HOW THE 224 WORKS BEST!

June 29th, 1929 **15 Cents**

RADIO WORLD

REG. U.S. PAT. OFF.

The First and Only National Radio Weekly

379th Consecutive Issue—Eighth Year

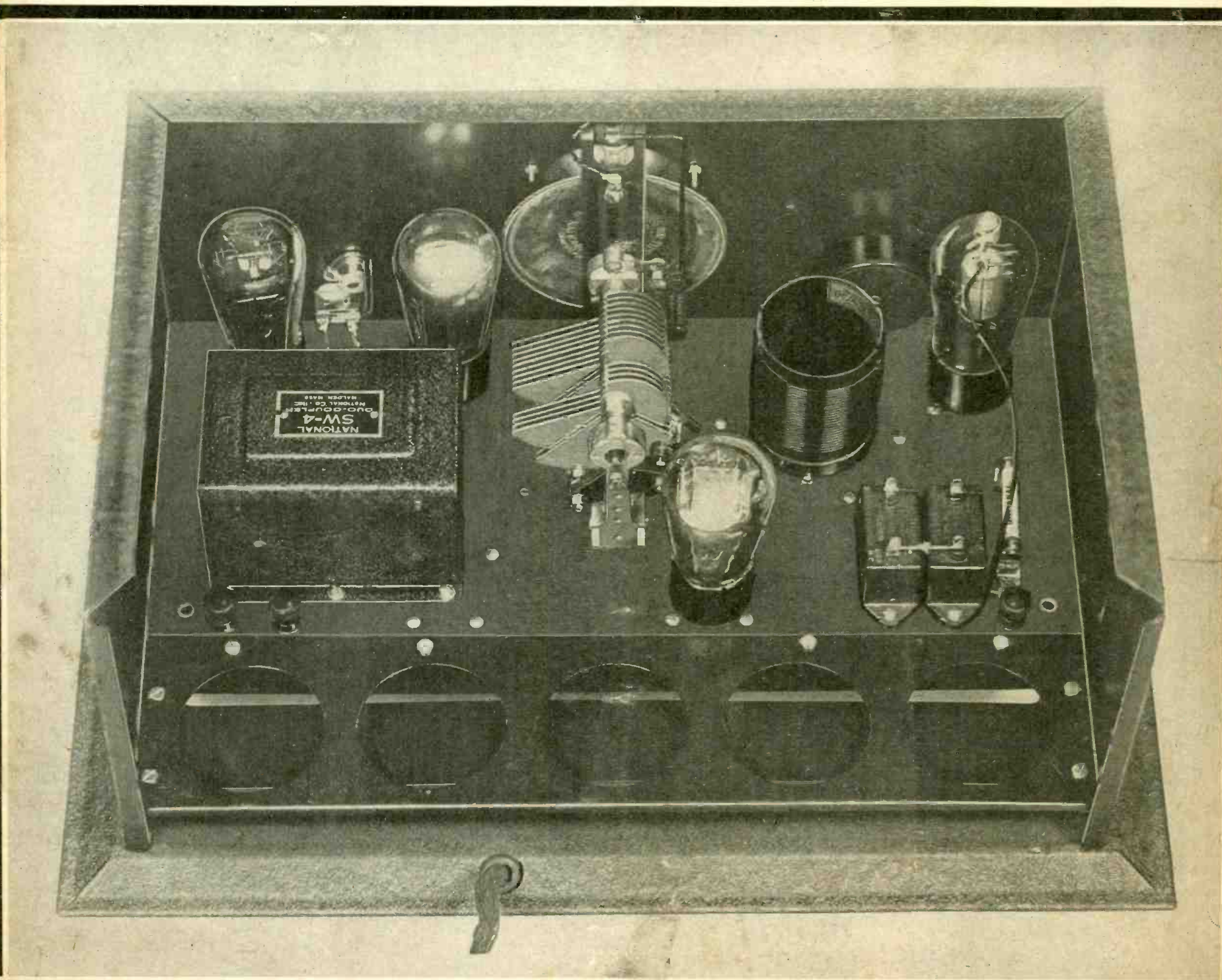
New Push-Pull Data

DC Eliminator Problems

Screen Grid Audio

Power Amplifiers

NEW THRILLS IN SHORT WAVES!



The New National Thrill Box—Short and Broadcast Waves. **See page 17.**

RADIO WORLD, owned and published by Hennessy Radio Publications Corporation, 145 West 45th Street, New York, N. Y. Roland Burke Hennessy, President and Treasurer, 145 West 45th Street, N. Y.; Herman Bernard, Secretary, 145 West 45th Street, New York, N. Y.

Leaders—224 and 245!

What These Marvelous Tubes Do

224 *AC-SG Tube*, $3.00

The Radio Trade Show in Chicago established the 224 AC Screen Grid Tube and the 245 AC Power Tube, both new, as by far the leading tubes for 1930. The master designers of circuits have chosen these tubes, the 224 for radio frequency amplification, the 245 for output tube. They merely confirmed what experimenters already had established—extreme sensitivity, great distance and fine stability are possible with the 224, while maintaining needle-point selectivity.

The 224 is capable of RF amplification of a higher order than engineers are able to capitalize in full. The tube can easily be worked at a gain of 60, as compared with 8 for the 201A.

Indirect heating is used. The filament, called heater, requires 2.5 volts and draws 1.75 ampere. The plate voltage should be 180, the screen grid voltage (G post of socket) 75 volts. The control grid connection is made to the cap at top of tube. The cathode is the electron emitter. Negative bias, 1.5 volts. Type of socket required: UY (five-prong).

Ordinary coils may be used with this tube by doubling the number of turns on the primary.

If still greater amplification is desired a larger primary may be used, and if still greater selectivity is desired, the primary may be reduced, but should have at least one-third more turns than for ordinary tubes.

"Look for the Green Box"

The 245 has a low filament voltage, 2.5 volts, at a relatively high current, 1.25 ampere. This eliminates the objectionable hum. The tube requires only 250 volts on the plate to be able to handle about as great undistorted power as the 210 does at 350 volts. A single 245 output tube will handle, without overload, the largest input to a last stage as would be required in any home. It works well into a dynamic speaker, or, by filtering the output, into a magnetic speaker. In push-pull two 245s give superb tone at doubled power handling capacity. The 250 requires 50 volts negative bias at 250 volts on the plate and draws 32 milliamperes under those conditions. The direct filament heating method is used. Type of socket, UX (*four*-prong).

There never was a power tube so excellently suited to home use—one **that handles such large** input without strain, yet which operates on a plate voltage now regarded as in the "medium" class. Use this power tube and know supreme performance. 245 *Tube, Price* $2.25

OTHER SPECIAL PURPOSE TUBES

222 Screen Grid, for battery or AC eliminator operation; 3.3 volt filament, @ .132 ampere; 135 volts plate 22 to 45 volts screen grid; negative bias 1.5 volts..$3.50

240 high mu tube, for detector or audio circuits, where a resistor or impedance coil is in the plate circuit; amplification factor, 31. Filament 5 volts, @ .25 ampere; plate 135 to 180 volts, negative bias 1.3 to 3 volts..$1.25

280 full-wave rectifier, 125 mils at 300 volts or less; 5-volt filament @ 1.25 amperes....................$2.50

281 half-way rectifier, 7.5-volt filament............$3.50

227 detector and amplifier for AC circuits, indirect heating type; 2.5 volts filament @ 1.75 amperes; 90 to 180 volts plate, negative bias 1.5 to 6 volts; excellent for power detection $2.25

226 AC amplifier; 1.5 volts filament @ 1.05 amperes; 90 to 150 plate volts; negative bias 2.5 to 4.5 volts.$1.25

112A output tube for battery or AC operation; filament 5 volts @ .25 ampere; 135 plate volts; 9 volts negative bias $1.50

171A power tube for battery or AC operation; 5 volts filament @ .25 ampere; 180 plate volts @ 40 volts negative bias $1.50

250 power tube, 7.5-volt filament @ 1.25 amperes; 450 plate volts; 80 volts negative bias $6.00

210 power tube $4.50

GENERAL PURPOSE TUBES

201A, 5-volt filament @ .25 ampere; 45 to 135 volts on plate, 5-volt positive for detector to 4.5 negative bias, for amplifier $1.00

199, 3.3-volt filament @ .06 ampere; 45 to 90 volts on plate; 3.3-volt positive bias for detector, to 4.5 negative for amplifier...................................$1.25

PUSH-PULL PAIRS

The 250, 245, 171A and 112A are sold in matched pairs for push-pull, insuring balanced, symmetrical circuits. Order MP 250, MP 245, MP 171A or MP 112A. The matched tubes are of equal mutual conductance. They are boxed together and bear "Matched Pair" identification stickers. No extra charge for matching.

Kelly Tube Company, 57 Dey Street, New York City.
(Walter J. McCord, Manager.)

Gentlemen: Please send me the following tubes:

Quantity	Type	Quantity	Type	Quantity	Type
☐	224	☐	222	☐	280
☐	245	☐	201A	☐	281
☐	226	☐	240	☐	250
☐	227	☐	199	☐	210
☐	112A	☐	171A	☐	MP.

If ordering C.O.D. put a cross here ☐

If enclosing remittance with order put a cross here ☐

On prepaid orders we pay cartage. On C.O.D. orders you pay cartage plus post office money-order fee.

Name ....

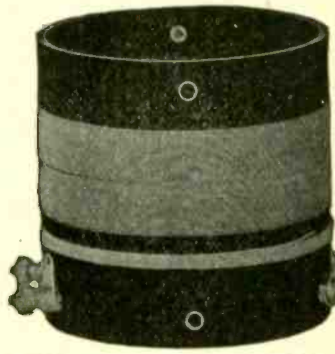
Address ....

City .... State..................

Kelly

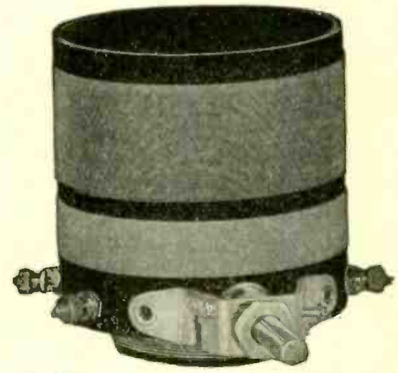
RADIO TUBES

DIAMOND Pair



AC5 . . . . $1.50

Highly selective antenna coil for any circuit, and interstage coil for AC circuits. Step-up ratio, 1-to-8. Tunes with .0005 mfd.
Model AC3, for .00035 mfd..............$1.75



SGT5 . . . . $2.75

Tuner to work out of a screen grid tube. The large primary is fixed and is connected in the plate circuit of the screen grid tube. Tunes with .0005 mfd.
Model SGT3, for .00035 mfd............$3.00

UNIVERSAL Pair

TP5 . . . . $3.00

Interstage coupler to work out of a screen grid tube, where the primary in the plate circuit is tuned, the secondary, in the next grid circuit, untuned. Tunes with .0005.
Model TP3, for .00035 mfd............$3.25

RF5 . . . . $1.50

Excellently selective antenna coil for any circuit, and interstage coil for any battery operated receiver, excepting output of screen grid tube. Tunes with .0005 mfd.
Model RF3, for .00035 mfd..............$1.75

A5 . . . . . $1.75

Conductively coupled antenna coil, for maximum pickup, where selectivity is not the main consideration. Continuous winding in two colors. Tunes with .0005 mfd.
Model A3, for .00035 mfd...............$2.00

Model T5 screen grid Transformer for .0005, $1.50; T3 for .00035, $1.75.
Screen Grid Coil Co., 143 W. 45th St., N. Y. City

LYNCH METALLIZED

Standohm—The "Self-Supporting" Resistor. Tinned wire leads which can be directly soldered into circuits. Moderate in price. Efficient in operation.

ARTHUR H. LYNCH, Inc.
1775 Broadway New York, N. Y.
Write for complete information.

More Profits To Set Builders

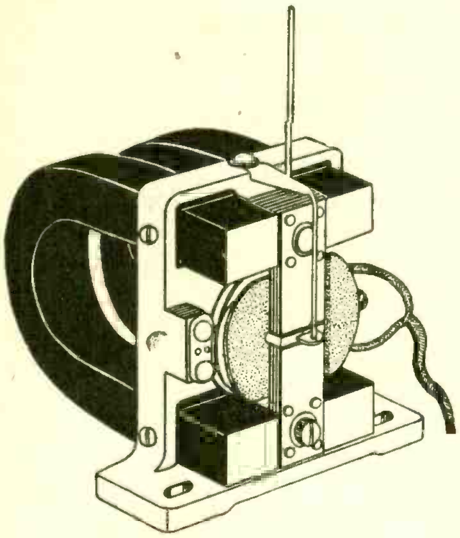
One good radio idea may be worth millions. Barawik has thousands of ideas for radio set builders to make more money. **Barawik's Big Radio Book** will help you while elections are on and big national events stir the world.

Send for your copy today — NOW.

BARAWIK CO. 3 Canal Station, CHICAGO, U. S. A.

Look at the date of the label pasted on the wrapper containing your subscription copies. If this date on wrapper is older than the date of the issue received, then your subscription has expired and should be renewed.

New Junior Model
POLO UNIT $4



The famous twin magnet principle for double sensitivity, large magnets for great flux, permanently adjusted armature, all are in the new junior model Polo Unit. Weight, 2¾ lbs. Stands 150 volts unfiltered. Stands up to 250 push-pull filtered. Works any output tube, power or otherwise. Supplied with 10-ft. cord. Order unit now. Five-day money-back guarantee.

Acoustical Engineering Associates
143 West 45th Street
New York City
(Just East of Broadway)

HAVE AN EXPERT PUT YOUR SET IN SHAPE!

If your receiver or amplifier, no matter of what kind, is not giving proper results, send it to us, prepaid. We will test it FREE and let you know what's wrong, telling you cost of repairs. Our charges are very reasonable. Six years' experience. Loudspeakers and units repaired. Burnt-out coils replaced. Jaynxon Laboratories, 57 Dey Street, New York City.

COMPLETE PARTS for the New, Highly Selective
SCREEN GRID DIAMOND

(Four-Tube Battery Model)

Exactly as Specified by Herman Bernard — **$29.00 Net**

Guaranty Radio Goods Co.
145 West 45th Street
New York City
Just East of Broadway

KELLY TUBES
Prescribed for the
Screen Grid Diamond

One screen grid 422	$3.50
Two 410A at $1.00 each	2.00
One 412A (for 135 volts)	1.50
or One 471A (for 180 volts)	1.50

KELLY TUBE COMPANY
57 Dey Street New York City
10-Day Money-Back Guarantee

LACAULT'S BOOK

"Super-Heterodyne Construction and Operation," giving the master's most masterful exposition of the theory, performance and construction of this fascinating type of circuit, is a necessity to every serious radio experimenter. More than 100 pages and more than 50 illustrations. Buckram cover. This book by R. E. Lacault, FREE if you send $1.00 for an 8-weeks subscription for Radio World. Present subscribers may accept this offer. Subscription will be extended.

RADIO WORLD 145 W. 45th St., N.Y. City Just East of B'way

Recent Issues of Radio World, 15 cents each Any number published in 1928 available for a short while. Six issues 75 cents, 10 issues $1.00 Send stamps, coin or money order NOW, before the issues are sold. Radio World, 145 West 45th Street, New York City.

FAMOUS
NATIONAL
Velvet B Eliminator 180 Volts (280 Tube Free) **$16.13**

Latest Model National Velvet-B, Type 3580, in handsome crackle finish black metal casing, for use with sets up to and including six tubes. Input 105-120 volts AC, 50 to 60 cycles. Output, 180 volts maximum at 35 milliamperes. Three variable output intermediate voltages. (Det., RF, AF). Eliminator has excellent filter system to eliminate hum, including 30 henry choke and 18 mfd. Mershon condenser. No motorboating!
(Eliminator Licensed under patents of the Radio Corporation of America and associated companies.)

Guaranty Radio Goods Co.
145 W. 45TH STREET
(Just East of Broadway)
NEW YORK CITY

GUARANTY RADIO GOODS CO.,
145 W. 45th St., N. Y. City

☐ Please send C. O. D. on 5-day money-back guaranty, one National Velvet B (180 volts maximum with three variable intermediate voltages), 280 tube free, at $16.13.

☐ Enclose find $16.13. Please send above. You are to pay cartage.

Name ....

Address ....

City .... State ....

5-DAY MONEY-BACK GUARANTY

Aluminum Subpanel
for the New, Highly Selective
SG Diamond

Battery or AC Model (specify which)

The best appearance of the New Diamond of the Air results from using the official aluminum subpanel, 10 x 20 inches, with the four sockets built in, and with self-bracketing front. Hardware and insulating washers supplied with each sub-panel. The aluminum sub-panel is exactly the same as the one used in the laboratory models of the battery operated and the AC Screen Grid Diamonds. Holes are drilled for mounting parts, but as this aluminum drills like bakelite you can drill any holes you want.

RADIO WORLD, 145 W. 45th St., N. Y. City.
(Just East of Broadway)

☐ Enclosed please find $3.00 for which please send one aluminum subpanel 10x20" for the new battery model 4-tube SG Diamond of the Air, with sockets built in, and with self-bracketing front and side and rear supports; also send hardware and insulating washers.

☐ Enclosed please find $2.35 for which please send 7x21" drilled Bakelite front panel for the new battery model Diamond.

☐ Enclosed please find $3.25 for the 10x20" aluminum subpanel, etc., for the new AC Screen Grid Diamond.

☐ Enclosed please find $2.35 for the 7x21" drilled Bakelite front panel for the new AC Screen Grid Diamond.

☐ Enclosed please find $5.00 for both the aluminum subpanel, etc., and the drilled Bakelite front panel of the battery model.

☐ Enclosed please find $5.25 for both the aluminum subpanel, etc., and the drilled Bakelite front panel of the AC model.

Name ....

Address ....

City .... State ....

Twice as Much for Your Money!

Send $6.00 for one year's mail subscription for RADIO WORLD (52 numbers, one each week), and you will be given **one full year's subscription for any one of the following six magazines:**

Radio News (monthly)
Science and Invention (monthy)
Radio, San Francisco (monthly)
Radio Engineering (monthly)
Youth's Companion (weekly)
Boys' Life (monthly)
☐ **Citizens Radio Call Book and Scientific Digest**

SPECIAL **TWO-FOR-PRICE-OF-ONE** COUPON

RADIO WORLD, 145 West 45th Street, New York City (Just East of Broadway):
Enclosed please find $6.00, for which send me RADIO WORLD each week for one year, 52 numbers, and also send me, without exrta cost, for one year ONE of the following magazines as indicated:

☐ RADIO NEWS
☐ SCIENCE AND INVENTION
☐ RADIO (San Francisco)
☐ RADIO ENGINEERING
☐ YOUTH'S COMPANION
☐ BOYS' LIFE
☐ CITIZENS RADIO CALL BOOK AND SCIENTIFIC DIGEST

[Put a cross in the proper square above. Fill out coupon and send $6.00. If you are a subscriber for RADIO WORLD or for the other magazine you select, or both, check off squares below at left.]

