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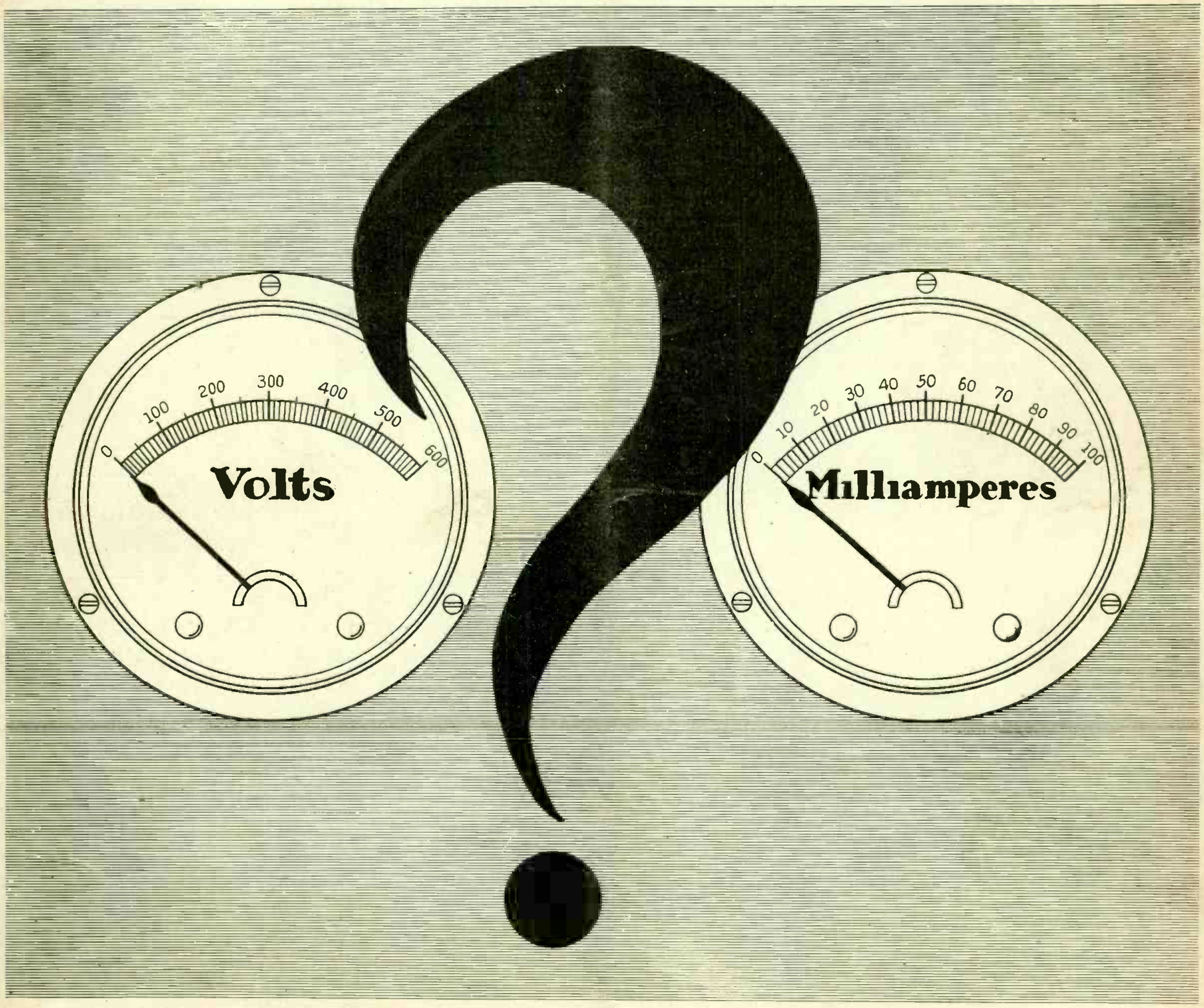

What is the Basis for Judging Meters? See Article on Page 5

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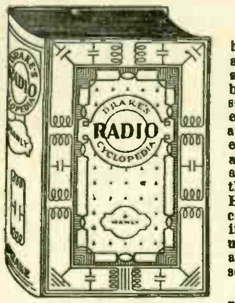

