AUGUST 10th, 1929 15 CENTS

RADIO WORLD

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The First and Only National Radio Weekly

385th Consecutive Issue—EIGHTH YEAR

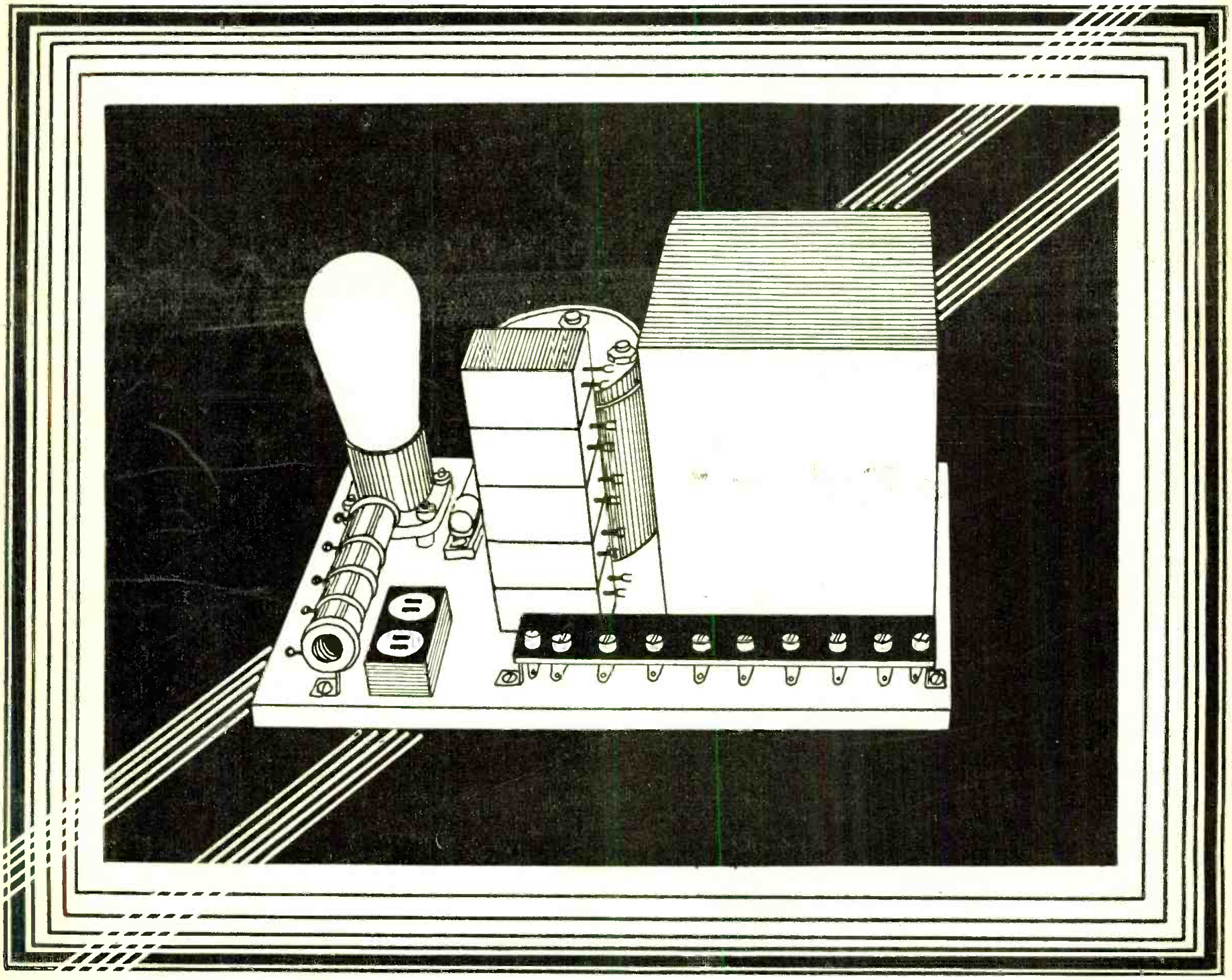
ELECTRONS EXPLAINED

ANALYSIS OF SHIELDING

DISPUTE OVER RESISTANCE AUDIO

MOTORBOATING CURES IN POWER AMPLIFIERS

ABC COMPACT FOR 224, 227 AND 245 TUBES



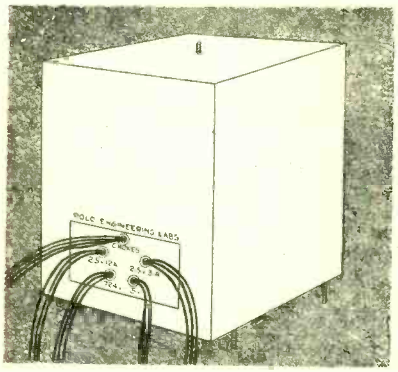
See Article on Pages 4, 5 and 6 Describing the ABC Compact

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

POLO

Transformer Block

2.5 v. at 3 amps., 2.5 v. at 12 amps., 5 v. at 2 amps., 724 v., CT; two chokes, all in one casing . . . $10



HERE is a compact transformer block, enabling you to build an ABC supply of finest design, to furnish the required voltages to operate screen grid AC tubes, 227 AC tubes, and 245 power tubes in single or push-pull circuit. This transformer block is expertly engineered and properly voltaged. The high voltage secondary, for instance, is fully high enough, so that when the voltage drops in the choke coils, tube and other apparatus in the B supply are taken into consideration, the direct current output across the voltage divider is 300 volts when the maximum current flowing through a section of the divider is 80 milliamperes. This enables correct proportion of 250 volts for the plate of the 245 and 50 volts for negative bias for the last audio tube or tubes, total 300 volts.

Notice particularly that the filament winding for the radio frequency and first audio frequency amplifier tubes and detector tube is rated conservatively at TWELVE amperes. Look around for a transformer that has such a high current rating. Twelve amperes mean that you can operate six tubes from this winding without any danger of overload, while the overload in operating seven such tubes would be less than 5 per cent. The power tube filament winding enables the heating of single or push-pull 245 tubes, as the 3 amperes will easily satisfy requirements.

This transformer block is housed in a shielded, cadmium-plated metal casing, with mounting feet and a top projection, so that upright or horizontal mounting may be used. The total height of the casing is only 6⅛", so even that if a ¾" thick baseboard is used, the casing fits upright into a receiver that has the usual 7" high front panel.

The voltage leads emerge from a clearly marked plate, with center taps in red. You can make no mistake. Everything is plain and clear.

Notice that even the choke coils are included inside this same casing, so all you need are the resistors, tube and condensers, and you have the ABC supply that you've been craving for.

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Component Parts for Herman Bernard's ABC Compact

to provide all filament, grid and plate voltages for A.C. hookups, using 224, 227 and 245 tubes, including push-pull, up to seven tubes, 100 milliamperes.

One Polo transformer block, with two chokes, of 400 ohms D.C. resistance each, all in one cadmium-plated shielded casing, 6⅛" high, 4½" wide and 4½" front to back, with mounting feet attached; voltages, 2.5 at 3 amperes, center-tapped; 2.5 at 12 amperes, center-tapped; 724 A.C., rms., center-tapped; 5 volts at 2 amperes. Voltages marked at openings from which insulated connecting wires emerge; center taps are red. Cat. TBH 245 ....$10.00

C1, C2, C3, C4, C5—Five 2 mfd. compact filter condensers, size of case, 2" high, 1 3/16" wide, 1 3/16" front to back; provided with mounting feet at bottom and connection lugs at top. Cat. HV2. $1.70 ea., total $8.50

C6, C7, C8, C9—Four Mershon electrolytic condensers in one copper can, 8, 8, 8 and 8 mfd. $4.65

C10—One Aerovox .006 mica dielectric condenser. Cat. AV6 ....$0.40

One mounting bracket for Mershon 8-8-8-8 condenser. Cat. MEBS $0.35

One mounting strip for the five filter condensers, with bracket. Cat. HVS $0.40

R1—Five resistors as follows: 6 ohms, 20 ohms, 800 ohms, 4.500 ohms, 2.500 ohms, the last three of 10 watts rating or higher. Cat. ABCS $1.95

One binding post strip, with 10 posts and brackets. Cat. ABCBP $1.60

One sub-panel. Cat. ABCSP $2.00

One socket, UX type (four prongs) $0.30

One 1,500-ohm 10 watt resistor (for push pull 245s). Cat. B15 ....$0.50

Total $30.65

[NOTE: The 1 ampere fuse, fuse holder, lamp cord, two male plugs, 2-way convenience outlet and A.C. pendant switch are carried by most hardware and all electrical stores, and there is no advantage ordering these by mail.]

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SINGLE OR PUSH-PULL

245 Stage Powered by ABC Compact

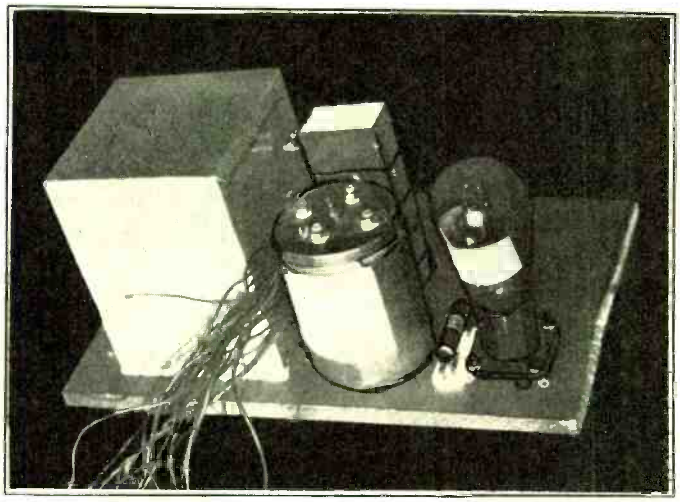


FIG. 2
SIDE VIEW OF THE 245 ABC COMPACT, THE PICTORIAL WIRING DIAGRAM OF WHICH WILL BE PUBLISHED NEXT WEEK.

another to drop 2 volts and another to drop .5 volt. The total drop is used for the power tube biasing, i.e., 50 volts, while the 2-volt drop is used for negative bias on radio frequency and preliminary audio frequency amplifier, with either the .5-volt drop or the 2-volt available for negative grid bias detection. The odd voltage of .5 is supplied because this works best if a screen grid tube is used as space charge detector, with a .5 meg. resistor in the plate circuit, and a .1 meg. or 50,000-ohm resistor in the grid circuit, with a condenser, from plate of detector to grid of the first audio tube, of .02 mfd. capacity or higher. The space charge detector tube would then have 180 volts in the plate circuit, .5 volts for negative grid bias, and the G post of the socket would be used as the control grid, to C minus, and the cap used as the space grid, connected to B plus 50 volts, point (4) on the voltage divider. If a 227 tube is used as detector, with 50 volts in the plate circuit, the 2-volt negative bias is used.

The assumption made is that a maximum of 80 milliamperes will flow. Of course this maximum will be in only a small part of the voltage divider. Under any conditions the bleeder current, or that current flowing through all of R1 even if no tubes are worked from the supply, is 30 ma., so 50 ma. are allowed for the receiver. The 245 draws 32 ma. at 250 plate volts and 50 volts negative grid, and the rest of the receiver may draw 12 milliamperes for the designated voltages to apply. But if more current is drawn, because a multi-tube receiver is used, the B supply automatically takes care of this, the plate and biasing voltages falling a little below what are printed on the wiring diagram. Up to 100 milliamperes may be drawn without overloading the rectifier or the filter system and without making any change in the circuit.

If push-pull 245 tubes are to be worked one change is necessary—lower resistance for the section between points (1) and (4) on the voltage divider. The intermediate bias voltages of 2 and .5 volts will not be practically affected, because the shunt resistor alone will carry the extra current, the current in the fundamental biasing section remaining as before. The voltages all along the line will drop a trifle due to the extra current drain, but this exception is of no practical importance.

In any B supply the plate voltages can not be given absolute values applicable to all receivers, for the amount of current drawn at different voltages produces different results, but working limits may be established as they have been in this special design, which is nevertheless made applicable to a variety of receivers. For instance, the maximum current to be drawn from the present device is 100 milliamperes, which takes care of an average AC set consisting of five heater type tubes (e.g., three stages of radio frequency amplification, detector and one audio stage) and a pair of 245s in push-pull, in all seven tubes. If the voltages remained the same when the extra current is drawn by the seventh tube, occasioned by push-pull, over what is included in the diagram, then the total current would be 112 milliamperes, if 80 ma. were the previous amount, but the voltage drops sufficiently to keep the current at 100 maximum. It should be borne in mind that the maximum current flows only through the resistor between points (1) and (2) on R1, which in the design shown in Fig. 1 for single-sided audio output is 80 milliamperes. Between points (2) and (3) 79 ma. flow, deducting 1 ma. for the detector plate current, while between points (3) and (4) 62 ma. flow under the stated conditions.

The values of the resistors for the above reasons, plus some other reasons affecting resistors higher up in the voltage scale, should be:

Between points (1) to (2) 6.25 ohms (.5 volt), commercial value 6 ohms.

Between points (2) to (3) 19 ohms (2 volts), commercial value, 20 ohms.

Between points (3) to (4) 774 ohms (48 volts), commercial value 800 ohms.

Between points (4) and (5) 4,400 ohms (132 volts), commercial value 4,500 ohms.

Between points (5) and (6) 2,510 ohms (118 volts), commercial value 2,500 ohms.

The small values of resistance may be those used ordinarily in battery sets for filament voltage drop, i.e., the 6 and 20-ohm units, while the others should be rated at 10 watts, or more, if you desire.

It will be seen that the commercial resistors are closely approximate, and the voltage difference is small, hence the difference in voltage reading obtainable from the output will be small, as compared to what is shown in Fig. 1, provided of course that a single-sided output stage is used. If push-pull is used, then Ohm's law calls for a resistor of 1,562 ohms connected in parallel with the strip from point (4) to point (1), but a commercial value of 1,500 ohms would be used. This extra resistor keeps the bias around 50 volts for the push-pull 245s despite the extra plate current drawn by the second 245.