Present RADIO WORLD subscribers may renew under this offer. If renewing, put a cross here ☐.

If renewing for the other magazine you select, put a cross here also ☐.

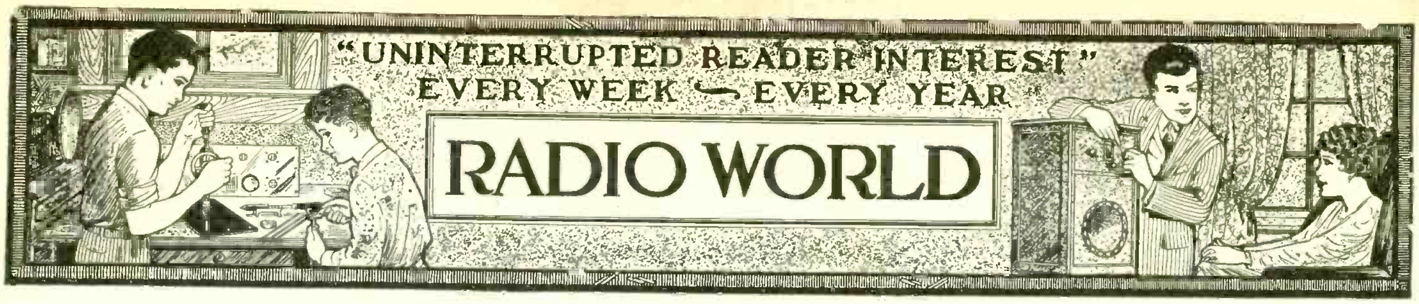
Name ....

Street Address ....

City .... State ....

THIS OFFER EXPIRES AT NOON JULY 30TH, 1929

RADIO WORLD, a weekly paper, published by Hennessy Radio Publications Corporation, from Publication Office, 145 West 45th Street, New York, N. Y. Phone: BRYant 0558 and 0559. 15c per copy, $6 per year. This issue is dated June 29th, 1929, and is Vol. XV, No. 15. Whole No. 379. Entered as second-class matter, March, 1922, at the post office at New York, N. Y., under Act of March, 1879.



Vol. XV, No. 15 Whole No. 379
June 29th, 1929
15c per Copy, $6.00 per Year
[Entered as second-class matter, March, 1922, at the Post Office at New York, N. Y., under Act of March, 1879.]

Technical Accuracy Second to None
Latest Circuits and News

EIGHTH YEAR

A Weekly Paper published by Hennessy Radio Publications Corporation, from Publication Office, 145 West 45th Street, New York, N. Y.
Telephone, BRYant 0558 and 0559
(Just East of Broadway)

How 224 Works

First Curves for Resistive Plate Load

By J. E. Anderson

Technical Editor

IN THE August 18th, 1928, issue of RADIO WORLD curves on the battery type screen grid tube 222, were published. These curves indicated some remarkable properties of this tube. takes all the electrons and the plate current cannot increase. Herewith are presented certain curves taken on the AC screen grid tube, 224.

The curves for the battery type tubes were grid voltage plate current characteristics for no load on the tube, and grid voltage plate output voltage characteristics with certain values of plate resistance. The present curves for the AC tube will show grid voltage plate current curves for various load resistances and voltage adjustments.

Let us first turn to Fig. 1. All the curves shown in that figure were taken with an applied plate voltage of 180 volts and a heater voltage of 2.5 volts. The two higher curves are for a plate resistance of 100,000 ohms, and the two lower for a plate resistance of half megohm. In all these curves Ed signifies the voltage applied to the screen grid.

The curve for Ed equals 45 volts and R equals .5 megohms begins at a plate current of .25 milliampere. The current remains at that value until the grid bias (control grid) is 3.5 volts, when it begins to drop. It is down to about .13 milliamperes at a bias of 4.5 volts, the highest bias for which an observation was made. Between 4 and 4.5 volts the current drops .08 milliampere, or .16 milliampere per volt. Since the plate load resistance is .5 megohms, the amplification in this small region is 80. The bias must be 4.25 volts and the possible voltage swing is .25 volt. Of course, the curve would continue straight a short distance farther, so that the bias could possibly be increased to 4.5 volts, making the possible voltage swing .5 volt.

Low Plate Resistor Desirable

The reason the curve remains flat from zero to about 3.5 volts is that when the voltage drop in the external resistor becomes equal to the difference between the voltage applied in the plate circuit and that applied on the screen, the screen takes all the electrons and the plate current cannot increase.

Let us see how the tube behaves when the screen grid voltage applied is 22.5 volts. The curve begins at a plate current of about .31 milliamperes. It remains level for a short distance and begins to drop. On the downward slope it does not remain straight for any great distance, but at a bias of about 1.8 volts it is steepest. Between the bias values 1.6 and 2.0 volts the current drops .1 milliampere, or .25 milliampere for volt. Multiplying this by the plate load resistance gives an amplification of 125. This is very good, but the possible voltage amplitude is only .2 volt. For a very high voltage gain, this adjustment of the circuit could be used, provided that the input voltage were less than .2 volt.

In view of the flattening of the curve for lower bias values it appears desirable to use a lower resistance in the plate circuit. Note how the curves appear when 100,000 ohms are used. When the screen grid voltage is 45 volts the curve begin at 1.45 milliamperes, begins to curve downward immediately, and at 1.25 volts becomes straight, remaining so until the bias is about 3.5 volts. Suppose the grid bias be adjusted to 2.25 volts. At this point the current drops at the rate of .4 milliampere per volt. Multiplying this by the plate resistance of 100,000 ohms we get an amplification of 40. This is considerably lower than the amplifications obtained when the .5 megohm resistance was used in the plate circuit. However, a possible voltage swing in either direction of 1.25 volts can be used without an appreciable reduction in the amplification and without the introduction of distortion. This means that the output voltage can swing 90 volts in either direction. This is enough to load up a 250 type power tube.

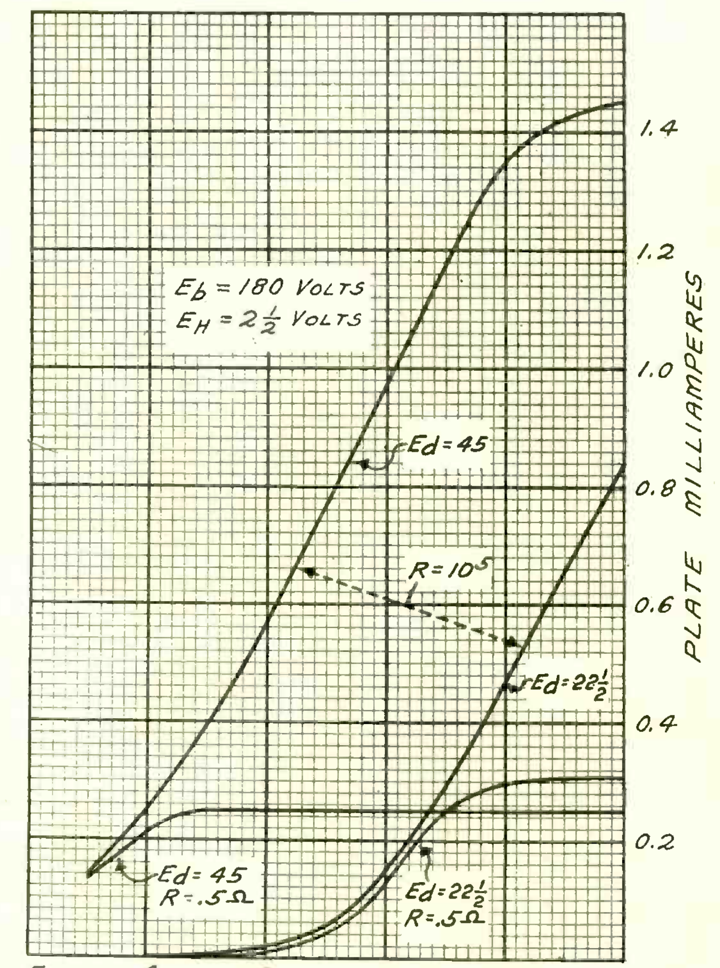


FIG. 1

GRID VOLTAGE, PLATE CURRENT CURVES FOR AN AC SCREEN GRID TUBE UNDER VARIOUS CONDITIONS OF OPERATION.

Now let us look at the curve for Ed equals 22.5 volts and a plate load of 100,000 ohms. It begins at a current of .84 milli-

224 as Detector

How Effective Plate Voltage Rises

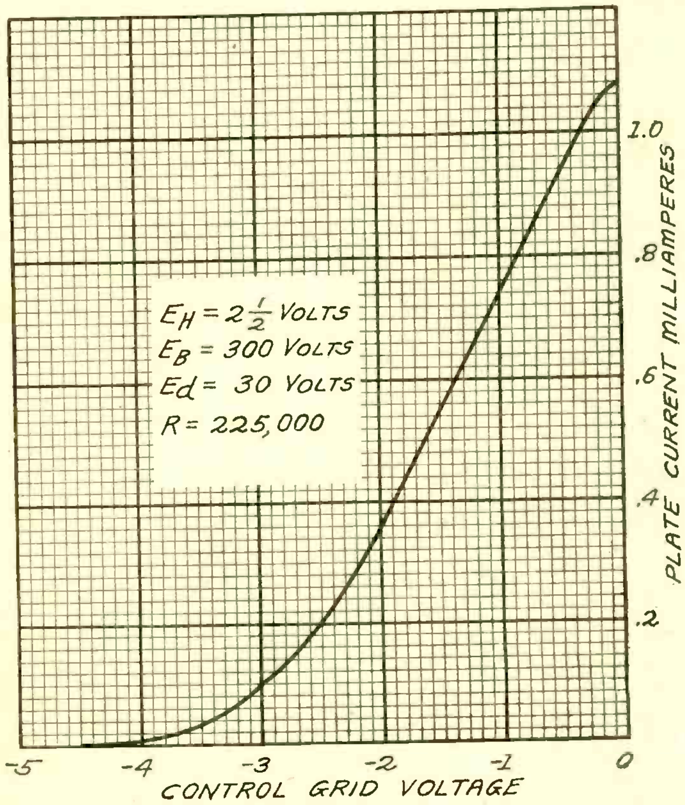


FIG. 2

GRID VOLTAGE, PLATE CURRENT CURVE FOR AN AC SCREEN GRID TUBE WITH UNUSUALLY HIGH VOLTAGE ON THE PLATE AND A COMPARATIVELY LOW VOLTAGE ON THE SCREEN.

(*Continued from preceding page*)

ampere and is straight from the start. It remains sensibly straight down to a bias of 1.5 volts. The grid bias could then be adjusted to .75 volt. At this point the current changes at the rate of .37 milliampere per volt. Hence the amplification is 37. The permissible voltage amplitude is .75 volt, so that the amplitude of the output voltage will be 27.75 volt. This is not nearly enough for the input to a 171A tube. However, the bias could be increased to one volt without any great reduction in the amplification or increase in the distortion. The amplification is about 36 and the voltage swing one volt. That makes the voltage swing in the output 36 volts, which is almost enough for a 171A power tube.

It is obvious from the shape of the two curves for 100,000 ohm load that the screen grid voltage could be increased somewhat, without introducing any great curvature at the upper end. Suppose that it is made 33 volts. The amplification will then be about 38 and the bias could be made 1.5 volts. The permissible voltage swing is about 1.5 volts, and the output voltage swing would be 57 volts. That is enough for a 171A power tube and some to spare, which is desirable to avoid distortion from curvature.

The flattening of the curves at the upper end in Fig. 1 is due to the fact that the applied plate voltage is too low for the screen voltage used. The only way to avoid this flattening for high values of plate resistance is to make the plate voltage relatively much higher than the screen grid voltage. To get a high amplification the plate resistance must be high.

In order to get a high amplification and at the same time a wide signal swing, a circuit was set up with 225,000 ohms for plate resistance, an applied plate voltage of 300 volts, and a screen grid voltage of 30 volts. The curve taken on this circuit is shown in Fig. 2.

As will be seen, this curve begins at a current of 1.08 milliamperes. There is a slight bending of the curve at the upper end. At about .2 volt it becomes straight and remains so at least down to 2 volts. Let the bias be one volt. At this point the current falls at the rate of .38 milliampere per volt. Multiplying this with the plate resistance of 225,000 ohms gives an amplification of 85.5. And since the permissible voltage swing is practically one volt, the output voltage will be 85.5 volts. This is enough to load up a 250 type power tube.

In view of the shape of the curve in Fig. 2 it is apparent that the circuit adjustment represented is a good one. It should be pointed out that the high voltage on the plate is not particularly dangerous to the tube, because the effective voltage on the plate is only about 178 volts at the normal bias of one volt.

It is clear from the shape of the curve in Fig. 2, that the tube can be used effectively as a grid bias detector, provided that it is followed by a plate load of 225,000 ohms. The optimum bias for this purpose is about 3 volts, since best detection occurs at a point slightly higher than that for which the curvature of the characteristic is greatest. The curvature is greatest at about 3.5 volts. By "higher" is here meant less negative.

With a bias of 3 volts on the tube, the radio frequency signal could swing up to .2 volts, or through an amplitude of 2.8 volts. The resulting change in the plate output voltage would be much larger than any amplifier tube could stand.

When the tube is operated as a detector the effective plate voltage is very high, because the plate current is small and the voltage drop in the load correspondingly small. For almost half of the time the voltage on the plate would be equal to the applied voltage. But this should not cause any damage, for there is no current.

Seven Causes of Fading Listed

Washington.

The following is a summary of a new report by the Department of Commerce on fading:

At the beginning of 1928 the Bureau of Standards started an investigation of short-period fading of radio broadcast transmissions. This was directed particularly to those changes of intensity in the receiving antenna which range in period from a few seconds to several minutes between peaks. These variations have been studied by other investigators and attributed to various causes. The aim of the investigation was to separate the effects of these several causes with a view to determining to what extent each affected the total fading.

The method consisted in selecting a particular broadcasting station and making simultaneous graphic records of its transmission as received by different types of antennas attached to duplicate receiving sets and recording systems. The antennas used were (1) a vertical single-wire; (2) a vertical coil with its turns in the great-circle plane passing through the transmitting station; (3) a vertical coil with the plane of its turns perpendicular to the great-circle plane; (4) a so-called barrage antenna by which the ground ray reception is eliminated.

All observations were made at the Bureau's field station located at Kensington, Md., five miles north of the Bureau and in a position practically free from man-made interferences and distorting influences. Observations were concentrated largely upon two stations, but less frequent records were made on transmissions from other stations involving frequencies of 550 to 1,480 kilocycles and direct transmission paths of 8 to 930 miles.

While this work is still incomplete, the following conclusions may be drawn at the present time: (1) Considerable fading is caused by the fact that the indirect ray from a broadcasting station undergoes variations of intensity during its course through the upper atmosphere on its way to the receiving antenna; (2) in the case of nearby stations much fading is caused by interference between ground and reflected rays; (3) direction shifts are responsible for certain types of fading; (4) no proof of fading caused by fluctuating height of the ionized layer is found, but evidence of refraction of the indirect ray from a rising layer was found during the sunset period; (5) rotation of the plane of polarization of the ray reflected from the upper atmosphere is indicated as the cause of much fading, particularly during the sunset period; (6) reflections by multiple paths are shown by a periodic type of fading superposed on the main intensity variations; (7) the rapid periodic type of fading noted in a previous investigation as occurring during the sunset period of transmissions from a selected station has been found to be quite common in the reception from two other stations. The newer data point toward rotation of the plane of polarization of rays arriving from the upper atmosphere rather than to interference as a cause.

New Push-Pull Point

Condenser Across Resistor Often Useless

By James H. Carroll

Contributing Editor

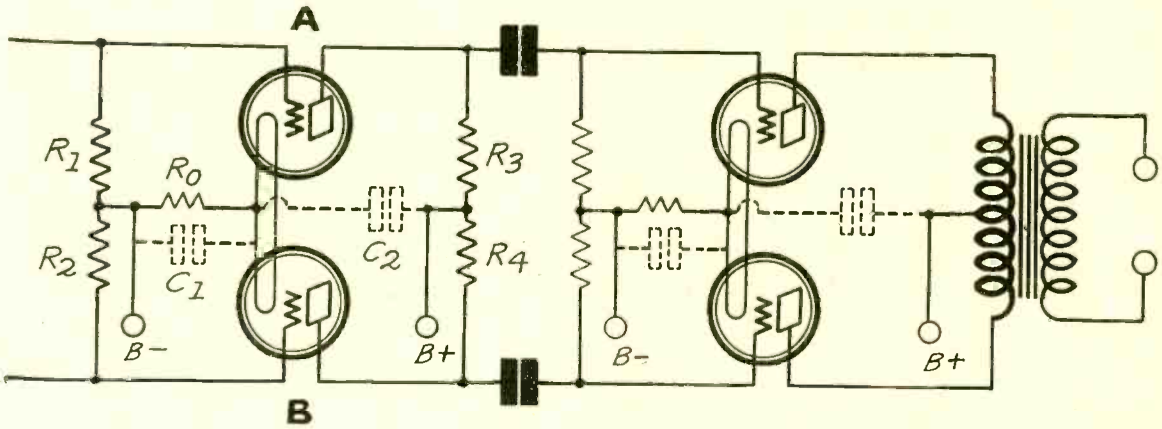


FIG. 1

This circuit illustrates by-pass condensers that do not serve a useful purpose. Without the grid bias by-pass condensers the feedback through the grid bias resistors tends to balance the circuit.

IT has been asserted many times that the more and larger by-pass condensers that are used in a radio receiver the better is the operation. This is generally true provided that the condensers are not placed across a line carrying signal current. If bypass condensers must be placed across the line they should be made as small as practical while assuring satisfactory performance of the intended function.

But is it always desirable to put large bypass condensers across filament, plate and grid voltage sources and grid bias resistors? There seem to be exceptions.

Consider Fig. 1, which represents a stage of a push-pull amplifier. Resistance coupling is shown. Ro is a grid bias resistor which serves both tubes. Now the question: "Is it always desirable to put a condenser C1 across this resistor?"

Suppose that the amplifier is perfectly symmetrical. There is, then the same signal voltage drop in R1 as in R2, but the drops are in opposite phase. Since the tubes are exactly equal, the plate signal currents also will be equal, but opposite in phase. The same thing applies to the signal voltage drops in R3 and R4, which will be the signal input voltages on the next pair of tubes.

