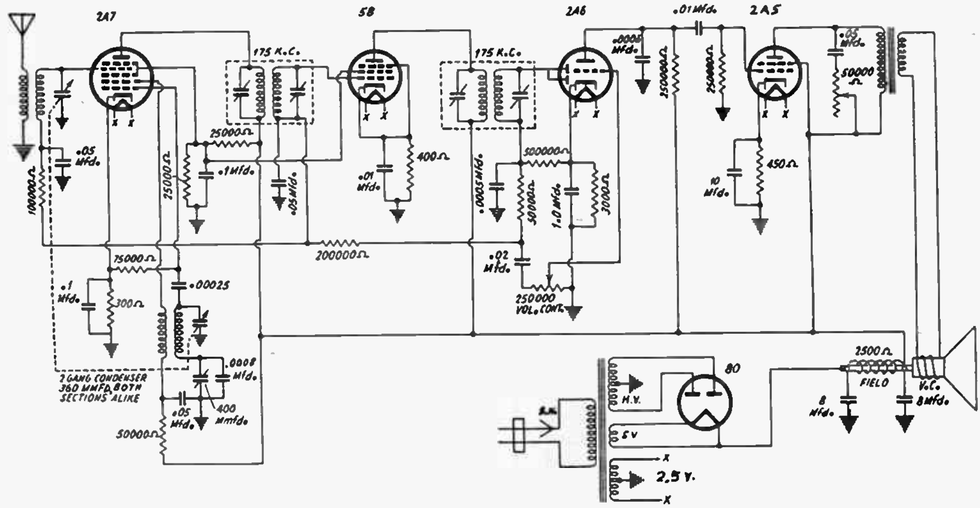
maintain its undeflected spot position. Suppose a car was going at a certain speed and a certain deflecting force was exerted on it, say, a push in an off-road direction. Suppose the speed of the car was doubled, and the deflecting force remained unchanged. Would the car be deflected as much? No, because as the speed of the car is increased greater deflecting force is needed to obtain the same deflection as existed when the speed was at its first and lower value. As for the second part of your question, the horizontal plates in the tube are the ones that cause the vertical deflection, because the plates act upon the beam at right angles.

* * *

CORRECTION OF DIAGRAM

REGARDING the five-tube superheterodyne on page 46 of the January, 1937, issue, is the diagram correct as to B voltage on the output tube, and what tube should be used?—I. D.

There is an omission in the diagram, resulting in the absence of any B voltage applied to the power tube, which may be a 47 or a 2A5. If a 2A5 is used the biasing resistor is connected between cathode and B minus. If a 47 tube is used, the biasing resistor goes from heater center to B minus. We are printing the corrected diagram herewith for use of the 2A5 tube and showing the B voltage properly connected to this tube.



A five-tube a.c. superheterodyne.

* * *

TESTING CONDENSERS

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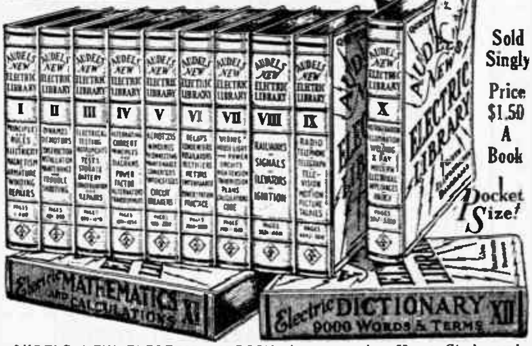

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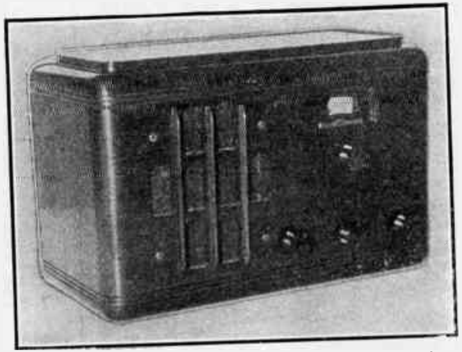