The variation factors therefore are fully taken care of, and excellent results will be obtained, with proper voltages, although where there is any difference it is always in the safer direction of a little lower plate voltage than the rated recommendation of the tube manufacturers, and where a different bias results, the bias is a little higher than the rated amount.

The 2-volt bias is available for all radio frequency amplifiers and for the first audio stage, of whatever type. Assuming in the case for the first audio stage a 1-to-3 ratio (primary to secondary) audio transformer working out of a 227, plate voltage of 50, or a resistance-coupled, impedance-coupled or Clough stage working out of a 224 first audio amplifier at 180 plate volts, even two 245 tubes in push-pull will be loaded up.

On the filament side, the 2.5-volt winding for the power stage is rated at 3 amperes, which amply takes care of the 2.5 amperes drawn by a pair of 245 tubes, while if a single-sided output stage is used, with 245, the same winding is used without change, since the resistance of the winding is so low the voltage does not change measurably whether one or two tubes are in this filament circuit. For the other 2.5-volt winding the rating is 12 amperes. This will safely carry the current of 10.5 amperes drawn by six heater type tubes, so an 8-tube set can be worked safely, so far as the filament is concerned, but the plate voltage and current considerations lead us to limit the entire device to not more than seven tubes of the types stated.

The question of AC voltage is important. The no-load voltage of the secondary feeding the anodes of the 280 tubes is 724 volts root mean square across the total winding, 362 volts rms across each half, measured from center tap to either extreme. The choke coils, of which there are two built into the transformer block, have a DC resistance of 400 ohms each, and this resistance was allowed for, as well as the resistance of the rectifier tube at 80 ma., the resistance of the high-voltage winding itself and indirectly the resistance of the voltage divider, so that the resultant DC voltage across the entire divider becomes 300 volts, apportioned as follows: between points (1) and (4), 50 volts, and between points (4) and (6), 250 volts. The two extra bias taps and the 180-volt tap are intermediate to the two others.

The main filter section consists of the two choke coils and five high-voltage (HV) condensers across the line. Each of these condensers is 2 mfd., rated at 550 volts rms, 800 volts DC, hence afford abundant safety margin. C1 and C2 are placed across the tube output and the midsection of the choke chain respectively. The chokes are represented by four insulated leads emerging from the transformer block, the two leads of one choke being paired, for identity, while the other two leads from this opening are for the

OUTLET PROVIDED FOR AC DYNAMICS

AERIAL IN ABC UNIT

Lamp Socket Antenna Serves Sensitive Sets

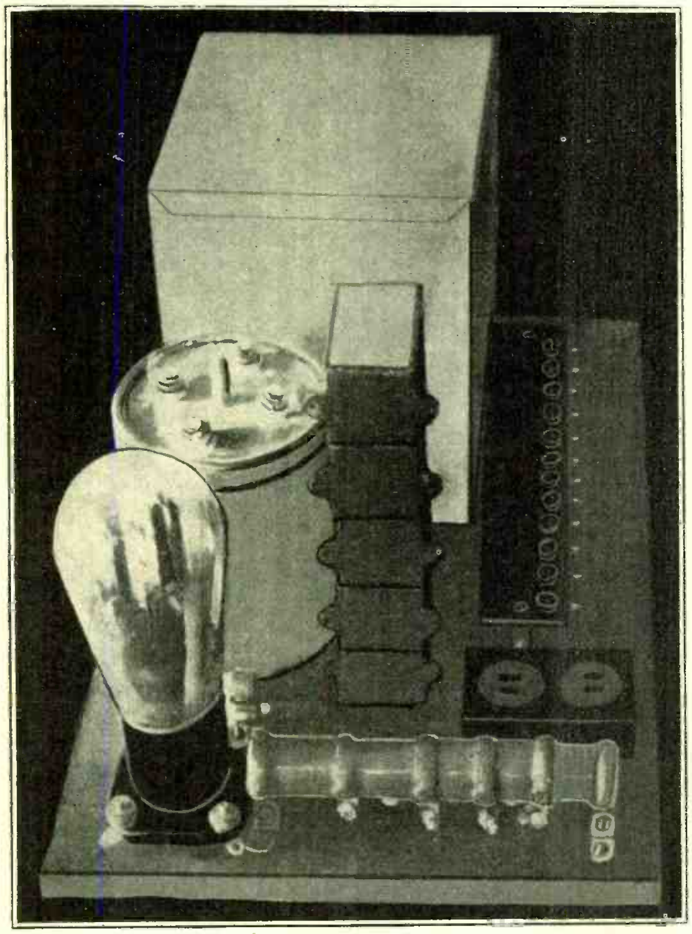


FIG. 3.

other choke. Hence one of the paired leads is joined to one unpaired to constitute the midsection. Then at the end of the choke chain three of the 2 mfd. condensers are connected in parallel, constituting an excellent amount of capacity for the purpose. These condensers, by the way, are very small, and may be stacked one atop the other without coming any higher than the transformer block.

The four by-pass condensers are 8 mfd. each, Mershon electrolytic condensers in one copper can. These are rated by the manufacturer at a little more than 400 volts DC, so there is no danger of running into any trouble here, either, if the sole precaution is taken to connect the copper can to negative, point (1), and the four lugs atop the can respectively to points (2), (3), (4) and (5). The Mershons should not be used as the filter capacities in this circuit, as the paper dielectric condensers specified have twice as high a voltage rating. But for bypass the Mershons here serve an excellent purpose in stabilizing even a resistance-coupled audio amplifier and in sustaining low-note reproduction by reducing the impedance which, if high, is obstructive to low notes.

The AC input to the device is made through a fused lamp-cord, with male plug at one end, the AC switch being inserted in one side of the line between the male plug and a two-way convenience outlet. The two marked primary leads of the transformer block are attached to another male plug, and when this is inserted in one of the openings of the convenience outlet the AC line is tapped when the switch is turned "on." The switch of course may be on the receiver, or, if desired, an AC pendant switch may be inserted as shown in Fig. 1. In any event the entire installation, including receiver and ABC supply, is turned on and off by the same switch.

The second socket in the convenience outlet is for the cable of AC type dynamic speakers, as all these speakers have rectifiers built in, and need only be connected to an AC convenience outlet and to the speaker posts of the receiver. The extra receptable,

LIST OF PARTS

T1, Ch1, Ch2—One Polo transformer block, with two chokes of 400 ohms D.C. resistance each, all in one cadmium-plated shielded metal casing, 6⅛" high, 4½" wide and 4½" front to back, with mounting feet attached; voltages, 2.5 at 3 amperes, center-tapped; 2.5 at 12 amperes, center-tapped; 724 A.C., rms, center-tapped; 5 volts at 2 amperes (may or may not be center-tapped); voltages marked at openings from which insulated connecting wires emerge; center taps are red.

C1, C2, C3, C4, C5—Five 2 mfd. compact HV filter condensers, size of case, 2" high, 1 3/16" wide, 1 3/16" front to back; provided with mounting feet at bottom and connection lugs at top. (Cat. HV2, Guaranty Radio Goods Company).

C6, C7, C8, C9—Four Mershon electrolytic condenser in one copper can, 8, 8, 8 and 8 mfd.

C10—One Aerovox .001 mica dielectric condenser.

F—One fuse of 1 ampere capacity, with fuse holder.

R1—Five resistors as follows: 6 ohms, 20 ohms, 800 ohms, 4,500 ohms, 2,500 ohms, the last three of 10 watts rating or higher.

One mounting bracket for Mershon 8-8-8-8 condenser.
One mounting strip for the five filter condensers, with bracket.
One binding post strip, with 10 posts.
One baseboard.
One socket, UX type (four prongs).
Length of lama cord.
One two-way convenience outlet.
Two male plugs.
One AC switch.
One 1,500 ohm resistor (if push-pull is to be used).
One Kelly 280 tube.

then, permits energizing the dynamic speaker from the self-same switching arrangement that governs the receiver and the ABC supply.

A fixed condenser is shown in series with one side of the AC line. This gives aerial connection for sensitive receivers, so that no outdoor aerial would be needed. Such pickup is not great enough in all locations to render this of universal advantage, but many may want to try the method. The aerial post of the receiver is connected to the Ant. post of the ABC supply. Do not connect any aerial to the Ant. post shown in the diagram. This post is not to receive an aerial but to give one, so to speak. The common C minus post, however, may be connected to external ground. In many localities the self-grounding effect of the ABC supply is sufficient, and no external ground need be connected, so that a sensitive receiver may be worked "without batteries and without aerial or ground." The expression "without aerial" is of course a non-technical phrase, meaning no outdoor or indoor or other external aerial, but not meaning that no aerial at all is included, since the pickup from the AC line through the .001 mfd. condenser C10 is indeed that of an aerial in every sense of the word.

The binding posts for Ant. and Gnd. are not shown in the photographs, as an outdoor aerial was used, and the common C minus was picked up through a lead run from point (1) without going through the binding post strip.

As to constructional hints, the main ones are to follow the layout as shown in the illustrations, so as not to put a hot rectifier tube and resistance strip too near the filter condensers, also to place the transformer block so that its leads are at the outside, not between the block's cadmium-plated shielded case and the binding post strip. In the layout the leads emerge at the side opposite to the binding post strip.

The filter condensers, 2 mfd. each, are mounted on a piece of wood or hard rubber or bakelite, one next to the other, with mounting lugs pointing to the binding post strip and to the connection leads of the transformer block, respectively.

In joining the leads to their intended places observe the picture diagram carefully, following it exactly, with one exception: if the transformer block has a center-tapped 5-volt winding for the filament of the 280 rectifier tube, connect this center tap as the positive lead running to the first choke, Ch1. Otherwise use either side of the filament, as suggested in the diagram, as the positive B voltage lead to the choke.

[Other Illustrations on Front Cover]

*[In the August 17th issue, next week, the picture diagram of the wiring will be published.—*EDITOR.*]*

SPACE CHARGE DETECTOR VOLTAGES

J. E. A. Talks Back

Insists Morecroft Fell Into Traditional Error

EDITOR RADIO WORLD:

PERMIT me to call attention to July 27th issue of RADIO WORLD, page 7, "New Morecroft Book for Novices."*

J. E. A. states that the author is in error in saying that resistance-coupled amplifiers require a plate voltage twice as high as that required by a choke coil-coupled amplifier because of the high voltage drop in the resistance.

J. E. A. says: "This statement is erroneous because for equal impedance and equal signal amplitude the voltage drop in the coupling device is the same whether the device is pure resistance or inductance."

It seems to me that J. E. A. should review AC fundamentals. It can be seen from the impedance triangle and the equation E (drop) = I times the square root of (R^2+X^2) that if resistance is substituted for the reactance (X) in order to keep the value of Z the same, although the AC impedance drop remains the same, the DC resistance drop IR is proportionally increased and is a much greater value than when the impedance Z consisted of R and X.

The result is that the DC plate voltage must be increased to a proportionally much higher value, as Mr. Morecroft states, to impress the normal voltage on the plate.

FREDERICK W. MILLSPAUGH,

7224 Sommers Rd., W. Oaklane, Philadelphia, Pa.

* * *

He who questions the accuracy of statements made by a recognized authority on radio like Prof. John H. Morecroft must be prepared to defend his position. I am, for letters of the type written by Mr. Millspaugh were expected, and I shall attempt to explain my view on this question.

For a long time there was a battle between the proponents of resistance-coupled amplifiers and impedance-coupled circuits. Those interested in resistance coupling maintained that a higher plate battery voltage was not necessary, while those interested in inductive types of coupling insisted that the plate battery voltage at least should be doubled.

The argument used by the proponents of inductive coupling was indeed strong. It is perfectly obvious that if the effective plate voltage is to be the same when a low resistance choke or transformer is used in the plate circuit as when a high resistance is used, a much higher battery voltage is required for the resistance-coupled amplifier. I was so convinced that the proponents of resistance coupling were wrong that I did not give the argument a second thought. In fact I was amused at the apparent absurdity of their position.

Then one day I took a curve on a resistance-coupled amplifier. Taking a curve on an actual amplifier led to conclusions totally different from those arrived at by taking hearsay. The curve confirmed the argument of the resistance-coupling protagonists, namely, that an increased plate battery voltage is *not necessary*. Then it seemed odd that so many had based their arguments on the impedance triangle, or on hearsay, and that so few had taken curves on actual amplifiers.

Increased Voltage Permissible

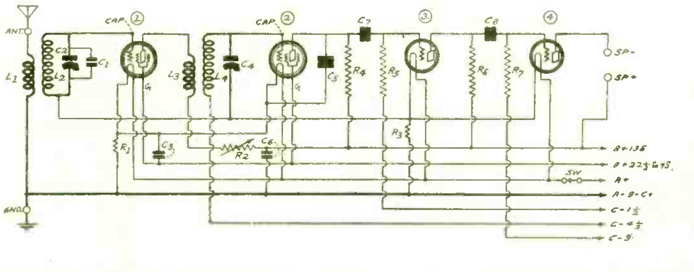
It can not be denied that a higher plate battery voltage *may* be used on a resistance-coupled amplifier, for that is perfectly obvious, since the limiting factor is the current that flows in the tube. But it is denied that a higher battery voltage *is* necessary. Experimental curves show that the important thing is the voltage in the plate circuit, rather than the voltage effective on the plate at a given grid bias. Is there anything sacrosanct about the effective plate voltage specified by the manufacturers of tubes for conditions of no load in the plate circuit?

The voltage in the plate circuit, that is, the plate battery voltage, should be high enough to support a given voltage swing on the grid without forcing the plate current over the curved portions of the grid voltage, plate current characteristic. Increasing the plate battery voltage increases the permissible grid voltage swing, but it does not appreciably change the shape of the curve over a small operating region.