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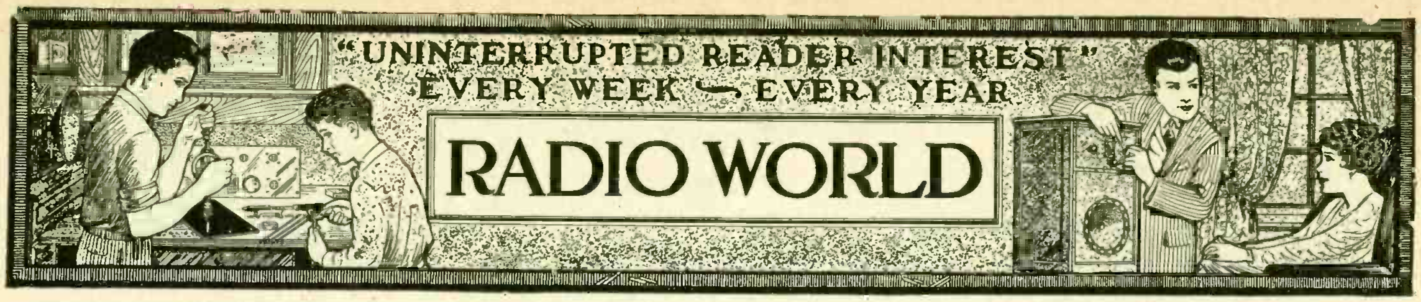

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Push-Pull Puzzle

Is There Any Way to Apply System to Detection?

By J. E. Anderson

Technical Editor

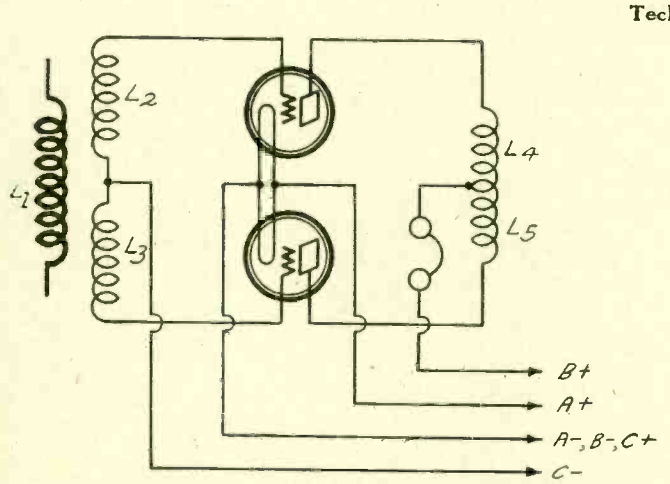


FIG. 1

A TWO-TUBE DETECTOR CIRCUIT IN WHICH THE GRIDS ARE IN PUSH-PULL AND THE PLATES ARE IN PARALLEL.

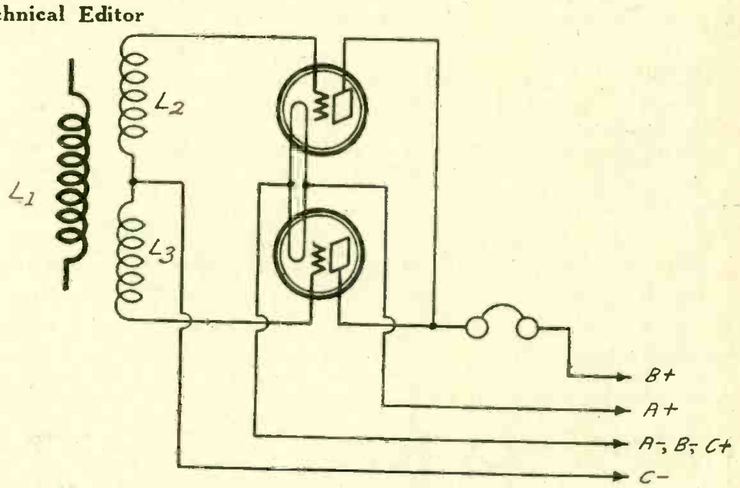


FIG. 2

A DETECTOR CIRCUIT LIKE THAT IN FIG. 1 BUT WITH THE TWO CHOKES IN THE PLATE CIRCUITS OMITTED.

