JULY 13th, 1929 15 Cents

RADIO WORLD

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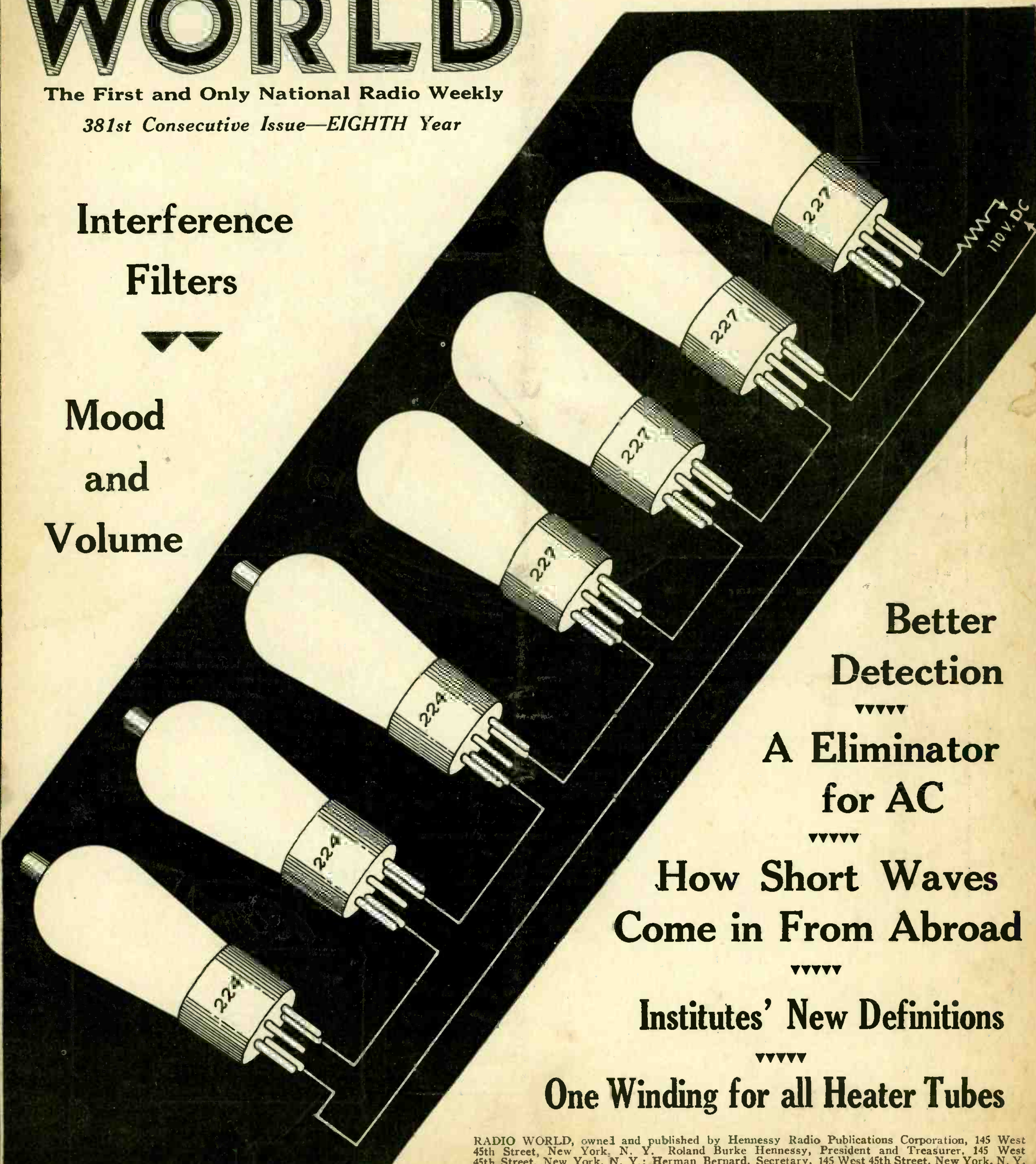
The First and Only National Radio Weekly

381st Consecutive Issue—EIGHTH Year

HEATER TUBES IN SERIES FOR DC OPERATION



Interference Filters

Mood and Volume

Better Detection

A Eliminator for AC

How Short Waves Come in From Abroad

Institutes' New Definitions

One Winding for all Heater Tubes

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, New York, N. Y.; Herman Bernard, Secretary, 145 West 45th Street, New York, N. Y.

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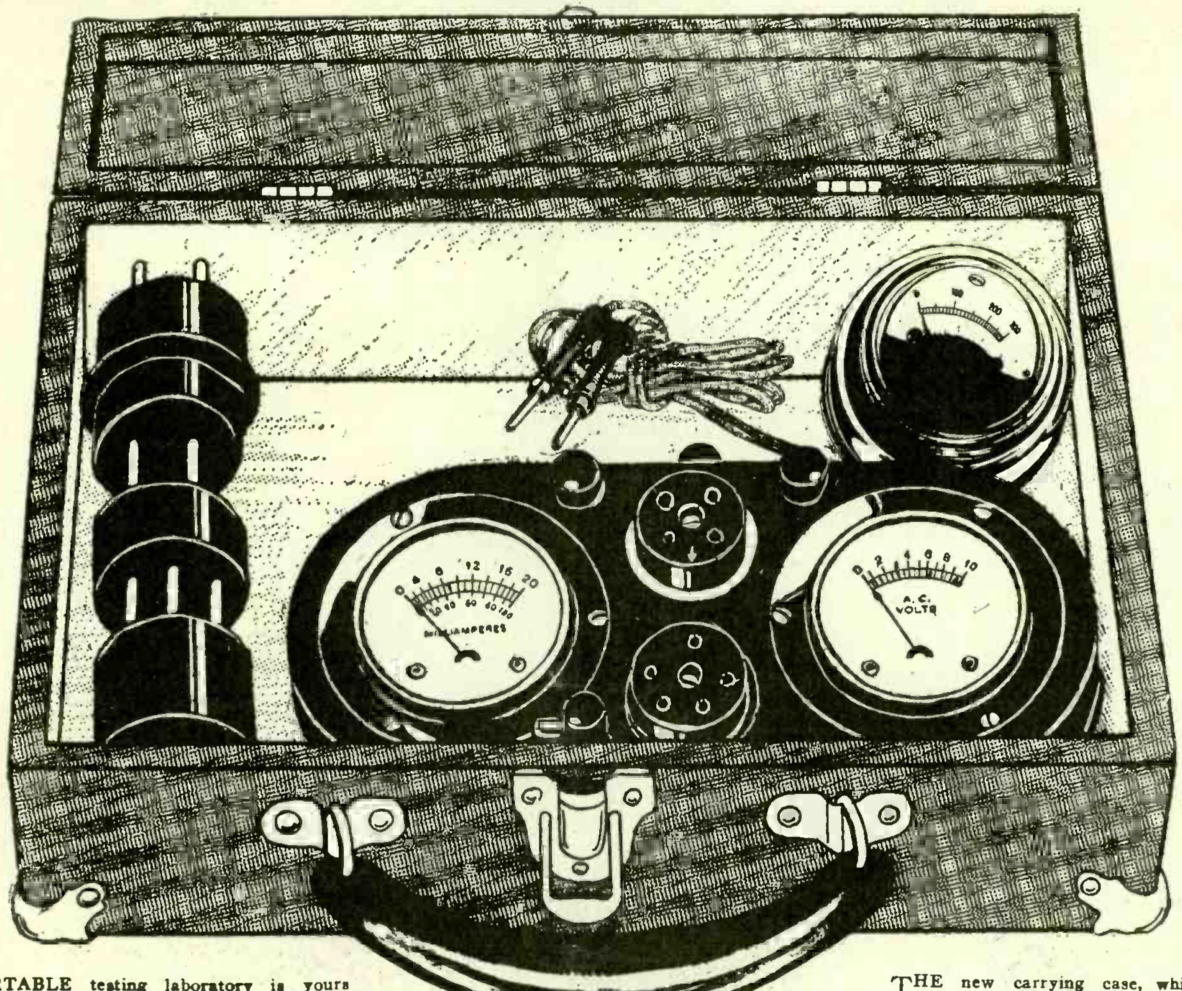
This combination of meters tests all standard tubes, including the new AC screen grid tubes and the new 245 tube, making thirteen tests in 4½ minutes! Instruction sheet gives these tests in detail.



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.

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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.

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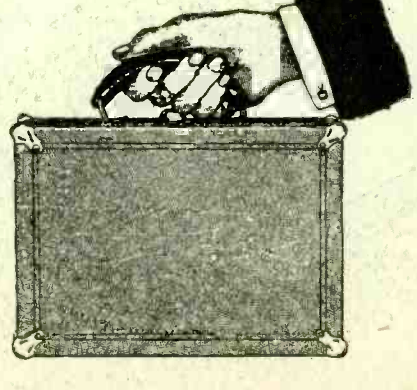
FIVE-DAY MONEY-BACK GUARANTY



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

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EIGHTH YEAR

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Better Detection

Bleeder to Cathode of Heater Tubes Important

By Herbert E. Hayden

IF the resistance to direct current were the only consideration, the choice of values would be very simple, many problems would cease to exist in this direction, and all would be serene, but in radio we are interested in alternating current operation of a vacuum tube, and the resistance to direct current present in any resistor is not even half of the story. The impedance, or behavior to alternating current, concerns us most because we find that a circuit that looks attractive on paper will not work out even fairly well because of impedance obstacles.

First Revelation

When B supplies were beginning to gain popularity, and were used in conjunction with audio circuits, particularly resistance or impedance coupled, motorboating was a common complaint, and the reason was not well understood until J. E. Anderson explained it in an issue of "Proceedings of the Institute of Radio Engineers." He revealed it was due to oscillation at audio frequencies and showed the relationship between the oscillation and the circuit that produced it, ascribing the common impedance of the cascaded circuits as the cause, and indeed contributing the phrase "common impedance" to radio terminology.

And ever since then the investigation of impedance has been one of paramount importance. The clue once given in a particular case was quickly seized upon as the possible cause of trouble in other instances. As the relative impedance is what counts, means of reducing a common impedance were sought. Mr. Anderson himself, last Fall in connection with an amplifying circuit, using a 227 tube, showed in RADIO WORLD a resistor joined from a high B potential to the cathode of the tube, so that the bleeder current through this additional resistor would flow through a biasing resistor to B minus. Thus the value of the biasing resistor was lower for the same bias, and the impedance was lower, which helped to solve a problem then considered, for the biasing resistor naturally was common to grid and plate circuits, and had to be treated with respect for that reason. No circuit union could be more disastrous if awkwardly engineered than one comprising the grid and plate circuits of the same tube as the components, or the grid circuit of one tube and the plate circuits of that tube and other tubes, as is very common.

First Application to Detector

Little attention was directed to the detector circuit, however, although the impedance question is just as important there. Everything revolves about the AC circuit when impedance is to be considered it is nearly always more important in an AC circuit, meaning one with filaments using AC, and with a B supply that rectifies the line voltage and current. The "AC" referred to previously as being the important consideration in vacuum tubes has to do with the signal voltage and current, for they are AC, no matter if the tubes are battery-operated.

When James Millen and Prof. Glen H. Browning were working on the design of the MB29, an AC tuner using four 224 tubes and a 227, the last-named as detector, they found that the plate current was decidedly unsteady when an orthodox biasing resistor was used in the detector circuit to provide detection. This unsteadiness disclosed the presence of distortion, the needle of the micrometer wabbling seriously. So a means was sought to remedy this.

Prof. Browning hit upon the solution, which was to introduce a resistor from a high B voltage point to the cathode of the 227, and to send this bleeder current along with the tube's plate current

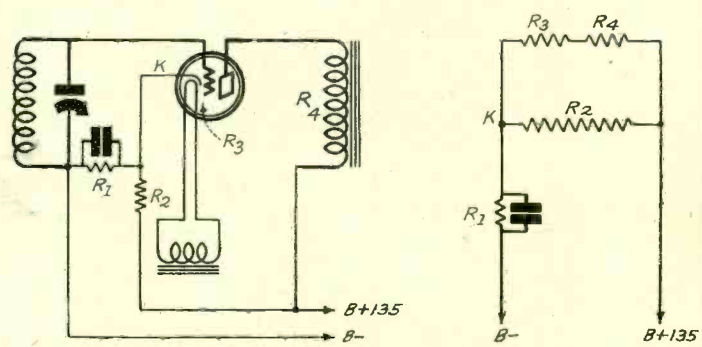


FIG. 1

THE BLEEDER METHOD OF REDUCING THE IMPEDANCE OF THE BIASING RESISTOR IN A DETECTOR CIRCUIT USING A HEATER TYPE AC TUBE, 227. THE SCHEMATIC DIAGRAM IS THE SAME AS THE CIRCUIT REPRESENTED BY RESISTORS ALONE, SO FAR AS THE IMPEDANCES ARE CONCERNED.

through the biasing resistor, which might now be of a much lower order of resistance, hence of lower impedance. It was recognized that the trouble sought to be remedied could be overcome by bypasing the original resistor with a condenser, but when one considered the value that the condenser would have to possess, that method was not advisable. More than 100 mfd. would have to be used to attain a result commensurate with reducing the resistor from 50,000 ohms, as originally used, to 1,800 ohms. Now a bypass condenser is still included in the circuit, but it need be only 1 per cent. as large. So that problem was solved fully, and the circuit then was ready for publication. RADIO WORLD was the first periodical to print the constructional details of the circuit (May 18th, 25th, June 1st and 8th). It is one of the most sensitive receivers ever presented. With two stages of audio and a B supply working it, nine Pacific Coast stations were picked up at Malden, Mass., in one night.

Plate Current Unchanged

The method of connecting the detector circuit for grid bias detection of the 227 is shown in Fig. 1A, where R1 is the biasing resistor and R2 is the resistor furnishing the bleeder current. Regarding only the direct current resistance for the moment, we see that from high voltage to zero the resistors are R4 for the primary of an audio transformer, R3 for the plate resistance of the tube, R2 for the bleeder resistor which is in parallel with the series-connected load-plate resistances, and R1, which is the biasing resistor in series with aforementioned series-parallel arrangement. The current therefore flows from B+ through R4 and R3, and simultaneously through R2 which is in parallel with them, next uniting to flow through R1. As the voltage drop in R1 is proportional to the current, the higher the current, the lower the necessary resistance to obtain the required negative bias.

The same circuit is shown in Fig. 1B, where the resistances are identified on the same basis as in Fig. 1A, but where resistors alone are used. The voltage source is 135 volts. This is the drop from B+ to B—. The drop takes place through four resistors. Two

Lessen Impedance!

Better Detection by Bias Method Results

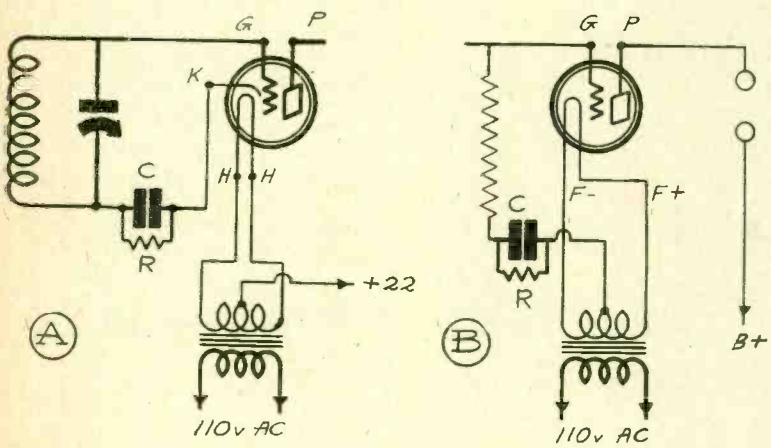


FIG. 2

THE 227 TUBE AT LEFT IS SHOWN WITHOUT BLEEDER CONNECTION. AT RIGHT IS A DIRECTLY HEATED FILAMENT, TO WHICH THE BLEEDER PRINCIPLE CAN BE APPLIED.

(*Continued from preceding page*)

of these are in series, R3 and R4. The current through these is the plate current, which is the same by the bleeder method or the other. This series pair is in parallel with another resistor, R2. This is the bleeder in parallel with the series resistances of plate and load. R1 is in series with the series-parallel group previously discussed. So the current flowing from B+135 volts divides between R2 on the one hand and the series-chain, R3R4, on the other, and then unites in R1 to return to B—, completing the circuit through the source of potential.