Suppose the load resistance is 100,000 ohms and the plate battery voltage is 90 volts. The grid voltage, plate current curve has a certain shape. Now if the load resistance is increased to .5 megohm, without changing the battery voltage, the characteristic curve becomes straighter, permitting a slightly higher signal voltage for the same amount of distortion. Hence adding more resistance, with or without adding more voltage in the plate circuit, is advantageous from the viewpoint of fidelity or freedom from wave form distortion. It also increases the amplification.

The fallacy of the argument for the need of a higher battery voltage for resistance coupling seems to rest on the assumption that the inductive drop does not count. Mr. Millspaugh conveniently dropped the X component, after having admitted that the AC and DC drops were equal under the circumstances stated. Others seem to do the same, apparently forgetting that it is the reactance component (X) which is the predominating term in choke coil-coupled circuits.

Why should not an adequate battery voltage be provided to take care of the inductive drop in the plate circuit? Will there be less distortion if the plate current is reduced to zero through an inductive drop than through a resistance drop, that is, reduced to zero long before the grid voltage peak has been reached in the negative direction? What special prerogative does an inductance enjoy in this respect? Is it that the inductance supplies its own voltage necessary to maintain the current?



BETTER QUALITY FOR THE SAME OUTPUT IS OBTAINED FROM A RESISTANCE COUPLED AMPLIFIER LIKE THIS THAN FROM AN IMPEDANCE COUPLED CIRCUIT EVEN WHEN THE SAME PLATE BATTERY VOLTAGES ARE USED ON BOTH, SAYS J. E. ANDERSON IN HIS ANSWER TO A CRITIC.

Maximum Undistorted Output

The assumption that extra voltage comes from some unexplained source seems to be made when the maximum undistorted output of power tubes is computed. A voltage of 180 volts, say, is put in the plate circuit, either in series with a load resistance or in series with a high inductance choke, and then the power output is computed on the basis of 180 volts on the plate when no signal is impressed on the grid. At this point the current in the plate circuit is assumed to be that given when there is no load on the tube and when the specified plate battery and grid bias voltages are used. The computation leads to certain maximum and minimum voltages on the plate as the signal varies from minimum to maximum. And the maximum voltage on the plate at minimum current is often more than double the applied plate voltage, that is, than the battery voltage. Where does the extra voltage come from?

It appears that the conventional rating of power tubes is greatly exaggerated—approximately by a factor of 2.5. The rating is based on effective plate voltages and not on plate battery voltages. If the battery voltage on a 171A tube, for example, is 180 volts, and if the plate load resistance is twice the internal AC resistance of the tube, the maximum undistorted power output is approximately 300 milliwatts as against an output of 710 milliwatts when the effective plate voltage is 180 volts. Yet the output is given as 710 milliwatts when the battery voltage is 180 volts.

When the DC resistance is low in a high inductance load, the DC current is high at the operating point. Does not this current add to the power output? It does to the so-called wattless component. The power factor is also neglected in computing maximum output, that is, it is assumed to be unity. The wattless component of the power has a bearing on the wave form distortion or on the permissible voltage swing on the grid, but it does not contribute anything to the loudspeaker.

Therefore in tube and load technique there is more than one viewpoint, whether DC voltage requirements or other considerations are at stake, and it should surprise no one that a close analysis of a given situation exposes a few traditional errors even in high places.

J. E. ANDERSON.

* "Elements of Radio Communication," by Prof. John H. Morecroft.

ELECTRON PRINCIP

Orderly Turmoil Rages in Battle of

By Harrington

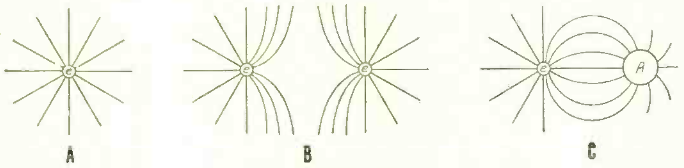


FIG. 1

(a)—An electron is usually represented by a circle with radial lines to represent the field.

(b)—When two electrons come near each other their electric fields become distorted and they repel each other.

(c)—An electron and a proton, a positively charged atom, attract each other. The electron tends to fall into the atom just as a ball dropped from an airplane falls to the earth.

TO understand the operation of a vacuum tube as used in radio receivers for detection and amplification it is essential to know the behavior of electrons as well as the behavior of conductors when they contain a greater or smaller number of electrons than the normal amount. The normal amount is that which leaves a conductor uncharged or without any electrification.

An electron is the smallest unit of electrical charge or quantity of electricity which can exist. It is a negative charge, as determined by the classical definition of polarity.

A proton is the opposite of electron, that is, it is the smallest positive charge, as determined by the same definition of polarity. When an electron and a proton are united they neutralize each other's effect so that there results no electrification.

An electron is apparently a small particle of matter, for it has mass and inertia, but it is of a special type of matter because the apparent mass changes with the velocity with which the electron moves. The proton is a property of an atom, and the atom is the smallest particle of ordinary matter which can exist. A simple atom, such as that of hydrogen, has one positive charge or proton only, so that a neutral or uncharged atom of hydrogen has one electron and one proton. The mass of the hydrogen atom is about 1800 times greater than that of the electron.

Complex Atoms

An atom of any substance is thought to be simply a central nucleus with a number of electrons revolving around it just about the same as the planets revolve around the sun. The hydrogen atom has only one electron or planet revolving around it. A helium atom has four electrons. Atoms of other and more complex substances have many electrons.

On this view an atom becomes charged negatively when an extra electron attaches itself to it, and positively charged when one of the normal number of electrons is detached from the central nucleus.

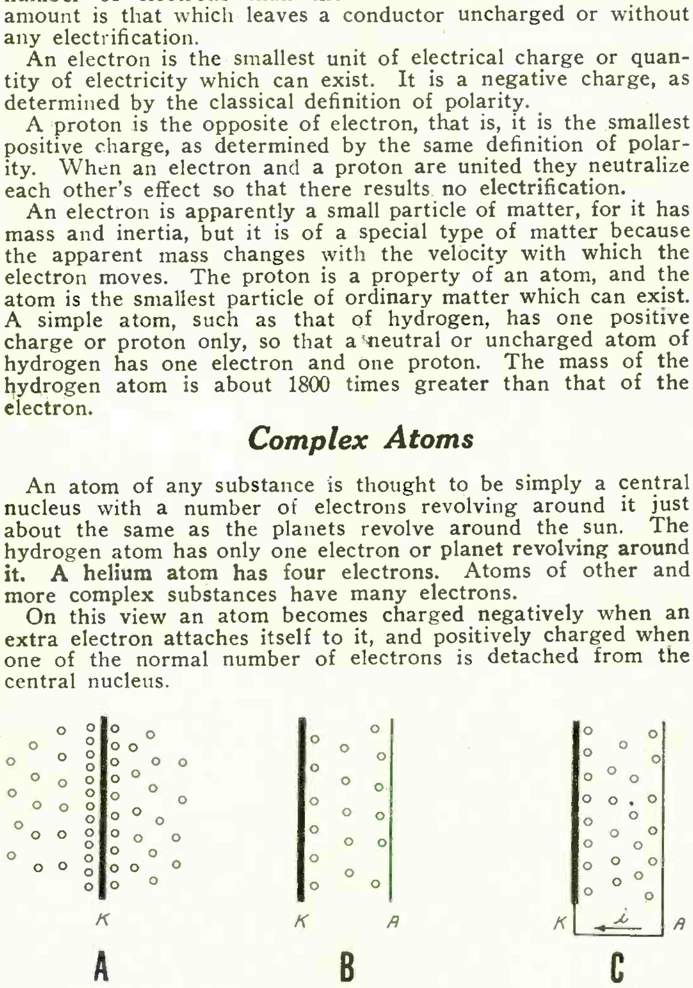


FIG. 2

(a)—Electrons are projected from a heated conductor like water is projected from a geyser. They return again unless they are attracted away by a greater force.

(b)—If a conductor A, insulated from the cathode, is placed near it, some of the electrons will reach the conductor and charge it up negatively.

(c)—If the cathode and the anode A be connected with a wire, a current will flow through the wire because the anode continues to attract electrons.

A conductor is a large aggregate of positive nuclei, each nucleus having its complement of electrons. In an uncharged conductor every nucleus has all its electrons in place. In a conductor feebly charged positively, an electron has been removed from each of a few of the atoms. In a conductor more positively charged a larger number of electrons has been removed from the aggregate. If the conductor is negatively charged, electrons have been added to the aggregate of atoms constituting the conductor, above the normal number.

Two electrons repel each other when they come within each other's influence. It follows that two conductors, or any other bodies, charged negatively, also repel each other. This repulsion of electrons is illustrated in Fig. 1. At (a) is represented a free electron, with its negative charge *e*. The electron is surrounded by an electric field of force, radial in every direction, represented by straight lines. At (b) two electrons are represented, each with its field of force. There is a general law in physics that two bodies cannot occupy the same space at the same time, and this extends to the fields of electrons. At least this assumption may be made for the sake of explanation, because it leads to the correct results. Since the fields cannot overlap, they are distorted in the manner shown by the curved lines. These lines, representing the field of force of the electrons, tend to straighten out, and in doing so the electrons themselves are pushed apart, unless they are held together by some external force. If, instead of two electrons, we have two negatively charged bodies, the action is the same.

Protons Repel

Just as two electrons repel each other, so do two protons, or two atoms of matter positively charged. Also, two positively charged bodies repel each other just as two negatively charged bodies.

An electron and a proton attract each other. This is illustrated in Fig. 1 (c). A is a positively charged body or simply an atom from which an electron has been removed, and *e* is the electron. Each has a field of force which can be represented by radial lines in all directions. Every line of force from an electron must terminate on a positive charge. A line emerging from the electron and ending on a positive charge tends to shorten, and so the negative and the positive charges tend to attract each other. If A is a large positively charged body, *e* falls into A just as a ball falls to the earth when dropped from an airplane. The similarity is quite close, for the electron *e* had been lifted from A in the first place, unless *e* came from some other positive body, when it would fall into A just like a meteor falls to the earth.

Heat-Liberated Electrons

When a pan of water is heated over a stove, water evaporates. The rate of evaporation, however, does not become rapid until the temperature of the water is near the boiling point. The more heat that is applied to the water the more rapid is the evaporation.

This evaporation is not limited to water, but applies to all substances. For every substance there is a definite boiling temperature, although not all substances have melting points, and at the boiling temperature the molecules of the substances shoot out with great rapidity, and sometimes with great violence.

The temperature of boiling depends on the substance and on the pressure of the gas on its surface. The lower the pressure the lower is the boiling temperature. Evaporation occurs even below the boiling temperature. For example, there is a slow evaporation from ice, gold, sulphur and such substances.

Impurities on the surface of the substance affect the rate of evaporation. For example, oil on water prevents evaporation.

Electrons also are evaporated from substances as a result of action by heat and light. As in the example of evaporation of substances, the rate depends on the temperature, the pressure of air or gas above the surface of the emitting substance and on any impurities on the surface.

At ordinary temperatures the rate of electron emission is negligible. The same holds true of the evaporation at ordinary gas pressures, that is, atmospheric pressure. When the substance is hot, on the other hand, and when the pressure of the gas is extremely low, the rate of evaporation of electrons is rapid. Under these conditions the electrons shoot out in large numbers and sometimes with very high velocities.

The rate of electron emission is also greatly affected by the

LE APPLIED TO TUBE

the Negative and Positive Armies

J. Forbes

surface conditions of the emitting substances. Some impurities prevent the emission or reduce its rate at a given temperature and gas pressure. Other impurities greatly facilitate the emission. For example, thorium on the surface or in the body of a heated tungsten filament increases the rate at which electrons are shot out of a filament at a given temperature. Oxides of barium, sodium and of other alkali metals aid the emission enormously. Thus we have thoriated tungsten filament tubes, the kind that can be reactivated. We also have the oxide-coated filament tubes that are operated at a dull red heat. These oxide-coated tubes can be operated at a dull red heat because the oxide impurity on the surface of the heated metal increases the electron evaporation at a given temperature by a large factor.

Electron Evaporation

Let K in Fig. 2A represent a heated metal wire or any other heated conductor from which electrons can escape. The symbol K is used because the electron emitting member of a vacuum tube is the cathode. It makes no difference how it is heated, by an electric current through the wire, by heat radiation from another heated substance close to it, by electron bombardment from another electron-emitting conductor, by an alternating current induced in the conductor by induction, or by a flame. Any device which will make the conductor K hot will cause it to become a cathode, or electron-emitting electrode. It is assumed that K is inclosed in an envelope from which as much gas as possible has been removed.

The thermal agitation of the atoms of the conductor expels the electrons from the cathode. Some of the electrons are shot out with low velocity, and they do not get far from the surface. Other electrons are shot out with much higher velocities, and they get a considerable distance away from the cathode before they are pulled back. All the electrons that are shot out fall back to the cathode, for the cathode is positive as soon as one electron has left it, and so the cathode attracts the electrons back. It is just a question of how far away from the cathode they get before they return. The hotter the cathode the farther away they will go on the average. This emission and return is much like the action of a geyser. The thermal agitation inside the geyser shoots out the hot water, which returns to the earth after a short journey upward.

The heated cathode is surrounded by an atmosphere of electrons in about the same way as the earth is surrounded by an atmosphere of gas, and the density of electrons, that is, the number per unit volume of space, will vary in somewhat the same way as the density of air varies with the distance from the surface. Near the cathode the electrons are thick, farther away there are only a few per unit volume. In other words, the electron atmosphere becomes rarified as the distance from the cathode increases. The outer limit of the rarified atmosphere depends on the temperature of the cathode.

As long as we only have a heated cathode, nothing happens. The system is in equilibrium as far as external effects are concerned, although it is much disturbed internally.

Insertion of a Plate

Now suppose we insert another conductor A inside the evacuated envelope, as shown in Fig. 2B. Let this conductor be cold. This conductor is supposed to be insulated from the cathode and from all other conductors. Now some of the electrons will reach this electrode, being those which start from K with the higher velocities. Those electrons that do reach the anode (A) will make this conductor negative. After a small number has reached A, then A will repel other electrons coming up. Now only those having the very highest velocity will be able to reach A. Finally an equilibrium will be established so that no more electrons can get to A as long as the cathode remains at the same temperature. The electrons emitted are now both attracted to K by its own positive charge, and also pushed in that direction by the negative charge on A. The electrons will be concentrated nearer the cathode.