Due to the exact balance of the circuit there will be no signal current through the common portions of the circuit. That is, there will be no signal current in Ro, nor through the plate voltage supply. Therefore, as far as this balanced stage is concerned, there is no reason for bypassing either Ro or the plate voltage source. Condenser C1 and C2 can be omitted without the slightest change in the operation.

But no circuit can be balanced exactly. There will be inevitably some difference—in the amplification constants of the tubes, in the input voltages, in the filament emission, in the plate load resistances, and even in the plate and grid voltages which are supposed to be identical.

Result of Unbalance

What will happen if there is some unbalance? The first thing is that there will be signal current through the grid bias resistor and through the plate voltage source. Consequently there will be signal voltage drops in the corresponding impedances. Will these drops increase or decrease the unbalance? If they will increase it, large bypass condensers are desirable, even necessary. If the drops will decrease the unbalance, condensers are not desirable, unless the effect is to decrease the overall amplification.

It can be proved very easily that a grid bias resistor in an unsymmetrical, or single-sided amplifier will decrease the amplification. The signal current flowing through the resistor is in such phase as to oppose the input signal. That is, the drop in Ro, Fig. 1, due to the signal current, is opposite to the input voltage, and therefore it is a degenerative voltage. The larger Ro is, the greater the negative feedback. A condenser across Ro is the only means for reducing this feedback, and the condenser must be large if it is to be effective at low frequencies. A minimum is 4 mfd.

Now let us assume that the circuit in Fig. 1 is exactly balanced in every respect, with the exception that the input voltage on tube A is larger than that on tube B. That is, we assume that the voltage drop due to the signal is greater in R1 than it is in R2.

It follows that the signal current in R3 is larger than the current in R4. The larger current will determine the direction in which the net signal current flows through the plate voltage supply and through Ro. Hence the voltage drop through Ro will reduce the effective input voltage on tube A and it will increase that on tube B, because the drop in Ro will be subtracted from the drop in R1, but it will be added to the drop in R2. Therefore the feedback through Ro will tend to reduce the unbalance due to the unequal inputs, whence it appears that condenser C1 is not desirable. Since C2 serves the same purpose as C1 that, too, is superfluous, as was pointed out by J. E. Anderson, who discovered this unusual situation in regard to bypassing in a push-pull circuit.

Suppose that the circuit is perfectly symmetrical in every respect, excepting that the mutual conductance of tube A is greater than that of tube B. The net signal current through Ro will be such as to decrease the input to tube A and increase it on tube B. Again Ro serves to balance the outputs of the two tubes.

Unbalanced Output

Now suppose that the circuit is perfectly symmetrical with the exception that R3 is smaller than R4. The net signal current will be determined by tube A. Hence the drop in Ro will be subtracted from the input to A and added to the input to B. The current in R3 will be decreased and that in R4 will be increased. Again there is a tendency toward equalization of current outputs.

But not so the output voltages, that is, the signal voltage drops across R3 and R4. That in R3 will be less than that in R4, since R3 is smaller than R4 and the currents tend to be equalized.

There are complications, however. The input voltages to the tubes of the next stage are affected not only by the drops in R3 and R4, but also by the drop in the common portion of the circuit. In all the cases considered above the drop in the common impedance adds to the drop in R3 and subtracts from that in R4. The common portion might be considered to be from the filament B plus. Hence C2 serves a useful purpose in equalizing the input voltages to the next pair of tubes.

However, it is not essential, for Ro equalized the currents, and that means that the drop in the common portion is very small. Moreover, if there is any difference between the inputs to the second pair of tubes, this will be equalized by the unbypassed grid bias resistor in that stage.

If many push-pull stages are put on the same plate voltage supply there will be feedback from the later stages to the earlier, unless all the stages are perfectly balanced. This feedback will be introduced mainly in the plate circuits. The unbalance from this cause is cumulative and it may be so great that the self-equalizing property may not be sufficient to counteract it. Hence it is highly important to minimize the common impedance either by condensers or by using low resistance filter choke coils, or by both methods.

The use of resistors or inductances in the plate supply to any one pair of tubes will increase the unbalance, although it may stop motorboating.

POWER AMPLIFIERS

By J. E. Anderson and Herman Bernard

["Power Amplifiers," by J. E. Anderson and Herman Bernard, was begun in the June 1st issue. In the June 8th issue loudspeaker coupling devices and battery-operated amplifiers were explained. A special analysis of resistance-coupled audio was included. In the June 15th issue the exposition was carried forward to the DC supply of A, B and C voltages, e, g., for operation from 110-volts DC obtained from the convenience outlet. Ohm's law was explained in conjunction with the design of a DC supply. Then the part was begun that treats of AC fully, with rectifier and filter analysis exceptionally well set forth. The AC topic was continued last week, June 22d. In the following instalment, the fifth of the series, intimate details on AC type B supplies are set forth. Next week, July 6th, there will be another big instalment. The series will continue each week for several weeks.—Editor.]

The choice of capacity for any condenser associated with the voltage divider does not depend so much on the thoroughness with which it is desired to eliminate ripple from the rectified current as it does on the completeness with which signal frequency currents must be prevented from entering the B battery eliminator. The effectiveness of a given capacity in bypassing signal currents depends on the frequency of those currents and on the resistance across which it is connected.

Since the condenser must work at all signal frequencies that are likely to occur, it must be large enough to be effective at the lowest frequency at which the amplifier is efficient. This may be a very low frequency indeed, and hence the capacity must be large. The resistance across which any condenser is connected in the plate voltage divider is not likely to be much less than 3,000 ohms. Hence this resistance should be kept in mind.

The impedance of a condenser of capacity C and a resistance R in parallel is given by the formula R divided by the square root of $(1+C^2w^2R^2)$, in which w is 6.28 times the frequency of the current. If R is 3,000 ohms, C 2 mfd., and w 100, what is the value of the impedance of the parallel circuit? The formula gives 2,564 ohms, which is not much less than the resistance. Hence at this low frequency, 15.9 cycles, a 2 mfd. condenser has very little effect. A 4 mfd. condenser at a frequency of 31.8, for which $w=200$, has an impedance of 1,154 ohms, or about one-third the value of the resistance.

These computations show that the condensers across the various sections of the voltage divider must be very large. Hence the capacities given in the complete eliminators in the following section should be regarded as the minimum that should be used, rather than the most suitable. There is one exception, namely, the one connected across the filter next to the rectifier tube, which need not be larger than 2 mfd.

The Complete B Supply

We are now ready to discuss circuits of complete B battery eliminators, now called B supplies.

In Fig. 28 is given a circuit especially designed for a receiver incorporating 245 type power tubes and 224 type screen grid tubes. In this only three different B voltages are provided, namely 300 for the power tube, 180 for the plate of the screen grid tube, and 75 for the screen grid of that tube. Other types of receivers could be powered from this supply, provided the plates of the tubes used are suited to the B voltages available.

The total current drawn from the rectifier is supposed to be 75 milliamperes, distributed as follows: a bleeder current of 15 milliamperes through the 5,000 ohm resistor R3; 20 milliamperes through the 5,250 ohm resistor R2; 43 milliamperes through the 2,790 ohm resistor R1, and 32 milliamperes to the 300 volt tap.

The power transformer T should have one centertapped 600-volt winding, and a 5-volt winding for the filament of the rectifier tube, which may be center tapped. Each of the two chokes, L1 and L2, should have an operating inductance of about 30 henries, with a current rating in excess of 75 milliamperes. Indeed, it would be well to select choke coils which are rated conservatively at 150 milliamperes so that a greater load may be put on the B supply, if desired.

The values of the condensers may be as follows: C1, C2, C4 and

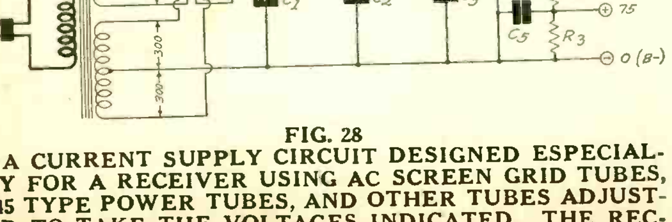


FIG. 28
A CURRENT SUPPLY CIRCUIT DESIGNED ESPECIALLY FOR A RECEIVER USING AC SCREEN GRID TUBES, 245 TYPE POWER TUBES, AND OTHER TUBES ADJUSTED TO TAKE THE VOLTAGES INDICATED. THE RECTIFIER IS FULL WAVE, FILAMENT TYPE.

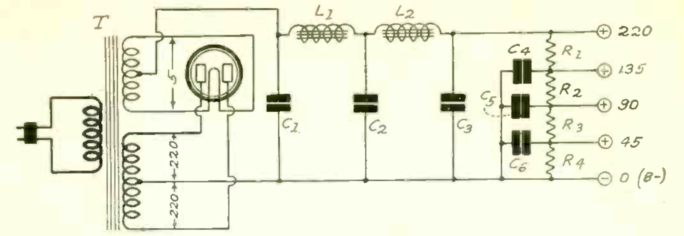


FIG. 29
A CURRENT SUPPLY CIRCUIT DESIGNED ESPECIALLY FOR A RECEIVER USING DC SCREEN GRID TUBES, 171A TYPE POWER TUBES, AND OTHER TUBES REQUIRING THE VOLTAGES INDICATED. THE RECTIFIER IS FULL WAVE, FILAMENT TYPE.

C5, 2 mfd. each, and C3, 4mfd. The voltage rating of the condensers should be 600 volts DC working voltage, or more for the first three, and 400 volts DC working voltage for the two condensers across the taps on the voltage divider.

For receivers incorporating 171A power tubes and 222 screen grid tubes the current supply circuit shown in Fig. 29 may be used. It differs from that in Fig. 28 only in the power transformer and the voltage divider. The power transformer has a 440-volt center-tapped winding instead of a 600-volt winding. The voltage divider is tapped to provide 45 volts for the screen grid, 90 volts for various plates, 135 volts for the plates of the screen grid tubes and other plates, and 220 volts for the power tube or tubes.

The total current delivered by this circuit is supposed to be 60 milliamperes, distributed as follows: A bleeder current of 15 milliamperes through the 3,000 ohm resistor R4; 20 milliamperes through the 2,250 ohm resistor R3; 26 milliamperes through the 1,730 ohm resistor R2; 40 milliamperes through the 2,125 ohm resistor R1, and 20 milliamperes to the 220 volt tap.

If the total voltage changes, the divided also change, as do the currents. If a different current distribution is desired it may be effected by changing the values of the resistors. If more than 60 milliamperes are taken, the total voltage will be less than 220, and if less than 60 are taken the total voltage will be higher.

The extra condenser in this circuit should have a value of not less than 2 mfd. and it should be rated at 400 volts DC working voltage. The specifications for the other parts may be the same as for the corresponding parts in Fig. 28, with the exception of the power transformer.

Fig. 30 shows the same B supply as in Fig. 29, except that a gaseous type rectifier is used. The power transformer T in this instance does not require a filament winding, but if it has one, this winding may be used to heat the filament of the power tube in the amplifier. The buffer condensers Co. should be used in this circuit, and they may have values from .01 to .1 mfd. The rectifier is exemplified by the Eveready-Raytheon BH type.

Since the regulation of a BH tube is approximately the same as that of the 280 type rectifier, the high voltage, center-tapped winding for the circuit in Fig. 30 should be 440 volts.

In the circuits Figs. 28, 29 and 30 it was assumed that only one power tube was used. In many modern amplifiers push-pull is used. When either of these circuits is used with a push-pull amplifier the current to the high voltage tap is doubled. For example, in Fig. 28 the total current would be 107 milliamperes instead of 75, assuming that the extra current does not cause any voltage drop. But this assumption is not valid because the regulation is not perfect. The same applies to the circuits in Figs 29 and 30. The current in these would be 80 instead of 60, if the voltage remained constant.

A small drop in the voltage is not serious, for it is not necessary to operate any tube in the receiver at maximum voltages. The receiver will probably not give appreciably poorer results if the voltage falls by 10 per cent. And if the receiver is operated at slightly lower voltages than maximum specified for the tubes, all the tubes, including the rectifier, will last longer.

In Fig. 31 is shown a half-wave rectifier employing one 281 type tube. With an effective voltage of 600 volts on the plate of the rectifier, this circuit will deliver approximately 90 milliamperes at the rated voltage of 534 volts. The current may be distributed as follows: 55 milliamperes to the high voltage tap, assuming a single 250 type power tube is used; 12 milliamperes to the 180-volt tap; 6 milliamperes to each of the 135—, 90—, and 45-volt taps, and 5 milliamperes for bleeder current.

For this current and voltage distribution the resistors should have the following values: R1, 10,114 ohms; R2, 1,956 ohms; R3, 2,647 ohms; R4, 4,091 ohms, and R5, 9,000 ohms.

Condenser C1 should have a value of 2 mfd., with a conserva-

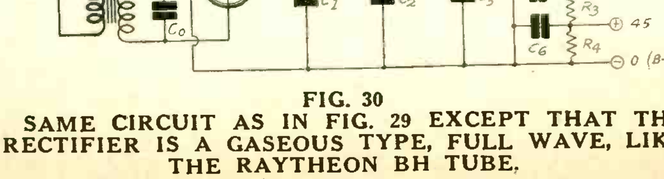


FIG. 30
SAME CIRCUIT AS IN FIG. 29 EXCEPT THAT THE RECTIFIER IS A GASEOUS TYPE, FULL WAVE, LIKE THE RAYTHEON BH TUBE.

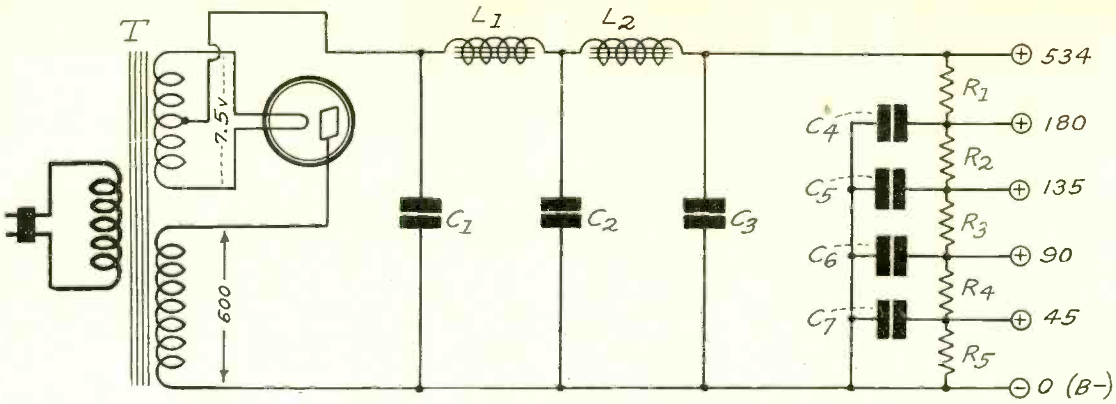


FIG. 31

A CURRENT SUPPLY CIRCUIT USING A HALF WAVE, FILAMENT TYPE RECTIFIER AND DESIGNED FOR USE WITH A RECEIVER HAVING ONE 250 TYPE POWER TUBE.

tive rating of 1,000 volts. C2 and C3 should be 2 and 4 mfd. condensers respectively, or larger values, with voltage rating of 1,000 volts. The remaining condensers should not be smaller than 2 mfd., with a voltage rating of 400 volts or more.

The power transformer should have one center-tapped, 7.5 volt winding for the filament, and a single 600 volt winding. The requirements of the chokes are that they carry more than 90 milliamperes and have an inductance of 30 henries or more at the operating current.

This B supply should not be used with any amplifier in which there are two or more 250 type tubes, but it may be used in a push-pull circuit employing two 210 amplifier tubes. If used for these tubes the plate voltage will be too high. This can be corrected by connecting the high voltage tap at a suitable point on R1 or by inserting a resistor of suitable value in the line between L2 and the high voltage tap.

When two 250 type power tubes are used in the amplifier the circuit shown in Fig. 32 can be used. This is a full-wave rectifier employing two 281 type rectifier tubes. When the effective AC voltage across each side of the power transformer is 600 volts, the circuit will deliver approximately 170 milliamperes at a steady voltage of 550 volts. This is the maximum current that should be drawn from the two rectifier tubes.

The voltage regulation of this B supply is very good. At a current of 75 ma the output voltage is only 650 volts. At 100 ma the voltage is down to 620 ma, at 125 ma it is 590 volts, and at 150 ma it is down to 570 volts. These, of course, are approximate values.

The voltage regulation depends on the resistance in the filter chokes as well as on the characteristics of the rectifier tubes and the power transformer. However, if low resistance chokes are used this dependence is negligible. For example, it is possible to get chokes which have a resistance of only 145 ohms. The resistance of 290 ohms of two of these would be small in comparison with the resistance of the rectifier tubes.

The inductance of these coils is not so high as would be desirable for thorough filtering, but this can be compensated for by using larger condensers in the filter. A variation of this circuit will be shown which combines good filtering with good regulation.

Let us now determine the values of the resistors in the voltage divider on Fig. 32 for a typical current and voltage distribution. Let the receiver contain two 227 type radio frequency amplifiers operated with 90 volts on the plates, one detector tube of the same type operated at 45 volts, one audio frequency amplifier of the same type operated with 135 volts on the plate, and two 250 type power tubes operated at 450 volts on the plates and 84 volts on the grids.

Under these conditions the currents will be approximately as follows: 1 ma to the 45-volt lead, 18 ma to the 90-volt lead, 9 ma to the 135-volt lead, none to the 180-volt lead, and 110 to the high voltage lead. This makes a total of 138 ma and we may allow 12 ma for the bleeder current, making the total drain 150 ma. At this drain the voltage will be 570 volts, but we shall assume that it has been adjusted to be exactly 534 volts.

Since 12 milliamperes flow in R5 and the voltage drop must be 45 volts, the resistance of R5 should be 3,750 ohms. The current in R4 is 13 milliamperes and the voltage drop in it is 45 volts. Hence the value of R4 should be 3,461 ohms. R3 carries 31 milliamperes and the drop in it is 45 volts. Hence the resistance is 1,451 ohms. The current in R2 is 40 milliamperes and the drop is 45 volts. Hence R2 should be 1,125 ohms.

As no current was assumed to flow to the 180-volt tap, the current in R1 is the same as that in R2, namely 40 milliamperes. Hence R1 should have a value of 8,850 ohms, since the current drop in it must be 354 volts. If current flows into the 180-volt tap, this must be taken into account when R1 is determined.

The specifications of the condensers in the circuit in Fig. 32 may be as follows: C1, 2 mfd., 1,000 volt DC operating voltage; C2, 4 mfd., 1,000 volts; C3, 8 mfd., 1,000 volts; C4, C5, C6 and C7, each 2 mfd. or more, with an operating voltage of 400 volts. Of course, if the 180-volt tap is not used it is not necessary to use C4. It would be preferable to increase the size of C7.