It can be seen that the point where the currents unite is R, which in Fig. 1A is the cathode of the 227 tube. The applied plate voltage is not 135 but the difference between the biasing voltage and the applied voltage, since plate voltage is reckoned from the cathode of the 227. Therefore if the negative bias is 20 volts, the applied plate voltage is 115 volts. But part of the applied plate voltage is dropped in the primary of the audio transformer, R4 in both diagrams. It is only a small part, however, since the plate resistance of the tube is more than 10,000 ohms (especially when worked as a negative bias detector,) while the resistance of the primary of the audio transformer is only a few hundred ohms.

Whatever the required values of R2 or R1 to obtain the required bias, it is plain that the effective plate voltage is the same, the plate current and bias are the same, and that nothing essentially is changed except the value of R1 which is lowered.

Important Improvement

This is the important contribution—the reduction of the impedance of the biasing resistor to such a low value (1,800 ohms as compared with 50,000 ohms) that stability, tone quality, freedom from motorboating and ease of operation are assured. These considerations make it imperative to use this method in an AC receiver, if the detector tube is to be worked in the region of high bias. Operation on that part of the characteristic curve (represented by plate current plotted against grid voltage) is a necessary safeguard where the radio frequency amplification is high, for otherwise the detector would be overloaded even on stations of a secondary order of field intensity at your antenna.

The other method is shown in Fig. 2A, where the bleeder is omitted, and R has to be prohibitively high. The plate voltage and current and the grid bias are the same as in Fig. 1A. The bleeder method can be applied to a directly heated filament, for then no high positive voltage would be applied to the filament to burn it out. In the heater type tubes the cathode or electron emitter is wholly independent of the heater or filaments except to the extent of their association by thermal radiation. The heater therefore is not a part of the radio circuit proper, and positive voltages applied to the heater do not destroy the emitter, either.

Right or Wrong?

(Answers on page 15)

(1) A radio receiver incorporating one or more screen grid tubes motorboats more readily than one in which all the tubes are of the three-element type.

(2) The inductor-dynamic speaker does not depend on magnetic attraction between a magnet and a piece of iron.

(3) A photo-electric cell does not require any voltage for its operation but the electrons are shot from the cathode to the plate to establish a current.

(4) Radio waves decrease in amplitude according to the same law as the intensity of light decreases, that is, their amplitude is inversely proportional to the square of the distance from the source.

(5) The screen grid in a screen grid tube does not take any current but operates in a manner similar to the control grid.

(6) The blue glow that appears inside a vacuum tube when the plate voltage is excessive is due to ionization of residual gases, brought about by the collision of electrons and atoms.

(7) The amplification factor of a vacuum tube depends on the distance between the grid and the filament.

(8) The amplification factor depends on the mesh of the grid and on the distance between the plate and the grid.

(9) The amplification factor of a tube can be calculated from the geometrical structure.

(10) When the grid of a tube becomes positive with respect to the filament it assumes the characteristics of a miniature plate and as such draws current.

Bar Is Unit of Pressure

The term bar is beginning to appear in radio literature, especially in connection with acoustic devices. What is its meaning?

The bar is the unit of pressure in the centimeter-gram-second system of units and means one dyne per square centimeter. A bar is very nearly equal to one millionth of an atmosphere.

The Prefixes

IN radio literature one often meets terms like megacycle, kilocycle, centimeter, milliampere, and many other terms containing prefixes indicating various multiples or sub-multiples of the units in question. These prefixes often occasion some confusion in the minds of the readers.

The system of prefixes to designate various multiples is taken from the metric system of weights and measures and is really very simple. The following table gives the values of the various prefixes. The number in each instance indicates the multiple or submultiple of the basic unit.

Mega	1,000,000	micro	.000,001
Myria	10,000	....	
Kilo	1,000	milli	.001
Hecto	100	centi	.01
Deka	10	deci	.1
Unit	1	unit	1.0

There is also the prefix pico, which is often used with capacities of condensers. It indicates micro-micro.

In the above table the multiples Myria and Deka are not used very often. The prefix Myria is sometimes used to indicate a metric mile. For example, one Myriameter equals 10 kilometers, which is one metric mile.

From the above table it is clear what one megohm means. It is one mega-ohm, or one million ohms. Likewise, it is clear that one megacycle means one million cycles. The prefix Kilo is used in kilocycle, kilowatt, kilometer and sometimes in kilohm. To say kilo is the same as to say one thousand.

Of the sub-multiples micro and milli are used most frequently in radio. We have microfarad, microampere, microwatt and microvolt. To say micro is the same as to say one millionth.

We would also have had micrometer for one millionth of a meter had it not been for the fact that the term was applied to an instrument for measuring very short distances long before the need for a name of one millionth of a meter was recognized. Now this unit of length is called the micron.

The prefix milli, meaning one thousandth, is used in milliampere, millivolt, milliwatt, millimeter, millihenry.

Heaters in Series

Screen Grid Circuit Is All-Electric on DC

By Randolph Charters

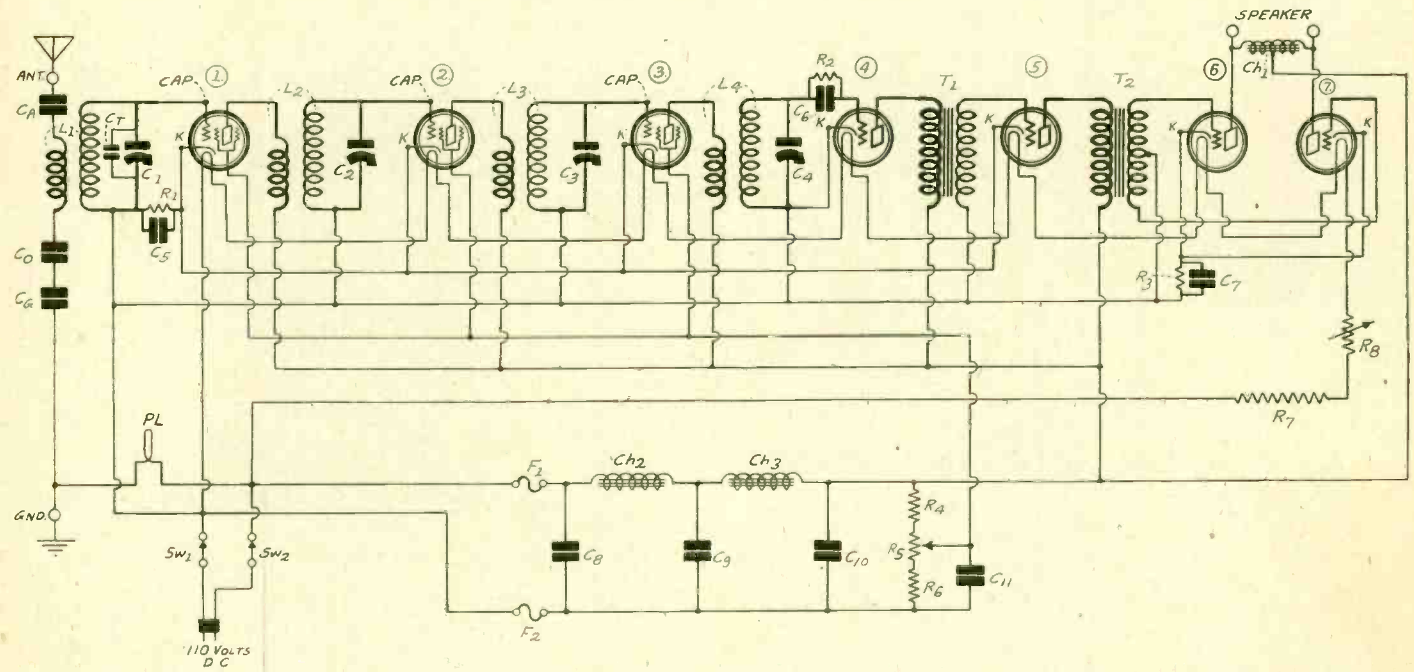


FIG. 1.

HEATER TYPE TUBES WITH FILAMENTS IN SERIES ARE USED IN THIS DC ALL-ELECTRIC RECEIVER. THE BIASING VOLTAGES ARE OBTAINED THROUGH THE VOLTAGE DROPS IN R1 AND R3. THE 110-VOLT INPUT IS DROPPED TO 17.5 VOLTS BY A RESISTANCE OF 52.9 OHMS. THREE 100-WATT LAMPS MAY BE CONNECTED IN PARALLEL FOR R7 TO DROP THIS VOLTAGE, AIDED TO A SMALL EXTENT BY THE SERIES RHEOSTAT R8.

THE biggest problem in a DC electric receiver, meaning one operating entirely from the 110-volt DC house lighting line, is obtaining a suitable resistor, of sufficient versatility and wattage rating, to dissipate the wattage between the 110 volts input and the 6 volts for the filaments of quarter-ampere tubes. But this problem can be avoided by using the heater type tubes with heaters in series.

This has two advantages: (1), the heater circuit is independent of the radio circuit, and (2), the total filament current is the same as the filament current of one tube, i.e., 1.75 amperes. This current is not comparatively low, since 2 amperes would be "top" current if eight quarter-ampere tubes were used, but when the heaters are connected in series the voltage dropped across the series is the sum of the voltages dropped across the heater of each tube. As the voltage is 2.5 volts for one tube, for the seven tubes shown in the diagram the total drop is 17.5 volts. Hence the desired voltage drop in a resistor in series with 110 volts is 92.5 volts. The wattage is the product of the voltage drop, 92.5, and the current, or 154.875 watts.

The resistor that drops this voltage at this wattage rating is R7 in Fig. 1. Thus R7 would have to be 52.9 ohms, rated at 300 a watts at least, because it is safer to use a resistor at half its rated wattage. A mazda lamp of 100 watts rating, at 120 volts, draws .833 ampere, hence has a resistance of 120/ .833, or 144 ohms. Two such lamps in parallel have a resistance of 72 ohms, three in parallel a resistance of 48 ohms (300 watts rating), or 4.9 ohms less than the required amount. Therefore a series rheostat R8 may be used as a vernier adjustment. Rheostats of 6 ohms resistance to carry 2 amperes are generally available, usually being of the ribbon type, and may be used here. Then the A problem is solved. Nothing is required except resistors, and these may be principally lamps. No filter is required.

Push-Pull Is Advisable

On the B side simplicity exists also. The line voltage of 110 is passed to the filter chokes CH2 and Ch3, which are aided in the filtration by the condensers C8, C9 and C10, each 4 mfd. of 200-volt DC working voltage rating. All plates of the receiver have the same applied voltage, about 100, due to the voltage drop in the choke coils Ch2 and Ch3. The detector and audio tubes will get a little less than that, actually effective, because of the drops in the primaries of the audio transformer and in the output impedance Ch1.

R5 is a volume control potentiometer, with a fixed resistor on either side, one (R4) to drop from the maximum voltage to about 30, for the screen grid positive voltage, the other (R6) to avert a zero voltage on the screen grids when the potentiometer arm is moved to a position of no resistance.

Series heaters lend themselves admirably to push-pull, because of the independence of the heaters from the radio circuit. Push-pull has an extra advantage, for the maximum undistorted power output, with about 100 applied volts and something less than that as the effective voltage, is rather low, but is approximately doubled by the series arrangement represented by push-pull. R3 takes care of the negative bias, which is 5 volts. R3 is 600 ohms.

A common resistor, R1, 800 ohms, provides a negative bias of a little more than 1 volt to the three screen grid tubes and the first audio tube.

The circuit is a sensitive one, and works very satisfactorily. The precautions required by a DC electric receiver are heeded, for instance, by use of series condensers in aerial and ground, double switching and fusing, and pilot light for indication of correct connection to the convenience outlet. The two switches may be physically one, if a double-pole double-throw switch. Both sides of the line are shut off when the switch is open, which is advisable, because one side is grounded, and if the "high" side is active, and some external ground is connected thereto by accident, the line would be shorted, and one or both of the fuses (F1, F2) would blow out. The fuses in the circuit protect the fuses in the home or in the common outlet for multiple families, as in an apartment house.

Data on Constants

The antenna series condenser CA is protective, also, as it safeguards the installation even if some grounded or "high" wire falls on your aerial. CO and CG serve the same relative purpose on the grounded side by preventing the connection of one side of the DC line to the receiver proper. There are two series condnsers in the ground side, merely as an extra safeguard, in the event one should short. This is indeed a remote contingency, if mica dialectric is used.

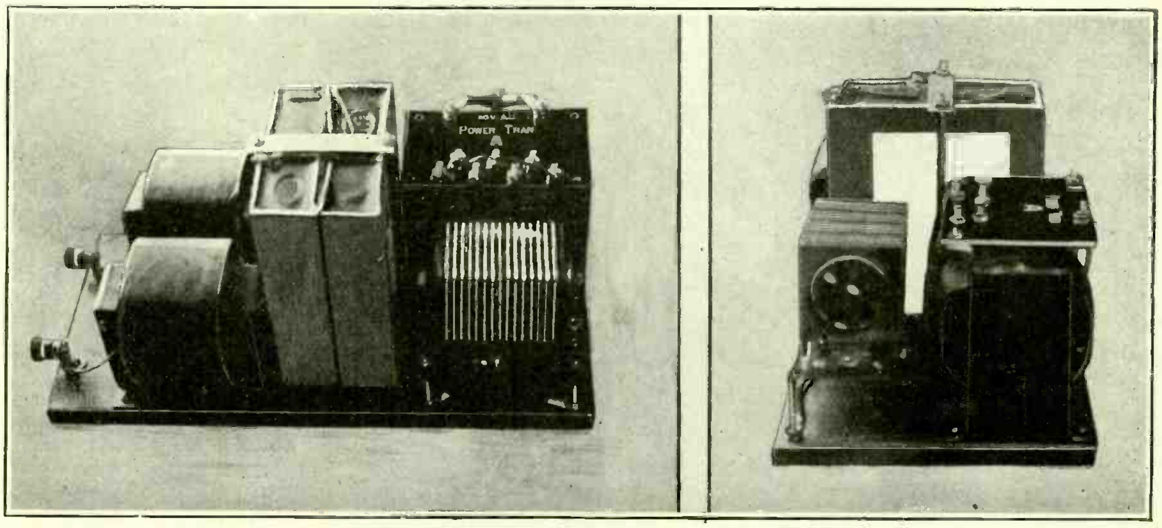
(*Continued on page 8*)

An A Supply

Works From 110v AC—Electrification Methods

By James H. Carroll

Contributing Editor



TWO VIEWS OF AN A SUPPLY TO WORK FROM THE 110-VOLT AC LINE

DESPITE the steadily growing sale of all-electric AC receivers, battery sets are still being sold and there will always be a certain demand for them. There are upwards of 6,000,000 battery sets in use throughout the United States and a large percentage of these owners is only now considering the problem of adapting them to electrical operation.

This is a comparatively easy task, in these days, and there are several effective ways of doing it, namely, by A and B eliminators, by rewiring the set for the use of AC tubes, or by attaching a harness, so that AC tubes may be inserted in the sockets, leaving the receiver otherwise as it is.

Eliminators of To-day

The addition of A and B eliminators is the most practical, satisfactory and easily applied method. Hum is eliminated. The majority of such units of the present day is dry, and long life under careful usage is assured.

If one already has a B eliminator, half the problem of electrification is solved. Fortunately, aside from the rectifier tube which should be replaced at the end of approximately a thousand hours' use, there is little to wear out or break down in the properly designed and constructed modern B eliminator.

Plate power requirements being taken care of, the C potential or grid biasing source is to be considered. Ample grid bias may be obtained by means of voltage drops through resistances in the various B circuits. Again, if a factory built B eliminator is used, it is practical to obtain C voltages by the insertion of suitable variable resistances, such as Clarostats, in unused or extra B plus taps. Another method is the use of a small, added C battery.

Sturdy A Eliminator

There are several good A eliminators on the market.

For the fan who can build his own or who wishes to have a competent service man build one for him, we will give here the diagram and list of parts for an unusually sturdy A supply. This has provided ample power for as many as ten tubes.

Filaments in Series

There is still another method of electrification available, in which all the tube filaments with the exception of the power tube are connected in series. This means rewiring the filament circuits of the receiver, however, and unless the fan is a skilled set-builder the services of a good service man or professional custom set builder should be sought. This method calls for an extra large B power unit, employing a 350 milliampere rectifying tube if 201A, one-quarter ampere tubes are used. However, if the low current 199 tubes are used, the 125 milliampere rectifier tube will amply supply the increased current drain.

In using this means of electrification, two important points should be borne in mind during rewiring, namely, the application of the proper voltages on filaments, plates and grids and confining the radio frequency tubes to their proper circuits.