DETECTORS operating on the push-pull principle are often suggested, and even receivers incorporating them are proposed from time to time. Yet they never progress beyond the suggestion stage. There must be a reason. What is it?

The main advantage of the push-pull amplifier is that it prevents the transmission of the even harmonics generated by the two tubes in the amplifier stage. Why does not a push-pull detector do the same? It does, and that is just the reason a push-pull detector has not been made to work successfully.

The object of the detector is to create harmonics and to transmit them to the audio amplifier. If the circuit is so arranged that the harmonics created cannot be transmitted, obviously the detector does not function.

The detector does not create audio frequency harmonics, or at least it should not. The harmonics created by the detector are of the radio frequency carrier wave.

How Circuit Works

Consider Fig. 1. The input transformer L1L2L3 is arranged so that the secondary voltage is divided equally between the two tubes and in opposite phase, just as the input transformer to an audio frequency amplifier of the push-pull type. When the signal current in L1 is in such direction that the grid of the upper tube goes less negative, that of the lower tube goes more negative. Hence the plate current in the upper tube increases and that in the lower tube decreases. The radio frequency voltage across L4 increases and that across L5 decreases. Hence if the increase on one tube were equal to the decrease in the other the voltage difference across the two coils would be twice the signal drop across either one. This is how the circuit works as an amplifier.

The sum of the two plate currents would be the current in the common lead where the telephone is placed. This current does not contain a component of the signal frequency because the two plate currents are equal and opposite in phase so that when they are united there is no current.

But the increase in the plate current of one detector tube is not equal to the decrease of that in the other. The increase is greater than the decrease. Therefore there will be some change in the common current through the telephone. To a first approximation this current will equal twice the sum of the current flowing in either tube when no signal is impressed and a term depending on the square of the signal voltage impressed on either tube. For example, let Io be the current in either tube when no signal is impressed and e the signal voltage impressed on each grid. Then the current in the telephone will be $2(Io+Ke^2)$, where K is some constant depending on the tubes.

Harmonic Component

Io is a direct current and will not produce any sound in the telephone. Ke^2 is a current having a frequency twice as great as the radio frequency impressed on the grids of the tubes. Since that was too high for audibility, obviously a frequency twice as high is inaudible. It would seem that there is no detection.

But e is not a simple radio frequency voltage. It is modulated with an audio frequency. That is to say, the amplitude of e varies periodically at an audio frequency rate. When this fact is taken into consideration in analyzing Ke^2 this term will be found to contain a term which is proportional to the audio frequency fluctuation in the modulated signal. This portion will make a sound in the telephone.

The two coils L4 and L5 in Fig. 1 serve no purpose. It is preferable to arrange the circuit as in Fig. 2 in which the two

(*Continued on next page*)