All the resistors in the voltage divider should be able to carry 60 milliamperes without excessive heating. The power transformer and the chokes should be designed for plate current not less than 150 milliamperes. The transformer, in addition, should have one 7.5-volt center-tapped winding for the filaments of the rectifier tubes and one 1,200-volt center-tapped winding.

In the circuit shown in Fig. 32 it was necessary for practical reasons to use filter chokes of low inductance values, resulting in unsatisfactory filtering in some instances. Increasing the capacities of some of the filter condensers was suggested as one remedy. But a better way, especially when the last stage in the amplifier is push-pull, is to arrange the filter circuit as shown in Fig. 33. In this L1 is a heavy-duty choke coil, which will carry the entire current without serious saturation effects, and L2 is a choke of much higher inductance and lower current carrying capacity. The high voltage tap is taken at the junction of the two choke coils.

When the power stage is push-pull and well balanced, a small amount of ripple in the supply will not affect the operation of the amplifier to a noticeable degree, and therefore it is not necessary to filter this supply as thoroughly as that for the single-sided amplifiers and the detector.

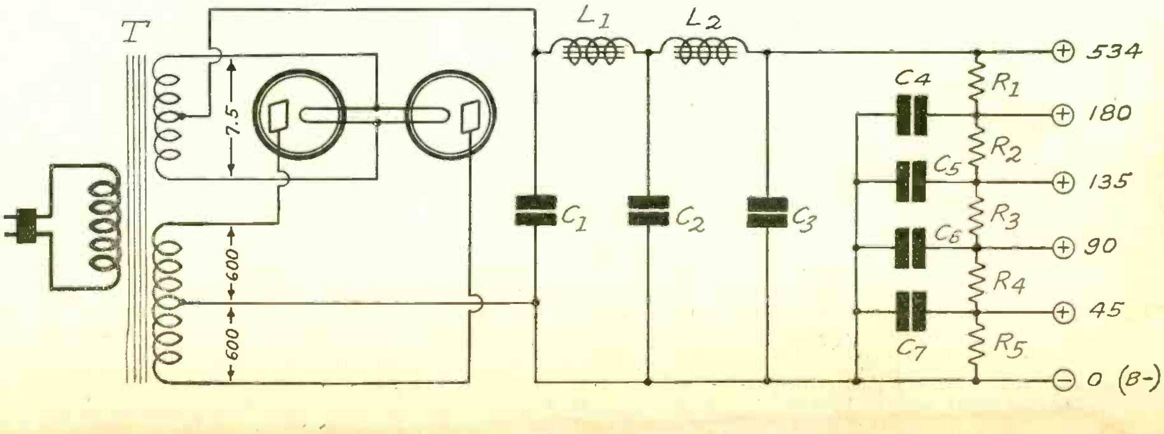
The tap at the junction of the two chokes diverts nearly half of the total current and hence L2 need not be designed for as high current as L1. If L1 has a high inductance at the operating current the plate supply to the tubes connected to the voltage divider will be thoroughly filtered.

The high voltage winding on the power transformer has 550 volts on each side in this instance. The lower voltage is permissible on account of the smaller drop in the choke coils also to the fact that 600 volts give a slightly high output voltage even when the total current flows through both the chokes.

The capacities and voltage ratings of the condensers used in the circuit in Fig. 33 are the same as those in the circuit in Fig. 32. The values of the different sections of the voltage divider are also the same, except R1, because the current and voltage distribution has not been changed. R1, however, must be determined so that the voltage drop in it and in L2 is the difference between 534

FIG. 32

This circuit is essentially the same as that in Fig. 32 except that it uses full wave rectification and is designed for much higher current output. It is suitable for a receiver using two 250 type power tubes.



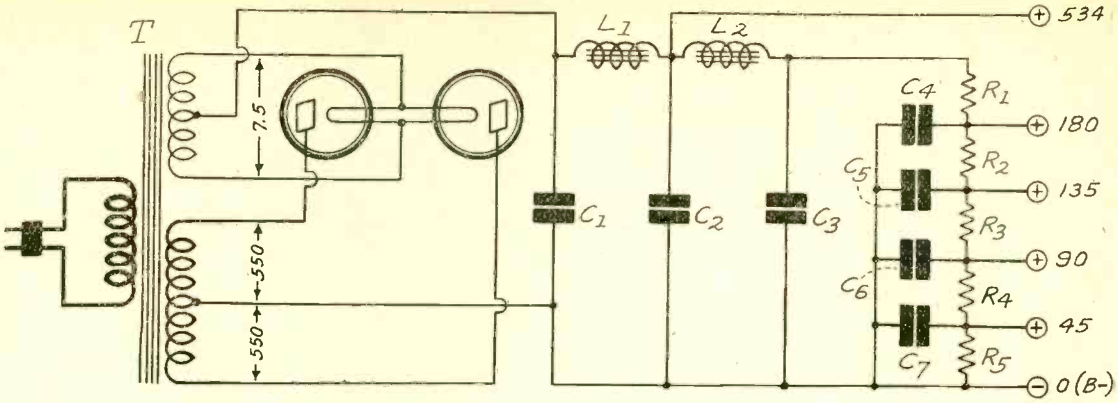


FIG. 33
A heavy duty current supply circuit similar to that in Fig. 32 but having a filter arranged for more thorough filtering and better voltage regulation

and 180 volts. If it is assumed that the resistance of L2 is 500 ohms and that the current through it is 40 milliamperes, the difference between 150 and 110 ma, the value of R1 should be 8,350 ohms.

L1 should be a choke which will carry 150 milliamperes or more without heating or saturation, and it need not be rated at more than 10 Henries. L2 should be a choke rated at 60 milliamperes and 30 henries.

Methods of Adjusting Output Voltage

In each of the circuits shown in Figs. 28 to 33 it was assumed that the voltage across the voltage divider had a definite value. This assumption is not justified in all instances because of several variable factors. First the line voltage varies from place to place and from time to time. This variation changes the output voltage. Then the current drawn from the B supply varies with the filament, plate and grid voltages on the tubes in the receiver. This variation causes changes in the voltage across the output.

In most instances small variations make no practical difference in the results, but in some the circuit will not work satisfactorily unless the voltages are very carefully adjusted. This is especially true when there are screen grid tubes in the receiver, and more particularly when these tubes are operated in resistance and impedance coupled circuits. A very small change in one of the voltages applied to the screen grid tube, for example, will in some instances completely upset the adjustment and render the circuit inoperative.

Some means, therefore, may be needed to adjust the output voltage, and we shall describe a few methods that have been used with success. All of these reduce the output voltage.

In Fig. 34 are shown two different methods of controlling the voltage across the voltage divider. The first is a rheostat Rh in the primary of the power transformer, and the second is a potentiometer PR on the output side of the filter.

The rheostat method is very satisfactory, provided that the power transformer contains no windings except those required for the rectifier. The reason for this will be clear when it is understood how the rheostat works.

A certain current flows in the primary of the power transformer when the circuit is in operation. The voltages in the secondary windings depend on this current and on the voltage established across the primary by this current. If a rheostat is inserted in the primary there will be a voltage drop in its resistance, and this drop is deducted from line voltage. That is, the voltage across the primary is less than the line voltage by the amount of drop in the rheostat. Consequently the filament and high voltage windings in the secondary are reduced in proportion. Since these voltages are reduced, the rectified and filtered voltage across the voltage divider is also reduced.

The resistance value of the rheostat depends on the power that is required by the current supply circuit and on the necessary reduction in the voltage. The power required by the circuit determines the current that will flow in the primary, and from the known power in the secondary the current can be estimated.

Suppose the value of the total rectified current is 100 milliamperes and that the output voltage is 300 volts. The power is 30 watts. But this is not the total wattage for there are losses in the transformer and in the chokes, and some power is required by the filament. We can assume a loss of 20 watts in the circuit ahead of the voltage divider, since the efficiency is about 60 per cent. This includes the 10 watts required to heat the filament. Hence the total power taken from the line is 50 watts.

The wattage is the product of the voltage and the current, assuming unity power factor. Since the voltage is 110 volts, the current in the primary must be 5/11 ampere, or about ½ ampere. Suppose then that the line voltage rises to 120 volts and that the rectified voltage is correct when the line voltage is 110 volts. The resistance of the rheostat, therefore, should be such that the drop is 10 volts when the current is one-half ampere. That is, it should be 20 ohms. This applies only to the assumed case. If the power taken from the line is greater than 50 watts, the rheostat should have a lower resistance; if the power is less, the resistance should be greater.

If the line voltage is correct and the rectified voltage is too high, due to a high step-up ratio of the power transformer, or for any other reason, the rheostat may be used to lower the voltage across the voltage divider just as if the excess voltage were due to a high line voltage.

Now if there is a filament winding for one or more amplifier tubes on the same power transformer, when the voltage is cut down with the rheostat the voltage on the filaments will be reduced also. This is not always desirable. It is all right if the line voltage is high, but not when the plate voltage alone is excessive.

The rheostat Rh, Fig. 34, may therefore be retained as a control for adjusting the voltage in case the line voltage is excessive, but an additional voltage control operating independently of the line voltage should be introduced. One way of doing this is by means of the potentiometer PR shown in Fig. 34.

This potentiometer may be a part of the voltage divider, or it may be another instrument connected across the divider. If it is an integral part of the voltage divider it is only necessary to increase the highest resistor section in the voltage divider, or to put in a suitable, variable resistor above the highest voltage tap.

When using a separate potentiometer in parallel with the regular voltage divider it should be remembered that all the current delivered to the receiver flows through the upper portion of R, that is, the portion above the point P. Since this point may be moved to various positions of the resistor, R must be able to carry the heavy current.

The extra condenser C4 should be used whether the parallel potentiometer or the series resistor is used. The capacity of this condenser should be from 2 to 4 mfd. and the voltage rating should be the same as that of R3. Both of these condensers are in critical positions and are often subjected to voltage surges that are greater than the steady voltages maintained across them.

In Fig. 35 is shown an arrangement for adjusting the output voltage in which the potentiometer PR is put next to the rectifier tube. This has an advantage over that shown in Fig. 34 in that the current drawn by the potentiometer resistance does not flow through the filter coils. Hence this current does not add to the saturation of the cores of the chokes. Also, the potentiometer is placed so that the voltage across the filter condensers is reduced. This is of some importance, especially when the voltage is so high as to be near the voltage rating of the condensers.

The arrangement in Fig. 35 was especially developed for a B supply in which the first condenser C1 is of the electrolytic type and when the voltage output of the rectifier was higher than the safe operating voltage of the condenser. It is because C1 is supposed to be of the electrolytic type and of very high capacity that

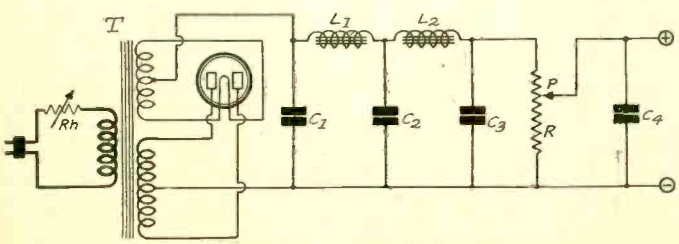


FIG. 34
A CIRCUIT ILLUSTRATING TWO METHODS OF ADJUSTING THE OUTPUT VOLTAGE OF A PLATE POWER SUPPLY. THE RHEOSTAT RH CONTROLS THE INPUT VOLTAGE TO THE RECTIFIER AND THE POTENTIOMETER PR CONTROLS THE VOLTAGE APPLIED TO THE RECEIVER.

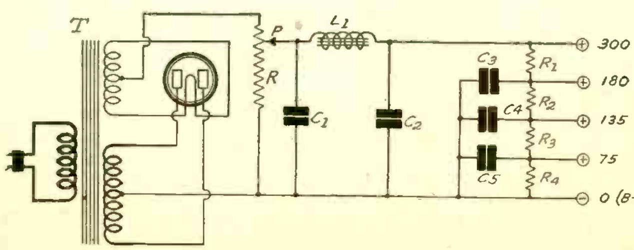


FIG. 35
ANOTHER METHOD OF CONTROLLING THE VOLTAGE APPLIED TO THE RECEIVER. A POTENTIOMETER PR IS PLACED BETWEEN THE RECTIFIER AND THE FILTER.

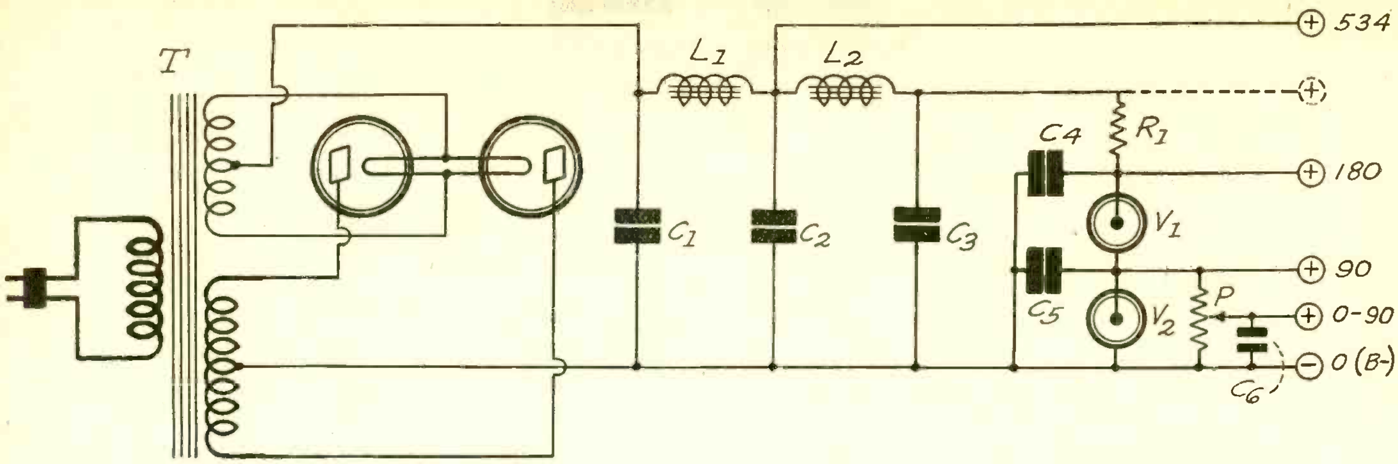


FIG. 36
THIS CIRCUIT ILLUSTRATES THE METHOD OF USING GLOW TUBES, V1 AND V2, FOR MAINTAINING THE VOLTAGE APPLIED TO THE RECEIVER AT CONSTANT VALUES.

only one choke coil is shown. The condenser is so large that the use of a second choke coil is unnecessary.

As in the case of the potentiometer in Fig. 34, all of the current drawn by the circuit flows through the upper portion of the resistance R. Hence the current carrying capacity must be high,—from 60 to 150 ma, depending on the B supply in which the potentiometer is used. The resistance value of the potentiometer should be adjusted so that not more than about 10 ma flow in the lower portion. If the output voltage is to be 300 volts, the drop in R is very nearly the same, since the drop in L1 may be neglected. If the current through R is 10 ma, the resistance below the point P should be 30,000 ohms.

While 280 type rectifiers are shown in the circuits in Figs. 34 and 35 the voltage controls illustrated apply equally well to any other types of rectifiers.

In some circuits variations in the plate voltage on the power tubes is not accompanied by any serious effects but it is highly desirable to keep the voltage on the other tubes constant. When this is the case a circuit arrangement like that in Fig. 36 can be used. V1 and V2 are two output voltage regulator or glow tubes, which hold the voltage very constant.

The characteristic of one of these glow tubes is that for all values of current through the tube from 10 to 50 milliamperes the voltage is 90 volts. Thus when two of these tubes are connected in series, as in Fig. 36, the voltage across the two tubes is 180 volts. This voltage is maintained as long as the current in either tube does not go outside the limits mentioned above.

The circuit in Fig. 36 is provided with an adjustable tap which may be varied from zero to 90 volts. The position of the slider P depends on the voltage desired on the tap and the current taken by that tap. The current through the upper tube V1 must not exceed 50 milliamperes. Suppose that it is 35. The current through V2 must not be less than 10. Suppose that it is 15 milliamperes. Then the current taken by the potentiometer, the variable tap, and the 90-volt tap must be 20 milliamperes. Assign 5 milliamperes to the lower portion of the potentiometer and 5 ma to the variable tap when this is set at 45 volts. Then the lower portion of the potentiometer should have a resistance of 9,000 ohms. Since the current in the upper portion is 10 milliamperes and the voltage drop in it is 45 volts, the value of this portion should be 4,500 ohms. This requires that the total resistance of the potentiometer be 13,500 ohms.

If this value cannot be obtained in a commercial potentiometer, a 15,000 ohm unit can be substituted. The current distribution will be slightly different, requiring a different setting of the slider, but the change in the current will not be so great as to upset the constant voltage drop across either tube.

In order to obtain a drop of 180 volts across the two tubes, V1 and V2, it is necessary to take the current in the 180-volt tap into consideration, and to determine R1 accordingly. Suppose the current to the 180 volt tap 15 milliamperes. Then the total current through R1 and L2 is 55 milliamperes. Hence the resistance of R1 and L2 combined must be 6,436 ohms to drop the difference between 534 and 180 volts. The resistance of R1 alone will be slightly less.

It will be observed that the circuit in Fig. 36 is essentially the same as that in Fig. 33. The high voltage tap in both is taken off between the two choke coils. Hence L1 should be a choke of low inductance and low resistance, with a current carrying capacity of 165 milliamperes or more, assuming that two power tubes are connected to the high voltage tap, each taking 55 milliamperes.

There will be little hum in a push-pull amplifier served by this B voltage supply although there may be a greater saturation effect due to the current taken by the voltage regulator tubes. In the first place the power stage is push-pull, which can tolerate considerable ripple before it becomes audible. In the second place any reduction in the filtering due to saturation is more than offset by the regulatory effect of the two glow tubes.

The condensers used in the circuit in Fig. 36 may have the same capacity and voltage rating specifications as those used in the circuit in Fig. 33. There are fewer condensers in Fig. 36 than in the other, but it is obvious which have been omitted.

If a voltage of 135 volts is desired it may be obtained by connecting a potentiometer between the 90 and 180 volt taps and dividing this voltage just as the voltage between zero and 90 volts is divided. Another 2 mfd., 400-volt condenser then should be connected from the 135-volt tap to B minus.

The two glow tubes are not only valuable in holding the voltage constant but in preventing oscillation and distortion in the amplifier which the circuit serves. The tubes reduce the common impedance among the plate circuits of the amplifier, and therefore reduce feed back which may result in oscillation or motor boating. The tubes act as very large condensers in this respect.

If it is only essential to maintain the voltage across the 90 volt tap constant, V1 may be replaced by a suitable resistance and V2 alone used.