Suppose now that K and A be connected with a wire as shown in Fig. 2C. This wire, if of very low resistance, will keep A at the same potential as K. When an electron leaves K, making the electrode slightly more positive, A also becomes more positive by the same amount, but this requires that a current i flows in the connecting wire. The arrow points in the direction the electrons move. The conventional current would flow in the opposite direction. Since A is at the same potential as K, the electrons that are shot out from the cathode are not only attracted back to K, but they are also attracted to A. Thus those electrons which are shot out farthest will be attracted more by A than by K, and many more will now be shot out to a great distance. Hence with this connection a considerable number of electrons will reach A. Since A cannot build up a negative charge as it did without the connecting wire, the electrons that reach A will return to K by way of the wire, and the current i will be established.

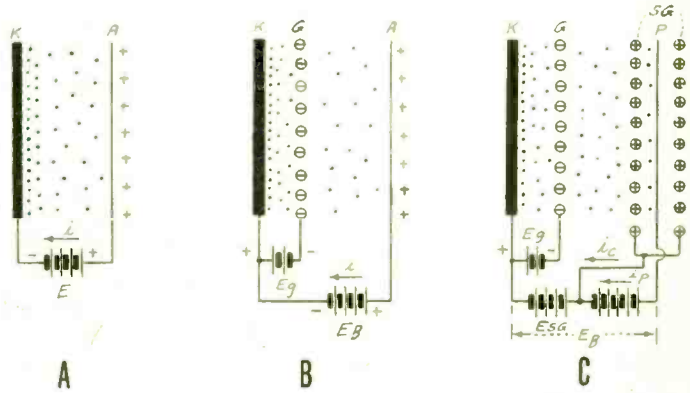


FIG. 3

(a)—A heated cathode K and an anode A in a vacuous space connected together with a battery E. A current flows in the circuit because the anode attracts the electrons and returns them to the cathode by the external circuit.

(b)—When a negatively charged grid is interposed between the cathode and the anode the electron flow is limited by the repelling force of the grid.

(c)—A screen grid positively charge placed around the anode P aids the plate in pulling over electrons, but it also robs the plate of some so that the current in the plate circuit is reduced.

Adding Anode Battery

Now let us connect a battery E in the connecting wire between K and A, with its positive polarity connected to A and the negative to K, as shown in Fig. 3 (a). The electrons are now strongly attracted by the positively charged plate, and the higher the voltage of battery E, the more strongly they are attracted. Now a very large number of electrons will reach the anode, or plate, to be returned to the cathode by way of the connecting wire and battery. The field of influence of the positively charge plate extends over to K, and if the voltage E is high enough, the pull of A on even the electrons very close to K will be greater than the pull of K on those electrons. When the attraction of A predominates, all the electrons emitted by K will be pulled over to A, and the resulting current in the external circuit is the saturation current. As is to be expected, the saturation condition is approached gradually as the voltage E is increased.

The so-called space charge also determines the current flow, as well as the distribution of the space charge. This charge is simply the charge on the electrons which are in transit between K and A in the evacuated space. Those electrons which are near the plate repel all those which are behind, opposing the attraction by A and aiding that of cathode. Each layer of electrons, wherever situated., repels all the electrons in all the layers nearer the cathode and those near the cathode are very strongly repelled toward the cathode by the entire space charge. The attraction of the plate must be high enough to overcome this space charge repulsion. The energy necessary to overcome this repulsion and bring the electrons to the anode is the internal voltage drop in the tube, and the drop divided by the current actually flowing is the internal resistance of the tube. It is clear why the internal resistance decreases as the plate voltage increases. The attraction by the plate reduces the space charge.

AUDIO OSCILLATION AN

Methods for Stability in

By J. E. Anderson

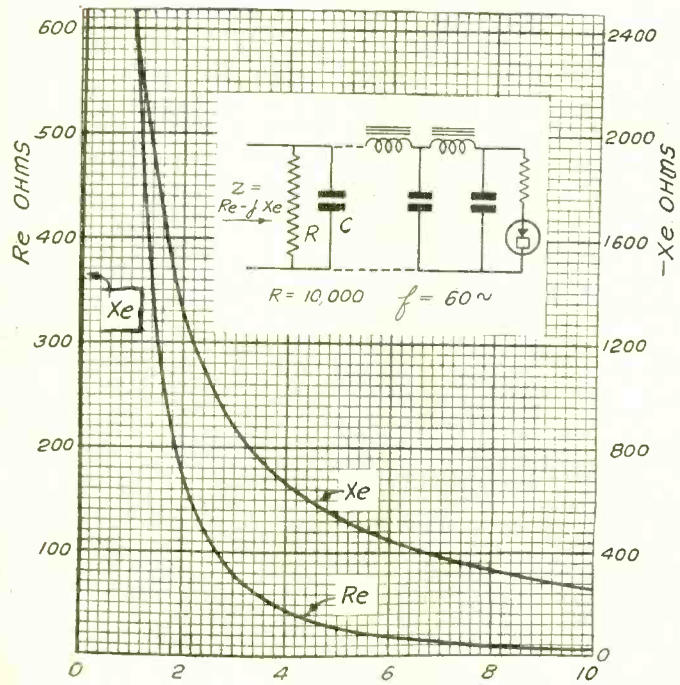


FIG. 60
CURVES ILLUSTRATING THE VARIATION OF THE EFFECTIVE RESISTANCE Re AND THE EFFECTIVE REACTANCE Xe AS THE CAPACITY C VARIES IN A B SUPPLY.

[What the remedies are for oscillation in audio amplifiers, and how to apply them, surely constitute an interesting subject, discussed this week in the serial work, "Power Amplifiers," begun in the June 1st issue, and continued each week since then. If you have missed any of these instalments be sure to get it now, as the subject of power amplifiers is not only uppermost, but will even increase in importance. When trouble comes it is a wise man who has the solution right at hand. Next week the same subject of trouble in audio amplifiers will be discussed along different angles.—Editor.]

Methods of Suppressing Audio Oscillation

Since nearly all amplifiers are powered with devices in which the impedance is high enough to cause either oscillation or serious distortion, it is necessary to find means for reducing the feedback. There are three general methods of attack. The first is to reduce the common impedance, the second is to introduce devices to detour the signal currents in the plate circuit around the common impedance, and the third is to arrange the circuit constants so that the common impedance is relatively low compared with other impedances in the plate circuits.

Reduction of the common impedance can be effected by employing a storage B battery. The internal resistance of such a battery, when fully charged, is so low that it will not cause oscillation in the most unstable set. Almost the same can be said of dry cell batteries as long as they are fresh. But these quickly develop a high internal resistance which ultimately may cause oscillation or distortion.

Under reduction of the common impedance also comes the use of high-grade B supply units having a very good regulation. But to effect any improvement in this manner it is necessary to employ units having output voltage regulators and units designed to supply much more plate current than the receiver itself will require. It is not economical to obtain stability in this manner, for the B supply will cost more to procure and to operate than the rest of the receiver.

The only practical way to reduce the common impedance in a given B supply is to connect more and larger condensers across its output terminals. It is only the last condenser in the B supply which is effective in reducing the common impedance, for the signal current cannot reach the other condensers without going through one or two choke coils. There may be an exception to this statement for very slow frequencies, because for these the chokes do not offer much impedance. At any rate, the last condenser is the only one that need be considered for frequencies above 60 cycles.

If the various plate returns are connected to different taps on a voltage divider, as is usually the case, the common impedance is very complicated and any two tubes may not have the same common impedance as any other two. The condensers connected from the various voltage taps to the negative side of the line, or to the cathodes, enter the problem. The voltage divider resistance reduces the common impedance and at the same time it reduces the effectiveness of a condenser of given capacity.

Suppose that the resistance in the voltage divider is 10,000 ohms and that all the plate return leads are connected to the highest voltage point. For high frequencies the impedance of the choke coils and the rectifier may be considered infinite in comparison with a 10,000-ohm voltage-divider resistance. Now the question is: How is the common impedance affected by the condenser across the entire voltage divider? Let C be the capacity of the condenser in farads, R the resistance of the voltage divider, and let w be 6.28 times the frequency of the current. The impedance of the resistance and the condenser in parallel is equivalent to a resistance of R/A and a capacitative reactance of R^2Cw/A, where $A = 1 + C^2w^2R^2$. Let the frequency be 60 cycles, the lowest value for which the impedance of the choke coil branch of the circuit can be considered large compared with the voltage divider resistance. We have already assumed that the resistance is 10,000 ohms. Let C be measured in microfarads. Then the formulas for the effective resistance Re and effective reactance Xe reduce to: $Re = 10{,}000/A$ and $Xe = 37{,}700C/A$, where A now equals $1 + 14.2C^2$.

The curves in Fig. 60 show the variation of Re and Xe as the capacity varies from zero to 10 microfarads. The resistance curve starts at 10,000 ohms when the capacity is zero and at first drops rapidly, then at a less rapid rate, until for large values of capacity it changes very slowly.

The reactance curve starts at zero when the capacity is zero, rises to a maximum of 5,000 ohms when the capacity is .266 mfd. and then drops rapidly. For the larger values of capacity the reactance decreases toward zero very slowly.

These curves show the importance of using a large by-pass condenser across the output terminals of a B supply unit. The capacity must be so large that the values of Re and Xe are smaller than the values of the common impedance which will make the circuit oscillate. Not only must the values of Re and Xe be less, but they must be so much smaller in impedance that there will be no appreciable tendency toward blasting.

At very low frequencies the impedance of the chokes and the rectifier must be taken into account. This impedance lowers the effective resistance across the condenser and at the same time it lowers the effect of a given capacity so that a larger condenser must be used to get the same effective values of Re and Xe. At the lowest frequencies at which motorboating may occur, it is not practical to use a condenser large enough to reduce the common impedance sufficiently to stop the oscillation. Even an electrolytic condenser of the order of 50 mfd. is ineffective in stopping some of the slower oscillations which occur.

No matter how unstable a circuit may be, a condenser of the size ordinarily used is effective for all frequencies down to about 100 cycles. Hence, in discussing remedies for motorboating it is only necessary to consider frequencies below that value, the higher frequencies having been provided for by the condenser across the output terminals of the B supply or by condensers distributed among the taps of the voltage divider.

Detouring devices for minimizing the effect of the common impedance are illustrated in Fig. 61, in which three different coupling arrangements are included in one circuit. The object of detouring is to keep the signal currents in the plate circuits out of the common impedance Z and thus to make the current *i* as small as possible.

The first plate current *i*1 flows through the coupling resistor R1. Most of it also flows through condenser C1, a very small portion of it flowing through the blocking resistor. This part alone flows through the common impedance Z to contribute to *i*. The larger r1 and C1 are the smaller this portion is and the more effective is the detouring.

In the case of transformer coupling the same arrangement is used as shown in the second stage. The current *i*2 flows through the primary Z2. Most of it flows through condenser C2 and a very small portion through r2. As before, the larger C2 and r2 the less of the plate current flows through r2 and hence through the common impedance Z. If most of *i*2 is forced through C2 by the blocking resistor r2 there will be very little reverse feed back and hence the common impedance will have very little effect.

D DISTORTION STOPPED

Amplifiers Discussed

and Herman Bernard

If r1 and r2 are of considerable magnitude, it is necessary to boost the applied voltage to compensate for the voltage drops in these resistors, for they are not a part of the coupling impedances. As there may be a considerable drop in these resistors, especially in r2, it is preferable in some instances to make r1 and r2 high inductance choke coils. If these are of low resistance, and if the condenser across Z is large, these chokes are particularly effective in forcing the plate current to go through condensers C1 and C2, and the direct-current drops in them will be negligible.

Now we come to the most important point in the circuit from the detouring viewpoint, the output tube. The last tube's plate current, which is much the largest, must be kept out of Z almost completely. In this circuit particularly it is that current which causes instability if allowed to flow through Z. And if it does not cause instability, it reduces the amplification.

The case illustrated is the type of output usually called an output filter. The direct plate current flows through the choke coil Z3 and most of the signal current flows through the load (speaker winding) and the condenser C4. If the speaker is returned to B plus, all the signal current flows through the common impedance. If it is returned to the cathode or the filament very little flows through Z. Hence to reduce the effect of the common impedance the speaker should be returned to the cathode, if the tube is of the heater type, to the negative end of the filament if it is a battery type tube, and to the mid-point of the last audio stage's filament transformer if the tube is of the AC filament type. There should be no deviation from this rule. If the output device is a transformer or if the speaker is connected directly a condenser should be used to produce the same effect.

Some of the signal current will flow through the choke coil Z3, especially the low frequency, and this part may be large enough to cause undesirable effects. To minimize this current the capacity of C4 should be large and the inductance of Z3 should be high. The larger they are, the less signal current will flow through Z, and the smaller the effect of the common impedance.

For very low frequencies C4 effectually will stop the signal current and Z3 will not offer much impedance. Hence at low frequencies a much higher proportion of the signal current will flow through the common impedance. The circuit, therefore, might well be stable throughout the audio range but be oscillatory at about 10 cycles.

In the event that C4 and Z are not large enough to prevent the signal current from flowing through the common impedance at the low frequencies, the condenser C3 and the choke Ch might be used in addition. These two serve exactly the same purpose in the last tube as C1 and r1 did in the first tube.

If the detouring has been done thoroughly, the current *i* in the common impedance will be very small and the circuit will behave almost as if Z were zero.

When an output transformer is used all of the signal current in the primary will flow through the common impedance unless it is kept out by a condenser in the position of C3 and a choke in the position Ch, assuming that Z3 is the primary of the output transformer. For this case the capacity of C3 and the inductance of Ch should be larger than when an output filter is used as in Fig. 61. Obviously, a resistor should not be used for Ch because the plate current in the last tube is heavy and the voltage drop would be too high.