Objects of Untuned Antenna

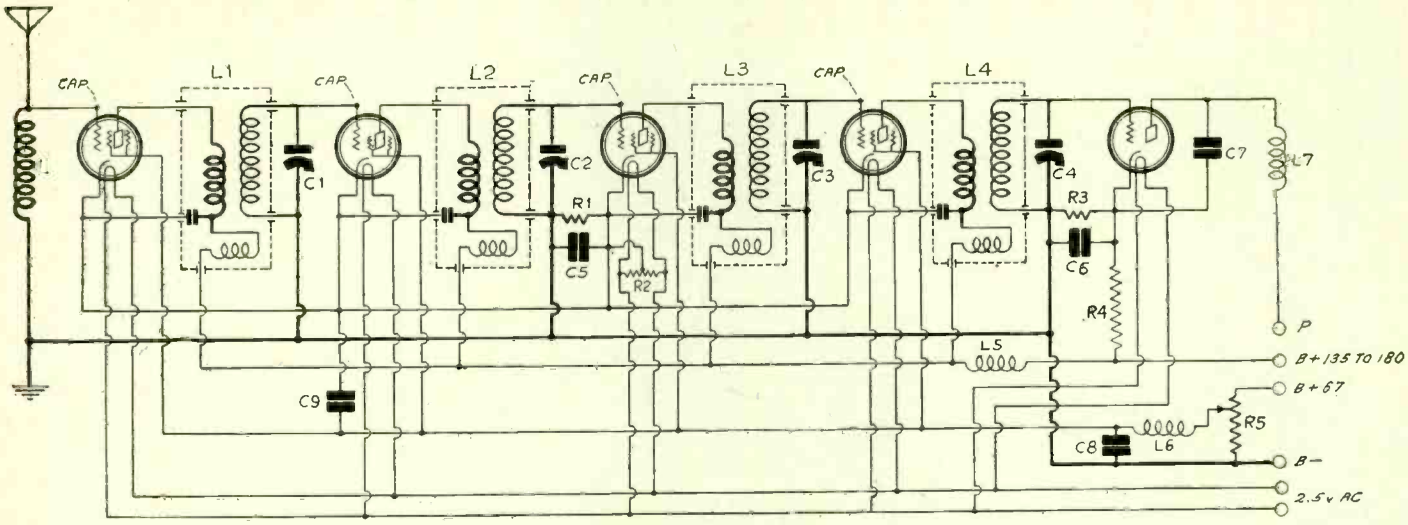


FIG. 1
THE OBJECTS OF AN UNTUNED STAGE ARE TO MAKE IT PRACTICAL TO USE A GANG CONDENSER AND YET OMIT A MANIPULATED TRIMMER ACROSS THE FIRST TUNED CIRCUIT, AND TO MAKE THE TUNING INDEPENDENT OF THE LENGTH OF THE AERIAL, SO THAT A DIAL CALIBRATION IS STANDARD.

THE use of an untuned input stage for antenna coupling simplifies one of the circuit problems provided there is enough selectivity following. Four tuned cascaded circuits, properly designed, will give excellent results with an untuned input. The objects of omitting tuning in the first stage are to permit single dial tuning without a manipulated small condenser in parallel with the otherwise first tuned circuit, and to permit standard dial scale calibration, e. g., on a frequency basis, so that a station comes in at its frequency number. The length of the aerial has no tuning effect on the first condenser in a second stage of radio frequency amplification. Equal conditions confront all four condensers

Tuning the first stage makes two-dial operation preferable, for sometimes less capacity is needed than is present, sometimes more, and with single control it is difficult to alter the capacity except by addition.

Fig 1 is the MB29, an AC screen grid circuit of high sensitivity and excellent selectivity.

Parallel Plates Work Push-Pull Input

(*Continued from preceding page*)

plates are connected together and the telephone placed between the junction and the plate battery. There should also be a condenser of about .0005 mfd between the junction and minus A.

The behavior of a push-pull circuit can be studied with the aid of sine curves suitably placed. In Fig. 3 let the upper curves represent the first and second harmonics of one of the tubes and the lower curves the same harmonics for the other tube. The values of the currents at any time can be regarded as the distance from the line AB to the curve in question.

The second harmonic waves are displaced 90 degrees with respect to the fundamental. To show the fact that the fundamental waves for the two tubes are in opposite phase the curves have been drawn symmetrically with respect to the line AB. The second harmonic waves are in phase.

Suppose we take the difference between the fundamentals, which at any place is the sum of the distances between the curves and the line AB. It is clear that the difference rises and falls. This difference may represent the voltage across the equal impedances placed in the plate circuits of the two tubes,