There are other devices for controlling the voltage output, but those discussed above are the easiest to apply and the most popular. There are line voltage regulator tubes, or ballasts, which are placed in the primary circuit like the rheostat in Fig. 34. These tubes now have a voltage range of 40 to 60 volts. There are two sizes of this tube type, one drawing a current of 1.7 and the other 2.05 amperes. When either tube is used, the primary of the power transformer must be wound for a voltage of 65 volts, and a current appropriate to the tube used. The normal voltage drop in the ballast will be 50 volts. If the line voltage rises or drops 10 volts for any reason, the voltage across the primary of the transformer remains at 65 volts, the fluctuation being taken up in the ballast.

These tubes are not used much because of the necessity of employing a special power transformer and because of the high power loss in the tubes. Other automatic voltage controls that have been proposed are subject to similar objections.

Methods of Obtaining Grid Bias

Every amplifier tube and plate bend detector requires a suitable grid bias. When designing circuits the question always arises as to the best manner in which to obtain it. Shall it be obtained from a battery, a rectifier-filter, a voltage drop in a resistor in a DC filament circuit, a voltage drop in the plate circuit of one or more tubes, or by a drop in a resistor placed in the negative side of the plate voltage supply circuit? All of these are possible methods.

Any one, or a combination of two or more of them, can be used. The choice depends on the type of circuit used and on certain other factors which will be brought out in the discussion.

In Fig. 37A, 37B and 37C are shown three different methods of obtaining bias for tubes using direct current on the filaments. The simplest is shown in Fig. 37A. A resistor R is put in the negative leg of the filament and the grid return lead is connected to the negative end of this resistor. Since some resistor, either a rheostat or a ballast, is needed in virtually every filament circuit, this method yields a bias without the use of any device which would not be needed were the bias not required.

It makes practically no difference whether R serves a single tube or all the tubes in the receiver, but of course the resistance value would depend on the number of tubes put on it. If the tube is one requiring a filament current of .25 ampere and a voltage of 5 volts, and if the voltage source is 6 volts, the value of R for one tube is 4 ohms. This gives the grid a bias of one volt, for the grid voltage is measured from the negative terminal of the filament to the point where the grid return is connected. The drop in R is just one volt, since the resistance is 4 ohms and the current is .25 ampere.

If more tubes than one, of the same current requirement, are put on the resistance, the value of R is 4 divided by the number of tubes. For example, if four tubes are put on R, the value should be only 1 ohm.

If the resistance is used for a tube requiring a different current, a different terminal voltage, and some other voltage source, the value of the resistance must be determined by Ohm's law from the known voltage drop and current in it.

[*Part VI next week*]

DC Suppl

A Neglected Side of

By Capt. Pete

THE problems of the satisfactory operation of a filament and plate voltage supply where AC is available are not problems any more, for concentration by engineering talent has brought the AC receiver to a high point, close to perfection. But with a DC supply for filaments and plates the situation is quite different.

Comparatively few persons have a DC source of supply, which means that perhaps only about 2,000,000 persons rely on direct current from the lighting mains. Most of these 2,000,000 do not know offhand whether their supply is AC (alternating current) or DC (direct current), much less do they know, if it is AC, what the frequency and voltage are, or, if DC, what the voltage is. DC has no frequency, because it is unidirectional, never changing its polarity.

The AC customers have 50-60 cycles, 40 cycles or 25 cycles, but those who have other than 50-60 cycles are in about the same fix as those possessing DC, since they are limited in number, and the market is not large enough, evidently, to encourage manufacturers to cater to them. Often manufacturers of AC devices receive letters from residents of districts where 25-cycle current is used, asking if particular apparatus can be installed with safety in the writer's home, but it can not. The 50-60 cycle type of apparatus will short the 25-cycle line, and should not be used even on a 40-cycle line.

Problems of a DC Supply

Considering alone this time the problems of the DC supply, we find, first, that there is difficulty in obtaining a suitable fixed resistor to carry the large current at large voltage drop, necessary so that the line source can be reduced to filament voltage; and, second, that it is hard to make the DC supply fool-proof.

Even specialists in making resistors do not go in for the heavy-duty type of fixed resistor necessary to drop 110 volts DC to 5 or 6 volts for filament purposes, since resistors that actually handle 200 watts without getting intolerably hot are necessary. Hence a 90-ohm resistor rated at 200 watts would not do, and two such re-

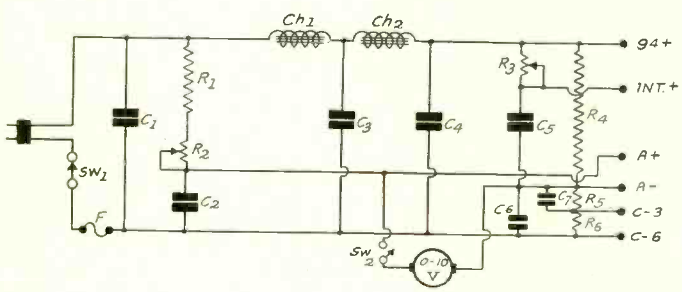


FIG. 1
DESIGN OF A DC ELIMINATOR OF A, B AND C BATTERIES, FOR OPERATION OF TUBES WITH FILAMENTS IN PARALLEL. THIS IS SHOWN IN CONJUNCTION WITH DESIGN PROBLEMS STATED IN THE TEXT.

sistors would have to be used in parallel, thus reducing the resistance to 45 ohms, and we would require more. Series-parallel fixed resistors would be a solution, but as the cost would become very considerable, this method is never going to prove popular.

Another sidelight on the main difficulty of obtaining the correct resistor is that the wattage rating does not govern the situation. That rating is often made under what might be termed an artifical condition, which presupposes the resistor is more than 12" from any object, so that a bulky DC outfit surely would result. The moment the resistor is used under conditions as existing in a compact device the rating does not hold. And the manufacturer tells you so. He points out also that resistors should be used at not more than half of their wattage rating (which makes the 200-watt general requirement read 400 watts) or at not more than 70 per cent. of the current rating.

This resistor is shown as R1 in Fig. 1. In series with it is a rheostat, but the rheostat would have to carry the same amount of current as would the fixed resistor, although the wattage rating could be less. This lessened rating for R2 is based on the assumption that R2 would be of lower resistance value even at maximum setting than R1 is. Design would suggest this type of difference, anyway, since a large voltage (110 volts) is to be reduced to 5 or 6 volts, and the main drop would take place in the fixed resistor, to give a vernier effect to R2 within desired bounds. The wattage of R2 would be less therefore because the resistance is less. Since the current is the same through both, the voltage drop through the rheostat at maximum resistance setting would be less than the voltare drop through R1. Wattage is the product of the voltage and the current. Hence if R1 were twice as large in resistance value as R2 maximum, the wattage rating of R2 could be half as great.

Problem of the Electrolytic Condenser

In Fig. 1 C1 is the first condenser of the B filter section, placed electrically the same as if it were moved to the right to be attached directly to the choke coil CH1. But C2 is connected from A+ to the negative side of the line, therefore across the filament voltage and the biasing voltage. Its capacity should be very large, if the condenser is included at all. Around 1,500 mfd. at 18 volts rating would be a good constant and rating. But to be of such large capacity it would have to be an electrolytic condenser, and could be of the so-called "dry" type, that is, non-liquid. It has a paste inside. Unfortunately the construction of the condenser is such that the condenser is sensitive to polarity. You can not maintain the condenser in operation for more than a short while with the polarities reversed without causing decomposition to set in at a fast pace, and the condenser soon will be ruined, and may short the circuit across which it is placed. It can be seen therefore that such a condenser, although it has its polarities plainly marked and colored for extra identification, can be put in circuit the wrong way just by putting the plug into the wall socket the wrong way.

It is a fact that a DC eliminator will not work if the plug is in the wall socket in reverse, no matter if the electrolytic condenser is used or not. One side of the line is negative and the other is positive. As you depend on your B voltages for connection to the proper side of the line—the positive—you would have a negative voltage on the plate if the plug were in the wrong way. However, the tubes would light under either condition, because it makes no difference in the mere heating of tube filaments whether the positive or the negative is connected to one side of the filament or the other. If C2 were omitted, then all you'd have to do would be to reverse the plug. But with the condenser you have to do more—you must get the plug in the right way every time.

A method of partly circumventing this difficulty is to put a switch in series with one of the condenser leads, and when you've got the set working, thus insuring correct polarity, for you get no signals with wrong polarity, you would close the switch to put the condenser in circuit. But you—or some other member of your family—might forget to pull the condenser switch when the set is turned off, and the plug might accidentally get kicked out of the wall socket as the result of entaglement, and the restoration of the plug to the socket might bring about the reverse connection. Result: condenser shot to ruin, and each shot costs more than $6.

Line conditions throughout the country are not so bad that the electrolytic condenser is required in a DC eliminator. One can get along quite well without the condenser. But if one must use the condenser the only safe solution—the one that costs the least in the long run—would be the inclusion of a circuit breaker. When 5 milliamperes or more flow through the B voltage part of the supply, then the relay would close, and the electrolytic condenser would be in circuit. Otherwise the plate current would not flow at all, so if reversed connection were made to the wall socket not only would you get no reception, the same as under any other conditions, but the sensitive condenser could not be injured. It would not be in circuit unless the wall socket were correctly connected.

Mark Polarity of Plug and Outlet

This gives rise to the easy precaution of marking the plug and the wall socket, so that any one inserting the plug will be guided as to proper method of connection. But besides that you have to inform any one who might make the connection that the marks on the one side of the plug and one side of the wall socket actually mean something. Also the mark on the wall socket or convenience outlet should be on top, so anybody can see it easily.

The B voltage and current problem takes care of itself, from the safety and economy viewpoints, since with wrong connection there is only negative plate voltage, hence no plate current, and no tube-functioning. But in the A side are a rub or two, not only the problem of dropping suitable voltage without generating the heat of a volcano or disintegrating a resistor beyond the point of further use, but also the problem of not blowing out or otherwise injuring the tubes because of voltage rise when fewer than the total number of tubes for which the A supply was designed are actually in use.

Here the two points of versatility and safety become closely associated. If a supply is to be "universal" it must take care of a given maximum number of tubes, and any smaller number, or, to put it more accurately, must provide correct filament wattage independent of the number of tubes used, up to the maximum of 10 watts. To do this without regard to safety is easy. But to do it with assured safety is not so easy.

We can have an A supply from the DC line in either of two general forms: one that changes the voltage to suit the filament needs by direct drop in a series resistor, or one that changes fila-

y Problem

Radio for 2,000,000

V. O'Rourke

ment voltage by a rheostat across the filaments. The series resistor will reduce or increase the filament voltage. The shunt resistor, connected from A minus to A plus, would only reduce the voltage, since the lower its value of resistance, the more current it draws, or takes away from the filament side, and the lower the current through the filaments the lower the voltage drop across those filaments. Stated differently, the shunt resistor used on an A supply designed to furnish 2 amperes for eight tubes (201A, 112A, etc.), would limit the filament voltage to 5 no matter if even 1 tube were used instead of 8.

This would be fine if the action were automatic, but the sorry part is that the rheostat would have to be turned, and if you forgot to turn it, and had only one tube in the socket receiver, the voltage across this tube would mount to about 12, and good-bye tube. If at 2 amperes the voltage is 5, at .25 ampere it is 12, assuming a 6-ohm shunt. The current through the shunt is 1 ampere, the current through eight tubes is 2 amperes, total 3 amperes at 5 volts. If only one tube is in circuit the current is reduced to .25 ampere, plus 1 ampere in the shunt, thence 1.25 amperes flow. The voltage in the series (main) resistor that dropped 105 volts, drops proportionately. The proportion is 1.25 to 3, or 1 to 2.4, so the single 201A tube gets 2.4x5 volts or 12 volts. And remember we couldn't find a fixed main resistor to carry 2 amperes, much less 3 amperes!

Remember These Two Rules

Therefore we have two great rules to remember:

(1) Always put the line plug into the convenience outlet in the correct direction.

(2) Never turn on the receiver unless all the tubes are in their sockets, and the A supply is set for that number of tubes.

So, even if a tube goes dead, and you don't find it out at once, the voltage on the other tubes goes up. Should two tubes go dead at once—filaments burn out, let us say—the situation begins to get serious, and it may easily happen that prostration to two means prostration to all. And with eight tubes in circuit that's something to worry about.

We haven't said anything yet about cost. Naturally, if you have 110 volts and want to use only 5 volts, you are going to use up 105 volts at let us say 2 amperes, or 210 watts. You may call it waste, if you like, but it has to be done. A lamp could be inserted and it would light up, so at least you'd get light for your money. But lamps limit you to the amount of resistance you can use. A 200-watt lamp, rated at 120 volts, draws 1.4 amperes and has a resistance of about 86 ohms, and after you've finished experimenting with the series and parallel lamps you must use you find you've gone into the lamp business instead of building a radio device.

Things may seem very black scientifically when one views the problems of a DC supply that will furnish A, B and C voltages. But there is still some "grief" to tell. One is that the output voltage always must be less than the input. How different with AC! You have 110 volts DC, let us say, at the convenience outlet. The choke coils will drop some voltage, say about 10 volts, so there's 100 left for plate supply, but if you desire C bias also, and who doesn't, then you must deduct the C voltage from the plate voltage. You connect A minus higher than at negative of the line. B voltage is reckoned from filament minus. You don't want to expend much voltage on C bias, as you can't afford to sacrifice the B voltage. You could add a B battery in series with the positive end or a C battery in series with the negative end, but the problem is to omit batteries, and it is no solution of the problem to do the very thing you want to avoid doing! So you take the smallest bias that the law allows for a modest plate voltage on a semi-power tube, and that leads you to a 112A. If you make the bias 6 volts then the plate voltage is 94 volts, and the combination is correct. But six volts isn't much. Push-pull would help, because it is effectively a series arrangement, and the push-pull output, at 94 volts on the plate, and at the same 6 volts negative bias, will handle twice as much undistorted power output as would a single-sided last-audio stage at the same plate and grid potentials.

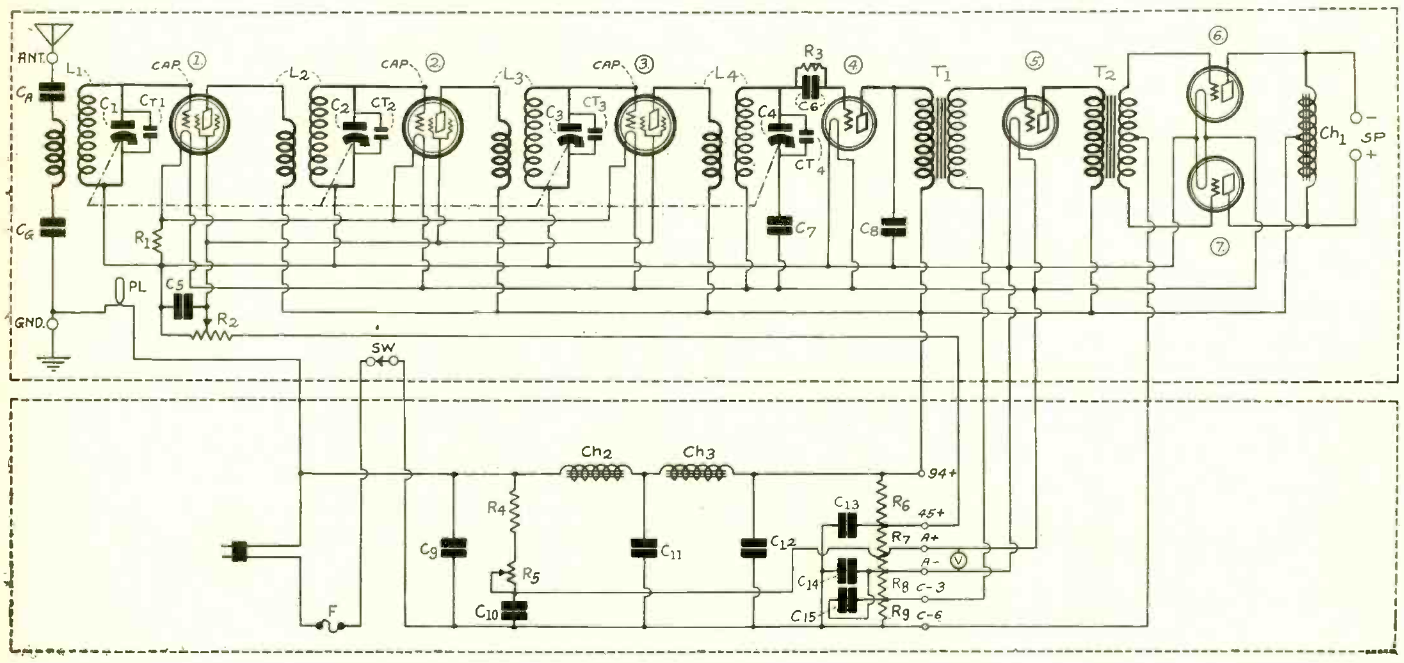


FIG. 2

THE DESIGN OF AN A-B-C SUPPLY TO WORK FROM DIRECT CURRENT, 110 VOLTS, IS SHOWN IN CONJUNCTION WITH A RECEIVER, AS IT IS PREFERABLE TO MAKE ONE COMPLETE INSTALLATION AS A MATTER OF ULTIMATE ECONOMY.

Five General Conclusions

From the foregoing some general conclusions may be adduced:

First, that the most satisfactory method of using a DC eliminator of A, B and C batteries is to have a supply designed especially for a given circuit.

Second, that it is advisable to use tubes that require the lowest filament wattage consistent with excellent performance.

Third, the output stage preferably should be 112A in push-pull.

Fourth, some visual warning signal should be introduced so that if the plug is connected to the line in the wrong way that cause will be observed, and no internal circuit trouble need be wrongly suspected.

Fifth, one switch should control everything and the line should be fused.

Fig. 2 shows a suggested design, using three screen grid tubes, two 201A tubes and two 112A tubes, the last pair in push-pull. The screen grid tube stages must be shielded and the detector tube stage may also be shielded. Single control is made possible, despite the detector's return to A positive, as contrasted with A negative for the screen grid tubes, because of a fixed condenser uniting the detector tuned circuit.