A C Tubes in Battery Set

This brings us down to the AC tubes themselves, which may be applied directly in the battery receiver. One way is by rewiring the receiver throughout and the insertion, of course, of the proper sockets for AC tubes. This is costly. A simpler means of substituting the AC tubes without rewiring is by use of a harness or ready made wiring cable with adapters wired in, suitably spaced together with a suitable stepdown transformer.

Plate Power Unit Always Essential

B power must always be supplied in any form of electrification, so a B eliminator is always essential for this form of operation.

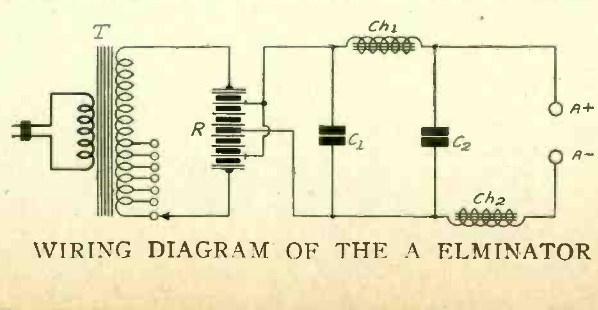
It is a wrong idea that AC tubes operate entirely on alternating current and do not need a B power unit. While the AC tubes operate on alternating current, a source of plate voltage is still necessary, and this voltage is always DC.

Most modern B eliminators provide voltage enough for the 171 tube and some of the new ones will provide 250 volts for the new 245 tubes.

No can or cover is needed, as very little heat is generated due to the construction of the transformer and chokes. The rectifier gets only moderately warm. There is no danger with the careful user and nothing to wear out. The rectifier may be replaced by removing a couple of screws.

LIST OF PARTS

One baseboard, 6x12 inches
One transformer
Two chokes
One Rectifier, electrolytic
Two 2,000 mfd. condensers
Two binding posts, A minus, A plus brackets for condensers



WIRING DIAGRAM OF THE A ELMINATOR

Foreign Reception

How Overseas Short-Wave Programs Sound

By H. B. Herman

[The construction of the Thrill Box was described in the June 29th and July 6th issues. Herewith are pointers on tuning and a description of the quality and type of reception to be expected.—Editor.]

FILLING the room with music from the other side—importing your programs, as it were—is indeed a great thrill. Moreover, with a good short-wave set it isn't hard. Unfortunately, location differences make it impossible to guarantee foreign reception, but no matter how poor the location, this side of a dead spot, long-distance reception is a virtual assurance. And even in a poor location foreign reception is to be expected at least once in a while.

So many persons have never even operated a short-wave receiver that perhaps they will be interested in some details of what foreign reception is like, and in what kind of reception they may expect on short waves in general. Much has been written on the subject, but rather too glowingly, so that a person who has thrown together some scrap parts eagerly looks forward to the reception of signals from the four corners of the earth, and maybe a peep from Mars, who knows? Well, Mars is out of the question for two reasons, one of them being you can't get it, and the other doesn't matter.

Listening to Chelmsford, England

As I am writing these lines I am listening on the loudspeaker to Chelmsford, Eng., coming in at 9 p.m. Eastern Daylight Saving Time, 1 a.m. London time the next day, playing phonographs records, and giving the number of each record. In fifteen minutes the announcer will sign off the station—shut down, as he will say—and will bid his listeners "good morning." But he knows that all over the earth persons are listening to his voice, some of them in the early evening hours, others rather later, as myself. But it's "good morning" in Chelmsford. Let's analyze the reception before it stops at 5SW.

It's coming in fairly clearly, with a small waxing and waning, on the fading fashion, but never reaching such low volume as to approach disappearance. Then the music stops. There is a pause. A rather long wait, we Americans think, for we expect our announcer to say something to break any pause, a habit that has grown upon us. But Mr. Britisher is somewhat more leisurely. Half a minute passes—seeming like 60 times as long—and we begin to suspect that we lost the station. Still, the dial reads the same—52. The coil hasn't been changed. It's still the B coil of the kit of coils with which the receiver may be worked. Then the music starts again, and we remember we are an impatient American, and muse that the British get more out of life than we do, anyway.

Around spins the record. No, you can not hear the needle scratch. Maybe a scratch filter is being used. More probably the high audibile frequencies aren't coming over as strong as they might. What about quality in general?

Frankly, we mustn't expect much quality. Remember that Chelmsford is in England, that the Atlantic Ocean stretches between, and that 2,900 miles separate the 4-tube National Thrill Box from that fascinating station across the sea.

The Announcer Says "Hahf"

Now comes an announcement. Each word can be understood. We hear the announcer say "hahf." Imported stuff, all right. Then we wonder if perhaps we are hearing the foreign program relayed—picked up on short waves by some American station and rebroadcast on short waves. We look at the coil chart and as we do so the announcer breaks the sad news that the station will "shut down." He gives the wavelength, 25.53 meters. That corresponds to the dail setting for coil B. It's direct reception all right. Now comes the inevitable "good morning" and the station is off the air.

Well, it was great fun while it lasted—a genuine thrill—well worth the whole price of installation. The outfit isn't expensive, four tubes, full set of coils, receiver, speaker and all. The tubes are, one screen grid 222 for RF, one 200A for detector, one 240 high mu for first audio, and one 171A output. Batteries energize the tubes. AC short-wave sets are too noisy.

With England gone for a while we are at liberty to try for some other stations. The coils permit us, with the aid of a switch built into the side of the condenser, to go from 15 to 535 meters, at least, sometimes to 570 meters. So we can listen awhile to some stations in the regular broadcast band, and notice how the set behaves. The switch is cut in only for coils E and F.

The feature of broadcast band reception is a handy one, but it must not be supposed that the receiver is well suited to this type of work. It just gets by. The quality is good, but the selectivity is of no high order. On short waves we found the selectivity all that it need be, and were well satisfied, but on broadcast waves we know now that a moderate degree of selectivity is all we can expect. But the volume is much greater than on short waves. There is no danger of overloading a 171A tube on any short-wave musical program that may be received, but on broadcast waves we can come near the undistorted maximum power output.

We'll go back to short waves, by pulling out the condenser switch and plugging in a short-wave coil. It is valuable to have the full set of six coils. There's no telling what band you will want to cover. Just the coil you will want is sure to be the one you haven't got, if you try to skimp along.

To tune in short waves you may invent your own method. Skill is required, but not of any high order. No. Ph.D. degree is required to fit you for this work. Just a little care, or more than a little care, plus patience and reasonable expectations.

Here is the method I use: I insert one of the short-wave coils in the receptable of the receiver and turn the regeneration control until the set is oscillating. Then I turn the control back a bit to get just under the oscillation point. Then I get the feel of the control, so I can turn it by the tinest fraction of a hair to go into and out of full oscillation. With that manipulation mastered, I turn the dial backward, that is, start at the highest number, 150, and go to higher frequencies. I go right up the line, passing up the code stations and trying for voice or musical instruments, in other words transmitted entertainment. There are at least ten times as many code stations easily receivable on one coil than entertainment programs, and on some of the other coils, particularly the smallest, the proportion is much larger. But still there are enough stations sending regular programs to make the play interesting. And it is fine play of a high order.

Three Settings for Each Division!

For each division of the dial I try to establish three settings. That is running pretty close, but you will find that two or three stations sometimes come in between adjoining dial divisions, and without a trace of crosstalk or other interference. Then when I get a voice station I listen until I hear the call letters, and these I record, giving not only the dial setting but also the letter of the coil.

In that way I get a pretty good grasp on the situation. Soon I will come to know your short-wave program stations by heart, as to coils and condenser settings, and also will know their hours on the air. There is no more thrilling way of learning these hours on the air than from experience.

The coil condenser data will help you:

Coil	Range	Condenser Switch
A	16,600-10,710 kc; 18-28 m.	Open
B	12,500-7,500 kc; 24-40 m.	Open
C	8000-4,600 kc; 37.5-65 m.	Open
D	5,000-2,650 kc; 60-115 m.	Open
E	2,680-1,750 kc; 110-175 m.	Open
E	1,1764-1,000 kc; 170-300 m	Closed
F	1,034-526 kc; 290-570 m.	Closed

As for foreign stations, 5SW is regularly on the air E. D. S. T. Monday, Tuesday, Wednesday, Thursday and Friday, 7:30 to 8:30 A.M.; 2 to 7 P.M. Also occasionally at other periods besides. PCJJ, Eindhoven, Holland, 31.2 meters, coil B, is on 6 to 9 P.M., Monday, Tuesday and Thursday.

A word about aerials. The Thrill Box has an untuned input stage, so your broadcast aerial will do. But try the set out with the ground connected to the aerial post. Sometimes you get better reception that way, leaving off the aerial proper. In general, a good aerial, with ground to cold water pipe, will give better results. Not always, however.

The antenna post is in the receiver. The ground should be connected directly to the common A+, B— and C+ point, equivalent to the yellow cable emerging from the receiver.

The Thrill Box you may build yourself from the official list of parts and blueprint, or you may obtain it built-up at a few dollars extra. In either event, use the steel cabinet, with its attractive, conservative brown finish. When operating the receiver, keep the cabinet lid down, to minimize microphonic effects sometimes present when regeneration is pressed too hard on the higher frequencies.

And by all means get into the short-wave swim and enjoy the thrill of thrills!

5SW, Chelmsford, England!

"Good Morning!"

Radio Seeks Tongue

Effort Made to Standardize Terms

By J. E. Anderson

Technical Editor

THE Institute of Radio Engineers is endeavoring to standardize the use of terms so as to make the meaning of terms used in radio literature more precise. This endeavor has led to the introduction of some new words. One of these is transduce, with its derivatives. To transduce is to transform energy from one form into another, for example, electric to acoustic. There are many forms in which energy occurs, such as electric, thermal, chemical, luminous, mechanical and acoustic. To transduce is to change the energy from any one of these forms into any other, and a transducer is any device which performs the transduction. In the definitions issued by the Institute, the term power is used rather than energy, and power is the time rate at which energy is delivered or absorbed, or transduced.

A distinction is made between passive and active transducers. A passive transducer is one in which the power supplied to the second system is derived entirely from the power available in the first system. An electrical generator is of this type as well as certain forms of microphones. An active transducer is one in which the power supplied to the second system is derived from a local source which is controlled by the power existing in the first system.

The Unsteadiness of Static

The term signal is used to denote "the intelligence, message or effect conveyed in communication." It would seem that this term is broad enough to include interference in certain instances because of the inclusion of the word "effect," particularly when interference is being studied.

Static is defined as "conduction or charging current in an antenna resulting from physical contact between the antenna and charged bodies or masses of gas." This seems to be an unfortunate definition, because it is self-contradictory. Static means steady while current signifies the reverse. No loss would result to the science of radio if the term "static" were eliminated entirely. There may be some justification for using the term to distinguish between steady state and dynamic characteristics, but even for this purpose it would be better to omit the term and use a more appropriate term. Curves obtained with steady current are not static characteristics.

An oscillator is defined as a non-radiating device for producing alternating power, the output frequency of which is determined by the characteristics of the device. This definition supposes that power is capable of alternating, a supposition which is not admissible.

C "Power" and Voltage Amplification

The term capacitance is used for that property of a condenser which most of us call capacity. This term is finding favor with writers because it fits in with the forms of other electrical properties without at the same time savoring of the ridiculous. Unfortunately, the term capacitance is defined but the term capacity is used in many definitions. The definition of capacity is omitted.

We note with satisfaction the omission of the term capacitor from the list of definitions. Apparently the committee that formulated the definitions were unable to discover just how a condenser capacitates, which every good capacitor must do.

Under the expression voltage amplification it is suggested that the expression should not be used to describe a process. A suggestion as to how the process should be described would have been helpful in this connection. Certainly the process of voltage amplification is important enough to be entitled to descriptive expression.

A loading coil is defined as an inductor and in the very next definition a choke coil is called an inductance coil. If a loading coil is an inductor so is a choke coil.

Under power supply devices a C power supply is defined as a device to be connected in the grid circuit of a vacuum tube to supply the grid bias. It would have been better to call this a C potential supply. A C voltage supply could be used to include both batteries and rectifier-filter devices.

A Constructive Suggestion

An electro-acoustic transducer is defined as a transducer actuated by power from an electrical system and supplying power to an acoustic system or vice versa. It would have been better to define another term, namely acousto-electric transducer, to account for the "vice versa" portion of the definition. Then an electro-acoustic transducer would be a loudspeaker, for example, and an acousto-electric transducer would be a microphone. The placement of the components of the compound words would indicate the direction of the transduction.

While the above is largely adverse criticism, it is the only adverse criticism of the definitions I have to offer; they are on a sound, high plane in general.

The various definitions are distributed in nine different sections, with a number attached to each definition to indicate the section to which it belongs and the number within each section. Thus Section 2 is devoted to Waves and Wave Propagation and all definitions coming under this section begin with the number 2. The eighth definition in this section is that of signal, the number of which is 2008.

This number system is convenient for referencce to the definitions when they are used by someone, but they are not convenient for looking up when the number is not given. Another list of definitions should be prepared in which all the definitions are listed alphabetically. In this list the section number could be inserted with each definition for reference to related definitions and concepts.

Other Contents of Year Book

The Year Book of the Institute of Radio Engineers contains, besides the list of definitions, two complete lists of Institute members, one giving them in alphabetical order and the other in geographical order as to residence. The geographical list is alphabetically arranged as to countries, states, provinces, cities and names.

A very useful portion of the book relates to circuit testing and the standardization of receivers. Various testing circuits are given for measuring selectivity, fidelity and sensitivity of receivers and for measuring the principal characteristics of vacuum tubes.

Constants for the DC All-Electric Receiver

(*Continued from page 5*)

CT is a trimming condenser, set once and left thus, hence is not on the front panel. Its capacity at maximum is 70 mmfd. The tuned circuits may be arranged for .00035 or .0005 mfd. condensers. A gang condenser, of four sections, may be used, as all grid returns are to the grounded side of the DC line. This is usually negative. PL will tell you which side is grounded. It will light only when connected to a given side of the line, and it is that side which is not grounded that will cause the lamp to light. This is because one side of the lamp is connected to external ground, so the other side is connected experimentally to one side of the line, then to the other. When connected to the wrong side of the line the lamp will not light, as there is no potential difference across its filament. When the correct side is found the lamp is left connected thereto permanently. However, the receiver may not work, because negative side of the line may be going to the plates. Correct this by reversing the plug in the wall socket and by reversing the connection of the pilot lamp. If the pilot lamp and the lead to the chokes Ch2 and Ch3 go to the same side, the lamp PL lights, and the set works, the positive side is grounded. If they go to the other side, the lamp PL lights, and the set works, the negative side is grounded

R4 is 2,500 ohms, R5 is 500,000 ohms, R6 is 100,000 ohms, F1 and F2 are 1 ampere cartridge type fuses, with fuse clips; Sw1 and Sw2 are a double-pole, double-throw switch, PL is a 110-volt pilot lamp with candelabra base, CA, CO and CG are .0005 mfd., C5 is 1.0 mfd. or higher capacity, R2 is 2 meg., C6 is .00025 mfd., C7 is 4 mfd., 200 volts DC working voltage rating, Ch1 is a center-tapped output impedance for push-pull, Ch2 and Ch3 are a Silver-Marshall Unichoke, 331. The coils are: 14 turns for primary of L2, 24 turns for primaries of L2, L3 and L4. All secondaries have 48 turns for .0005 mfd. or 60 turns for .00035 mfd. The diameters are 2½", the separation between windings ¼", the wire No. 24 single or double silk covered. All sockets are of the Y type, that is, have five prongs. The control grid connections to the 224 tubes (1, 2 and 3) are made with National grid clips. The four other tubes are 227s. The circuit works a dynamic, magnetic or inductor speaker.

A condenser of .0005 mfd. may be tried from plate of the detector tube (4) to cathode of that tube, as a possible improvement in detection.

POWER AMPLIFIERS

(This series was begun in the June 1 issue and has continued each week. Herewith is Part IX. Part X will be published next week.—Editor.)

Choice of Grid Bias

It is well known that when a vacuum tube is used either as an amplifier or as a plate bend detector a suitable grid bias must be used. How is this bias selected for a given tube and purpose? Upon what does the amount of bias needed depend?