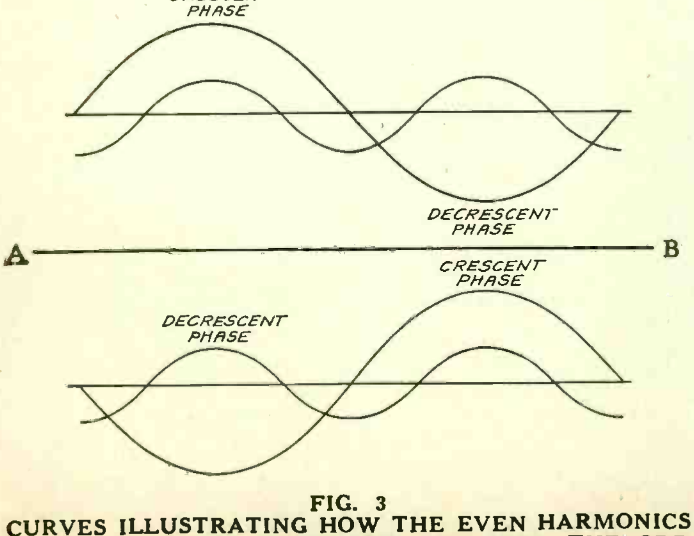


FIG. 3
CURVES ILLUSTRATING HOW THE EVEN HARMONICS ADD UP IN THE TELEPHONE AND HOW THE ODD HARMONICS ARE EXCLUDED.

as in Fig. 1. Now take the sum of the two curves at any point, remembering that the distances below AB are negative and those above positive. It is clear that the sum is zero all over. This represents first harmonic current in the telephone in Figs. 1 and 2. There is no such current in the telephone if the circuit is balanced.

Now consider the second harmonic wave. Take the difference between the two curves. It is clear that they remain at the same distance apart at all times. This is equivalent to no difference. Hence the second harmonic does not appear across the impedances in the plate circuit, as in Fig. 1. That is the reason a push-pull detector has not been made to work.

If the sum of the two second harmonics be taken it will be found that it is 2i, where i is the value of the current at any instant in either second harmonic. This is derived as follows: Let Io be the steady current in either tube and let i be the instantaneous value of the second harmonic. Then the current in the upper tube is Io+i and the current in the lower tube is —(Io—i). Adding the two gives 2i for the total current. This is the current that flows in the telephone in Fig. 2, for example.

It may be shown that all the even harmonics generated by the two tubes appear in the common portion of the circuit, that is, in the telephone in Figs. 1 and 2, and that all the odd harmonics appear across the plate impedance as L4, L5 in Fig. 2. The direct current is considered as an even harmonic because its order is one less than that of the first, which is odd. The direct current, of course, flows through the telephone.

There is some advantage in using a detector that is push-pull on the grid side and parallel on the output side. A single tube detector generates all the harmonics and does not prevent the transmission of any. The push-pull as shown in Fig. 2 generates all, but none of the odd harmonics appears in the telephone. Hence we have the direct current, which does not give rise to distortion, and the second harmonic, which gives rise to the desired detected signal. We also have the fourth, sixth, and eighth harmonics, but all of these and higher even harmonics are negligible.

It should be noted that the presence of the higher even harmonics in the current in the telephone does not result in harmonics at audio frequencies directly. But these RF harmonics indicate that the detected component is not proportional to the radio frequency input. The detected output increases with the input more rapidly than if the direct proportion held. This finally results in audio harmonics.

It is easy to detect by means of a push-pull circuit when the plates of the two tubes are parallel, but to couple a detector to a push-pull amplifier without the use of an input transformer is not so easy.