Series condensers are shown in both the aerial and ground circuits. The aerial condenser CA protects the receiver installation in the event an oppositely charged wire should fall on your aerial. The ground condenser, CG, makes it impossible to short the 110-volt line by wrong method of insertion of the wall plug. This

(*Continued on next page*)

Remarkab
from Two-Stage

Proper Use of Screen Grid Tube to Assure

By Herman
Managing

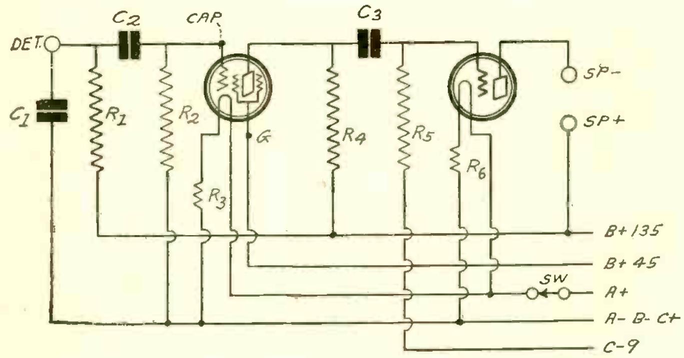


FIG. 1
TWO-STAGE AUDIO AMPLIFIER OF RECOMMENDED DESIGN, WITH A GAIN OF 3,100 OVERALL. THE SECRET OF STABILITY IS TO APPLY THE SAME PLATE VOLTAGE TO ALL TUBES AND USE 50,000 OHMS FOR R4 AT 135 VOLTS APPLIED. THE CONSTANTS CORRESPOND TO THOSE GIVEN IN FIG. 3.

THE use of the screen grid tube as an audio amplifier has been slighted considerably, possibly because experimenters quickly found that a tube with such a high amplification factor, if worked in a three-stage direct-coupled amplifier, caused instability of a high order. This trouble usually asserted itself in the form of motorboating, a low frequency oscillation. Regeneration took place in the audio amplifier. While there is always a remedy for this trouble, it is often an expensive one, necessitating special filter choke coils and in addition enormous capacities connected across the voltage sources, to reduce the common coupling among circuits.

Another way out is to use an audio amplifier of smaller gain, but one that permits stability. A two-stage resistance-coupled audio amplifier makes possible the use of the screen grid tube in the first audio stage, either in regular screen grid fashion, with G post to a positive B voltage and cap to the grid leak, or in space charge grid fashion, where the positive voltage is applied to the cap, the G post then becoming the control grid connected to the leak.

How Trouble Is Avoided

Even when these forms are used the amplification is high enough to cause a small order of audio feedback, but the difficulty is easily corrected. The 222 type screen grid tube, which is battery-operated as to its filament at least, causes the trouble and at the same time points to a solution of the difficulty. The answer is to use a lower value of coupling resistor in the plate circuit of the 222 tube than has been usually recommended.

The impedance of the first audio output and final audio input is at once reduced to a low enough value to insure stability when the plate resistor, R4 in Figs. 1 and 2 and R7 in Fig. 3, is made 50,000 ohms. Then the total amplification of the circuit is higher, due to the higher effective plate voltage and correction of instability that rendered the circuit partly inoperative. This lowered value of plate resistor affording higher volume is contrary to theory, but much of the theory surrounding the screen grid tube is based on conditions independent of performance of an operating receiver, and occasionally is propounded even under conditions of no load. Therefore experimental proof points the way to the successful use of the screen grid tube either with impedance coupling, with a lower impedance in this instance, also, and with the simpler form of direct coupling, which is by resistors. The coupling is solely performed by the resistor in each of the two plate circuits, and the union with the succeeding grid circuit is made possible only by the introduction of the isolating condenser that keeps the positive plate voltage off the grid of the next tube, which grid must be maintained negative. That is why the leak is necessary—to afford an impedance that serves as a path for the signal to fluctuate across. The plate resister couples the circuits, the isolating condenser and leak being in series with each other and as a circuit in parallel with the coupling resistor.

Screen Grid for Greater Volume

The 222 tube was worked very successfully in screen grid fashion in the first audio stage as shown in Fig. 1. This affords the greater volume. The space grid method, shown in Fig. 2, causes the plate impedance of the tube to be lowered, and reduces the amplification factor. With the space charge method of accelerating the flow of electrons, by having the space grid help by pulling the electrons to the plate, the amplification obtainable is of the order of 50 to 60, while in screen grid fashion the amplification is of the order of 100 to 350, depending on circuit formation and voltages. Therefore any receiver that has a modest or average radio channel, as in Fig. 3, should preferably

---

Screen-Grid Design

(Continued from

short would take place otherwise, because one side of the line is grounded, and if you plugged in so as to ground the other side, too, because your receiver is connected to external ground (cold water pipe or radiator), there would be a short.

It was the object of this article to set forth some of the problems and to show that they still ask for complete solution, especially where a universal A, B and C supply for direct current use is to be designed. Wholly satisfactory ones are far from numerous. Many experts have never come across one.

It is not the object of this article to set forth in detail the construction of a supply of this kind, even in conjunction with a receiver, but rather to provide some guiding advice to those who desire to construct a DC installation, and particularly to encourage the building of a receiver with supply especially intended for it. Fig. 2 will prove satisfactory.

It is not the object of this article, either, to argue that a suitable supply for universal use, up to 2 amperes at 5 volts, is not practical, for one has been built, although expensively. It is much more economical to suit the supply to a particular receiver.

Constants for Fig. 2

The designs set forth assume or specify the usual parallel method of filament wiring. Of course series filaments may be used, but trouble may result unless the heater type tubes (227 or 224) are used, since the heaters are independent of the radio circuit proper. The voltage-dropping resistor for filament use becomes less of a problem, and a lamp may then be used, without even getting more than warm—certainly never bright or hot.

le Results Resistance Audio

Stability at High Amplification Per Stage

Bernard

Editor

use the screen grid method of resistance audio coupling. The overall gain in the two stages of audio is 3,100.

The usual thought in connection with the screen grid tube is of enormous gain. In actual practice no enormity is achieved usually, but a gain considerably in excess of that provided by the 201A or equivalent tubes actually is established. Stability often requires putting on the brakes. The receiver must be operative before it can be considered useful. It is of no advantage to write down large numbers and multiply them by still larger ones, to obtain enormous results on paper, only to be baffled by an inoperative circuit. The most useful data on the screen grid tubes have been experimentally obtained in connection with receiver operation.

So the diagrams in Figs. 1 and 2, representing audio circuits that actually have been worked with excellent success, commend themselves to experimenters. There is no risk in building such an amplifier, as it will not only work, but it will provide a quality of tone that if capitalized by a good dynamic or inductor speaker, will give an enduring surprise. Besides, the circuit is very quickly assembled, and indeed many existing two-stage audio circuits can be converted to the screen grid resistance audio design in an hour.

A Surprise for Many

While the audio channel looks modest, it may surprise many to learn that it will provide a degree of amplification at least equal to that of the usual two-stage audio amplifiers where other forms of coupling and other tubes are used. It is advisable to have the output tube a 112A and apply from 7½ to 9 volts of negative grid voltage, depending somewhat on the voltage dropped in the output device, or the windings of the magnet coils of a magnetic speaker where no output device is used. None is necessary with any speaker at the plate voltage of 135 on the 112A tube.

If a very sensitive radio receiver is used, then the output tube may be a 171A or 245, with suitable bias.

It is hard to say anything about the fine quality of the audio amplifier shown in Fig. 1 that has not been said about the most distorting arrangement that ever was offered to the public, since modesty of claims has not yet become a golden rule of radio. But the quality of this audio amplifier has greatly pleased radio engineers who know their acoustics, as well as musicians who are supposed to have ears trained to detect the slightest presence of distortion. At least the metered tests for frequency response showed up astonishingly well, and justified in every particular the design of the circuit and the values of the constants used.

A screen grid tube is used in the first socket of the radio receiver shown in Fig 3 because at radio frequencies great gain is accomplished, something of the order of 75 for the first stage. The detector is a 240 tube, with a mu of about 31, which is almost four times as much gain as would be provided were a 201A tube used here. The detector is hooked up in leak-condenser fashion, with grid return made to positive A, but single control may be used, if desired, by returning the detector grid coil to A plus while the common rotor of the condenser is connected to F minus of the 5-volt tubes. This grid return method gives the first screen grid tube, in socket 1, a negative bias of 1.7 volts, which is approximately correct.

Desirability of a Higher Bias

But in the audio stage a somewhat higher bias is desirable, hence the grid return may be made to A minus as shown. The bias is then 2.7 volts negative, or the difference between the supply voltage of 6 at the battery terminals, and the filament voltage of 3.3. The resistor R1 in Fig. 3 should be 10 ohms, which is easy to obtain commercially, so 10 ohms may be used, or two 5-ohm resistors may be connected in series, or two 20-ohm resistors in parallel.

(Continued on next page)

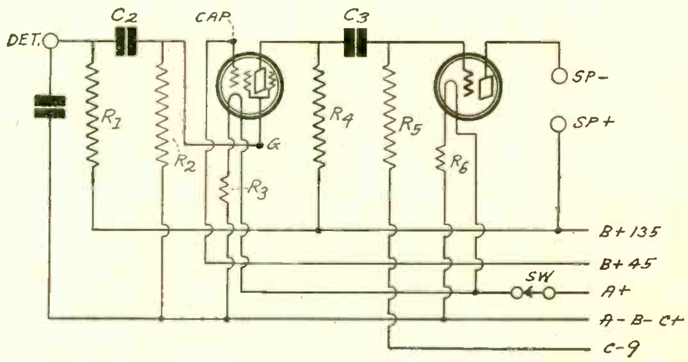


FIG. 2
THE FIRST AUDIO TUBE IS USED HERE AS A SPACE GRID AMPLIFIER AT LOWER GAIN.

for DC Operation

preceding page)

For the guidance of those who desire to follow the receiver-supply diagrammed in Fig. 2 the unusual constants are given herewith:

F is a 1 ampere cartridge type fuse. Get a fuse holder for it. C9 is 4 mfd. 200 volt DC test. R4 and R5 may be combined, since a new resistor has appeared, the Power Clarostat, 25 to 500 ohms, where R4 is automatically 25 ohms and R5 is 25 to 500 ohms. This device is rated at 250 watts actual operating wattage. Ch 2 Ch3 is a Silver Marshall Unichoke, 331. C11 and C12 are like C9. C10 may be an electrolytic condenser as described, or may be omitted. R6, R7 is an Aerovox Pyrohm, total of 9,000 ohms midtapped (4500, 4500). R8, R9 are two 4-ohm resistor strips, 2 ampere rating. C13 is 2 mfd., C14 is 4 mfd., C15 is 2 mfd., all 200-volt DC rating.

The switch should be of the AC 110-volt snap type or other switch for 110 volts DC or AC, known as line switches. Do not use a radio switch designed for battery use. PL is 120-volt mazda, candelabra type. Get a small screw base for it. PL is connected to that side of the line that lights this pilot light when the other side goes to ground.

In the receiver most of the parts are standard and familiar. CA and CG are .02 mfd., mica dielectric. R2 is a high resistance potentiometer, 5,000 ohms or more. C5 and C7 are .02 mfd., C8 is .0005 mfd. R1 is 8 ohms.

A voltmeter, if included, should have a button switch, to protect the meter. A reading obtains only when the button is pressed. The range is 0-10 volts DC.

Turn the Power Clarostat knob to the *left* until you strike the end stop. Then the full 500 ohms is in circuit and you can safely install your tubes in their sockets and turn the knob to the right until the filament voltages read 3.3 and 5 respectively.

Higher Bias Pays

When 224 Tube is Used as Audio Ampflier

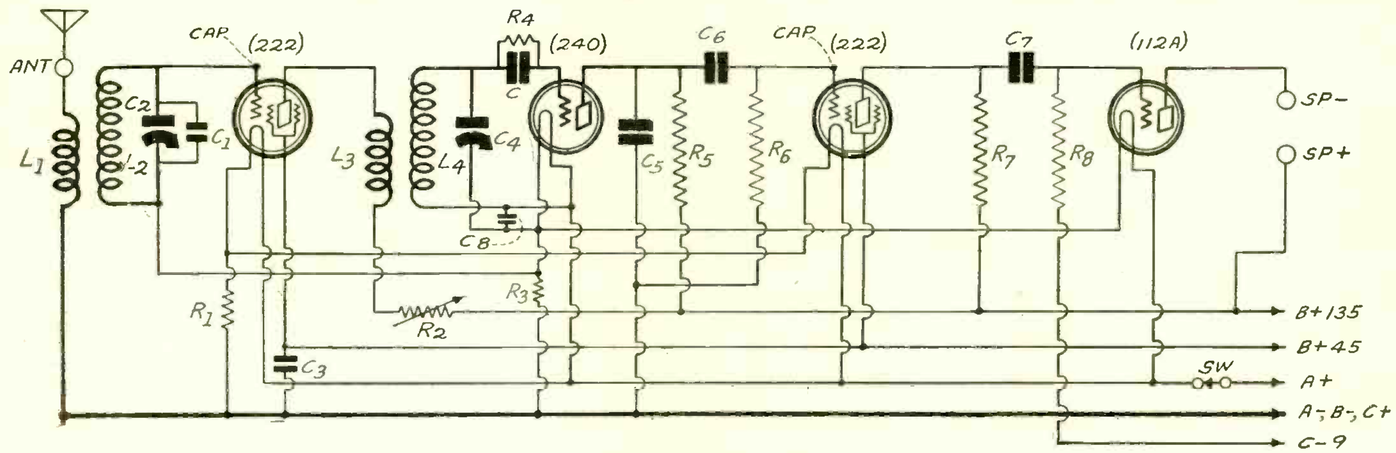


FIG. 3

A RECEIVER USING THE SCREEN GRID RESISTANCE AUDIO. L1 L2 ARE 14 AND 48 TURNS FOR .0005. L3 AND L4 ARE 24 AND 48 TURNS. THE DIAMETERS ARE 2½", THE WIRE NO. 24 COVERED. R1 IS 10 OHMS, R3 IS 2 OHMS. R2 IS A STANDARD CLAROSTAT. R4 IS 5 MEG., C5, .0005 MFD.; R5, 1 MEG., R6, 5 MEG.; R7, 50,000 OHMS; R8, 5 MEG. C6 AND C7 ARE .02 MFD. C1 IS 70 MMFD., ADJUSTED ONCE. C IS .00025 MFD. WITH CLIPS. C3 IS .02 MFD. OR HIGHER. C8 IS AS LARGE A CONDENSER AS YOU HAVE. A MINUS MAY BE GROUNDED IF DESIRED.

(*Continued from preceding page*)

The screen grid voltage in Figs. 1 and 3 may be 45 volts, when the applied plate voltage is 135 volts. A distinction should be made between the applied plate voltage and the effective plate voltage. The difference between the two is that the applied voltage is always the maximum and the effective plate voltage is always less to the extent of the drop in the plate load. As there must always be some load in any circuit, some impedance drop when current flows, and this drop is often considerable.

For rough estimating the applied voltage in a resistance audio is often regarded as twice as great as the effective voltage, where the load resistor is high. This is merely a method of driving home the fact that there may be a vast difference between the two, but it is not a scientifically accurate one, for not only does the value of the resistor used change the plate current, reducing the current when the resistor is higher than the datum, and increasing the current when the resistor is lower, but the effective plate voltage changes. This change is so great in some instances that almost the entire voltage is dropped in the plate resistor, if the resistor is high enough, and virtually no plate current flows. However, when the plate resistor is of a low value, as the 50,000 ohms recommended for the plate of the screen grid tube in the first audio stage, then, although plate current flows sufficiently, the voltage drop in the resistor is negligible.

It is apparent therefore that changing the value of the resistor alters the circuit considerably, by changing the impedance presented to the plate circuit and the grid circuit that follows, and changes the plate voltage considerably, the latter point not having been brought out in screen grid tube data because if any load circuit was considered in running curves it was almost always some pure resistive load (non-reactive circuit) of a fixed value of resistance. The value of 100,000 ohms resistance has been used often for curve purposes.

The plate resistance of the screen grid tube type 222 is 850,000 ohms at a negative bias of 1.5 volts, and at a bias of 2.7 volts, as used in the first audio stages of the circuits diagrammed, it is 1,120,000 ohms. If the plate resistor, R4 in Figs. 1 and 2, R7 in Fig. 3, is 50,000 ohms, then the plate resistance is 22.4 times the load resistance and the voltage drop across the resistance of the plate is 22.4 times that across the load. Always the same current flows through both, whatever that current may be, since the two resistors are in series. The sum of the two resistances is 1,170,000 ohms, therefore the plate current may be determined without further recourse.

By Ohm's law the current in amperes equals the voltage divided by the resistance in ohms, hence the current is 135 divided by 1,170,000, or about .1 milliampere (.0001 ampere). For this reason no plate current reading would be obtained from an ordinary milliammeter, but a 0-to-1 milliammeter, which necessarily has a resistance of 1,000 ohms per volt, would be used, or a still more sensitive instrument, known as a microammeter, would be used. The actual reading would be 110 microamperes.

Therefore the plate voltage source of 135 drops in its entirety across the series resistances of load and plate. As the proportion of the voltage drop is the same as the proportion of the resistances, 50,000 ohms drop 5/112 of 135, or 6.025 volts, which is negligible. Contrast this, however, with a high resistance load, say, 1 meg. The sum of the resistances of the load and the plate then would be 2,120,000 ohms, and the plate current would be only 63 microamperes (.00063 ampere). The voltage drop would be in the proportion of 1,000,000 load to 2,120,000 plate resistance, or, 25 to 28. Therefore the load resistor would drop 67.175 volts and the plate itself 67.825 volts, which would be the effective plate voltage. Hence the effective voltage is only about half of the applied voltage. Such a low effective voltage would call for a lower grid bias, and that would reduce the plate resistance, so that the load resistor would drop more than the effective voltage on the plate, that is, the effective voltage would be considerably less than half of the applied voltage. So when curves are run at a fixed voltage, due to absence of load, or with the use of only a fixed resistive load, the theoretical data are merely indicatory and not controlling.

The worthiness of introducing a low value of resistor in the plate circuit of a screen grid tube, used as an audio amplifier, is therefore not only justified experimentally but theoretically as well, as resistance value for the load beyond a certain point makes it impossible practically to obtain a sufficiently high plate voltage and reduces the plate current so much that it is too small by far to support the modulation component of the plate current (the swing of the pulsating plate current) sufficiently to copy in amplified fashion the swing on the detector grid. When the plate current fluctuation is not a true copy of the grid fluctuation you have distortion.

The bias applied to the first audio tube, although only 2.7 volts negative, is far higher than otherwise required. There would be no objection to making it less, by connecting the first audio tube's grid return to F minus of a 5-volt tube, as was done with the screen grid RF amplifier tube, except that the effective plate voltage would be made lower by this process. Since increasing negative bias increases the plate resistance, the load resistance, which is considered fixed at 50,000 ohms, becomes a smaller percentage of the total resistance, hence drops a smaller amount of voltage, a favorable condition. The plate current is lessened as the negative bias is increased which is also in the same favorable direction of dropping as small as practical a part of the applied voltage in the load resistance, since the voltage drop in a resistor is directly proportional to the current.