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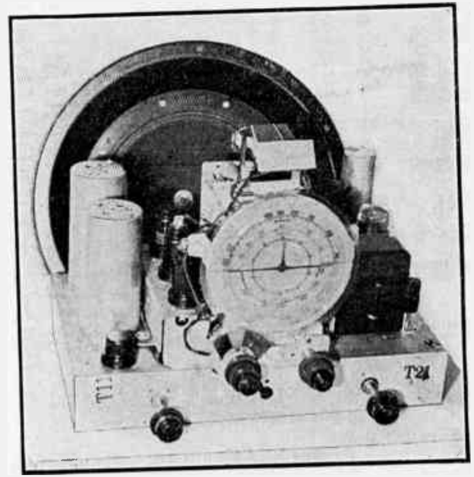

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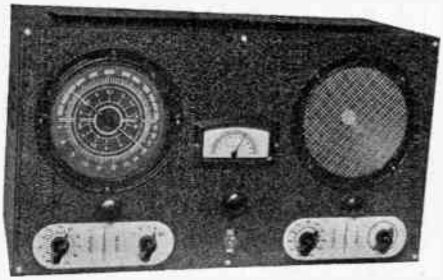

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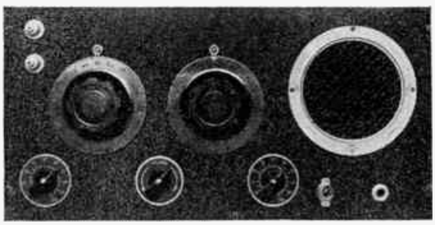

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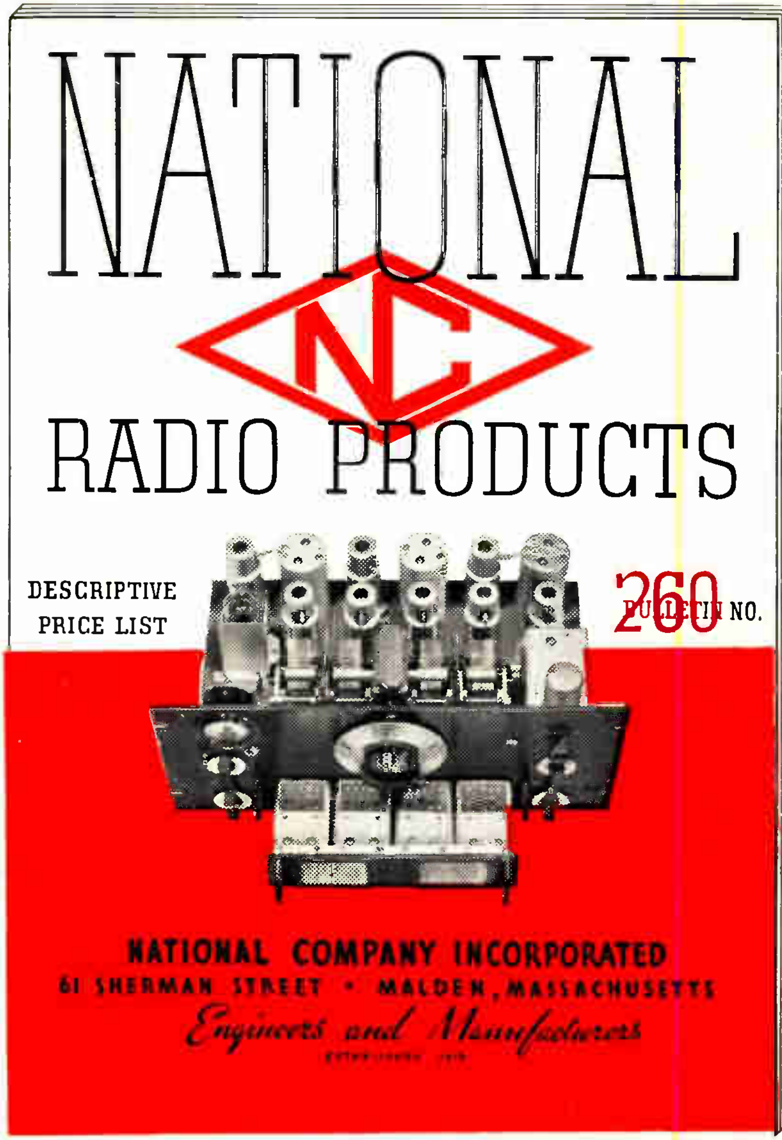

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