Judging Meters

Resistance Per Volt Often Vital Factor

By Herbert E. Hayden

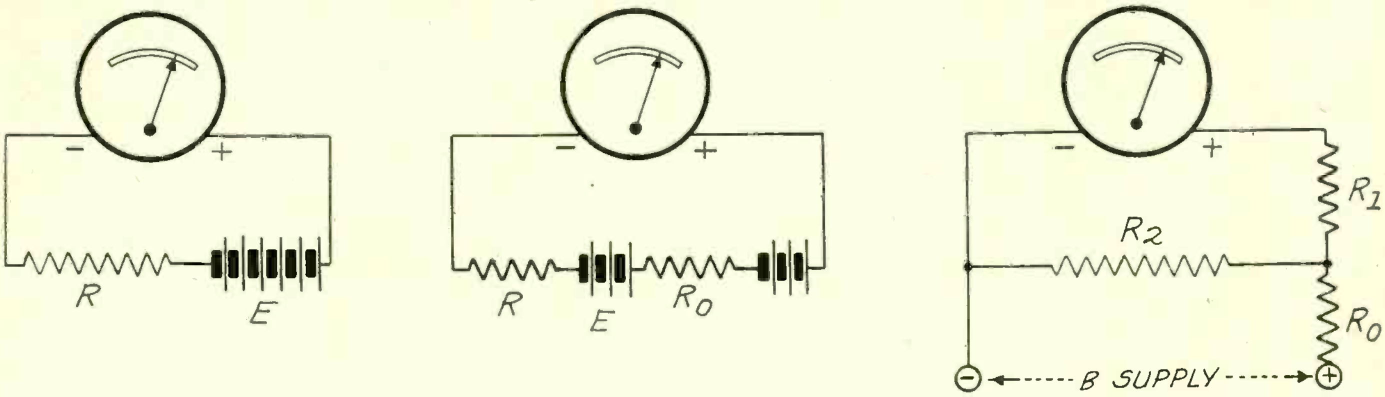


FIG. 1

LEFT—A VOLTMETER IS IS SIMPLY A MILLIAMMETER WITH A RESISTANCE IN SERIES WITH IT AND HAVING A DIAL CALIBRATED IN VOLTS.

MIDDLE—IF THE VOLTAGE SOURCE BEING MEASURED HAS AN INTERNAL RESISTANCE THE VOLTAGE INDICATES TOO LOW VOLTAGE. THE HIGHER THE RESISTANCE OF THE METER, THE MORE NEARLY CORRECT IS THE READING.

RIGHT—A HIGH RESISTANCE VOLTMETER IS NECESSARY WHEN MEASURING VOLTAGE DROPS IN RESISTORS OR VOLTAGES OF B BATTERY ELMINATORS.

THE importance of resistance in meters is not generally realized. Fans will measure the voltage of a B battery eliminator or the voltage drop across a grid bias resistor and find that they do not get correct results, or that they get different results with different meters. The assumption usually is that the meter in the one instance is in error or that one of the two in the other case is incorrect. But the fact may be that when the two meters are connected across the same place at the same time that they will read exactly alike.

These discordant results should not be used to condemn any meter but rather they should be used as an indication of what resistances are associated with the meter and what the sensitivity of the meter is.

An ammeter should have the lowest possible resistance and a voltmeter the highest possible. These requirements come directly from the manner in which the two meters are used. The ammeter is always connected in series with the line, and therefore its resistance should be so low that the circuit is not changed when the meter is inserted. The voltmeter is always connected across the line, and therefore it should have such high resistance that there is no change in the current when the meter is put across the line.

High Sensitivity, High Resistance

Meters designed to measure heavy currents usually have very low resistance, often a small fraction of an ohm. As the sensitivity of the meter is increased the resistance is greatly increased. Thus a microammeter may have a resistance of several thousand ohms. While it is unavoidable that the resistance should increase with the sensitivity, it is desirable that the resistance for any current meter be as low as possible, because the higher the resistance the more the meter changes the circuit when the meter is inserted. And it is always desirable to leave the circuit as nearly as possible as it was.

A voltmeter is only a very sensitive current meter with a high resistance in series with it. The more sensitive the current meter that is used for a voltmeter, the better will the voltmeter be.

The important characteristic of any voltmeter is its resistance per volt. This quantity tells how much current the voltmeter will take at full deflection, and hence indirectly at any other deflection. When the resistance per volt is high it is known that a very small current is needed to cause full-scale deflection, and it is also known that a very sensitive current meter was used in making the voltmeter.

If the resistance per ohm is low, it is known that a large current is needed to cause full-scale deflection and that a very insensitive current meter was used in making the voltmeter.

If a 0-20 milliammeter is used for making a voltmeter the resistance per volt will be 50 ohms. This is not so good, but there are many meters which have a lower resistance per volt. If a 0-5 milliammeter is used for the voltmeter the resistance per ohm will be 200 ohms. This is much better. Still there are many applications for which this meter draws too much current, and consequently gives erroneous readings.