Using 25,000 ohms instead of 50,000 in the stated instance would reduce the volume somewhat,, while using 10,000 would drop it considerably. At 400 ohms it would be scarcely possible to hear anything. On the other hand, at 100,000 ohms the volume declines, in respect to 50,000 ohms, due to the lessened effective voltage and the damping effect of negative feedback at audio frequencies, produced when the load resistor is too high an impedance in respect to the common impedance. The load impedance should be at least 50 times as great as the common impedance, and the plate impedance should be at least 1,000 times the common impedance for stability. For general purposes the DC resistance of the resistor may be taken as its impedance.

15 to 550 Meters

Thrill Box Brings in DX Clearly and Smoothly

By Dawson Furlough

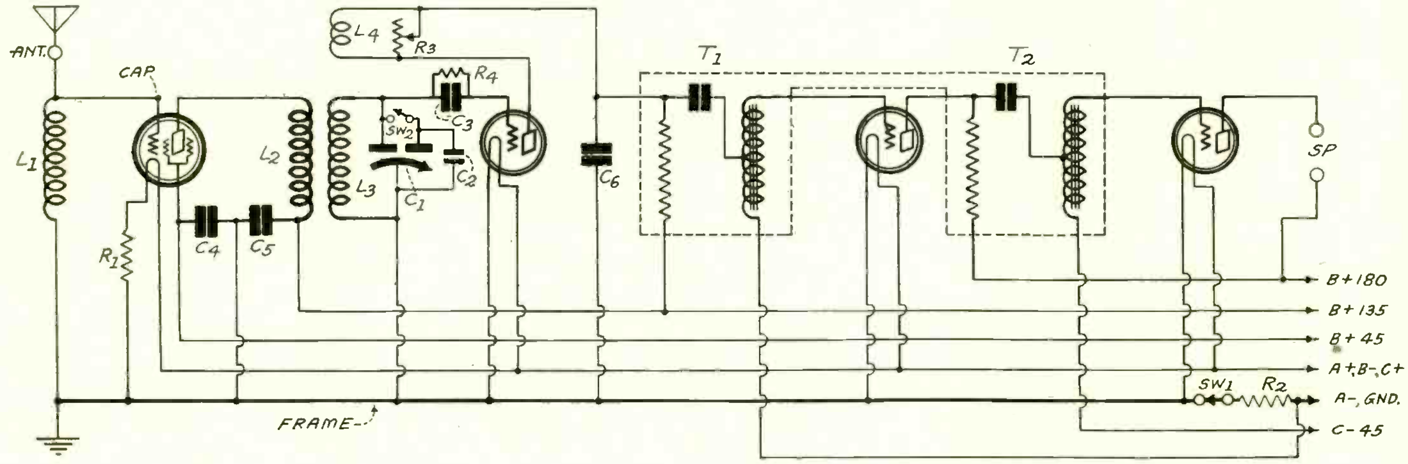


FIG. 1
THE CIRCUIT OF THE NATIONAL THRILL BOX THAT T UNES IN THE STATIONS FROM 15 TO 550 METERS

THE interest in short wave reception is increasing continually, and this increase is paralleled by the rapid strides made in the transmission of short wave signals. Individuals in every nation are clamoring for licenses to transmit on these waves. Groups and large corporations everywhere and of every commercial field are fighting for channels in this band of the radio spectrum. Nations and governments are doing the same. There is a universal scramble for places in the short wave spectrum.

The skeptical might ask: Is there really very much on the short waves which would interest the listener who does not understand code? Well, there are short wave broadcasting stations in nearly all countries, in some countries many of them. There are about as many short wave broadcasting stations within the reach of one who has a short wave receiver as there are broadcasting stations within the reach of his regular receiver. And these short wave stations are not local; they are international. There are stations in Japan, Java, Australia, Germany, Holland, France, Switzerland, England, Sweden, and in many other foreign countries. There are local stations, too, in New York, New Jersey, California, Massachusetts, Washington, D. C., and in several other states or territories. All of these are local to any man living in the United States or Canada, because the short waves have an uncanny carrying power.

Use of Adapter

Not so long ago there was an epidemic of short wave adapters. Usually one of these adapters consisted of a short wave tuner, using a single tube, a plug being furnished for insertion in the detector socket of the broadcast receiver. These devices worked very well when they were specially suited for the set with which they were used. But in most instances there was no adaptation at all. As a rule these devices gave fair satisfaction, although a very few of them are really excellent.

Makeshifts rarely do work, and about all that can be said of the inferior adapters is that they were makeshifts. It soon became apparent that a receiver especially designed for short waves, with the tuner and audio amplifier built together as a unit just as broadcast receivers are built, would bring in more stations.

One of the first to realize this was the National Company, and the realization turned out to be a happy one. For this thanks are due to James Millen and Prof. Glen H. Browning. They have turned out a short wave receiver that has a pleasing appearance, is compact, and brings in the stations whether they are located nearby or on the other side of the earth.

Chelmsford Speaking

Every part that enters this receiver was designed for short waves and for this particular circuit. The effect of this is noticed the instant the set is on and the dials twisted. Stations just roll in, and the circuit is no respecter of nationality of stations. Not at all.

One afternoon in Malden, Mass., one of these sets was tuned in on the wave of 5SW, Chelmsford, England, and the signals came with loudspeaker volume, not for a few moments but for over an hour. That is not so bad, is it, for a receiver comprising one stage of screen grid amplification, a regenerative detector, and two stages of audio amplification? Most of us are willing to concede that it is a good performance.

Malden, Mass., is not a charmed place in respect to reception. No, indeed. A similar set was brought to New York and tested under adverse reception conditions. It did not exactly repeat the performance in Malden, for it did not bring in 5SW, but it brought in so many stations, local and distant, that it was a job to keep track of them. And all came in on a loudspeaker, for it was not tested with a headset. When listening in with a receiver like this it immediately becomes plain why everybody is fighting for short wave channels and why the Federal Radio Commission has difficulties finding room for any more such stations. There is not a half a division on the dial free from some station, at least for some of the tuning ranges of the set. The ether is simply jammed with signals.

Don't they interfere with one another? Some do, to be sure, in one sense. But there is no destructive interference. Short wave broadcast stations are given enough room to be heard without any interference from code stations, and the tuner in this receiver is sharp enough to discriminate between any two broadcast channels.

[Part II next week, July 6th]

LIST OF PARTS

L1—One National No. 10 RF choke coil.
L2, L3, L4—One set of National short wave plug-in coils.
C1, C2—One National tuning condenser consisting of two sections.
C3—One .0025 mfd. grid condenser.
C4, C5—Two .5 mfd. condensers.
C6—One .001 mfd. condenser.
R1—One 15 ohm ballast resistor.
R2—One 1-ohm ballast.
R3—One variable high resistance.
R4—One 6-megohm Lynch grid leak with mounting.
SW1—One filament switch.
SW2—An integral part of C1, C2.
T1, T2—One National SW-4 Duo Coupler.
One specially designed National steel cabinet.
Tubes—222, 200A, 240, and 171A.
One cable for terminals.
Three binding posts.
One National flat type dial with pilot light.

A Question and Answer Department conducted by Radio World's Technical Staff. Only Questions sent in by University Club Members are answered. Those not answered in these columns are answered by mail.

RADIO UNIVERSITY

Annual subscriptions are accepted at $6 for 52 numbers, with the privilege of obtaining answers to radio questions for the period of the subscription, but not if any other premium is obtained with the subscription.

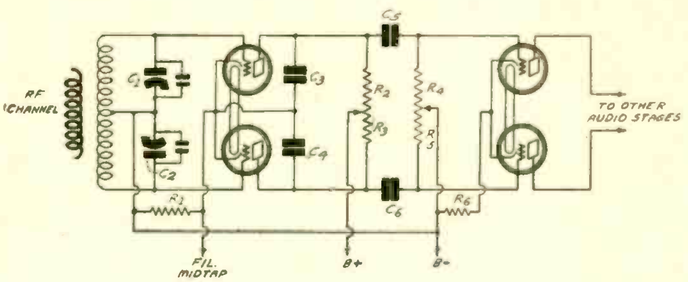


FIG. 764

DESIGN FOR AN EXPERIMENTAL PUSH-PULL DETECTOR IN AN AC CIRCUIT. THE PRIMARY IS WOUND AT THE CENTER OF THE COIL FORM, WITH EQUAL SECONDARIES ON THE TWO SIDES. R2, R3 TOTAL 200,000 OHMS, R4, R5 TOTAL 4 MEG. C5 AND C6 ARE .02. MFD. ACCURATE BALANCE THROUGHOUT IS REQUIRED. ONCE ESTABLISHED, TEST BY REMOVING ONE DETECTOR TUBE.

CAN a push-pull detector be used? I am desirous of obtaining results from a resistance-coupled push-pull amplifier, but the circuit becomes one-sided, that is, works as well, if not better, with the other side out. I am at a loss to obtain suitable output from a single-sided detector, where push-pull is to follow, and do not think it can be done, unless a transformer is used to couple the detector to the first push-pull audio stage, or a push-pull detector can be worked.—K. M.

Fig. 764 shows a suggested design for a push-pull detector. It is not guaranteed to work with great satisfaction, as some problems remain to be solved in push-pull detection. At all hazards, the output should be oppositely phased, as to the two detector plate circuits. A difficulty with a push-pull detector is that the phases are different by far from what are present where tubes are used as amplifiers. If the differences can be sustained all through at input and output of the detector, so as to effectuate equal but opposite voltage and current in the output, a good solution will have been reached. The circuit shown is worth trying, as a method of avoiding a transformer, if that is the academic aim. There is no proven satisfactory method of obtaining an output from a detector to feed push-pull except by using a transformer, unless a push-pull detector is successful. The resistances have to be accurately balanced, so potentiometers are suggested, or if equal leaks and plate resistors are used, a small potentiometer, say, 1,000 ohms, may unite the two resistors physically, while dividing them electrically at the movable arm. The subject of resistance coupled push-pull is very interesting and is one of the fields of audio amplification that have not been subjected to much research. Several experimenters, with a fair knowledge of radio, have gone into it a bit but have given it up as hopeless, but others, more far-sighted, and courageous, are continuing their own efforts, and some day something worth-while may be expected from this heretofore barren type of audio.

* * *

IN trying out the battery model screen grid tube, type 222, as space charge detector and as regular screen grid detector, I find that the volume is louder by the screen grid method. I use resistance coupling in the first audio stage, hence there is a resistor in the plate circuit of this screen grid detector. I also find that the negative bias for detection, since I use grid bias detection, has to be changed if the screen grid voltage is changed much. I thus got detection on 16 volts negative, with a high plate voltage on the G post of the socket. What is the best region of detection by both methods?—A. M. P.

Which method produces louder signals depends on voltages used and the circuit formation. As you use resistance coupling, you present a more suitable load impedance to the screen grid tube used in regular fashion, that is, G post to B plus intermediate, and cap to the tuned circuit. The space charge method reduces the plate impedance. Also, when worked at good sensitivity the space charge tube is microphonic, but this can be overcome by taping the envelope or otherwise physically deadening the tube, so its mechanical vibration will be stopped. A shield cap over the entire tube, especially with an anchoring spacer between shield and glass, will end microphonism. The negative bias has to be changed if the voltage on the screen grid is altered much, but it is well to stick as closely as possible to the rated voltages, as specified on the instruction sheets accompanying tubes. A normal detecting voltage is 4½ volts external. Add to this the voltage drop of 2.7 volts in a filament resistor (assuming a 6-volt battery source) and you have an actual bias of 7.2 volts. This works well with 135 volts applied to the plate resistor, which should be .1 meg. or less. The screen grid voltage would be 22 to 45.

* * *

THERE is a boominess in the reproduction of so many console receivers and some other types that I am wondering if this must be? I am interested in tone quality and would like to receive suggestions.—J. K.

One of the principal reasons for the boominess is the resonating effect of the speaker's surroundings, usually a cooped-up box. However, this condition has arisen from public preference in furniture effects, with speaker hidden, so there must be an enclosure about the speaker. The sound waves are therefore cast back, instead of flowing freely into space. They oscillate in the box. Any method of avoiding this may lead to a less acceptable piece of furniture, but to vastly improved tonal effects. A good solution is to have a separate speaker, not housed in a console, and to provide this speaker with a baffle or board against which to press the front rim of the cone, under conditions that permit free circulation of air from back, top and sides. The back may be entirely open, the top and sides grilled or of cane construction, as in the seats of chairs. This may not greet the eye quite as gracefully as the other, but it does look good and is much more generous to the ear, also avoids boominess, which is one of the serious shortcomings of radio today. However, radio as such is sold to persons who do not stop to think much about tonal effects, but are guided much by exploitation nonsense of manufacturers and by "consolitis."

* * *

IS the new inductor type of unit sensitive? How is its performance in respect to reproduction of audio frequencies? Can it stand great input? How does it compare as to overload with a regular dynamic?—N. M. B.

The inductor type of unit, which consists of a permanent magnet, or pair of magnets, with the armature moving up and down, instead of from side to side, is sensitive indeed. It reproduces low frequencies with astonishing emphasis, although without maximum possible distinction as to these frequencies. There is a tendency of frequencies below 125 cycles to sound the same, although there is much "punch" to the reproduction. The condition of extreme sensitivity to low notes is unusual in any unit, and naturally makes the treble, or high register, seem somewhat slighted. The middle register is excellent, hence voice sounds particularly good. All told, therefore, the unit is a fine one, and earns the popularity it is enjoying. Frequency discrimination is present in all units, and the remarks herein stated are not to be construed against the inductor type at all. Its response characteristic is something like that of the condenser type speaker, but with the results more simply accomplished. Both the inductor and the condenser speaker are now in the public crucible, and what ultimate popularity will be theirs probably the coming radio season will indicate. The inductor units tested in RADIO WORLD's laboratories, including models on which J. E. Anderson has been working since 1923, proved worthy of a high rating, although means of improving the power-handling capacity might well be introduced. So far as we know, available types of inductor units will not stand the gaff that the moving coil type dynamic speakers will. However, the volume the inductor unit will stand is sufficient for home use. No doubt refinements of all existing units of whatever type are engaging the attention of experts.

* * *

I HAVE a six-tube set, using 201A tubes up to the output, which is a 112A. Can I omit my storage battery by using a filament transformer? I have 110-volt AC line voltage.—C. J. A.

No. The receiver would have to be rewired in part and provision thus made for use of AC tubes, except that the output tube may be heated by AC without substitution.

* * *

IN constructing an A and B supply to work from 110 volts direct current I find that the resistor that I use to drop the 110 volts to 6 volts for the filaments get terrifically hot. In fact this is the third one I have put in. The two others burned out. What is the trouble?—M. B.

The resistor has an insufficient capacity for heat dissipation. For instance, if you use six .25 ampere tubes the current is 1.5 amperes. The resistor that is to drop 110 volts to 6 volts must drop 104 volts at 1.5 amperes, and therefore the wattage is 1.5 $\times$ 104, or 156 watts. It is well to use a resistor of higher rating, as a precaution, therefore you should have a 200-watt resistor, whereas you are probably using one of around 50 watts or so.

* * *

IS there any way of reducing the voltage strain on B filter condensers? I would like to use condensers of lower rating than ordinarily specified, because I have them, so your ideas would be welcome.—A. M.

Yes. See Fig. 765. This shows the first and second condensers across the total drop in the potentiometer network, while a strain is taken off C3 because it is across a lower drop.

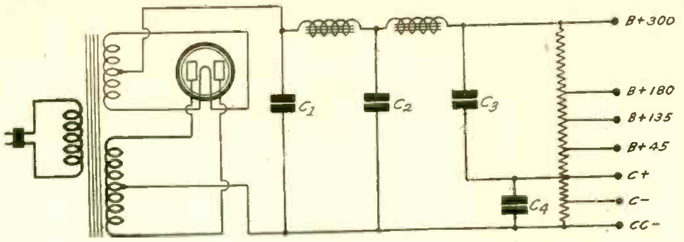


FIG. 765

THE STRAIN ON THE LAST FILTER CONDENSER IS LESSENED BY CONNECTION TO C4 RATHER THAN ACROSS THE LINE TO CC. C4 WOULD HAVE TO BE INCREASED BECAUSE OF CONSEQUENT FILTRATION REDUCTION. AT LEAST 4 MFD. IS IMPERATIVE FOR C4.

* * *

I KNOW Ohm's law and will prove it. The current in amperes equals the voltage divided by the resistance in ohms. The resistance in ohms equals the voltage divided by the current in amperes. The voltage is the product of the resistance in ohms and current in amperes. But I am often at a loss as to how to apply Ohm's law, as, frankly, I can't ascertain what it is that I want to ascertain. How can ths be done?—H. O. P.

It is easier to learn Ohm's law than it is to apply that law, which takes the three forms that you state. You certainly must find out what two quantities you are to work with, to determine the third. Close attention to circuit formations will help you considerably. Also, read the instalments on "Power Amplifiers," which have been printed each week beginning with the June 1st issue of RADIO WORLD, as circuit analysis is strongly stressed in this series. As a preliminary guide, we will set forth two examples, which should aid you in visualizing future situations. Assume that a 222 tube is being used. The A battery measures 6 volts across its terminals. The filament voltage recommended for the 222 is 3.3 volts, which causes a drain of .132 ampere. What should the resistance of a filament resistor be to reduce the 6-volt source to the 3.3-volt requirement? You know that the resistance in ohms equals the voltage divided by the current in amperes. The resistance is the missing quantity. The voltage — well, that seems to be a missing quantity, too, at your first glance. But think a moment. You have 6 volts to start with and 3.3 volts to end up with. The voltage in the formula will be not 6 or 3.3 but the voltage drop in the resistor, whose value you seek. This drop is 6—3.3, or 2.7 volts. Hence the resistance equals 2.7 divided by .132, or 20.45 ohms. In practice 20 ohms would be used. Another problem is: Suppose you know the current that will flow through a biasing resistor that is part of the output potentiometer of a B supply, and biasing voltage is to be obtained from this section of the resistor. What should be the value of the resistor be? It seems that all you know is the current, but it is necessary to know the voltage also before you can obtain the resistance, However, the biasing voltages for any and all tubes at stated plate voltage are known, and if not known to you, can be obtained from tube data sheets. Suppose the output tube to be biased is a 245 with 250 volts actually on the plate? Suppose the total current flowing in the potentiometer network is 100 milliamperes. The resistance of the biasing section equals the required bias voltage divided by the current, or 50 divided by .1, or 500 ohms.

* * *

FILTER condensers, as used in B eliminators, have two ratings, AC and DC. Also there is a test voltage on some and a working voltage on others. Some condensers have only one rating, say "350 v. DC." How can one determine when it is safe to use a condenser?—M. O'M.