If the tube is used as an amplifier the first condition imposed on the bias is that it be greater than the peak of the strongest signal voltage that will be impressed on the tube. This condition is necessary to prevent distortion, for as soon as the grid goes positive with respect to the filament or cathode, current flows in the grid circuit and this results in a lowering of the output current. The peaks of the output current corresponding to the positive peaks of the signal voltage will be flattened out.

The significance if this is illustrated in Fig. 41, in which Eo is the grid bias, Ip the plate current for any given grid voltage Eg, and E is the amplitude of the signal voltage. A sinusoidal voltage wave is assumed. It will be noted that as soon as the Eg, Ip curve reaches the point of zero grid voltage it flattens out. For a certain region of negative bias, as between P1 and P2, the curve is practically straight. Below P2 it flattens out again.

The operating grid bias is Eo and the operating point on the curve is Po. The signal voltage wave of amplitude E changes the grid voltage between the limits Eo—E and Eo+E. Eo is inherently negative so that Eo—E corresponds to the point P2 and Eo+E to the point P1. The sinusoidal variation of the grid voltage about Eo results in a sinusoidal variation in the plate current about Io, with a current amplitude I. The actual plate current varies between the limits Io+I and I—Io. As long as the grid voltage wave remains on the straight portion of the Eg, Ip curve the plate current wave will have the same form as the grid voltage wave, and there will be no distortion.

Now suppose Eo be decreased. The operating point Po will then be moved higher on the curve, nearer the axis OIp. The peak of the signal voltage will now pass beyond the zero line into the positive region of grid bias. The top of the positive current loop will be cut off as shown in Fig. 41A. The dotted portion of this loop indicates where the curve should go if there were no distortion.

If the bias remains as in Fig. 41 and the amplitude of the signal voltage wave is increased until E is greater than Eo is as clear that the top of the current curve will be flattened out just as shown in Fig. 41A. This shows the importance of keeping the grid bias greater than the peak of the signal voltage which will be impressed on the tube.

However, increasing the grid bias until it is greater than the highest signal peak does not insure against distortion. The Eg, Ip curve flattens out at the higher values of Eg also. If the bias is increased until the operating point is P2, it is clear that the negative current loops will be flattened out, as illustrated by the

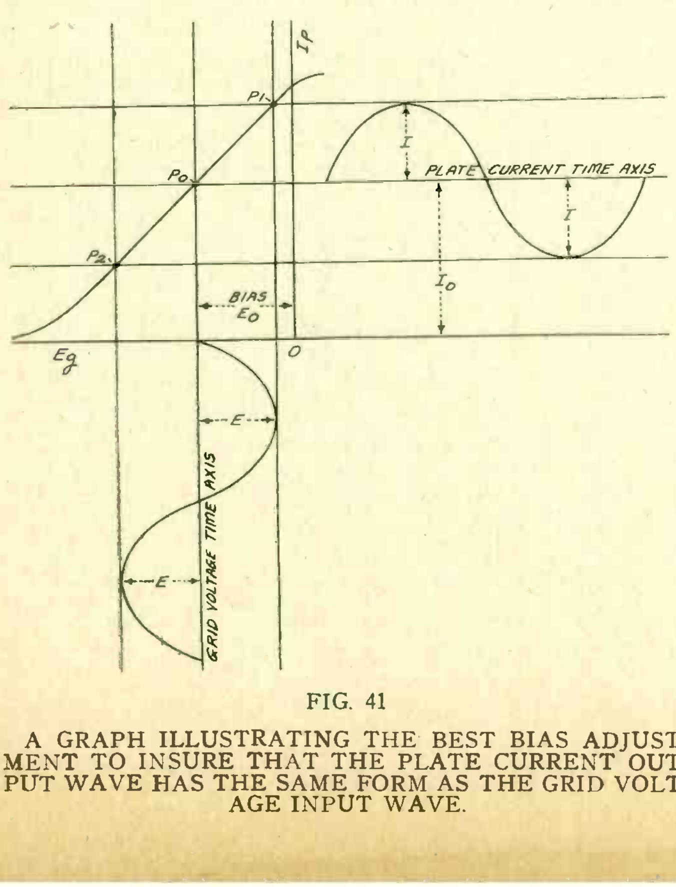


FIG. 41

A GRAPH ILLUSTRATING THE BEST BIAS ADJUSTMENT TO INSURE THAT THE PLATE CURRENT OUTPUT WAVE HAS THE SAME FORM AS THE GRID VOLTAGE INPUT WAVE.

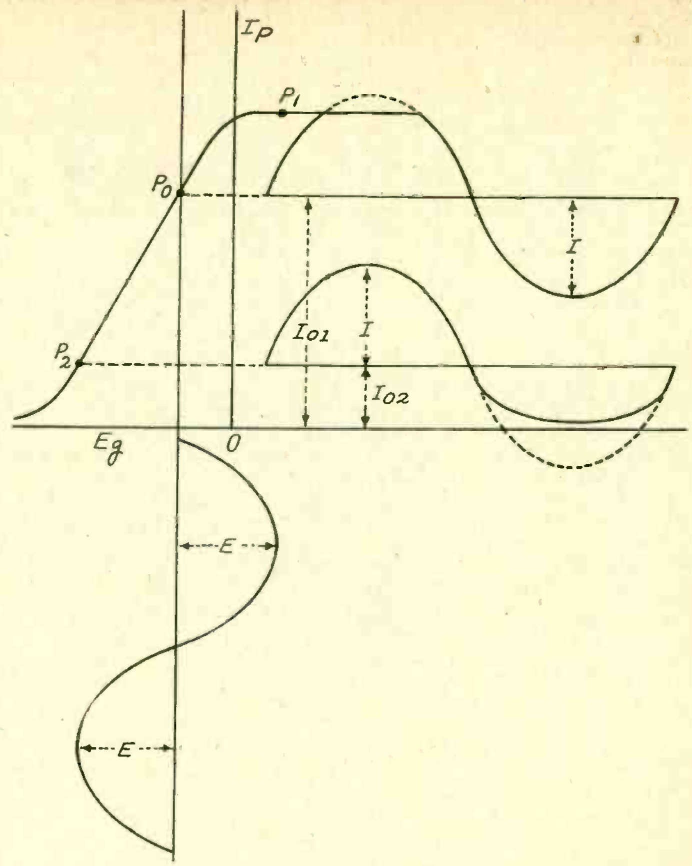


FIG. 41A

GRAPH ILLUSTRATING THE FLATTENING OF THE PEAKS OF THE PLATE CURRENT OUTPUT WAVE WHEN THE BIAS IS TOO LOW (UPPER CURVE) OR TOO LOW (LOWER CURVE.)

lower current curve in Fig. 41A. Hence the bias cannot be increased beyond a certain value without introducing distortion in the plate current wave form.

There must be, then, a certain value of grid bias which gives the best results for a given signal amplitude.

Let the grid bias be adjusted as in Fig. 41, which seems to be the optimum for that particular Eg, Ip curve. Now if the signal amplitude E increased considerably so the positive loop encroaches on the positive voltage region and the negative loop on the curved portion to the left of P2, both peaks of the plate current curve will be flattened out. Hence even if the bias has the optimum value, only a signal of a certain amplitude can be impressed on the tube without introducing wave form distortion in the plate current.

The first consideration in selecting a grid bias for a tube is to make sure that it is larger than the largest signal peak that will be encountered. If this bias throws the operating point too far into the negative region, so that the negative current loops will be flattened, it becomes necessary to make other circuit adjustments, such as increasing the plate voltage or substituting a tube of a lower amplification constant.

It is customary to list tubes of various types with normal grid bias and plate voltage. It is not necessary in all instances to use the full grid bias specified for a given plate voltage. A greater amplification and less distortion may often be obtained if the bias is less. This is true when the amplitude of the signal voltage is small, for if the plate voltage is high and the signal voltage low, the only limit on the grid bias is that determined by the condition that the grid must never go positive. There is one objection against the use of a low grid bias and a high plate voltage, and that is that the plate current will be higher than is necessary for satisfactory operation. This objection is not serious except when B batteries are used.

When the amplified tube is operated with alternating current on the filaments the grid bias is measured from the mid-point on the filament. In such circuits grid current will begin to flow before the grid bias is zero. In fact it will begin approximately when the grid bias is equal to one-half of the peak value of the filament voltage. For example, suppose the tube requires a filament voltage of 7.5 volts. One-half of this is 3.75 volts and the peak value, assuming a pure sine wave heating current, is 1.41 times 3.75 volts, or nearly 5.3 volts. Allowance must be made for this either in selecting the grid bias or in judging the maximum signal voltage that can be impressed on the tube. If the tube in question is a —50 type requiring a plate voltage of 450 and a grid bias of 84 volts, the maximum signal that should be impressed is 78.7 volts. If the amplitude of the signal voltage is greater than this the peaks of the positive current loops will be flattened slightly. If the full 84-volt amplitude is desired, the bias on the tube should be raised to 89.3 volts. It is assumed that the operating point can be shifted to this bias without resulting in flattening of the negative current loops by the curvature of the Eg, Ip curve.

If the tube is a 245 type the grid will not begin to draw current until the bias is 1.76 volts. The normal bias of 50 volts should be increased by this amount or else the maximum signal voltage should be reduced by the same amount. In this tube the curvature at the upper end of the Eg, Ip curve is not great and very little distortion is encountered even if the grid voltage is allowed to become zero.

It is often asked whether it is necessary to adjust the grid bias to suit the type of impedance in the plate circuit of an amplifier. This is particularly asked with respect to resistance coupled amplifiers in which the plate resistance is very high. The argument is that the voltage drop in the plate coupling resistance is so high that the net voltage on the plate is very low, and therefore the bias should be reduced to fit the lower effective plate voltage. In a three-element tube the drop in the plate impedance has nothing to do with the required grid bias. Neither is it necessary to raise the effective voltage on the plate. It is not the effective voltage on the plate that counts, but the effective voltage *in* the plate circuit. The bias should be selected to fit the signal and the applied voltage in the plate circuit. And the voltage in the plate circuit should be high enough to support the grid voltage swing without reference to the type of load on the plate. It is just as important to use a high voltage in the plate circuit when employing transformer coupling as when employing resistance. Just why an inductive voltage drop should be discounted is difficult to fathom.

In a four-element, or screen grid tube, the plate load impedance as well as the screen grid voltage affect the value of grid bias that should be selected. Moreover, an inductive or resonant load of given value affects it just as much as a resistance load of the same value.

In the four-element tube, for a given plate load, the bias must be increased as the screen grid voltage is increased, and for a given grid voltage, the bias must be increased as the plate impedance is increased, the plate voltage being assumed constant. For given values of screen grid voltage and plate load impedance, the grid bias for optimum amplification may be held constant by increasing the voltage in the plate circuit.

The same rules apply to the selection of bias for best plate bend detection as for amplification, for the same type of tube and circuit adjustment, except that the grid bias must be increased to the point where the Eg, Ip curve bends upward most rapidly. In Figs. 41 and 41A, the best bias for detection a distance to the left of P2. While good detection could be obtained theoretically at the upper bend of the Eg, Ip curve, the detecting efficiency at this point is not as good as the sharpness of the bend indicates because the grid current that flows when the grid is positive introduces resistance in the tuned circuit ahead of the detector tube.

The best operating point for detection on the lower bend is usually quite critical so that careful adjustment is required to get most out of the tube.

The bias required on an amplifier tube is associated with the progress of the amplification in the circuit as well as on the other factors discussed, that is, it is dependent on the signal voltage level on the grid of each tube. Let us see how the required grid bias varies in a typical circuit. Suppose the last tube is of the 245 type and that the plate voltage is 250 volts. With this plate voltage the tube takes a normal bias of 50 volts. But we have seen that the signal voltage should not cause the grid to come closer than 1.76 volts of zero. Therefore, we are limited to a signal input of 48.24 volts.

Let the tube ahead of the power tube have an amplification factor of 30 and let the coupler between the two tubes be resistance such that the effective voltage step-up is 20 times. The signal voltage amplitude on the grid of the high mu tube must therefore be 48.20/20, or about 2.4 volts. Therefore the bias on this tube must be greater than this amount. The tube in question is a DC tube, in which the bias is measured from the negative end of its filament. No allowance need be made for any voltage drop in the filament as in the case of an AC tube.

There will also be a 4-ohm resistor in the negative leg of the filament, in which the voltage drop will be one volt. Hence we need provide an additional grid bias of a little more than 1.4 volts. A dry cell will furnish 1.5 volts, which is suitable.

This bias, 2.5 volts in all, does not make any allowance for a variation in the amplification. If this is smaller than the assumed 20, the high mu tube will overload before the power tube is loaded to its capacity. Hence it is advisable to increase the bias on the high mu tube, and it can be done without introducing wave form distortion provided that the voltage in its place circuit is high enough to support the fluctuations. We might well make the total bias on the high mu tube 4 volts, that is, 3 volts in addition to the drop in the ballast. If the plate coupling resistor is 100,000 ohms or more, and if the voltage in the plate circuit is 180 volts, the wave form will not be distorted appreciably when the grid swings about 3 volts either side of the operating point.

The question now is how to get the signal voltage on this high mu tube. If a power detector is used it may be obtained directly from that, either by means of resistance or transformer coupling. If the detector is not capable of delivering the voltage, another amplifier tube is needed. This, too, can be of the high mu type and direct coupled to the detector. Since this tube with its coupler can be made to amplify 20 times, the signal on the grid need not be greater than .125 volt. This is well within the bias limit of the voltage drop in the ballast resistor, so no other bias need be provided. The plate voltage on this high mu tube need not be greater than 45 volts, although a higher voltage will give a little higher amplification.

The selection of bias for radio frequency amplifiers is done the same way as for an audio amplifier. The starting point is the bias needed on the detector. In most instances the radio frequency voltage is so low that it is not necessary to give any of the amplifier tubes a bias greater than 1.5 volts.

In a radio frequency amplifier, especially one followed by a tuner, it is of little importance whether or not there is wave form distortion, but it is very important that no grid goes positive during any part of a cycle. If the grid goes positive grid current flows and the selectivity of the circuit is greatly reduced as a consequence. Hence the important thing in the selection of a bias for a radio frequency amplifier is that it be large enough not to permit the grid to go positive. With that assured the bias can be selected so that the amplification is the greatest possible. For three-element tubes that means that the bias should be as small as the first condition permits. For four-element tubes it means that the steepest operating point on the Eg, Ip curve should be found. It may be found at a high bias value. Only a trial will determine where the most sensitive point is.

Bias Required

The grid bias required by a tube depends on the amplification factor of that tube. The lower this factor is the greater should the bias be. Thus the 171A tube, which has an amplification factor of 3, requires a bias of 40 volts, and a 240 type tube, which has an amplification factor of 30, requires a bias of about 3 volts.

The plate current that flows in a tube depends on the factor Ep+uEg, where Ep is the actual plate voltage, u the amplification constant of the tube, and Eg the actual grid voltage. Ep is always positive and Eg may be either positive or negative, although it must always be negative when the tube is used as an amplifier. Since Eg is essentially negative, and as the plate current contains Ep+uEg as a factor, it is clear that if Eg is increased there will be one value at which the plate current is zero. The value of Eg which just reduces the plate current to zero is Ep/u.

For a given value of Ep, the larger u is the more quickly is the plate current reduced to zero as the bias is increased. It is clear therefore that if the same bias is used for a high mu tube as for a low mu power tube, there may be no plate current at all. The operating bias for any tube must be such that the plate current can increase as the bias is reduced and decrease when it is increased.