A meter having a range of 0-1 milliamperes when used for measuring voltages yields a voltmeter of 1,000 ohms per volt. This is a very sensitive meter and is suitable for measuring voltages in B supply units with only a small error. It is entirely feasible to make voltmeters having a much higher sensitivity.

If meters of higher resistance per volt are required it is possible to use galvanometers, which are available in all ranges of sensitivity up to 10 micro-microamperes, and vacuum tube voltmeters, which are practically unlimited in application and range. They have infinite resistance per volt, at least for direct current.

Operation of Voltmeters

The performance of voltmeters can be understood with the aid of a few simple diagrams, as in Fig. 1. At the left is a milliammeter connected in series with a resistance R and a battery E. The milliammeter and the resistance constitute the voltmeter, and it is to be used for measuring the voltage of the battery E. Suppose the meter has a scale of 0-5 milliamperes and let R be 10,000 ohms. The deflection on the meter is 4.5 milliamperes. What is the voltage of the battery E? We know by Ohm's low that E=RI and that R is 10,000 ohms and I is 4.5 milliamperes. Then it is clear that E equals 45 volts. If R is built into the case of the meter so that it will always be the same it is obvious that it is permissible to calibrate the scale of the milliammeter in volts instead of in milliamperes. Instead of writing 4.5 milliamperes we would write 45 volts.

If a switch is built into the case of the meter so that the resistance R either can be thrown in or out, the same meter may be used both as a voltmeter and a milliammeter. That is the way volt-ammeters often are built.

It often happens that the voltmeter resistance is not the only resistance in series with the voltage that is being measured. In that instance the meter reads low, and the amount by which it reads low depends on the ratio of the resistance in the circuit not in the meter to the total resistance in the circuit. It is clear that for a given resistance in series with the battery, the higher the resistance of the voltmeter, the smaller will this error fraction be. That is, the more sensitive the meter, or the greater its ohms per volt, the smaller will the error be.

It is particularly desirable to have a meter of high resistance per volt for measuring voltages in B supplies and drops in resistors which form a portion of a high resistance circuit. A case is shown in the right-hand drawing in Fig. 1.

How Interference

Man-Made Molestation of Remedy, as Nature to Still Her

By James

Contributing

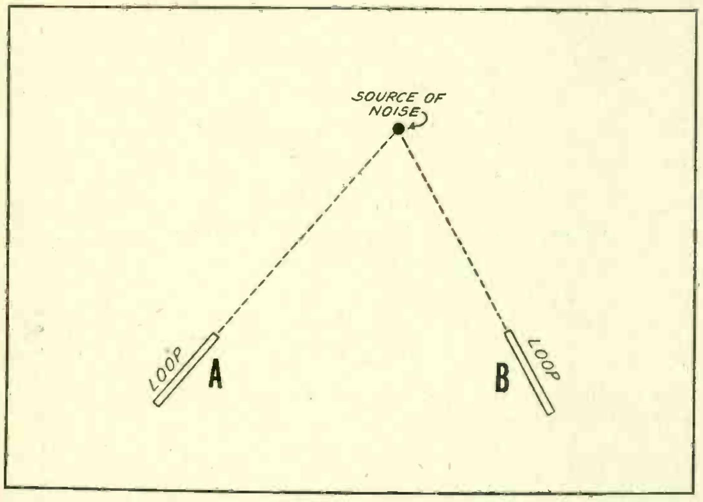


FIG. 1
METHOD OF USING A LOOP RECEIVER FOR LOCATING THE SOURCE OF AN INTERFERENCE NOISE. THE LOOP IS ADJUSTED TO POSITION OF MAXIMUM SIGNAL IN TWO DIFFERENT LOCATIONS.

WHENEVER two persons are conversing there is always some interference, a background of noise which sometimes requires that the two persons raise their voices in order clearly to understand each other. The amount of this background noise depends on the location, time of day or year, and on the weather.

On water or near the sea shore most of the noise comes from the wind-whipped waves. In the open fields it comes from rustling of leaves, buzzing of insects, singing of birds, and the characteristic sounds of other animals. In the forest all of these are sources of noise and there is in addition the soughing of trees in the wind. Near swampy places there is likely to be the din of frogs and the humming of mosquitos.