The working voltage test is the one that counts in a B supply. The flash test merely reveals what voltage the condenser may be expected to withstand momentarily, rather than steadily. If a condenser is rated at 350 volts DC, assuming the manufacturers' rating to be correct, it may be used up to that voltage where direct current alone enters. In the filter section of a B supply there is a large AC component, even after rectification by the tube. Hence the AC working voltage is the one to rely on. If this is not stated, do not work the condensers at an AC voltage exceeding 50 per cent. of the DC rating. Hence for the condenser you mention, 175 volts, where AC is present, would be the working limit for safety against blowout. Some manufacturers rate their condensers more conservatively than do others, but the 50 per cent. allowance is not too large, where DC values are to be converted to AC values, because of voltage surges, including equivalent conditions developing when a large load is removed from the B supply's output, or the rectifier tube is removed from the socket when the power is on. Such removal is a careless act.

* * *

PLEASE state whether a voltmeter that reads AC is also good for reading DC? Is there any error factor? How about the comparative resistance per volt?—A. C. G.

An AC voltmeter of the type in general use will read DC satisfactorily. The AC type meant is of the root mean square variety, which means that the meter determines the average heating effect of the current. This is the same heating effect as DC would produce at the same current. Hence the interchangeability. If anything, the DC reading might be assumed to be slightly more accurate than the AC reading, where both readings are made with the same meter, if there is a large difference in frequencies, at which the AC measurements are made. No error factor need be considered. The resistance per ohm of an AC meter will be less than that of an exclusively DC meter. A DC meter might have a resistance of 1,000 ohms per volt, a comparable AC meter 760 ohms per volt.

* * *

WILL you please give accepted definitions of selectivity, sensitivity and tone quality? I would prefer to obtain definitions recently formulated, as I notice some old ones don't cover conditions today.—E. P. B.

In "Year Book of the Institute of Radio Engineers," just published, these definitions are given along accepted lines. Fidelity is the word used in this book for covering the phrase you specify. Here are the definitions:

"Selectivity—The degree to which a radio receiver is capable of differentiating between signals of different carrier frequencies. . . .

"Sensitivity—The degree to which a radio receiver responds to signals of the frequency to which it is tuned . . . .

"Fidelity—The degree to which a system, or a portion of system. accurately reproduces at its output the signal which is impressed upon it."

Your Choice of These Nine Meters FREE!

- ☐ 0-6 Voltmeter D.C. .... No. 326
- ☐ 0-50 Voltmeter D.C. .... No. 337
- ☐ 6-Volt Charge Tester D.C. .... No. 23
- ☐ 0-10 Amperes D.C. .... No. 338
- ☐ 0-25 Milliamperes D.C. .... No. 325
- ☐ 0-50 Milliamperes D.C. .... No. 350
- ☐ 0-100 Milliamperes D.C. .... No. 390
- ☐ 0-300 Milliamperes D.C. .... No. 399
- ☐ 0-400 Milliamperes D.C. .... No. 394

Equip Yourself Now With Necessary Meters!

To do your radio work properly you need meters. Here is your opportunity to get them at no extra cost. See the list of nine meters at left. Heretofore we have offered the choice of any one of these meters free with an 8-weeks subscription for RADIO WORLD, at $1, the regular price for such subscription. Now we extend this offer. For the first time you are permitted to obtain any one or more or all of these meters free, by sending in $1 for 8-week's subscription, entitling you to one meter; $2 for 16 weeks, entitling you to two meters; $3 for 26 weeks, entitling you to three meters; $4 for 35 weeks, entitling you to four meters; $5 for 44 weeks, entitling you to 5 meters; $6 for 52 weeks, entitling you to six meters. Return this offer with remittance, and check off desired meters in squares at left.

RADIO WORLD will help you in your radio work, so you will be able to use the meters most valuably. Keep abreast of all the new circuits, intimate details on perfecting existing sets, and get inside track on sensitivity, distance reception, tonal quality, and news of radio, technical and non-technical. Enjoy the writings of Dr. Lee De Forest, McMurdo Silver, J. E. Anderson, Herman Bernard and a host of other radio engineers who contribute their knowledge to you through the medium of RADIO WORLD, the first and only illustrated national radio weekly. You can find no magazine that better caters to your needs than RADIO WORLD. Short waves? RADIO WORLD will tell you all about them. Extremely sensitive broadcast receivers? Their construction and operation are fully discussed with confident regularity. Power supplies --push-pull or otherwise? AC receivers? Screen grid tubes? Large receivers that give a super-abundance of performance—small, economical receivers that give performance out of all comparison to their size? Are you interested in these? Then you're interested in RADIO WORLD.

Present mail subscribers may renew their subscription under this remarkably generous offer. Put a cross in square. ☐

RADIO WORLD

145 W. 45th St., N. Y. City—Published Weekly.
All Newsstands, 15c per copy—$3, six months—$6 a year

SUBSCRIBERS!

Look at the Expiration Date on Your Wrapper

Please look at the subscription date stamped on your last wrapper, and if that date indicates that your subscription is about to expire, please send remittance to cover your renewal.

In this way you will get your copies without interruption and keep your file complete.

SUBSCRIPTION DEPARTMENT
RADIO WORLD
145 WEST 45TH ST., N. Y. CITY

CONE ASSEMBLY WITH DOUBLE MAGNET UNIT $6.00

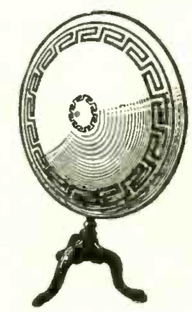
An excellent magnetic type speaker for installation in any cabinet. The unit is a double-magnet Paratone, with two magnet coils, for utmost sensitivity. Each horseshoe magnet is ¾" thick. The magnet coils are forever protected against dust and other foreign, injurious substances, by special bakelite housings. The pin is reverse drive. The cone frame is metal. The 9" cone is specially treated buckram.

All assembled, with long cord, ready to play, Shipping weight 6 lbs. (Cat. CAS) Net **$6.00**

The unit alone (cord included). It will operate any type sounding surface, including paper, cloth, wood, etc. Shipping weight 4 lbs. (Cat. UA). Net **$3.50**

Guaranty Radio Goods Co.
145 West 45th St., New York City

BUILD A 36-INCH CONE—LOWEST COST FOR FINEST TONE!



NEW POWERTONE UNIT
with 5-ft. cord
Designed Front Sheet
Plain Rear Sheet
Radio Cement
Mounting Bracket
Apex
Chuck
Nut
Tri-Foot Pedestal
Instruction Sheet
ALL FOR ONLY
$6.00

24" KIT, SAME PRICE.
Build the speaker. If not overjoyed at results, return the built-up speaker in five days and get ALL your money back!

GUARANTY RADIO GOODS CO.
145 WEST 45TH STREET
N. Y. City Just East of Broadway

Quick Action Classified Ads

Radio World's Speedy Medium for Enterprise and Sales

10 cents a word — 10 words minimum — Cash with Order

LOUDSPEAKERS TESTED and guaranteed, 24" diameter, contain powerful unit. $21.75. Lemsers Shop, 6326 Frontenac, Detroit, Mich.

RADIO RECEIVING TUBES, by Moyer and Wostrel, first edition just off the press. No radio service man, experimenter or student of radio should be without this authoritative book on the principles and applications of vacuum tubes. It answers all your questions relating to receiving, amplifying and rectifying tubes. Price postpaid, $2.50 Radio World, 145 W. 45th St., New York

REDUCE STATIC: The Phantom increases selectivity, chokes out static. No lightning danger, no aerial, no holes to dig. Completely shielded. Hook up in three minutes. Guaranteed fifteen years. Price $7.50 postpaid. Brighton Radio Lab., Brighton. Iowa.

ARTISTS and Art Students are printing 250 signs or pictures an hour without machinery. Sample and particulars 10c. Straco, 1014 Mulberry, Springfield, Ohio.

HOOK UPS made easy. Plug in all parts and connections on a Standardized Radio Hook-up Board. Three tube board, plug in bases, connections $2.75 post paid. Larger boards. Francis Livingston, owner and inventor, 1594 Humber Street, Memphis, Tenn.

RADIO INFORMATION
Reliable, prompt, accurate, in every-day language, 25c per question. Radio Information Bureau, 1426 South Clifton Park, Chicago.

THE CRAFTSMAN Dollar Speaker Filter is guaranteed to relieve speaker of the plate direct current, up to 250 volts. $1.00 postpaid. Refund if not satisfactory. Attach dollar to This Ad and receive FREE Solid-molded grid-leak, 1 to 5 megohm. Craftsman Radio Products, 351 Halsey St., Newark, N. J.

ARTISTS and Art Students are printing 250 signs or pictures an hour without machinery. Sample and particulars 10c. Straco, 1014 Mulberry, Springfield, Ohio.

ELIMINATE AERIAL. Greater distance, volume, selectivity with "Little Black Box." Rosens Shop, 616 Plant St., Utica, N. Y.

MARVELOUS NEW pick up for phonograph. Only twelve left, all pippins. Money-back 10-day guarantee. Send $3.75.—P. Cohen, Room 1214, at 143 W. 45 St., N. Y. C.

RADIOLA 18 AC.—All-electric special $70. Radiola 100 A speaker, special $21. Act quick. Offer limited. A. S. Cooke, 1304 Pacific Street, Brooklyn, N. Y.

HAVE AN EXPERT PUT YOUR SET IN SHAPE!
If your receiver or amplifier, no matter of what kind, is not giving proper results, send it to us, prepaid. We will test it FREE and let you know what's wrong, telling you cost of repairs. Our charges are very reasonable. Six years' experience. Loudspeakers and units repaired. Burnt-out coils replaced. Jaynxon Laboratories, 57 Dey Street, New York City.

ORIGINAL BALDWIN PHONES, tested and guaranteed, $3.65, postpaid, Blan, the Radio Man, 89 Cortlandt Street, New York City.

AGENTS AND SALESMEN WANTED
Sell $5.00 Men's Daily Necessity for 50c. Cost quantities 20c. Sample postpaid 30c. Catalog hundreds household articles free. Mills Sales Co., 901 Broadway. New York.

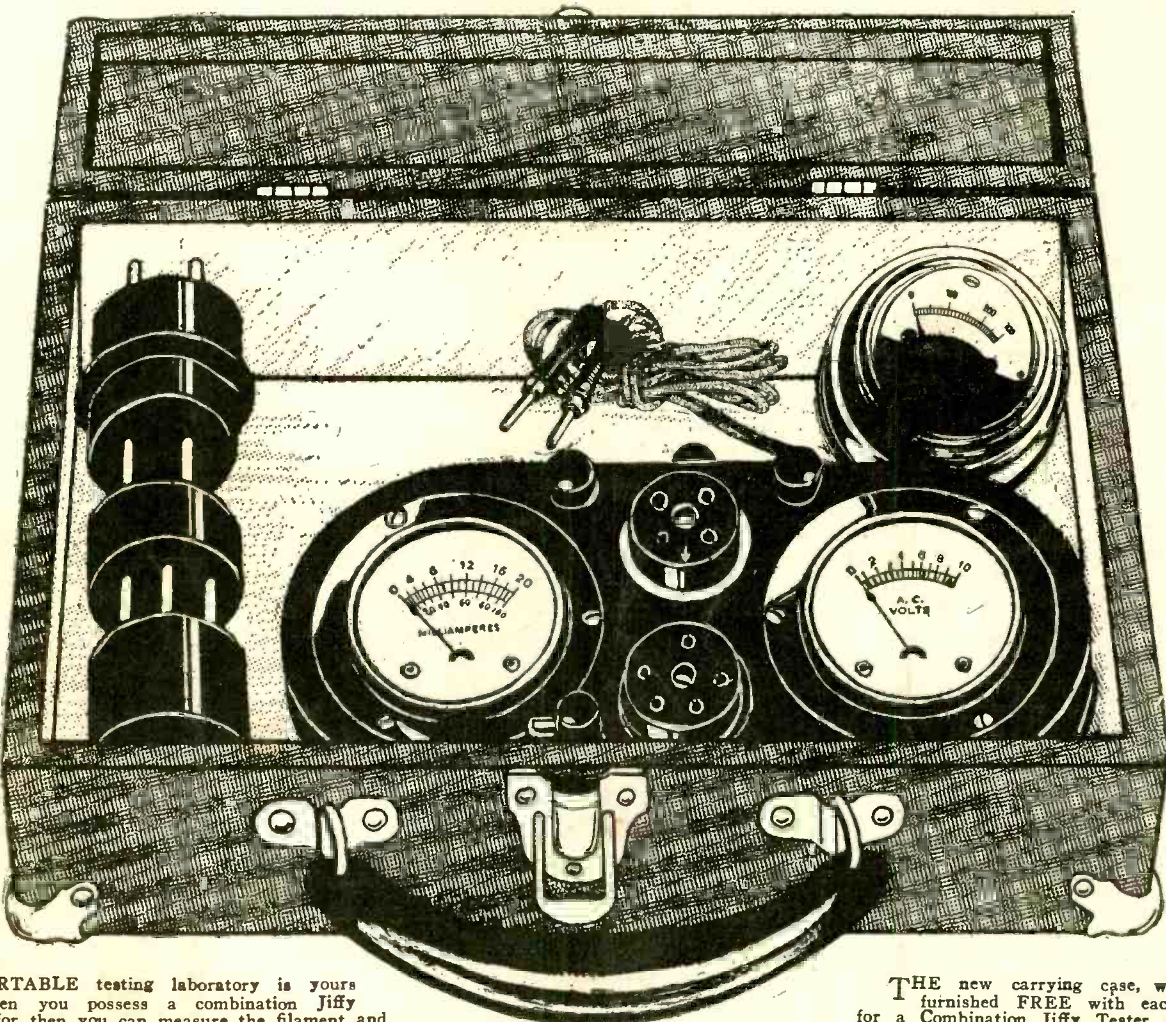
SAFETY FIRST!!! Protect your electric set and tubes from expensive blowouts, reduce noises and hum. Simply plug in "Protect-o-set" A.C. or D.C. $1.00 guaranteed. Kingsway Radio Co., 207 Kings Highway, Brooklyn, N. Y.

RADIO FANS: Improve summer reception by using my new method of grounding your set. Cheaply installed, more economical in operation. Full instructions 25 cents. Address Leslie Churchill, Route 3, Batavia, New York.

RADIO WORLD, published every Wednesday, dated Saturday of same week, from publication office, Hennessy Radio Publications Corporation, 145 West 45th Street, New York, N. Y., just east of Broadway. Roland Burke Hennessy, President; M. B. Hennessy, Vice-President; Herman Bernard, Secretary. Roland Burke Hennessy, Editor; Herman Bernard, Managing Editor; J. E. Anderson, Technical Editor; Anthony Sodaro, Art Editor.

New Style DeLuxe Leatherette Carrying Case FREE with each Jiffy Tester!

This combination of meters tests all standard tubes, including the new AC screen grid tubes and the new 245 tube, making thirteen tests in 4½ minutes! Instruction sheet gives these tests in detail.



A PORTABLE testing laboratory is yours when you possess a combination Jiffy Tester, for then you can measure the filament and plate voltages of all standard tubes, including AC tubes, and all standard battery-operated or AC screen grid tubes; also plate voltages up to 500 volts on a high resistance meter that is 99% accurate; also plate current.

The Jiffy Tester consists of a 0-20, 0-100 milliammeter, with change-over switch and a 0-10 volt AC and DC voltmeter (same meter reads both), with two sockets, one for 5-prong, the other for 4-prong tubes; a grid bias switch and two binding posts to which are attached the cords of the high resistance voltmeter; also built-in cable with 5-prong plug and 4-prong adapter, so that connections in a receiver are transferred to the Tester automatically. Not only can you test tubes, but also opens or shorts in a receiver, continuity, bias, oscillation, etc. The instruction sheet tells all about these tests.

In addition you can test screen grid tubes by connecting a special cable, with clip to control grid (cap of tube) and other end of special cable to the clip in the set that went to the cap before the tube was transferred to the tester.

THE new carrying case, which is furnished FREE with each order for a Combination Jiffy Tester, contains the entire outfit, including the three meters, cable and plug, and three adapters (one for 4-prong tubes, two for 199 tubes). This case is 10½x7¾x3½" and has nickel corner pieces and protective snap-lock. The case is made of strong wood, with black leatherette overlay.

To operate, remove a tube from the receiver, place the cable plug in the vacant receiver socket, put the tube in the proper socket of the Tester, connect the high resistance meter to the two binding posts, and you're all set to make the thirteen vital tests in 4½ minutes!

The Combination Jiffy Tester is just the thing for service men, custom set builders, experimenters, students, teachers and factories. Order "Jiffy 500." The price is only $14.50.

If a 0-600 AC and DC high resistance meter (99% accurate) is desired, so house electricity line voltage and power transformer voltages can be measured, as well as plate voltage, instead of the 0-500 DC voltmeter, order "Jiffy 600" at $15.50.

GUARANTY RADIO GOODS CO., 145 W. 45 St., N. Y. City. (Just East of Broadway).

☐ Please ship at once on 5-day money-back guaranty one "Jiffy 500," at $14.50, consisting of
(1) One Two-in-One 0 to 10 voltmeter for AC and DC. Same meter reads both. Scale especially legible at 1½ to 7½ volts. This meter reads the AC and DC filament voltages.
(2) One DOUBLE reading DC milliammeter, 0 to 20 and 0 to 100 milliamperes, with change-over switch. This reads plate current.
(3) One 0-500 volts high resistance voltmeter, 99% accurate; with tipped 30" cord to measure B voltages.
(4) One 5-prong plug with 30" cord for AC detector tubes, etc., and one 4-prong adapter for other tubes.
(5) One grid switch to change bias.
(6) One 5-prong socket.
(7) One 4-prong socket.
(8) Two binding posts.
(9) One handsome moire metal case.
(10) One instruction sheet.
(11) One de luxe carrying case.
(12) One screen grid special cable.

☐ If 0-300 DC high resistance 99% accurate voltmeter is preferred to 0-500, put check here. Price is same, $14.50.

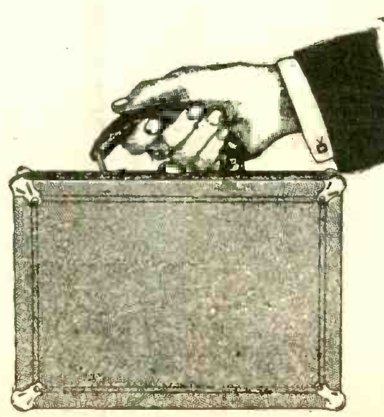
☐ Same as above, except substitute a 0-600-volt AC and DC high resistance 99% accurate voltmeter (same meter reads both) for the 0-500 DC meter. Price $15.50.

NAME ....

ADDRESS ....

CITY .... STATE ....

FIVE-DAY MONEY-BACK GUARANTY



The new de luxe leatherette carrying case is compact and handy. Size 10½" long, 7¾" wide, 3½" deep.