Note that the Ep used above is the actual plate voltage, not the plate battery voltage. If there is a considerable impedance in the plate circuit the plate voltage will be less than the plate battery voltage by the amount of drop in this impedance. When the grid bias is low the current is high and therefore the voltage drop in the plate load impedance is high. And when the grid bias is high,

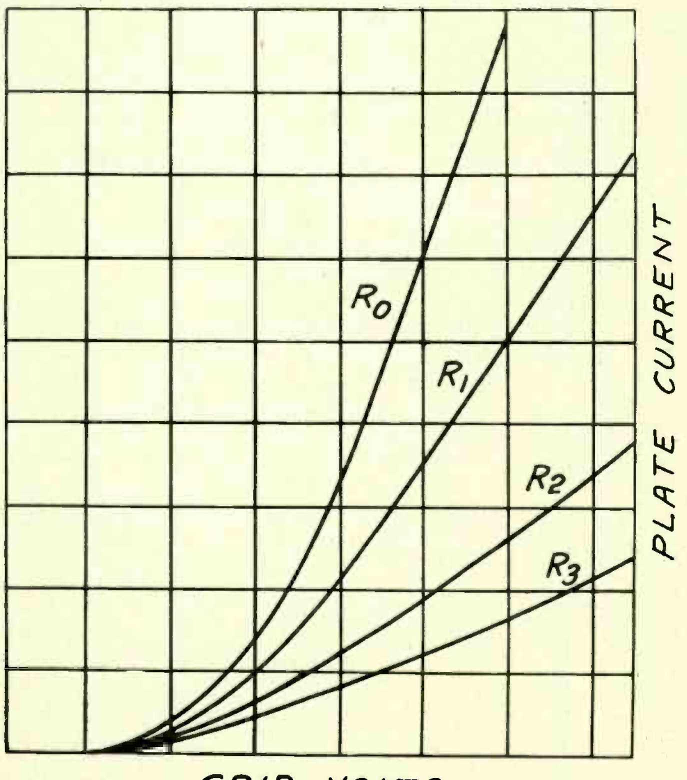


FIG. 42

CURVES SHOWING THE RELATIONSHIP BETWEEN THE GRID VOLTAGE AND PLATE CURRENT FOR VARIOUS VALUES OF LOAD RESISTANCE, THE PLATE BATTERY VOLTAGE REMAINING CONSTANT. RO IS FOR NO LOAD AND R3 FOR THE HIGHEST LOAD RESISTANCE.

the plate current and the voltage drop in the plate load impedance are low. That is, for high bias values on the grid the effective voltage on the plate is nearly the same as the voltage of the plate battery. When the current has been reduced to zero the voltage on the plate is exactly equal to the battery voltage. The grid bias at which the plate current is just reduced to zero is determined by Eb+uEg, where Eb is the plate battery voltage.

This is true whether or not there is a plate load impedance. Hence all the characteristic curves for different values of the plate load impedance will meet at a point on the grid voltage axis. The only difference between a curve for high plate load and no plate load is that the current in the plate circuit is greater for the lower loads, the difference increasing as the bias is reduced from the point of intersection of the curves. The curves for the larger plate loads will be less crowded, as shown in Fig. 42.

No change in the bias is required when a higher plate impedance is inserted in the circuit. The operating point may remain at the same grid bias value, and the position of the point is somewhere between the point at which the curves meet the Eg axis and zero bias. However, when the plate load impedance is increased, the grid bias may be increased, for the characteristic curve remains nearly straight over a larger range of bias.

If the condition that the grid always must remain negative demands a bias so high as to throw the operating point over on the crooked portion of the characteristic, the situation may be met by (1) increasing the plate voltage on the tube, (2) substituting a tube having a lower amplification constant, or (3) increasing the load impedance of the tube. The first of these is the simplest to apply, for it requires changing only one lead in the circuit. The second may be equally simple provided a low mu tube having the filament requirements of the high mu tube for which the circuit was designed. The third, that is, increasing the load impedance, is convenient in the case of resistance coupled amplifiers, for it is only necessary to change a resistor in a clip. However, this method does not afford the improvement that either of the other two methods does, for its range is limited.

The choice between increasing the voltage on the plate of the tube and the use of a lower mu tube rests on the amplification that is needed in the circuit. It may be that the amplification is just sufficient when the high mu tube is in the circuit. Then if a low mu tube is substituted, it becomes necessary to add another stage to the amplifier. Rather than do that it is better to raise the plate voltage on the high mu tube, permitting the use of a higher bias. On the other hand, if the amplification is more than sufficient, the low mu tube may be substituted without adding another stage. Of course, it is not necessary to change from a tube having a mu of 30 to one having a mu of 3.

Those who are interested in building high quality amplifiers should get into the habit of doing so by curves which they themselves have taken. The taking of a grid voltage, plate current curve on any tube, under any conditions is a simple matter. Static curves may be used, and these can be taken with a DC voltmeter and a DC milliammeter. As soon as the shape of a curve is known it is easy to tell how high the bias should be, and how high it can be made without introducing much distortion. The idea is to keep one peak of the signal voltage off the curved portion of the characteristic as well as to keep the other off the positive region, or the curved portion due to grid current.

Principles of the Push-Pull Amplifier

A push-pull amplifier is a balanced or symmetrical amplifier. The object of using such a circuit is to eliminate as much as possible the distortion of the wave form arising from the non-linear characteristic of vacuum tube.

If a tube and its associated circuit could be made such that the relation between the grid voltage and the plate current were a straight line, there would be no need for push-pull amplifiers. Similarly, if the relationship between the grid voltage and the plate current could be made symmetrical about some point, there would be no need for push-pull amplifiers. But so far it has not been possible to bring about either of these characteristics, except by the use of push-pull circuits.

The graph in Fig. 43A shows the usual type of unsymmetrical curve of a vacuum tube and its associated circuit. It follows a law which is nearly parabolic. No matter where the operating point Po be chosen, the curve will be steeper on the upper portion than on the lower, which means that the positive current loops in the plate circuit will be higher and more peaked than the negative loops. This distortion of the wave form is equivalent to the introduction of harmonics into the output. All harmonics of odd and even degree are present.

Fig. 43B shows a curve which is symmetrical about the point Po. If such a relationship could be brought about between the grid voltage and the plate current, and if the operating point were made to coincide with the point of symmetry Po, only the odd harmonics would appear in the output current. The even harmonics would be absent because of the symmetry of the curve about Po. If such a characteristic could be brought about in a circuit there would be no object of using push-pull, because the push-pull amplifier eliminates only the even harmonics. If they are not present there would be no reason for arranging a circuit for keeping them out of the plate current.

It may be recalled that many curves giving the relationship between the grid voltage and the plate current appear almost the same as the curve in Fig. 43B. They occur with screen grid tubes and also with three-element tubes in which grid current flows for small

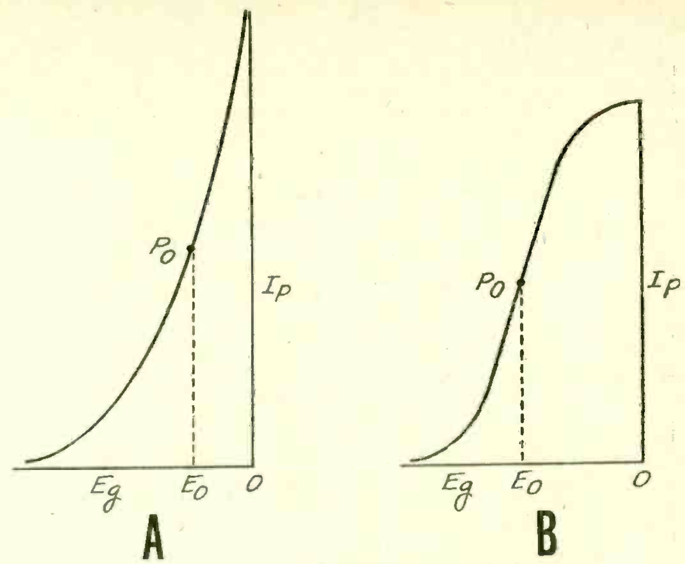


FIG. 43
THE CURVE IN (A) SHOWS A TYPICAL RELATIONSHIP BETWEEN THE GRID VOLTAGE AND THE PLATE CURRENT OF A VACUUM TUBE. HARMONICS OF ALL DEGREES ARE GENERATED NO MATTER AT WHAT BIAS THE TUBE IS OPERATED.
THE CURVE IN (B) SHOWS A POSSIBLE RESPONSE CURVE WHICH IS SYMMETRICAL ABOUT THE POINT PO. IF THE OPERATING POINT COINCIDED WITH THIS POINT THERE WOULD BE NO EVEN HARMONICS IN THE OUTPUT, BUT ALL THE ODD HARMONICS WOULD BE PRESENT.

values of grid bias. Fig. 44 gives two examples of such curves. If a single tube gives such a curve, is there any reason for employing push-pull?

Although the curves in Fig. 44 have the general shape of the curve in Fig. 43B, they are not symmetrical about any point. The curvature is more rapid at the upper than at the lower bend. Hence, even if the operating point be chosen most propitiously, there will be some even order distortion. Some improvement results, naturally, from the approximate symmetry. But the symmetry is not nearly so good as if push-pull were used.

The upper curvature of the curves in Fig. 44 is due to the flow of grid current when the grid voltage is less than one half the peak value of the filament voltage, that is, less than 1.06 volts for the —26 type tube and less than 3.5 volts for the —40 type tube. A similar bending is obtained with the screen grid tubes, because for the higher values of plate current the screen robs the plate of electrons.

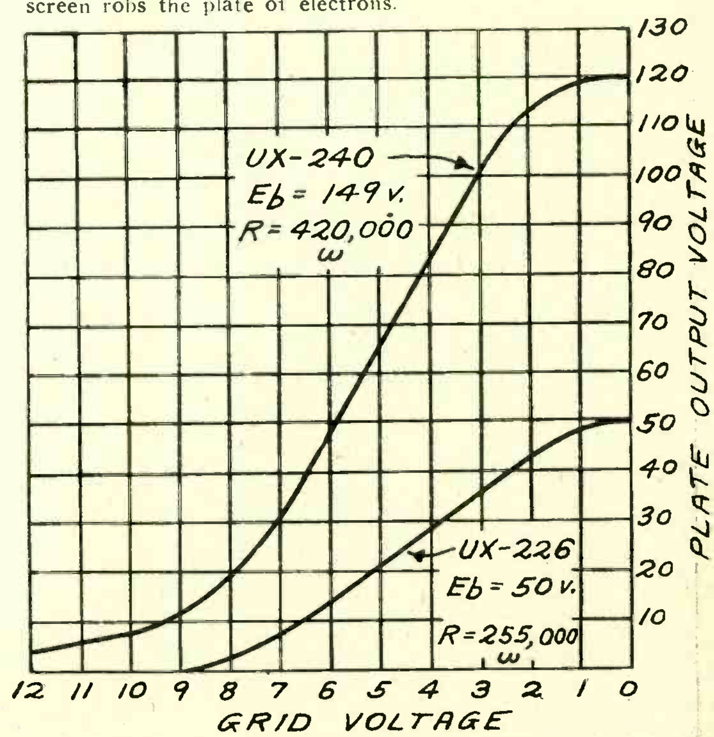


FIG. 44
EXPERIMENTAL CURVES WHICH SHOW APPROXIMATE SYMMETRY ABOUT A POINT. IF THE OPERATING POINT WERE MADE TO COINCIDE WITH THIS POINT IN EITHER CURVE, THE EVEN ORDER HARMONICS WOULD BE REDUCED IN MAGNITUDE.

How to Use Same for 224, 22

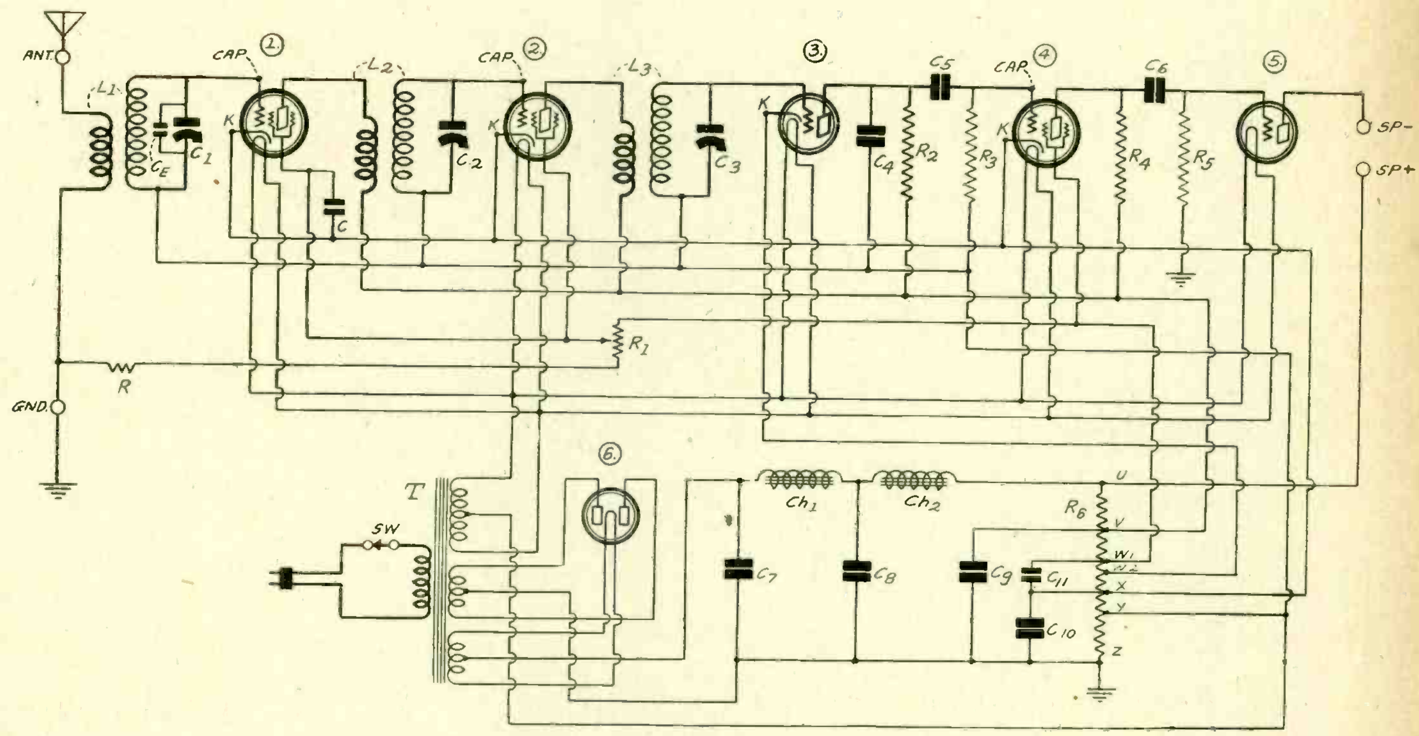


FIG. 1.

HOW THE SAME SECONDARY WINDING OF A FILAMENT TRANSFORMER, AT 2.5 VOLTS, MAY BE USED FOR HEATING THE FILAMENT OF THE 245 AND THE HEATERS OF 224 AND 227 TUBES. THE HIGH POSITIVE BIAS PROBLEM IS SOLVED BY CONNECTING THE CATHODES AND GRID RETURNS OF THE HEATER TYPE TUBES TO SUITABLE POINTS ON THE FIXED VOLTAGE DIVIDER IN THE B SUPPLY'S OUTPUT

Suitable Connection of Cathodes and Grid Returns to B Supply's Output Potentiometer Solves Problem

By Herman Bernard

Managing Editor

ONE of the problems of the AC screen grid tube, type 224, is the use of the same filament winding for this tube when the output tube is a 245. Both valves require 2.5 volts on the filament. Since the screen grid AC tube, like the 227, has a separate filament or heater, not connected to the radio circuit proper, except by thermal radiation, it would seem that the same filament winding could be used for the 224s, 227 detector and 245, since the required filament voltage is the same. However, the use of a biasing resistor to provide negative potential for the grid return of the 245 is the stumbling block.

In Fig. 2 is shown an outline of a 224 tube feeding a 245, direct coupling being used. The same filament winding serves both tubes. The midtap of the winding is positive in respect to the B minus lead. The voltage difference, in the case of the 245, is equal to the drop in R2. When 32 milliamperes flow in the 245 tube plate circuit, from midtap of the filament transformer through R2 to B minus (which is effectively C minus), the resistance of R2 should be 1,250 ohms. The wattage is the product of the current and the voltage, or 1.6, therefore on the safety-plus basis a resistor of 5 watts rating would be wholly adequate.

Heater 47 Volts Positive

It will be seen at once that the midtap M that is positive in respect to B minus by 50 volts also is positive in respect to the cathode K of the 224 tube by 50 volts less the drop in R1. Assume that 5 milliamperes flow in the combined plate and screen grid circuits of the 224 and that R1 is 600 ohms. Then the negative grid bias obtained through R1 on the 224 is 600x.005, or 3 volts. As the starting point or datum in calculations affecting a heater type tube is the cathode, then the cathode is zero, the grid return is 3 volts negative, and the midtap of the transformer secondary,

Filament Winding
7 and 245

or heater bias, is 47 volts positive. This makes the heater a subordinate plate, with a substantial positive bias for the 224 tube, and not only shortens tube life but reduces the flow of electrons to the plate, which impairs efficiency, and also tends to make the behavior of the tube erratic. For the 227 the 47 volts positive heater bias would not be serious, due to the different geometry of the tube.