In some instances oscillation may be stopped by increasing the values of the coupling impedances without taking any other precautions. The idea is to make the coupling impedances, whether they be resistances, choke coils or primaries of transformers, so large that the common impedance is negligible in comparison. This has the disadvantage of increasing the amplification toward the instability point, and this increase partly offsets the gain in stability obtained by making a high ratio of coupling impedance to common impedance. This method is convenient to try in resistance-coupled circuits. and it may effect stability.

Circuits having primaries with high impedance amplify well on low frequencies and for that reason motorboating may occur in them also. The gain in the amplification more than offsets the stabilizing effect of a high ratio of the primary impedance to the common impedance.

Another method of stabilizing a circuit which is often effective is to make the effective plate voltage high and thus reduce the internal plate resistance of the tube. When this resistance is zero the common impedance has no effect. Of course, this condition cannot be realized, but the internal resistance can be reduced considerably.

In circuits employing stopping condensers and grid leaks a very effective way of stabilizing a circuit at low frequencies is to reduce the time constant of the condenser and the leak. Either the isolating capacity or the resistance of the grid leak may be reduced, or both. This is effective because it reduces the amplification in the circuit at the low frequencies. When the frequency of oscillation in the circuit is lower than about 25 cycles per second this method is about the only one available, due to the inefficiency of by-pass condensers and series chokes at these low frequencies. It is understood that the reduction in the amplification impairs the frequency response of the receiver, since it reduces the amplification at the low frequencies and not at the high. But it is preferable to have an operative receiver than to have one that oscillates.

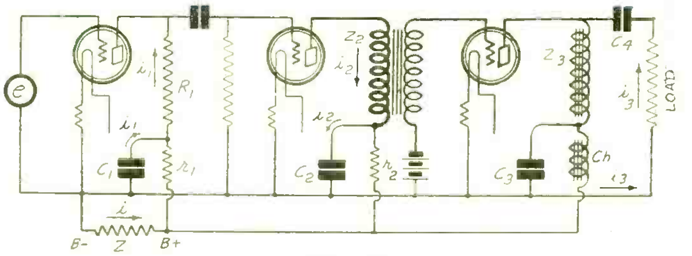


FIG. 61

CIRCUIT ILLUSTRATING THE USE OF RESISTORS, CHOKES AND BY-PASS CONDENSERS FOR DETURING THE PLATE SIGNAL CURRENTS AROUND THE COMMON IMPENDANCE AS A REMEDY FOR MOTORBOATING.

It should be remarked that reducing the grid leak resistance lowers the amplification at all frequencies more than does the lowering of the capacity of the stopping condenser. Hence reducing the grid leak tends to retain the quality.

This method of controlling the oscillation is even available in transformer coupled circuits, for there is no reason why a stopping condenser and a grid leak cannot be inserted between the secondary and the tube. However, it would be preferable to obtain stability by changing the connections of the windings, as was explained in connection with Figs. 54 to 59.

In severe cases of motorboating it may be necessary to provide separate B supplies for different tubes of the circuit. For example, one may be used for the detector and the radio frequency section of the circuit and another for the audio. Or, again, one may be used for the power tube and another for the rest. A relatively inexpensive B supply may be used for the first part of the circuit because it is the last stage which draws most of the current. It may be much cheaper to secure a given degree of stability by using two B supplies than by using a single one which can handle the receiver adequately.

Power Required by an Amplifier

Sometimes it is required to find the total current flowing in the power line supplying an amplifier and to determine the total power necessary to operate the circuit. For example, when a fuse is to be put in the line to protect the circuit the maximum current that will flow must be known so that a suitable fuse can be selected, and when the cost of operation of the amplifier is to be determined the total power required is necessary.

Both of these problems can be answered by summing up all the power dissipation in the amplifier and its plate voltage supply unit, because just as much power is taken from the line as is dissipated in the circuit, and the current in the primary is known as soon as the power and the line voltage are known.

The power required by the filaments of the amplifier and rectifier tubes is obtained by summing up the powers of the several tubes, and the power required by any filament is the product of the terminal voltage and the current in the filament. If there are any shunts across the filament windings the currents through these shunts also must be added. Suppose the amplifier contains one 227 type tube to 245s and one 280 type rectifier. The filament terminal voltage of the amplifier tubes is 2.5 volts. The current in the 227 is 1.75 amperes and that in the two 245s is 3 amperes. The total current at 2.5 volts is then 4.75 amperes. The product of the current and the voltage is 2.5x4.75, or 11.875 watts. The filament current in the rectifier tube is 2 amperes and the terminal voltage is 5 volts. Hence the power required to heat the rectifier filament is 10 watts. Therefore the filaments require a total of 21.875 watts. No shunt resistors are assumed.

WHEN A SHIELD

Induced Electric and Magnetic

By James

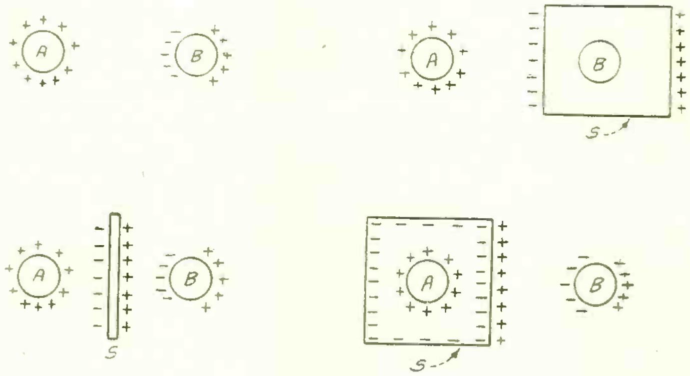


FIG. 1 (left)

(a)—Any electrified conductor as A induces electric charges on any other ungrounded conductor near it such as B.

(b)—A metal slab S, if ungrounded, placed between a charged conductor A does not protect another conductor B. If S is grounded B is protected.

FIG. 2(right)

(a)—If a conductor such as B is placed inside a metal box, any charged body outside the box, as A, can have no effect on B, whether or not the box is grounded.

(b)—If the charged body A be surrounded by a metal box the other body B is not shielded, unless the box ground A is grounded.

SHIELDING is a subject of much interest these days. Coils, condensers, transformers, tubes and nearly every piece of apparatus appearing in a receiver are shielded from each other and from external electrical disturbances. Magnetic shields also are used to protect coils and transformers from magnetic disturbances from whatever source.

But when is a shield a shield? When is it merely a piece of metal in the receiver?

Referring to Fig. 1A let A be a body charged positively, let us say, and let B be a piece of apparatus such as a coil, a condenser or merely a conductor. The positive charge on A induces a negative charge on B on one side and this negative charge in turn induces a positive charge on the opposite charge of B. Now if the charge on A is varied, there will be corresponding variations in the induced charges on B. B is thus affected by A. It is this effect which the shield is intended to prevent.

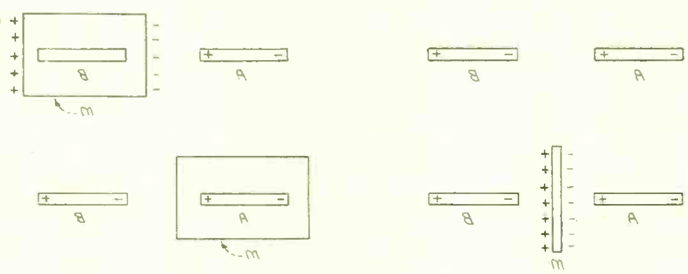


FIG. 3 (left)

(a)—A permanent bar magnet A induces magnetism in a piece of iron B placed near it.

(b)—If a metal slab M is placed between the magnet and the piece of iron, there is no change in the effect of A on B, even when the slab is of magnetic material.

FIG. 4 (right)

(a)—A piece of iron or other magnetizable body be placed inside an iron box, any external magnet A can have no effect on B.

(b)—If the magnet A is placed inside the iron box, A produces an effect on B just as if the box were not present.

Let a slab of metal, S, ungrounded, be interposed between A and B. Is S a shield between A and B? It appears not. The positive charge on A induces a negative charge on S on the side toward A. An equal positive charge appears on S on the opposite side. This charge in turn induces a negative charge on the near side of B, and this results in a positive charge on the far side of B. Any variation in the charge on A will produce corresponding variation in all the induced charges, and B is not protected from A by the metal slab S.

Grounding Helps

Suppose S is connected to ground by a good conductor. Induced charges cannot now appear on the metal slab, for as soon as they are induced they run down the wire to earth. B is almost completely protected from A. The shielding is better, the more perfect is the conductivity of the metal slab and the earth wire. Also, the larger the metal slab relatively to the dimensions of A and B, the better is the shielding. S may even be a screen of wire provided that currents can flow freely from all parts of the screen to earth.

Now refer to Fig. 2 (a), in which S is a metal-box completely surrounding the apparatus B to be protected from electric charge variations on A. Does the box protect B from A, (1) when S is grounded, (2) when S is ungrounded?

A induces a negative charge on the side of S near A and an equal positive charge appears on the opposite side of the box. No charge appears inside the box. There can be no electrification inside the box due to any electrification outside it. Hence B is completely protected, and this is true whether or not the box is grounded.

This shielding box is an adaptation of the old Faraday cage idea. Suppose A is a thundercloud charged with electricity instead of a piece of apparatus in a radio receiver. Let B be a person inside a wire cage, or a house with metal walls, ceiling and floor. That person is completely protected from any possible lightning stroke. The only way he could be hurt would be for the lightning to strike the cage and melt it. The damage would come from the molten metal and not from the lightning directly.

In Fig. 2B is the reverse situation. The charge A is now surrounded by the metal cage or box. Is B protected by the cage (1) if S is ungrounded or insulated and (2) if S is grounded by a good conductor?

When the box is insulated the positive charge inside S induces an equal negative charge on the inside walls of the box, and an equal positive charge appears on the outside of the box. This positive charge in turn affects B. Thus the ungrounded metal box around A does not protect B at all. It does not change the situation at all.

Let S be grounded by a very good conductor through which electric current can flow freely. The potential, or the state of electrification, cannot change now. Hence B is protected. If the charge on A varies, a current flows from the box to earth through the wire, or in the reverse direction, depending on the direction of the change.

A practical application of this is in the case of the oscillator

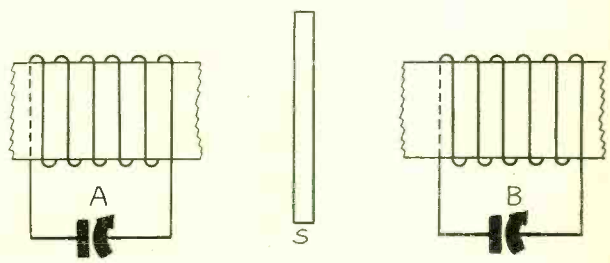


FIG. 5

A slab of high conductivity metal placed between two tuned or untuned radio-frequency circuits acts as a magnetic shield, and as an electric shield if grounded.

IS NOT A SHIELD

Effects Produce the Shielding

H. Carroll

in a superheterodyne, A being the oscillator and B being the rest of the circuit. If the metal box around the oscillator is grounded, and if the grounding wire and the metal box have good conductivity, there can be no external electric effects, except those associated with magnetic effects, for the box is not a good shield for the magnetic forces.

Another practical application of the shielding cage idea is the screen grid tube. The screen grid tube is a partial screen or shield of the plate against electric variations on the grid. And the grid itself, in any tube having a grid, is a partial shield of the plate against the cathode. The screen grid comes under Fig. 2 (a) and the grid under Fig. 1B. In these cases the shielding is not complete, for the grids have openings.

Magnetic Shielding

Let A in Fig. 3A be a bar magnet having the positive pole toward the right and the negative pole toward the left. Let B be a bar of soft iron or any other magnetizable material. The positive pole of the permanent magnet induces a negative pole in the previously unmagnetized bar B, as indicated. This makes the opposite end of B a positive pole. Can B be protected from A so that no magnetism is induced?

Suppose a slab M of non-magnetic metal be placed between the permanent magnet and the bar B. Is there any change in the magnetic field of A? None at all. The magnetic lines of force pass through the slab just as if it were not there.

But suppose the slab is made of soft iron or a highly permeable material such as silicon steel or permalloy. Does this slab protect B from the effects of A? Not at all. The permanent magnet induces a negative pole on the side of the slab toward A and a positive pole appears on the opposite side. This positive pole induces a negative pole in the near end of B, and a positive pole appears at the far end. The slab of magnetic material does not protect B from A any more than does an equal slab of copper or aluminum.

Could not grounding be resorted to as was done in the electric case of Fig. 1B? There is no magnetic ground. But there must be some way of protecting bar B from the permanent magnet.

Let us try putting B inside a box of soft iron or other magnetic material, as in Fig. 4A. Now the permanent magnet will induce a negative pole on the side of the shielding box near A, and a positive pole will appear at the opposite side of the iron box. There will be no magnetic field inside the box, and bar B is completely shielded. This is analogous to the electric case in Fig. 2A.

Copper Box Does Not Shield

If the shield box M is made of a non-magnetic material the magnetic lines of force will go through it just as if it were not there, and there would be no shielding at all. Hence such metals as copper and aluminum cannot be used for magnetic shields.

Since an iron box around B protected it from A, why can not the same protection be secured by putting the iron box around A? Fig. 4B illustrates the arrangement. The permanent magnet A induces a negative pole on the inside of the box toward B, and a positive pole appears on the outside of the box. This induces a negative pole in the end of B toward A and a positive pole appears at the opposite end. That is, B becomes magnetized just as if the box M were not around A. And this can not be remedied by grounding the box, as was done in the electrical case Fig. 2B, because there is no magnetic ground.

While a permanent magnet was used in these cases, only variable magnets, such as coils carrying alternating current, are of interest in radio. But the same principles apply to these as to the permanent magnets.

Variable Magnet Shields

When an apparatus is to be protected from an electro-magnet, particularly on in which the polarity changes with great rapidity, there are other means of securing protection.