The circuit represented by Fig. 2 is therefore unsuitable. The 224 requires a much smaller heater bias, and this bias may be positive or negative, and in either instance should not exceed 10 volts. A common recommendation is that the heater be negatively biased 9 volts.

Suitable connection to the potentiometer network of the B supply will furnish the remedy, however. This is shown in Fig. 1. The highest voltage is U, about 300 volts, for the 245 power tube (5), reckoned from the grounded midtap of the high voltage winding. The next highest voltage, V, is of a different value for different tubes, because the cathodes and grid returns of those tubes are connected to different places, which represents the solution of the problem. Notice that the *same* point, V, furnishes *different voltages* by virtue of this special and original method of connection.

Smooth Volume Control

W1 furnishes the positive voltage for the screen grids—a constant fixed voltage to the 224 used as first audio amplifier, an adjustable voltage to the screen grids of the two radio frequency amplifiers, for volume control. So that the potentiometer R1, which may be from 50,000 ohms maximum to 500,000 ohms maximum, will be effective over its entire physical range for volume control purposes, a fixed resistor R, of about half the value of the potentiometer R1, is connected in series. Then the screen grid voltage can never be zero, or indeed, less than half the voltage at W1, and the potentiometer becomes a vernier for the fixed resistor. The volume control then is not critical.

Now, at point W2 the cathode of the detector tube is connected. This is a 227 and is used as a negative bias detector, a so-called power detector. The grid return of this tube is made to Y. Therefore, the negative bias on the detector is the difference in voltage potential between the two points W2 and Y. Assume this is 16 volts.

Choice of Resistance Values

The same 16-volt bias for the radio frequency amplifiers and the first audio amplifier would be entirely too high, therefore the cathodes of these three tubes are connected to X, a point next lower down than W2, but the grid returns are made to Y. Assume that the potential difference between X and Y is 2 volts. Then the first and second radio amplifiers and the first audio tube—all the screen grid tubes in the receiver—get a negative bias of 2 volts. This is, of course, adequate for radio frequency. But what about audio? If the 245 gets 50 volts negative and if the first audio stage amplifies only 50 times, which is a fair estimate, then the bias would have to be only 1 volt negative, so 2 volts negative is ample even for audio purposes, where the last tube is a 245.

We have therefore brought about the use of only a single winding of a power transformer, and yet have provided for the 224s, 227 and 245.

The rotors of the tuning condensers are connected to a bus a little higher than ground potential. Simplicity and economy result from the use of a single winding. Of course, where two separate 2.5 volt windings are available there would be no need to have recourse to this method.

A Good Circuit

The entire receiver is diagrammed in Fig. 1 so that the method of connection will be clear. The constants are familiar, all except the values of the sections of the output potentiometer R6. But these values are easily computed. Be sure to allow for the bleeder current through all of R6, which is 15 mils when R6 is 20,000 ohms. All the plate and screen grid currents flow through YZ, a little over 50 mils, so YZ should be 1,000 ohms. Several

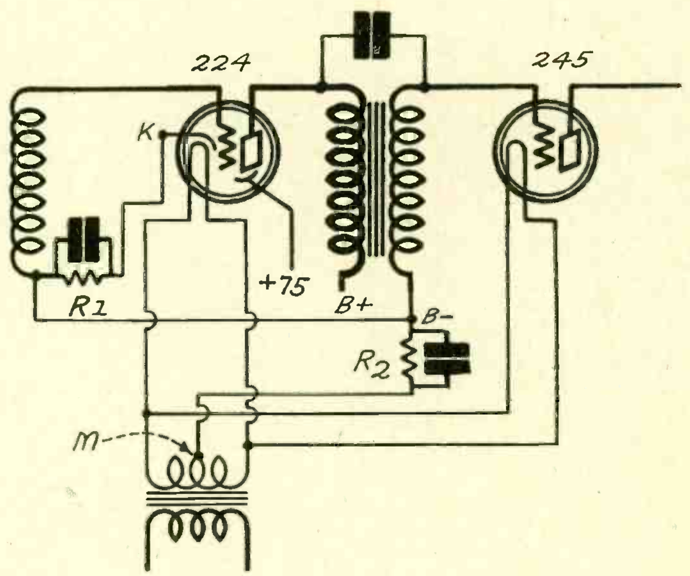


FIG. 2

THE HEATER OF THE 224 IS GIVEN A HEAVY POSITIVE VOLTAGE IN RESPECT TO THE CATHODE OF THE 224, BY THE DIFFERENCE BETWEEN THE BIAS FURNISHED BY R1 AND THAT FURNISHED BY R2, WHICH IS NEARLY THE ENTIRE 50 VOLTS.

commercial resistors providing 1,000 ohms at one end have inside taps that will furnish approximately correct voltages for the rest.

The circuit in its entirety is a good one, providing excellent amplification and adequate sensitivity. The tone quality is particularly fine.

The tuning condensers may be .00035 mfd. or .0005 mfd. and ganged. The number of turns on the secondaries of the coils will depend on the capacity of the condensers. For .00035 mfd. the winding data are: for the primary of L1, 14 turns, ¼" separation, and 60 turns on the secondary. The other primaries have 24 turns, ¼" separation, and the secondaries 60 turns. For .0005 mfd. the antenna coil is 14 and 48 turns, while the other coils are 24 and 48 turns. The wire is No. 24, the diameter 2½". Commercial coils that follow these data are RF3 and R3, for the antenna and interstage coils, respectively, for .00035 mfd., and RF5 and R5 for .0005 mfd., manufactured by the Screen Grid Coil Company.

C is 1 mfd., C4 is .0005 mfd., C5 and C6 are .02 mfd., R2 is .1 or .25 meg., R3 and R5 are 5 meg., R4 is 75,000 or 50,000 ohms.

The rectifier tube, 6, is a 280. The power transformer has three windings—one at 5 volts for the rectifier tube filament (and to which a pilot light may be attached if desired), one of 600 volts, center-tapped, to provide the high voltage to the rectifier tube plates, and a third winding of 2.5 volts, rated at 9 amperes.

SW is an AC switch, 110-volt type, C7, C8, C9 and C10 are 10 mfd. each (Mershon electrolytic condenser, 10-10-10-10). C11 is 4 mfd. 200 volts DC working voltage. R6 is a resistor of the fixed potentiometer type for B supplies, at least 20,000 ohms, with two terminal lugs and six or seven interior lugs, which can be used to obtain approximately the desired voltages, often by connecting to B plus maximum the terminal intended for B minus.

The use of a single winding for all heaters and other filaments is particularly economical where the drain is less than 9 amperes of filament current. In Fig. 1 the drain is 8.25 amperes. As there are several transformers available with 9 ampere 2.5-volt windings it is easy to apply the principles herein laid down. Where the total number of tubes is seven or more the custom no doubt will be to use two separate windings, one for the 245, the other for the heater tubes, as a 12-ampere single winding seems prohibitive.

Noise Filters

How They Are Used to Kill Off Interference

By Edward Dole

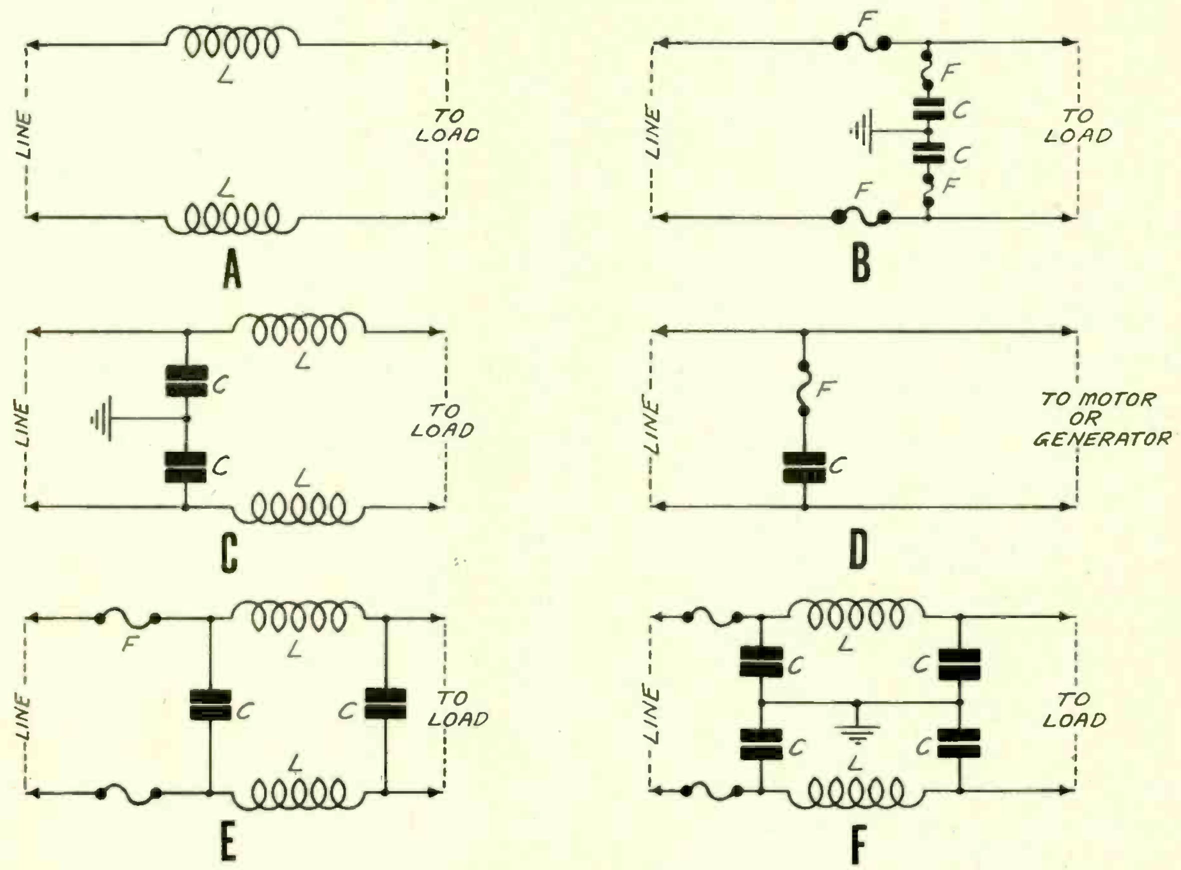


FIG. 3
SIX DIFFERENT FILTERS WHICH CAN BE CONNECTED BETWEEN THE POWER LINE AND A NOISE-MAKING ELECTRICAL DEVICE FOR PREVENTING THE RADIATION OF INTERFERENCE.

[Last week, issue of July 6th, types of interference were analyzed and remedies suggested. Herewith filters for interference elimination are discussed.—Editor.]

IN Fig. 3A is shown a filter, two choke coils L,L, one in each side of the line between the leads to the mains and the leads to the load or the noise making device. These coils should be RF chokes because their object is to prevent the radio frequency waves generated by the electrical device from entering the power line. Coils of about the same inductance as used in broadcast receivers are suitable provided they are wound with heavy enough wire to carry the current drawn by the device they are to quiet.

Fig. 3B shows a filter which consists of condenser C,C across the line next to the noise-making device. This condenser is made up of two equal units connected in series with the common side grounded. Fuses F are used not only in series with the main line but also in series with the two condenser sections. The two fuses in series with the condensers protect the wiring and the house in case the condensers should break down.

If one side of the power line is grounded, of course, it is not necessary to use both condensers, because one of them would then be short-circuited all the time. But even if one side of the line is nominally grounded it will do no harm to use both condensers and it may do some good, for sometimes the "grounded" line is not grounded as far as radio frequency potentials are concerned.

In Fig. 3C is shown a filter which combines the features of those in (A) and (B), that is, it uses both the shunt condensers and the series chokes. It is much more effective than either of the other circuits. While fuses are not shown they should be used.

In Fig. 3D is shown a very simple filter. It consists simply of a condenser across the line next to the noise-making device, which might be either a motor or a generator. This condenser short-circuits the line as far as radio frequency potentials are concerned.

In Fig. 3E is a more complex filter, consisting of two condensers C,C across the line and two coils in series. A still more complex filter is shown in Fig. 3F. It is similar to that in (E) but the shunt condensers are made in two sections in series with the common sides grounded.

The capacities of the condensers in the various filters in Fig. 3 depend on the service, that is, on the severity of the noise which is to be suppressed. They might vary between .5 to 4 mfd. When two condensers are connected in series across the line each should be twice the size of a single condenser used in the same place, but the voltage rating need not be so high.

If electricity generated by friction on a belt creates a disturbance in a radio receiver the trouble may be overcome by grounding the frames of both machines connected by the belt. Another method is to arrange a light, flexible metal brush to ride on the belt. This brush should be grounded. But grounding the frames of the two machines should prevent the generation of static.

In many instances the noise that is heard in the receiver is not due to outside interference at all. There is a condition in the set which brings it about. For example, there may be a defective contact between the prongs of a tube and the springs. This used to be one of the most prolific sources of noise in the set, but has been reduced since the advent of the new type socket. But even now there is a probability that the contacts are responsible for much noise. These are the few places in the circuit that are dependent on contact for connection. Most other connections are soldered. If they are not soldered they may be held together by screws or binding posts. In the sockets spring action alone determines the contact.

One of the common source of noise in the receiver comes from the refrigerator thermostat. Every time the thermostat opens or closes the motor circuit there is a click. Of course, when the motor is running, that, too, may give rise to a noise, hence the disturbance would click on and click off with a buzzing in between.

Volume and Mood

Adjust Intensity Without Getting Up

By Charles Golenpaul

Clarostat Manufacturing Company

LIKE every other great scientific discovery, radio may be a benefit or a curse. It may entertain or it may distract, it may soothe or it may slay. Your guests may come just to hear it, or they may stay away because of it. And you yourself may find it a delight or a nuisance.

How many times have you gone hurriedly to the telephone, picked up the receiver, and tried to hear above the full-toned music of the radio? How many times have you called to someone to "turn off the radio, please!" or, if no one was there to whom you might call, wished, quite vehemently, that you had thought to turn it off yourself before you answered the telephone? And, final annoyance, how many times have you had to say to the person who was calling: "Just wait a moment please, while I turn off the radio," and, when you returned, found that you had been cut off?

That very thing happens in the average American home every day.

Don't Spoil Bridge Rubber!

You are sitting down to a congenial four at bridge, and the radio is supplying a delightful musical background with the playing of delicate salon pieces by a string quartette. Everything is going along beautifully when, all of a sudden, the announcer speaks, and then a jazz band blares out "I Wanna Be Loved By You!" There is nothing wrong with the sentiment, and there is nothing more entertaining than a jazz band—but not during bridge. You can't think! You're right in the middle of a rubber, and you simply can't get up to turn off the blamed thing because you would interrupt the game. Yet it is impossible to play your hand with that awful racket. It is quite alright to be nonchalant in a situation like that, but it doesn't help much. What would be more effective would be to have an arrangement at your finger tips that would control the volume and the tone of the radio so that you could go on with the game.

Can't Outtalk Speaker

You are not feeling well, and you lie down. You don't want to think in silence, so you have the radio going. After a while, perhaps with a change of program, the volume or the tone becomes annoying, and you realize that your headache is worse than it was before. The noise gets on your nerves. You wish the radio was toned down, but you don't feel like getting up and regulating the volume. So you lie there and bear it, or, when you can stand it no longer, get up and turn it off.

You are having guests for dinner, and you tune in some appropriate music. The radio, of course, is in the living room, and you tune it in sufficiently loud to carry well into the dining room. You return to the table and realize that you have tuned it in too loudly. You wish that you hadn't. You wish that you could cut down the volume, but at that moment your partner addresses you and you learn, to your disgust, that you have to raise your voice in order to make yourself heard. You don't want to excuse yourself and get up again to turn down the volume because it is so awkward and ruins the pleasant atmosphere of the dining table. You try not to show how uncomfortable you are. But, after struggling valiantly to talk above the noise, you finally rise in desperation and adjust the volume.

Even though you may have been fortunate enough to have tuned in the music correctly for dining, a change of program often requires a change of tone. For instance, you have tuned in some dinner music, ensembles consisting usually of strings. Before the dinner is over a band, with its preponderance of brass, is playing. The band requires particular toning to be made pleasing as dinner music. If you only had something with which you could tone the band music, soften the sharp brass blares, and cut down the volume just a trifle so that it would more perfectly form just a background and not assume the important role.

A Home Adjunct

You may have that something. It is a simple little arrangement that is connected to your radio receiver and loudspeaker. It is provided with a generous length of cord so that you may carry it about with you, to the dinner table, to the bridge table, to the telephone stand, to the bedside, in fact, anywhere you go. The small, circular meal box has a knob that is turned for controlling volume and tone.

An arrangement of this kind, such as the Clarostat table-type control, is invaluable in the home. With it you may control the volume and tone of your radio music from wherever you may be simply by turning the control knob. It is very light, not awkward to carry around, and allows instantaneous and wonderfully convenient control.

With it, when you are at the table, you merely turn the knob to regulate the volume and the tone of the music to fit the needs of dinner talk, to make the music form a suitable aesthetic background without intruding. With it, if you are chatting pleasantly with a friend who has dropped in for the afternoon, you may tone down the music so that you do not have to raise your voice to be heard, or strain your ears to hear. With it you may hurry to the telephone and adjust the volume of sound coming from the radio so that it will not interfere with your hearing over the telephone. And when you are merely sitting down and enjoying the radio program, you may get so much more out of it by adjusting the tone for each individual selection.

Guests Are Particular

It is not an exaggeration to say that a radio blaring away with great gusto can and does cause nervous reactions that are irritating and that result in unpleasant situations in the home. It is difficult enough to get two members of the family to enjoy the same program without expecting several people to listen to a radio racket that rends the ear.

Guests, too, although they may not say anything about it, are sensitive to noisy radio music, and will not readily deliver themselves to the torture if they can help it. That means that they stay away. Good taste, or the lack of it, is just as evident in the tone and volume of your radio as it is in the furnishing of your home, in the clothes you wear or the books you read. And with radio music, as with the others, it is not so much a question of money as of discrimination.

Right or Wrong?

(Questions on page 4)

(1) Wrong. Motorboating occurs in the audio frequency amplifier. The radio frequency amplifier has nothing directly to to with it. Conditions may arise in the radio frequency amplifier which will cause changes in the plate voltage on the audio tubes, and which in turn might start motorboating, but screen grid tubes are no more likely to bring about these conditions than any other tubes.

(2) Wrong. The inductor-dynamic speaker works on the same principle as any other magnetic speaker, namely, the attraction of a piece of iron to a magnet. There is only a difference in the direction of the pull with respect to the direction in which the armature is free to move.

(3) Wrong. A photo-electric cell requires a voltage just as any other tube. The plate must be made positive with respect to the cathode or there will be very little current flowing to the plate.

(4) Wrong. Radio waves, as a rule, vary inversely as the distance because they travel along the surface. In free space they would follow the same law as light. And under similar conditions light will vary inversely with the distance instead of the square of the distance.

(5) Wrong. The screen grid is positive with respect to the filament and its circuit is closed, hence current flows.

(6) Right. When the voltage is high the electrons gain a high speed so that when they hit atoms there will be ionization at the collision. This is accompanied by a glow, the color of which is characteristic of the gas inside the tube. There is always some gas left in the tube, no matter how carefully the tube has been evacuated.

(7) Wrong. The distance between the filament and the grid does not enter into the expression for amplification factor.

(8) Right. A simple expression for the amplification factor for the flat plate type tube is $CprN^2 + 1$, in which C is a constant, p the distance between the grid and the plate, r the diameter of the grid wires, and N the number of grid wires per unit length.

(9) Right. The equation in (8) can be used to calculate the amplification factor, and it depends on geometrical quantities alone. This equation has been used in the design of many commercial tubes.

(10) Right. And that is a condition which should be carefully avoided when the tube is used as an amplifier. The grid must be made sufficiently negative to keep it from going positive for any part of the signal cycle, or distortion will result.

The Secret of Fine the Screen

Critical Situation Exists, But Adjustment

By Emerson

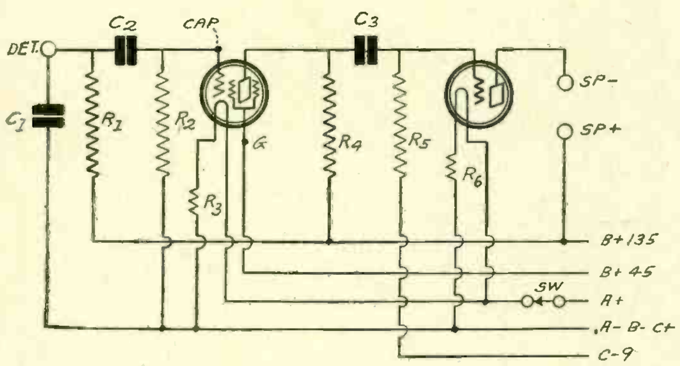


FIG. 1.

A TWO-STAGE RESISTANCE COUPLED AMPLIFIER EMPLOYING ONE SCREEN GRID TUBE. THIS CIRCUIT IS SUITABLE FOR USE WITH A SCREEN GRID, PLATE BEND DETECTOR CIRCUIT.

THAT the screen grid tube has some remarkable properties can be realized when it is appreciated that nearly all receiver manufacturers are incorporating these tubes in their receivers. But how is it that many have tried the tube without getting satisfactory results? Certainly it is not because the tube is not capable of the results claimed for it. If it were not so capable, the manufacturers would not risk their reputations and fortunes on the tube.

The reason for the unsatisfactory results in many instances is that the tubes have not been operated correctly. Many of the trials of the new tube were based on technique developed for the three-element tube, and the technique for the new tube is different in many essential particulars.

Use as Grid Bias Detector

Suppose the screen grid tube be operated as a plate bend detector. A transformer is placed on the plate of the circuit as is customary and then the bias on the grid is adjusted to what seems to be the proper voltage for detection. The results are not at all satisfactory. Yet experts on the tube have analyzed its performance and found that the screen grid tube should be capable of a very high audio frequency output if the bias is adjusted properly and the necessary radio frequency is impressed on the grid. Wherein lies the difference between predicted results and practical?

Adjustment Faulty

It lies in the adjustment of the tube and its circuit. In the first place the transformer does not have sufficient primary impedance to make the tube detect sufficiently. The internal plate resistance of the tube is very high and that requires that the load resistance or impedance also be high. The load resistance should be much greater than the internal resistance for good detecting efficiency. The transformer does not afford the necessary impedance, and hence we conclude that for good detecting efficiency a high resistance should be used in the plate circuit. This calls for resistance coupling between the detector tube and the first audio amplifier.

The circuit is illustrated in Fig. 1, with the detector tube omitted. The resistance of R1 and R2 in parallel should be high compared with the internal resistance of the tube. However, the internal resistance is so high that it is not practical to make R1 and R2 high enough, so that the resistance of the two in parallel is higher than the plate resistance. If R1 is .25 meg. and R2 is 2 meg. the coupling will be reasonably satisfactory.

Effect of Screen Voltage

Now it is not sufficient to put a high resistance load on the tube. The load impedance should be high for the audio frequencies. For the radio frequencies it should be as low as possible. Hence condenser C1 is connected from the plate to the filament of the detector tube. Sometimes enough capacity so developed across the plate load to permit omission of the extra condenser.

We have only begun to bring about the proper adjustment for good detection. We have to adjust the plate, screen and grid voltages. They are mutually interdependent, and in that fact lies one of the chief reasons why the tube has not functioned well in many experimental circuits. The normal adjustment of the 222 tube as an amplifier is that the plate voltage be 135 volts, the screen voltage 45 volts and the grid bias 1.5 volts. As a grid bias detector the negative bias would be considerably higher. But this adjustment is based on the supposition that the plate load is something less than 100,000 ohms. If the load has a higher value, either resistance or reactance, the adjustment is quite different.

For given values of plate voltage and load resistance there is a maximum value of screen grid voltage which can be used. If the screen voltage is increased beyond this point the performance characteristic is quite uncertain, particularly for low values of grid bias. The tube may be used as a detector provided that the bias be increased to high values. The higher the screen grid voltages the higher the grid bias must be for good detection.

How to Adjust Circuit

For a given values of grid voltage, plate voltage and plate resistance there is one screen voltage which gives best detection and still another which gives best amplification. The screen grid voltage that should be used for either purpose is lower, the higher the plate load resistance. If the screen voltage is to remain the same, it is necessary to raise the plate voltage almost in the same proportion as the plate resistance is raised.

Suppose the tube is to be used as a detector. First choose a high plate resistor, say .25 meg. (250,000 ohms). Then choose a plate voltage which is much higher than the rated voltage. For example, 180 volts in place of 135 volts. Then choose a screen grid voltage which is much lower than the rated value, that is, lower than 45 volts. Choose 30 volts or less. Then adjust the grid bias until the detection is the best as determined by listening. It may be that still better results may be obtained by readjusting the screen grid voltage.

How It's Done for Amplification

If the object is amplification, the same process is followed, except that the grid bias is made less, usually not more than one volt. Fig. 1 shows a screen grid tube in a resistance coupled circuit adjusted as a voltage amplifier, R4 being the plate resistance. The indicated plate and screen voltages are those recommended for comparatively low plate load impedance, and these, as was stated above, are not necessarily the optimum. The circuit in Fig. 1 shows the grid re-

Bias Detection from Grid Tube

of Screen Voltage is Good Solution

Porter Pierce

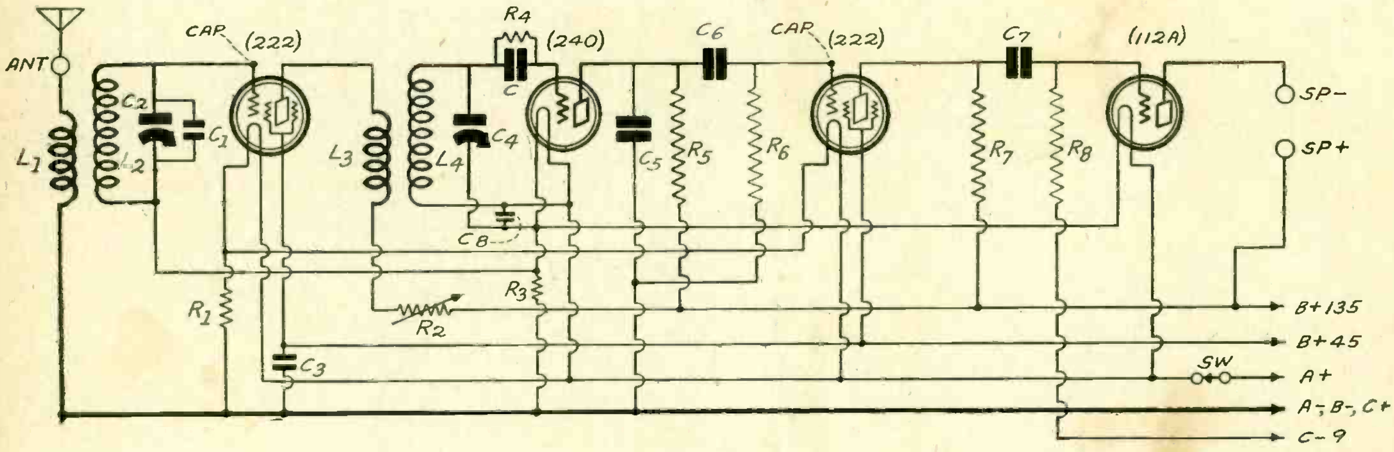


FIG. 2

A COMPLETE RECEIVER IN WHICH TWO SCREEN TUBES ARE USED TO OBTAIN A HIGH DEGREE OF AMPLIFICATION. A SCREEN GRID DETECTOR USING THE PLATE BEND METHOD OF DETECTION COULD BE USED WITH GOOD RESULTS IN THIS CIRCUIT. R2 AS A VOLUME CONTROL IS FAR FROM IDEAL.

turn of the screen grid amplifier going to the negative of the filament battery. This puts a bias of about 2.7 volts on the grid. This bias is so high that the tube would require an enormously high plate voltage for amplification. It is preferable to reduce the grid bias than to boost the plate voltage to the required value.

Due to the very high amplification factor of the screen grid tube the plate current comes to zero for a comparatively low value of grid bias. This means that the curve is steep, which in turn signifies that the point of best detection is very critical. If the grid bias does not have just the correct value, which is determined by the plate voltage, the plate load resistance and the screen voltage, the detection will not be good. Indeed, there may not be any noticeable detection.

Vernier Adjustment

The dependence of the optimum bias for detection on the screen grid voltage suggests that provision be made for varying the screen voltage to locate the best detection point. This is analogous to a variation in the plate voltage for the same purpose when a three-element tube is used. The screen grid voltage is not so critical, and therefore the optimum point can be found much more accurately. For example, the grid bias might be adjusted to a fixed value of 3 volts and then the screen voltage may be varied by several volts up or down to find the optimum adjustment. The adjustment of the grid bias to the proper value then may be made without touching the grid bias, and the adjustment may be made with vernier precision.

Fig. 2 shows a complete receiver in which a screen grid tube is used as audio frequency amplifier, working into a high resistance R7. A screen grid tube could also be used as detector in this circuit if a lead is brought from the screen grid to a suitable value of the plate voltage battery. However, a 240 type high mu tube is an excellent detector when working into a high resistance as in this circuit. The radio frequency amplification is so great in this circuit, due to the use of screen grid tubes for amplification that the detecting efficiency of the high mu tube is sufficient.

Co-ordination Important

The important thing in the use of screen grid tubes is to coordinate the plate, screen and grid voltages to suit the plate load resistance that is used, or to suit the plate load resistance to the plate voltage for constant values of the other voltages. It should be remembered that if the plate resistance is increased to obtain the high amplification of which the tube is capable the plate voltage must be increased correspondingly. This fact often is overlooked in the design of circuits embodying screen grid tubes. This requirement does not hold for three-element tubes. For such it is not necessary, nor even desirable, to increase the plate voltage as the plate resistance is increased.

Volume Control Problem

The problem of volume control is more difficult when screen grid tubes are used, the usual method being to vary the voltage applied to the RF amplifiers' screens, while another method is to use an adjustable resistor in series with the plate. The plate voltage variation method is not the best, for the plate voltage may be reduced to the screen voltage, or lower, which robs the plate of its principal function. The electrons are sidetracked to the screen, from the plate, and the phenomenon of intense, sudden selectivity loss arises. The selectivity is restored when the plate voltage is raised by cutting out some of the resistance of R2.

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.

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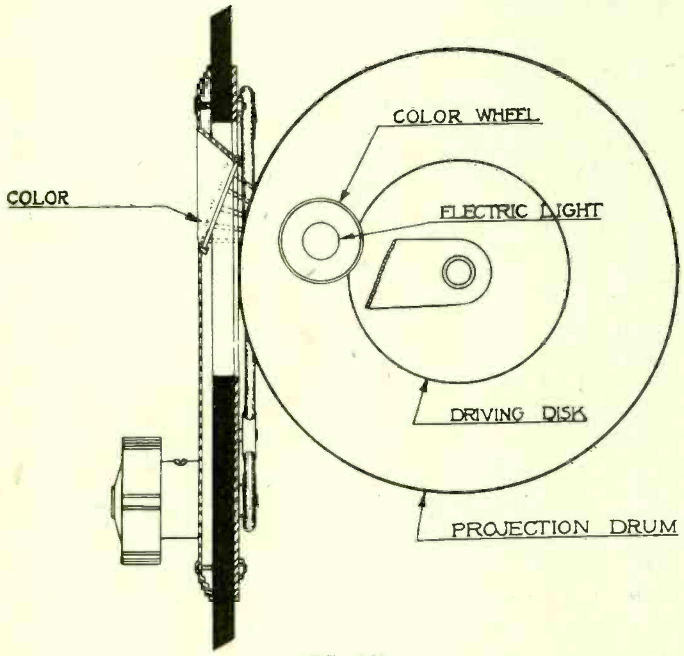


FIG. 768
HOW THE NEW NATIONAL DRUM DIAL WORKS, WITH COLOR WHEEL BUILT IN.

I HEARD that a dial has been marketed that shows up different colors on the scale as you tune from station to station. Please give detail.—C. J. M.

If you mean "detail," see Fig. 768. If "details," here they are, also. This is the new National velvet-vernier projection dial, with modernistic ecutcheon. The color wheel is simply inserted as a part of the new standard modernistic dial. The driving disc turns the color wheel, causing six different colors, one at a time, to illuminate the opening. These colors are red, green, yellow, purple, orange and blue. The scale is projected to a ground-glass screen in these new dials, so that the number read is the same no matter at what angle you hold your head or eye. In most dials the relative reading changes slightly as you shift position. The round drum dial, type H, with rainbow feature, lists at $5.50, without rainbow feature, at $5.00. The same arrangement is obtainable in the disc (flat) type dial, model G, at $3.75 list price with rainbow feature, and $3.25 without. These dials will be ready for the market about August 1st.