Let A in Fig. 5 be a tuned circuit in which high frequency current is flowing. The coil then is an electromagnet in which the polarity reverses with great rapidity. If a similar tuned circuit B is near A, an alternating current will be induced in B. This is ordinary coupling of two radio-frequency coils. The coil in circuit B will also be an electromagnet, the polarity of which varies at the same rate as that of A.

It may be that it is necessary to protect circuit B from circuit A, or vice versa. We found that if a slab of grounded metal S is interposed between the two, they will be shielded electrically. When high frequency currents flow they will be shielded magnetically, provided only that S is such that induced currents can flow freely in it. The better the conductivity of S, and the higher the permeability of the material, the better the magnetic shielding effect. For high frequencies the material does not have to be magnetic, for low it must be.

The reason the slab of metal is a magnetic shield is that currents are induced in it, and these set up an opposing magnetic field which otherwise would be set up in the coil that is protected. These are the so-called eddy currents. In effect, the eddy currents send back or reflect the magnetic lines of force, just as a mirror reflects light. The mechanism of reflection is thought to be the same for both magnetic and light effects. Since the lines of magnetic force are reflected, a shadow is established on the other side, and if the coil protected lies in this shadow, the shield is effective.

More complete shielding of B from A can be obtained if B is entirely inclosed in a metal box, as in Fig. 6. The box, to be effective, must be made of highly conductive metal, and the sides must not be too thin. Moreover, there should be no high resistance joints, but the induced currents must be allowed to flow freely wherever they will, or wherever demanded by the magnetic flux that falls on the box. As was explained previously, the box is also a complete electric shield.

In this case the box can also be placed around A in order to protect B, as shown in Fig. 7. As was explained in connection with Fig. 2B, the box must be grounded if it is to be an electric shield as well. In the arrangement in Fig. 6 the box need not be grounded if B is to be protected from A, but it must be if A is to be protected from B.

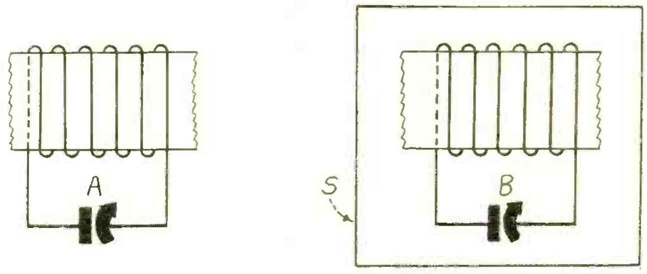


FIG. 6

If a circuit B is placed inside a metal box of high conductivity, it is completely shielded from an external circuit A.

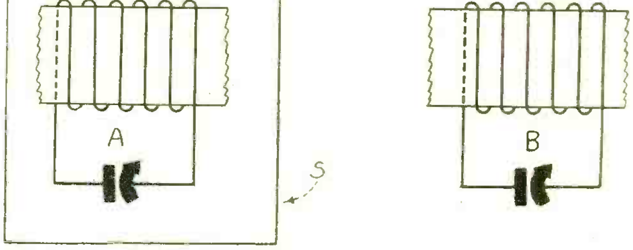


FIG. 7

If the metal box of high conductivity is placed around a disturbing circuit A it protects an external circuit B from magnetic effects, and from electric effects if grounded.

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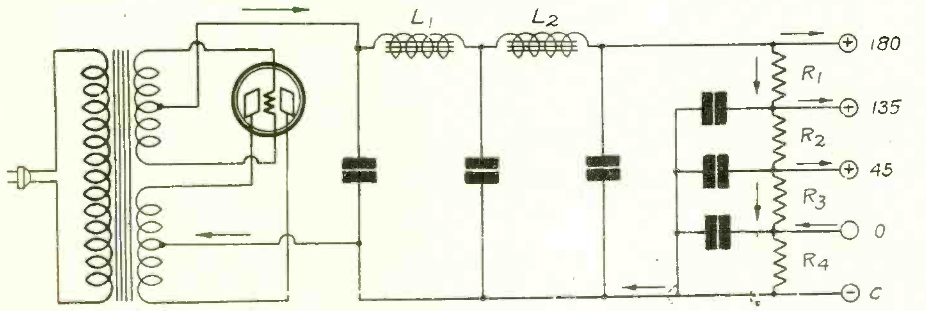

FIG. 776

MAXIMUM VOLTAGE MAY BE OBTAINED FROM THE CHOKE JOINT.

IN push-pull there is the advantage of hum reduction, therefore would it not be possible to take the high voltage for the power tube or tubes off the midsection of the filter chokes, instead of from the output end, so that the current through the second choke would be that much less, and the filtration by that second choke would be improved?—A.T.

Yes, that may be done. But you must understand what you are doing. The voltage drop in the second choke will not be effective on the push-pull audio tubes, as the choke is out of their circuit. If a single resistor biases the last stage only, then the increased voltage will increase the plate current and increase the drop across this resistor, hence increase the biasing voltage, which is all right. But if the bias is obtained through a section of a voltage divider, the proportion of increase in bias will not be large enough. So the biasing section's resistance value would have to be increased. Of course, the push-pull pair should not be worked in excess of their rated voltages, but if anything different, then a little under. Therefore with these precautions in mind you may make the change you suggest. See Fig. 776.

* * *

IS it better to use a commercially available general type of B eliminator with a receiver, or a B supply specially designed for the receiver? Since the only object is to supply plate current and plate and grid voltages, I don't see why a universal type is not as good as one I would have to go to the pains to build.—G.D.

Naturally a specially designed B and C supply is preferable, since is affords the proper voltages at the desired currents. Using a "universal" type is not conducive to best results. However, where a B supply is not designed for a special receiver, but is to serve a given type of receiver, as one using screen grid tubes and 245 output, single or push-pull, with directions for changes to incorporate push-pull, then this type may be used to good advantages. Strictly speaking it comes under the "special" rather than the "general" classification.

* * *

IS it better to obtain the bias for a battery-operated tube from a C battery, or will the voltage drop in the filament resistor be all right? The bias of course would be low, equal to the drop in the resistor, which is 2.7 volts.—G.F.

It is quite all right to obtain the bias from the voltage drop in the resistor. Then you have a permanent bias, one that needs no replenishment. Connect the resistor in the negative filament leg of the tube. Connect the grid return of the tube to A minus, not to filament minus.

* * *

I INTEND to use 245 push-pull tubes, with Silver-Marshall 257 push-pull input transformer 258 output impedance. I have a power transformer that has two 2.5 volt windings, one rated at 3 amperes, evidently for the power tubes, the other at 6 amperes. Since the 245 tubes draw 1.75 ampere each, total filament current for the two tubes, 3.5 amperes, will I not be overheating a winding rated at 3 amperes?—H.G.

The 245 tube draws 1.25 amperes, not 1.75 amperes. The 1.75 amperes are the rating of the 224 and 227 tubes. So the 3-ampere rating, if correct, is sufficient for the two tubes that draw a total of 2.5 amperes. The 6 ampere rating is good for only three 227 or 224 tubes.

* * *

I HAVE two filter choke coils for a B supply. Their DC resistance is rather large—625 ohms each—and as considerable voltage is dropped through them, and high common impedance established, I thought it might be feasible to connect a resistor of about equal DC resistance across each, to halve the total DC resistance.—K.G.

That plan does not work out. While it is true that equal resistors in parallel present only half the resistance of a single one to an applied emf, it must be remembered that as much current flows through the shunt as through the other. Therefore the current through the shunt resistor in the case you suggest would be half the total current flowing, and it would be almost totally unfiltered.

* * *

DO you consider earphones a requisite to a service man's kit?—T.D.F.

Yes. They provide a handy means of testing for continuity and operation. Especially in the audio circuit stages can operation be tested by the audibility method.

* * *

DOES the physical size of a condenser have anything to do with its voltage rating, that is, will a condenser of large physical dimensions withstand a higher voltage?—Y.R.

The physical dimensions have nothing to do with the voltage rating of condensers. Some condensers only 1⅛" square at top stand 800 volts DC, 550 volts AC, working voltages, while others four times as large stand only one-quarter as much voltage.

* * *

MY space limitations are severe, as I have a bookcase in which I desire to put my radio installation. I desire to use the AC screen grid tubes, 224, and a 245 as output tube. Please give me some suggestions for conserving space.—H.F.Z.

You may use upright radio frequency transformers of 2½" diameter, and place the sockets on the subpanel, inside the coils, for the tubes to which these coils are connected for input. You can mount the audio transformers, if they are in shield cases, one atop another, with audio tubes beside them. The power transformer block may include the two choke coils, also of course the necessary filament windings. With such a layout you could build a six-tube push-pull set, including 280 rectifier, on a 9"x15" subpanel.

* * *

FOR several months my magnetic unit gave me good service, but now it has developed a rattle, which seems to be caused by vibration of the pin. This rattle is not permanent, but takes place when a certain note is sung or struck by the broadcaster. Can you suggest a simple remedy?—T.E.S.

Take some medical adhesive tape or bicycle tape. Tear off a strip 5" long, and cut to ¼" width. Wind this ¼" wide strip around the pin from the point where it enters the cone to the point where it is connected to the armature. In this way you will lower the pin's natural period of vibration so that no more trouble need be expected from this source.

* * *

IN diagrams of B supplies I notice that where the voltage divider has no adjustable voltages that either no voltages are marked, except maximum and perhaps bias, or that the voltages are given in rather wide ranges, although the resistance value is fixed. Why is this?—O.G.O'T.

Where no voltages are marked it is because the author can not presume what type and number of tubes will be connected to given taps, hence what current will be drawn, for the greater the current flow, the greater the drop in the resistor, and the lower the available voltage at the taps. Maximum voltage may be marked, because that changes little compared with the other points, due to comparative changes in current drawn. Where wide ranges are cited for fixed resistors it is for showing the extent of the available voltages as determined by given values of current drawn.

* * *

IN a four-tube receiver, using batteries, where there are one stage of tuned RF, tuned detector input and two stages of transformer-coupled audio, should single control be used, or would it be better to use two separate tuning condensers?—F.S.E.

This is a matter of personal taste and circuit design. Where a single tuning dial is desired, and a ganged condenser used, the sensitivity will be a little less, at some points on the dial, unless a trimmer is provided at the front panel to take up small differences in capacity that will develop inevitably. Convenience is served by single control, while a little gain in sensitivity results from double control. Since you have two hands the two controls will not prove cumbersome. DX hounds will fare better with double control.

HOW can the relative selectivity of receivers be expressed accurately in words? What is the usual method of showing comparisons?—U.T.

There is no way of comparing accurately in words the difference in selectivity, as only very general terms are applicable, such as "poor selectivity," "good selectivity" and "high selectivity." These terms give no real clue to the situation. It is customary to show selectivity by plotting a curve of response against frequency. The cutoff at frequencies adjoining resonance will reveal the selectivity. The height of the curve will show the relative degree of amplification. Thus in Fig. 777 curve A represents the lowest order of selectivity, virtually none, while B is an improvement, as is C, and D represents a useful curve, that is, the selectivity is of the degree required for modern reception. E is the most selective curve, and at highest amplification, with a top that admits enough of a frequency band to preserve quality. If it is assumed that the width just under the hook at the top of curve is 10 kc the curve is then ideal, except for a minor absence of flatness at the top. the five curves may be taken as an indication of selectivity gained by cascaded tuned RF.

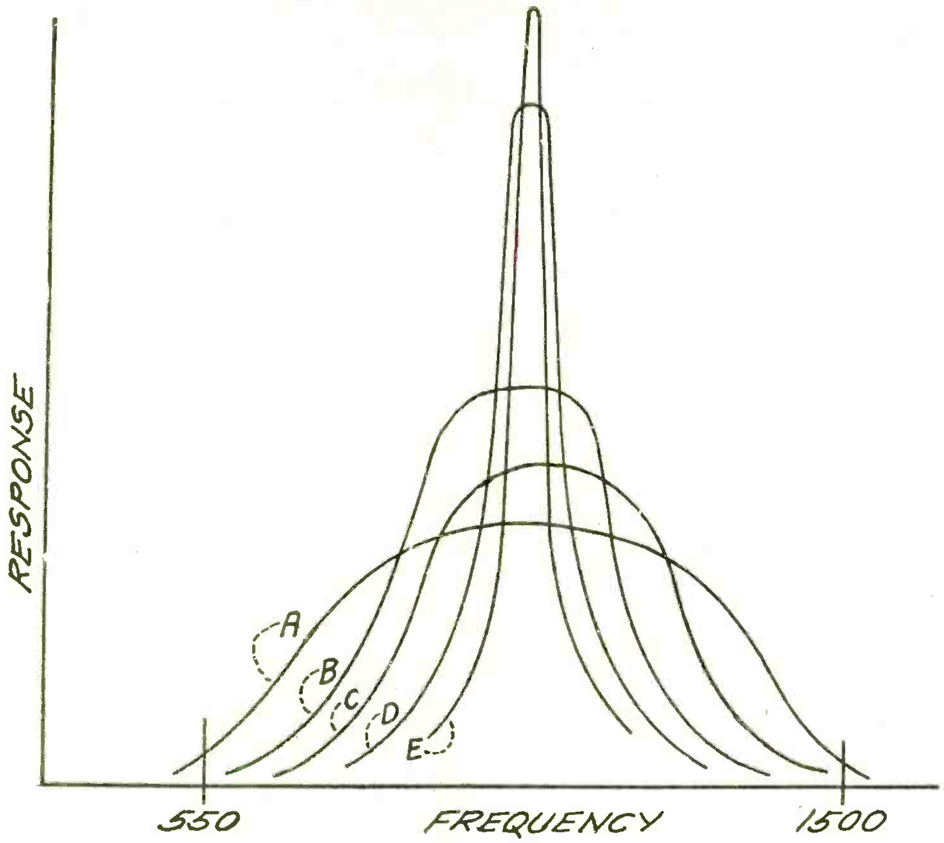

FIG. 777
SELECTIVITY IS USUALLY REPRESENTED BY CURVES, WHERE THE RESPONSE IS PLOTTED AGAINST FREQUENCY.