* * *

IN attempting to use the 222 screen grid tube as a detector, with negative bias, I find it difficult, if not impossible, to obtain detection. I use a resistor in the plate circuit. Please advise methods of insuring detection.—A. C.

The bias is critical for detection with this tube. Bias and applied voltage are complimentary, or, with applied voltage unchanged, the bias and the load are complimentary. It is highly advisable to put a high-resistance potentiometer across the biasing battery, with movable arm to detector grid return. In that way you can adjust the bias to a fraction of a volt. The tube is as critical as that in respect to bias detection. The value of the load resistor will affect detection also, so you may change this, besides. For 135 volts at the source, with .1 to .5 meg. load, try 5,000-ohm or higher potentiometer across a 7½-volt C battery. The detection point is around 6 volts when .25 meg. is used. The 222 is a four-element tube and the type and value of the load are important. The easiest tube for battery operation of the filament, for obtaining bias detection, is the 240. You may use 1.0 meg. in the plate circuit and apply from 3 to 4½ volts negative bias. The lower the negative bias the louder the signals, but if you have a high-gain RF channel favor the higher negative bias for precaution against detector overload.

* * *

WHAT I need is a milliammeter with a range of 0 to 1 ma. I note that nine different types of meters, some of them milliammeters, are offered free with subscriptions for RADIO WORLD, but the meter I desire is not among them. Can not such a meter be added to the list? I am sure it would prove popular. Or can't another milliammeter be connected to a resistor?—M. C. K.

A 0-1 milliammeter is a sensitive instrument, used commonly as a make shift for still more sensitive and still more accurate instruments because the more precise types are far too expensive for the user's non-commercial requirements. The 0-1 milliammeter, for instance, has a resistance of 1,000 ohms per volt, and a fair price for one is somewhere around $10, whereas the finer instruments, like microammeters, cost $80 and up. So if you send $1 for an 8-weeks subscription and free meter, you can not expect a $10 instrument. The resistance per volt of the 0-1 milliammeter is gauged on the basis of a series resistor converting the instrument into a voltmeter. At all hazards, the 0-1 draws 1 milliampere at full-scale deflection, whether in series with a line to measure current, or across a line, with suitable high resistance in series with the meter, to measure voltage. The resistance per volt is a constructional function of the meter itself. No external resistor can be used to increase the resistance per volt.

* * *

FREQUENTLY I have read that the sensitivity of a single control receiver is less than that of one where each circuit is tuned by a separately controlled condenser. Is this true? If so, why is single control so popular? I am using a receiver I built that has a single control, by the way.—J. M.

Separately tuned circuits always can be made absolutely resonant, because of their independence, hence are more sensitive. However, single control is much more convenient, particularly where there are several tuned stages. The far greater sensitivity of up-to-date receivers, compared with those of only two years ago, makes it advisable to use single control for convenience, even if a little sensitivity is sacrificed, because of the great height of that sensitivity even when there is a tiny deviation from resonance in one or two circuits. It is not unusual for manufacturers of condensers to maintain an accuracy of ½ of one per cent. among ganged condensers at any setting, and this type of precision workmanship is just as important as the greater threshold sensitivity. In RADIO WORLD's laboratory is a new experimental model receiver, with four separately tuned stages, and it is difficult for one not familiar with the dial settings to tune in any station at all, even the most powerful ones, although when resonance is found these stations come in with a mighty roar.

* * *

WHEN I purchased a filament transformer I desired center taps on the two 2.5-volt windings as well as on the 5-volt winding, but I do not know whether there are such center taps. The 5-volt one is O. K., I know, because the binding post is there for that centering, but as for the others, there are only butt ends in the center, pieces of metal I have access to. Should not the winding be center-tapped?—A. V.

Apply the continuity test, using a battery in series with any suitable indicating device, for instance, a lamp or meter. Connect one terminal of the battery to one terminal of the meter, the other terminals of meter and of battery to the test points. In this instance these two emerging leads would be connected to the butt end and one lug of each 2.5-volt winding and to the butt end and the other terminal of that winding. It will disclose a tap, if present, because the indicator will work. If there is no tap, use a center-tapped resistor across each 2.5-volt winding, of 6 ohms. A fairly good balance is struck by the center-tap-coil method, but often a better one when the independent resistor is used.

* * *

SOME units for loudspeakers have provision for altering the impedance. Is this important?—K. H. B.

It is an advantage. Power tubes have considerable difference in plate impedance (the opposition offered to the flow of alternating current). By setting the adjuster, greater undistorted power output and more volume are made possible. However, tubes may be chosen so as to conform readily to the impedance requirement of the speaker if no such adjustable feature is included. As a rule, the magnetic speakers require tubes of higher impedance. It is not unusual for the impedance of a magnetic speaker's windings to be between 2,000 and 4,000 ohms at 1,000 cycles. Dynamic speakers have a very low impedance, sometimes only a few ohms. An output transformer may have a high impedance primary and low impedance secondary and thus meet the requirements of both the plate circuit of the tube and the coil of a dynamic speaker. Matching impedances is important, but it does not mean that the impedances should be equal. For interstage coupling, as between tubes, the load impedance should be

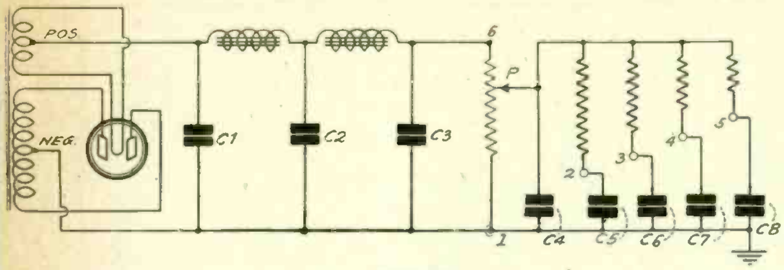


FIG. 769

In this capacity filter system the problem is to determine what resistance should be used for the units terminating at 2, 3, 4 and 5. The resistance will depend on the current, and this depends on the tubes and their voltages. The resistance, however, can be calculated easily.

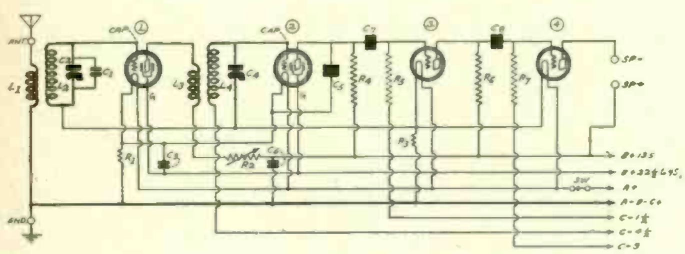


FIG. 770

infinite for maximum voltage, but this is not practical, since the coil would have too high a distributed capacity. The accepted compromise is to make the load impedance double the other impedance.

* * *

HOW does the screen grid tube function as an audio amplifier? I refer particularly to the 224 AC screen grid tube.—A. M.

The 224 is a good audio amplifier, providing high gain, and at low expense of parts for coupling. The bias may be a little more negative than ordinarily recommended for radio amplification. The plate load preferably should be a resistor, 50,000 to 75,000 ohms or more. The applied voltage should be 180. Some conditions would make a still higher voltage suitable, but special precautions would have to be taken not to operate the tube (for instance, for bias detection) near zero plate current, for then the voltage drop in the load is negligible, and of 300 applied volts, for instance, 290 might be easily effective. The tube would not last long under such conditions. Always remember that it is not the resistance of the plate load, whether coil or resistor, that counts, when taken alone, but only when taken in connection with the current flowing. When the current is extremely low the voltage drop in the resistor is low, so 100,000 ohms might drop 100 volts or 10 volts, depending on whether unit current or one-tenth unit current is flowing.

* * *

TELEVISION was much heralded six months ago, and the technical press had many articles about it, some of them even constructional. But now next to nothing constructional appears. Has television made any advance? If the subject was interesting then, advance or no advance, why is it not interesting now?—B. H.

The articles you refer to dealt with the reception of television movies, that is, of transmitted film recordings of silhouettes. It was interesting indeed to receive these, although they were small, about 1½" square, and none too clear. Pursuit of this line was retarded by two main factors: (a) disagreement among transmitting agencies as to types and arrangement of discs, and as to speed of rotation of discs, with consequent embarrassment of experimenters, who had to provide themselves with a variety of discs, and (b), lack of entertainment value, due to smallness of the image, obscurity, lack of variety, absence of detail, and confinement to "canned" pictures. What the public, even that part of it which is experimentally inclined, seems to want, is television that has entertainment value rather than novelty value. Having been educated to fine results from original, not "canned," aural radio, that public demands somewhat commensurate results from visual radio. The interest is as high as ever in the entertainment value of television, but the interest in the novelty branch of it has subsided quite effectively.

* * *

MY volume control is critical. Also it has a funny effect. I use screen grid radio frequency amplifying tubes. When I turn down the volume the selectivity disappears. Only the detector stage seems to retain its selectivity. What can I do?—B. B.

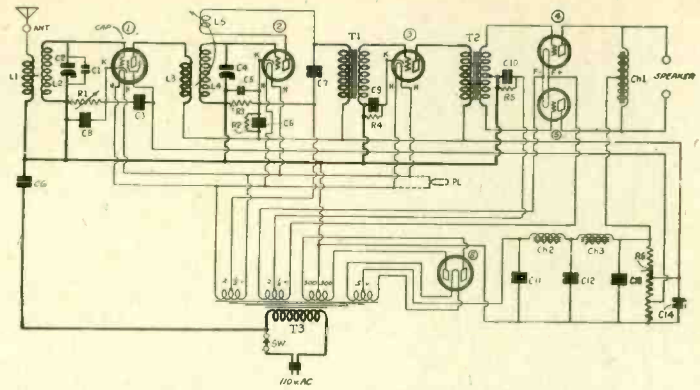
From your statement it seems the volume control must be an adjustable series resistor in the plate circuit of the screen grid radio frequency amplifying tubes. It is critical primarily because the value of the resistance is too high. Therefore the entire volume range is confined to a fraction of the total physical sweep of the knob. By reducing the resistance you can spread out the effective control of volume. An easy method of reduction is to put a fixed resistor across the adjustable one, about the same resistance value. This will halve the resistance, approximately. The queer effect you report about selectivity loss is due to the reduced effective voltage on the plates of the screen grid tubes, while the positive voltage on the screen grids themselves remains unchanged. It is not too much to assume that the reduction of effective plate voltage, due to adjustment of the movable arm, leaves the plates with less voltage than is fixedly applied to the screen grids. Under such conditions the plates are ineffective, because the electrons are detoured from the plates to the screen grids, and the screen grids have no circuit load. so you get only stray coupling to the detector. As the detector plate voltage is unaffected, the volume control not being in that circuit, you retain selectivity only in that stage. It would be better to put the adjustable resistor in the common B plus lead going to the screen grids (or posts), in which instance you need not reduce the value of the resistance as previously outlined.

* * *

IN Fig. 2 on page 8 of the July 6th isue the illustration did not conform to the text.—C. L. T.

The illustration did not conform in some of the copies printed. Fig. 769 herewith was the correct Fig. 2. The discussion concerned the values of the independent resistors, which could not be foretold without knowing the current. Reading Fig. 769 with Fig. 770, the following holds true: The plate current drawn by any type tube at standard values of bias is known, or can be measured, and the number of tubes used is known, so the resistor's value can be calculated. By Ohm's law the resistance in ohms equals the voltage divided by the current in amperes. Let us apply this formula and assume the Pointer P at position 6. The 224 tube at 180 volts on the plate draws 4 milliamperes, the 227, negatively biased for detection, draws 1 milliampere, the 227 as first audio amplifier draws 5 milliamperes. These three are enumerated because all are served from the 180-volt tap. The maximum voltage is 300 volts, so the voltage to be dropped is the difference, or 120 volts. Therefore the resistance of the independent resistor, let us say point 5 in Fig. 2, is 120 volts divided by .01 ampere. Hence resistor 5 should be 12,000 ohms. Since it drops 120 volts at .01 ampere it must dissipate 1.2 watts. Following the usual precaution of requiring a resistor of at least twice the rating of the actual wattage, this resistor would be of 3 watts rating. This is low wattage, so almost any resistor of that resistance value would do, 5 watts being a common minimum rating for resistors used for voltage dropping in B supplies. B+75 is connected to the screen grid of the 224. Assume the resistor terminating at 2 is used. Then the resistance is the voltage drop, 225, divided by .0013 ampere, or about 173,000 ohms. If the pointer is moved down, as advised, say to 200 volts, then the voltage above would be 200-180 and 200-75, or 20 and 125, and the resistors 2,000 and 96,100 ohms.

PARTS FOR PUSH-PULL DIAMOND



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- C7—One Aerovox .0005 mfd. fixed condenser .20
- C10—One Aerovox 4 mfd. bypass condenser 1.50
- C11, C12, C13, C14—Mershon 8-18-18-8........ 5.76
- R1—One Electrad Royalty variable resistor, 5,000 ohms, with 110-volt AC switch..... 1.50
- R2, R3—One 25,000 ohm Electrad resistor type B (with 3 terminals)..................... .75
- R4—One 1,000 ohm Electrad resistance strip .20
- R5—One 800 ohm Electrad resistance strip.. .20
- R6—One Aerovox Pyrohm type B (750, 750, 2,800, 3,000) 1.00
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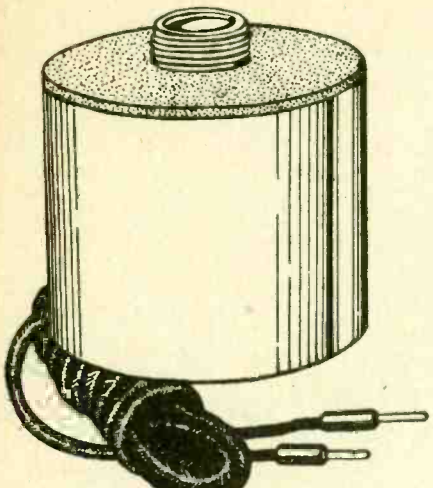

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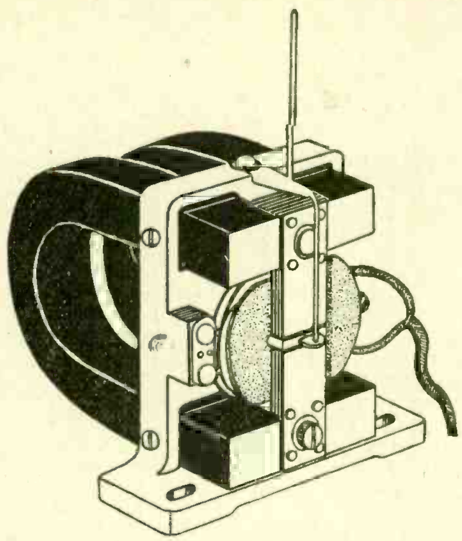

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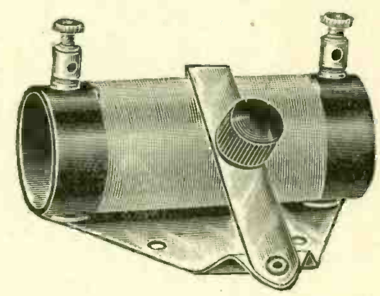

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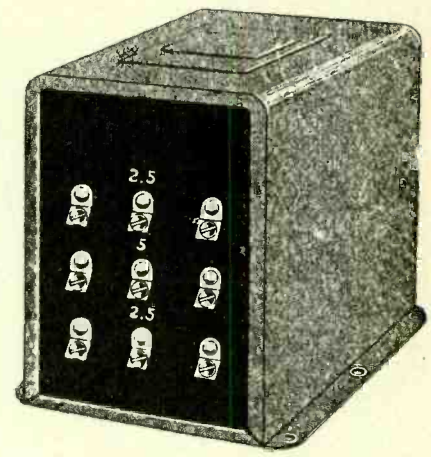

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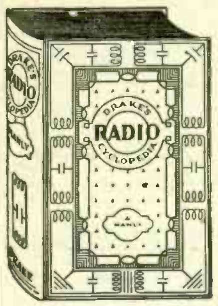

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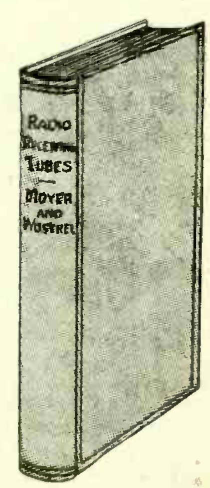

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