* * *

HOW can one tell an old radio set from a new set?—T.S.A.

If the receiver is a commercial model, inspect the serial number, and inquire from the manufacturer or his distributor as to the year of that model. Inspect the receiver as to its outward condition and general appearance, as a shopworn receiver of recent production may be considered "old." Test the receiver as to its ability to separate stations, as the newer receivers are more selective than those manufactured in previous years. The type of tubes used is another clue, because old sets did not include screen grid and 245 tubes, so if the receiver calls for these it is likely to be of recent manufacture.

* * *

PLEASE let me know what books on radio a beginner should study. I do not want anything that is complex or that has any mathematics in it, as I want to get started on a simple course and branch into the more complicated phases later.—G.F.

"Elements of Radio Communication," by Prof. John H. Morecroft, of Columbia University, is an admirable book for furnishing an elementary education on radio technique and processes. The importance of the vacuum tube requires that special attention be given to that subject, and "Radio Receiving Tubes," by Moyer & Wostrel, covers this subject in an excellent manner for novices. When you have digested these two important books, inquire of us for the next volumes to add to your radio library.

* * *

IN a push-pull circuit, with one tube out, should signals be heard? Should there be distortion? How should a push-pull stage be tested with one tube out?—H.G.S.

You should hear signals. Whether there will be distortion depends on how the grid bias is obtained. If it is through the potential drop across a resistor, as is common in AC circuits, and if the biasing resistor handles only the last audio plate current, then there will be distortion, due to the bias being cut in half when only half the accustomed plate current in flowing, since one of the two tubes is out of circuit. If the bias is obtained through the potential drop in a voltage divider, where it is customary to have all the plate current of all tubes flow through the power tubes' biasing section, then the bias reduction will be in the ratio of the current of the removed tube to the current of all the other tubes. If the biasing voltage is obtained from batteries, then there should be no distortion, as the grid bias is not affected by the removal of one tube. Connect a milliammeter with negative to plate of the remaining tube, positive to the coil that goes to B+.

* * *

IS it true that the voltage across the secondary to feed a 280 tube (anodes) should not be 300 volts per half-section, but more, for proper operation of the 245 tube, single or push-pull?—K.J.

The voltage should be more, because there is a voltage drop in the filter chokes, e.g., if the current is 60 ma and the DC resistance of two chokes is 400 ohms each, the voltage drop is 48 volts. There is also a voltage drop in the rectifier tube and one due to the resistance of the high voltage secondary, and drop due to the *amount* of current drawn from the rectifier, consisting of bleeder current and plate current. This subject was discussed fully in the August 3d issue of RADIO WORLD, pages 12 and 13.

* * *

MY set is not as selective as it might be. What may I add to it, without changing the set otherwise, to improve the selectivity?—G.H.

Try a tuning coil in series with the aerial. Several commercial models, all inexpensive, are on the market. They are called aerial tuners, clarotuners, etc.

OWNERSHIP OF WOR IS INTACT, SAYS DIRECTOR

The ownership of WOR, Newark, N. J., is still in the hands of the L. Bamberger Co., a New Jersey Corporation, even though the common stock of the company was sold to R. H. Macy & Co., large New York City department store, said Alfred J. McCosker, director of WOR.

He made this statement in reply to criticisms by some small New Jersey stations that WOR was a New Jersey station in name only, and was really operating as a New York station and poaching on the allotment of wavelengths made to New Jersey. The smaller stations that raised the point hoped to profit by improved wavelength position if WOR could be classified as a New York station.

Mr. McCosker said that the facts were well known to the Federal Radio Commission, and that no change of ownership of the station took place with the sale of stock. WOR has an exclusive wave and is assigned 5,000 watts.

Mr. McCosker said:

"It is definitely understood that L. Bamberger Company is a New Jersey corporation and will continue as such. Louis Bamberger merely resigned as president and has become chairman of the board of directors, WOR is, and will continue to be, owned and operated by L. Bamberger Company, without any change whatever in its policies.

"The Federal Radio Commission is thoroughly conversant with all of the above, Judge Ira E. Robinson, chairman, and W. D. L. Starbuck having been notified of the transfer of stock of the L. Bamberger Company."

Sound-Proof Booths to Be Used by Directors

Equipment which will permit communication from soundproof monitoring booths with radio artists during studio rehearsals is being installed by the National Broadcasting Company, in New York City. The installation is nearly ready for use in all studios.

Experiments in having program directors work from the monitoring booths, where programs may be heard exactly as they would sound on the air, have been conducted for several months.

A Thought for the Week.

SUGGESTION for introductory remark by radio band leaders whose men are about to offer the 99,999th rendition over the air of a popular number: "Folks, if you've heard this one, stop us!"

Forum

Numerologist Annoyed

YOU always omit the numbers from the second page and the next to the last page. This annoys me.

John F. Rasch, Seattle, Wash.

* * *

Consider It Upkept

I SEE that you keep before the public the identities of the most desirable technical books on radio that a fellow should read, and stress whether they are for the novice or for the more advanced student. This is fine stuff. Keep it up.

Archie Bain, Waco, Tex.

* * *

Moon of His Delight

I NEVER read a series of articles on a technical radio topic that was so comprehensive, authoritative and convincing as the one you are running on "Power Amplifiers," by Anderson and Bernard. Certainly if there is one topic that is outstanding in the radio and talkie fields it is power amplifiers, including speech amplifiers. I have learnt more about the really weighty side of radio from this series of articles than from anything else published anywhere. Each week I look forward to the new installment. I trust that when the theoretical discussion of "Power Amplifiers" is finished that the series will include hookups, showing how to capitalize on the advantages, as two such experts well ought to be able to show. I like your magazine immensely and find it a welcome and eagerly sought visitor at my home. I have saved every copy published for the last twenty-two months, at which time I saw for the first time a copy of my now favorite radio publication.

Henderson Foot, Atlanta, Ga.

"Radio" Has Become Trade Publication

"Radio," a monthly magazine published by the Pacific Publishing Company, at San Francisco, hitherto a technical periodical for the home constructor and custom-set builder, announced it is now exclusively a radio trade publication. "Radio Broadcast" inaugurated the same change of policy a few months ago.

"Radio News," the oldest in the field; "Radiocraft," the newest, two months old, and RADIO WORLD, now in its eighth year, are the remaining national technical radio magazines catering to parts buyers. "Radio News" and "Radiocraft" are monthlies. RADIO WORLD, the first weekly, for two years has been the only weekly. At one time there was a total of eighteen technical publications catering to parts buyers.

RIDER'S BOOK TELLS HOW YOU SHOOT TROUBLE

Trouble Shooter's Manual, by John F. Rider, published by Radio Treatise Company, New York, N. Y. ($3.50).

This book, just off the press, is the second volume of "The Service Man's Manual" by the same author. It deals with the principles and operation of radio receivers and accessories from the service man's point of view. The object is to provide the service man and amateur radio experimenter with the necessary information for quickly diagnosing trouble in any receiver and for remedying the trouble.

The book deals with many past and present models of receivers, and the discussion is wholly from the practical viewpoint. All mathematics has been omitted, except a few arithmetical computations.

The subject-matter is arranged so that the discussion on any given topic may be found instantly, and the various types of trouble that may be encountered are divided into sections and sub-sections so that as soon as the type of trouble has been decided, the different causes of that particular type are listed, in most instances in the order of frequency of occurrence.

By far the most valuable portion of the book to the service man is that devoted to diagrams of commercial receivers, and 112 of the 234 pages are devoted to this invaluable collection of diagrams. This list of diagrams is authoritative, having been supplied by the manufacturers of the various receivers, and can be found in no other book.

Canada to Tie in With Stations in U. S.

Montreal, Canada.

The Canadian National Railways radio department plans to extend its programs into the United States and include densely-populated Northeastern States, to add 20,000,000 listeners.

W. D. Robb points out that the Canadian National Railways operates thirteen stations from coast to coast, and owns the only transcontinental system of wires under one direction adapted for broadcasting.

CURING HUM

AC hum in electric sets sometimes is caused by an unbalanced grid return to the tubes. The centre taps on the transformers may be unbalanced. Clarostat engineers prescribe the use of a Hum-dinger across the filament terminals. A slight adjustment with a screwdriver finds the centre.

Dentist Sent First Radio During Civil War, Says Jenkins

Washington.

A jolt to the recorded history of radio was dealt by C. Francis Jenkins, inventor, who has been devoting his time lately almost exclusively to television. The first wireless telegraphy messages were sent during the Civil War, he said. He added:

"Although Professor Joseph Henry, in 1832, discovered that electrical oscillations could be detected a considerable distance from the oscillator, it remained for a Washington dentist, Dr. Mahlon Loomis, actually to send the first radio messages.

"In 1865 Dr. Loomis built an oscillating circuit and connected it to a wire aerial supported by a kite. One station was set up on Bear Den Mountain, Va., not very far from Washington, and a duplicate station was set up on top of Catoctin Spur, fifteen miles distant.

"Messages were sent alternately from one station to the other by dot and dash interruption of a buzzer spark circuit. Reception was attained by deflecting a galvanometer needle at the receiving point."

DAY RECEPTION NOW BEST, DUE TO SUN CYCLE

Washington.

Daylight radio signal intensity is at its maximum, but there are indications that conditions for radio reception are becoming less favorable, whereas static intensity has probably passed its minimum and is becoming greater, says the Bureau of Standards of the Department of Commerce.

The Bureau bases these forecasts on observations it made regarding the relation of daylight radio signal intensity and the relation of daylight static intensity with activities on the sun.

Text of Announement.

The full text of the announcement follows:

"Daylight radio reception is now at its maximum, with static at a minimum, investigation at the Bureau of Standards indicates.

"The laboratory for special radio transmission research at the Bureau of Standards has just compiled its annual report on long-wave daylight reception for the year 1928. The report covers the receiving measurements from 13 distant stations (mostly European) and 6 American stations within 500 miles of Washington.

"The curves showing the comparison of the reception conditions from 1923 to 1928 indicate that signals were weak in 1923 and 1924 and that a maximum was reached in the reception from most of the stations in 1927. The daylight static, on the contrary, which was high in 1924, fell to about half its 1924 value in 1927.

Ascribed to Sun.

"The 1928 values indicate that it has about reached its minimum and may probably increase during the present year. These changes in signal and static intensities are believed to be connected with changes in solar activity, which is now probably at or a little past its maximum in the present 11-year cycle."

Industry Attempts Screen Grid Definition

Louis B. F. Raycroft, vice-president of the National Electrical Manufacturers Association, announced a definition of "screen grid radio receivers" has been worked out for the use of the National Better Business Bureau in checking advertising.

R. H. Manson, chairman of the NEMA Radio Engineering Council, and W. E. Holland, director of the Engineering Division of the R. M. A., cooperated with Mr. Raycroft in formulating the following tentative definition:

"A radio receiver designed to utilize not less than two screen grid tubes in tuned radio frequency circuits may be properly classified as a screen grid receiver."

While Parachuting He' Phones Earth

In a demonstration at Roosevelt Field, L. I., Henry Bushmeyer, a civilian parachute jumper, leaped from a plane at 10,350 feet, with a 20-lb. short wave set strapped to his back. He took 18 minutes to land, meanwhile in radiophone communication with a station on the field.

WHAT IT COSTS TO RUN AC SETS

"It is easy to check the current consumed by an all-electric set," said George Lewis, of Arcturus Radio Tube Company, "and compare it with the current consumption of the average electric light lamps, by noting how fast the metal disc revolves on the watt-hour meter.

"For instance, with all current in the house turned off, the disc should not move at all. If, with a 75-watt lamp turned on, the disk revolves five times in one minute, and with only the radio set turned on, it revolves fifteen times in one minute, it is obvious that the radio consumes three times as much power as the 75-watt lamp, or 225 watts.

"Multiply this by the number of hours a month the set is in operation, divide by 1,000 and multiply by the cost of electricity to you per kilowatt hour (refer to your bill) and you will know what it costs for current to operate your radio for one month."

Ferranti to Build Largest Transformer

Ferranti, Ltd., whose main plant is located in Hollinwood, England, was commissioned to design and construct the largest transformer in the world. The transformer in question will handle 132,000 volts and have a rating of 80,000 kw. It is to be used in a super-power station to be part of the British National Electricity Scheme.

Especially designed and built flat cars will be needed to move the transformer from the Ferranti plant to its destination. To build it takes all the time of several hundred men for many months.

This new three-phase transformer is the fourth of a series of giant transformer built for the same company by Ferranti, Ltd.

NEW MOUNTFORD PERSONNEL

C. E. Mountford, manufacturer of resistors, 105 Sixth Avenue, New York City, appointed Rosse M. Gilson of Los Angeles as representative for California, and G. M. Cameron of Cleveland Heights for Ohio. C. E. Raymond with Mountford for six years, has been appointed salesman to cover the Metropolitan (New York) territory. W. S. Cole, has joined the Mountford engineering staff.

RURAL PUPILS TO BE TAUGHT IN BROADCASTS

Arrangements have been made for the broadcasting of test lessons to children in rural schools, to determine whether radio can be used to help solve one of the most serious aspects of rural education, that of supplying proper teaching. At present much of the rural instruction is given by one teacher for all grades, who usually has had no more than a high school education, and often has not completed primary school education.

Mabel Carney, professor of rural education at Teachers College, Columbia University, New York City, and Margaret Harrison, director of radio experimentation at the college, are interested in the movement.

Offers Opportunity

That radio offers an abundant opportunity for teaching a wide range of subjects is the statement of Professor Carney. She said:

"The programs must be definite. There must be lots of emphasis, as I see it, on appreciation. Farm children are the most needy of all school children, and they are the most neglected. Radio will bring them the things that will enrich their lives.

"The teachers are not the least fitted for their work, when they should be the most efficient.

"Only one in four farm children goes on to high school, while 44 per cent. of city children continue their education. We must bring these children the foreign culture, the music and art, the story-telling programs, and everything they are missing under the one-teacher system.

Wide Subject Range

"There is almost nothing in geography, history, travel and other fields that we cannot give them over the radio. The teacher would not be reduced to a mere dial-turner. She would simply coordinate the work of the class room with the radio programs.

"Much of the waste and inefficiency which is inherent in the one-teacher system would be eliminated."

CHATFIELD BACK AT NBC

Gerard Chatfield has returned to the National Broadcasting Company as program supervisor, after an absence of more than a year, during which he was connected with the broadcasting activities of the J. Walter Thompson advertising agency.

RADIALL TO MOVE SEPTEMBER 1

The address of the Radiall Company will be 561 Broadway, New York City, on September 1st. The present address is 50 Franklin Street.

New WTIC Transmitter on Mountain Top to Reach Out

Hartford, Conn.

A super-power station on a mountain top is the proud aim of WTIC, which has got its new transmitter into operation at Avon Mountain, fifteen miles from here.

The frequency is 1,060 kc, the power intended to be used is 50,000 watts, and it is hoped that full-time operation will be allowed, although a half-and-half sharing basis now exists with WBAL, Baltimore, Md. The power used by WTIC now is 5,000 watts, but plans are under way to get authorization of increase of this provisional power to the super-power class.

Careful tests were made of the new plant and finally the operation was satisfactory, and the station went on the air from the mountain-top, looking forward to reports from listeners that the signals were heard over a far wider area than WTIC ever reached before.

Gothic Polo Speaker, $6.50

JUNIOR POLO UNIT

Housed in a beautiful Gothic structure of genuine walnut; hand-rubbed to an attractive finish, the Polo driving mechanism and cone combine best quality reproduction with finest appearance. The grille is specially constructed for two-tone effect, so popular in walnut these days. The Polo Speaker in the Gothic housing is an adornment, besides being an outstanding speaker in performance. The design of the cabinet is exclusive. The height is 12½". Shipping weight, 10 lbs. Cat. No. T.M.P.G......

Guaranty Radio Goods Co.
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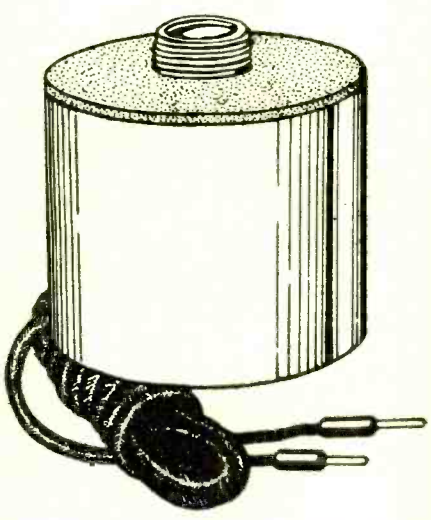
New York City

Horn Unit $2.25



This unit is pre-eminent for horn-type speakers, such as the exponential horns or other long tone-travel horns. The faintest word from a "whispering tenor" or the tumultuous shout of the crowd or highest crescendo of the band is brought out clearly, distinctly. Stands up to 450 volts without filtering. Works right out of your set's power tube, requiring no extra voltage source. Standard size nozzle and cap are die-cast aluminum, one piece, with milled platinum-like finish. The casing is full nickel, of highest possible polish. Works great from AC set, battery set or any other set, push-pull or otherwise.

For Portable Use

This unit can be used in a portable without any horn attached and will give loud reproduction. Order Cat. 225, with 4½ ft. cord attached . . . . (Shipping weight, 2 lbs.) $2.25

Air-Column Horn

8-ft. tone travel molded wood horn (less unit No. 225) is obtainable already mounted in a baffle box. Outside overall dimensions of baffle box, 21¼" high, 18" wide, 15" front to back. Shipping weight, 27 lbs. Order Cat. 596 @ $8.00.

The 225 unit and 596 horn built into a ply-walnut table 33" high, 24½" wide, 17½" front to back. Shipping weight, 50 lbs. Cat. No. 597 . . @ $20.00

Acoustical Engineering Associates,
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Please ship C. O. D.
☐ Cat. No. 225 @ $2.25 ☐ Cat. No. 596 @ $8.00
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☐ 0-50 Voltmeter D.C. .... No. 337
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☐ 0-25 Milliamperes D.C. .... No. 325
☐ 0-50 Milliamperes D.C. .... No. 350
☐ 0-100 Milliamperes D.C. .... No. 390
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☐ 0-400 Milliamperes D.C. .... No. 394

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

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

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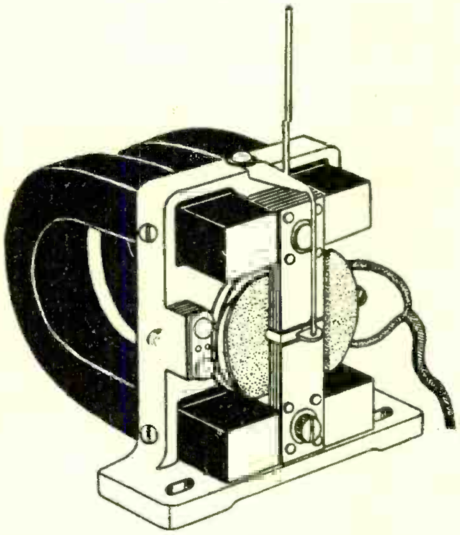
New Junior Model

POLO UNIT $4



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

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DC FILAMENT CIRCUITS: Calculation of resistances.

AC FILAMENT CIRCUITS: Transformers, wattage rating, distribution of output voltages, voltage reducing resistances, line voltage reduction.

CAPACITIES: Calculation of capacity, dielectric constant, condensers in parallel, condensers in series, voltage of condensers in parallel, in series, utility of parallel condensers, series condensers.

VOLTAGE DIVIDER SYSTEMS FOR B ELIMINATORS: Calculation of voltage divider resistances, types of voltage dividers, selection of resistances, wattage rating of resistances.

INDUCTANCES: Air core and iron core, types of air core inductances, unit of inductance, calculation of inductance.

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It consists of 193 pages and includes 68 illustrations. It is bound in maroon buckram.

There are three valuable tables in the book, also. One classifies harmonics into groups, e.g., sound, radio, short waves, heat, light, chemical rays, X-rays and "unknown." Another is a trouble-shooting chart, classifying "trouble experienced" and "causes" and referring to the text for specific solutions. The third is a table for converting broadcast frequencies to wavelengths (accurate to .1 of a meter) or for converting the wavelength into frequency.

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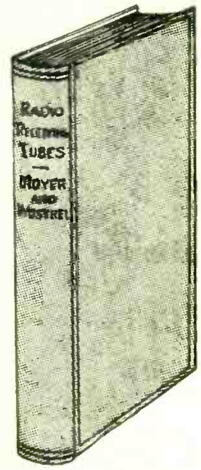

In this book the essential principles underlying the operation of vacuum tubes are explained in as non-technical a manner as is consistent with accuracy. The book covers the construction, action, reactivation, testing and use of vacuum tubes as well as specifications for vacuum tubes and applications for distant control of industrial processes and precision measurements.

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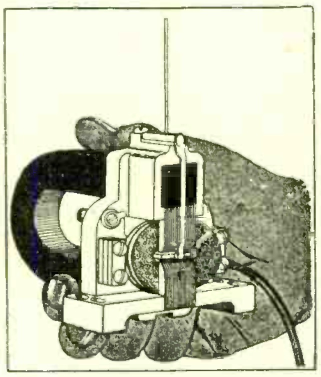

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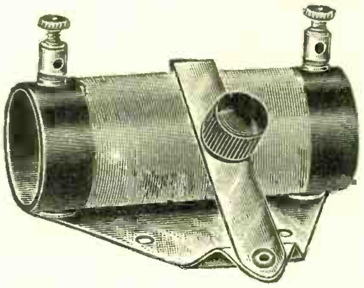
AERIAL TUNER
Improves Summer Reception



Remove aerial lead from set. Connect aerial instead to one of the binding posts of the Aerial Tuner. Connect the other binding post of the Aerial Tuner to antenna post of your set. Then move the lever of the Aerial Tuner until any weak station comes in loudest. The lever need not be moved for every different frequency tuned in. The Aerial Tuner acts as an antenna loading coil and puts the antenna's frequency at any frequency in the broadcast band that you desire to build up. It makes high wavelengths come in loud as low wavelengths. It helps separate stations and clear up reception. Makes great improvement in Summer reception. Price, $1.00.

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With Molded Wood Horn of 8 ft. tone travel (exponential type) with baffle and horn motor built in. Extraordinary bargain.

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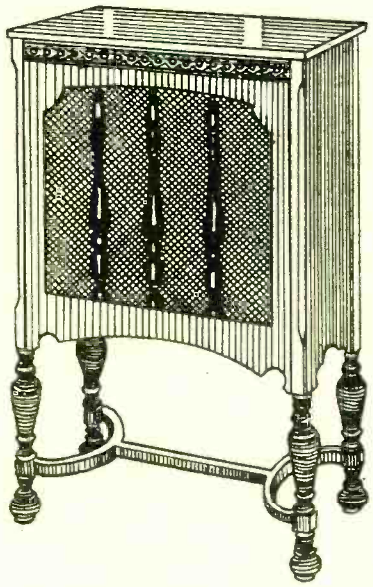

The speaker cabinet is walnut finish, 33" high, 24½". wide, 17½". deep, with carved legs. Golden cloth grille covers front opening. Built inside is No. 595 molded wood horn with baffle and No. 203 driving motor unit that stands 250 volts without filtration. Horn and motor removable. Table alone is worth price asked. Remit with order and we pay cartage on Aristocrat Floor Speaker.

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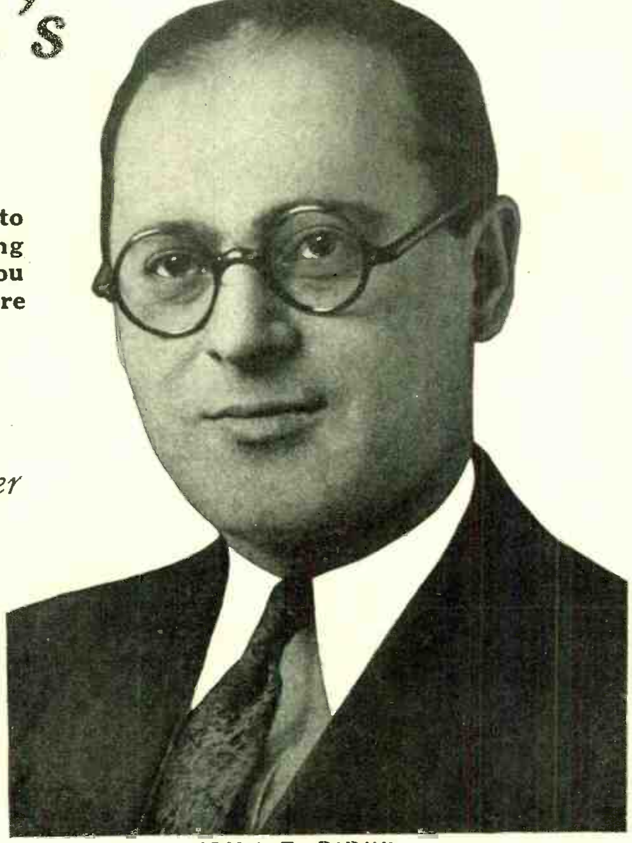

JOHN F. RIDER
Member, Institute of Radio Engineers

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Besides 22 chapters covering thoroughly the field of trouble shooting, this volume contains the wiring diagrams of models, as obtained direct from the factory, a wealth of hitherto confidential wiring information released for the first time in the interest of producing better results from receivers. You will find these diagrams alone well worth the price of the book. The wiring diagrams are of new and old models, of receivers and accessories, and as to some of the set manufacturers, all the models they ever produced are shown in wiring diagrams! Here is the list of receivers, etc., diagrams of which are published in this most important and valuable book:

R. C. A.
60, 62, 20, 64, 30, 105, 51, 16, 32, 50, 25 A.C., 28 A.C., 41, Receptor S.P.U., 17, 18, 33.

FEDERAL
Type F series filament, type E series filament, type D series filament, Model K, Model H.

ATWATER-KENT
10B, 12, 20, 30, 35, 48, 32, 33, 49, 38, 36, 37, 40 42, 52, 50, 44, 43, 41 power units for 37, 38, 44, 43, 41.

CROSLEY
XJ, Trirdyn 3R3, 601, 401, 401A, 608, 704, B and C supply for 704, 704A, 704B, 705, 706.

ZENITH
39, 39A, 392, 392A, 40A, 35PX, 35APX, 352PX, 352APX, 37A, 35P, 35AP, 352P, 352AP, 34P, 342P, 33, 34, 35, 35A, 342, 352, 352A, 362, 31, 32, 333, 353A, power supply ZE17, power supply ZE12.

MAJESTIC
70, 70B, 180, power pack 7BP3, 7P6, 7P3 (old wiring) 8P3, 8P6, 7BP6.

FRESHMAN
Masterpiece, equaphase, G, G-60-S power supply, L and LS, Q15, K, K-60-S power supply.

FADA
50/80A receivers, 460A Fada 10, 11, 30, 31, 10Z, 11Z, 30Z, 31Z, 16, 17, 32, 16Z, 32Z, 18, special, 192A-192S and 192BS units, R80A, 480A, and SF 50/80A receivers, 460A receiver and R60 unit, 7 A.C. receiver, 475 UA or CA and SF45-75 UA or CA, 50, 70, 71, 72, C electric unit for special and 7 A.C. receivers, ABC 6 volt tube supply, 86V and 82W, E180Z power plant and E 420 power plant.

FREED-EISEMANN
NR5, FE18, NR70, 470, N R 5 7, 457, NR11, NR80 DC.

STEWART-WARNER
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GREBE
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PHILCO
Philco-electric, 82, 86

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1A, 2B, 501, 502, 523, 524, 635, 636, 403AA power plant, 404 RA power plant.

ALL-AMERICAN
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A.C. 89.

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