In densely populated places there are innumerable noises produced by other people and by the countless mechanical contrivances which they use. All of these noises constitute interference with the conversation of any two persons, compelling them to speak with a louder voice in order to understand each other clearly. In certain places the background noise is so intense that it is impossible to shout loudly enough to be understood.

Just as all these noises interfere with conversation, so do they interfere with music, although in a different degree. Music in the first instance is much louder than ordinary conversational sounds, so that it easily overrides any background noise that may exist, and in the second, it is rarely played where there is much disturbing noise.

Interference to Radio

There is a similar interference situation in radio, but here the background noise is both electrical and acoustical. While there is only one source of background noise involved when one is listening to the original, there are two sources when listening to a radio reproduction. The first is the background of noise that exists in the transmitting studio and the second is the noise that exists around the receiver. Transmitting studios are treated acoustically in most instances so that there is a minimum of background noise, but the home is rarely treated so as to reduce the acoustic interference. In the Summer in crowded places, when all the windows are open, there may be many loudspeakers audible from one place. And many of these speakers blast forth different programs. The only way to reduce this interference is to shut the windows, for the neighbors will not turn down their radio sets.

When we speak of interference in radio we do not ordinarily mean acoustic interference but electrical, for this type is the cause of by far the greater amount of disturbance in the output.

Types of Electrical Interference

There are two general types of electrical interference, man-made and natural. Man-made electrical interference is that which is created by electrical apparatus of every description. Some electrical apparatus may not be intended as such, for it is mechanical. For example, a dry belt running on a wooden pulley, a printing press of a certain type, and a paper making machine, are all electrical machines from this viewpoint, although they are not intended as such and may not even have any electrical wiring near them. All of these and many others non-electrical machines create the same kind of electricity as is created when a cat's back is rubbed. Even the cat may be a source of interference.

Natural interference is that which is created by atmospheric conditions, such as lightning, and by the aurora borealis.

Man-made interference is controllable; natural is not. The only way that has been found for coping with natural interference is "to raise the voice," that is, to increase the power of the broadcasting stations until it is strong enough to override the natural electrical disturbances. To this increase in power we owe in a large measure the excellent reception which we now enjoy both Winter and Summer.

Sometimes the natural interference involves more power, instantaneously, than it would be possible to use in any broadcasting station, and for that reason there will be times when "static" crashes come through the loudspeaker even when the receiver is tuned to a high-power station nearby.

Man-Made Interference

Since natural interference is beyond our control, and since we can do something about man-made interference, we turn our attention to that.

The first thing to do when troubled with man-made interference is to locate the source. This can always be done by a systematic method of elimination. The receiving system arbitrarily can be divided into two parts, and then by a suitable test it is possible to tell which part contains the trouble and which is free. After it has been found that the trouble is in one division, that one can be subdivided, and the test be repeated. The trouble will be found to be in one of the subdivisions. The process of elimination goes on until there can be no doubt as to where the trouble is, because the ultimate division leaves no alternative.

Let us see how this works out in a few typical causes. There is an annoying hum in the loudspeaker when listening to a certain station. What causes it? The transmitting station, the receiver, or some interfering device may be at fault. To test whether the transmitting station is at fault, tune the set to some other station, one which has approximately the same signal intensity at the receiver antenna. Does the hum remain? If it does, the transmitter was not at fault. The hum is then either due to the receiver or to some source of interference. To test which, remove the antenna. If the hum remains, it originates in the set; if it disappears, it came from the outside.

Case of Crackle

Suppose there is a disturbing crackle in the sound output of the receiver. Where does it come from? Eliminate the station by tuning in on another station. If the noise disappears it was either on the carrier of the station or on a carrier of the same frequency as the frequency of that station. If the noise continues, its source is either in the receiver or in some electrical device in its vicinity.

One method of determining whether the noise comes from the outside or originates in the set is to remove the antenna, and also the ground in some instances. If the sound remains, chances are that the noise originates in the set; if the noise disappears it was probably due to an outside source.

The test is not conclusive, for in certain instances the noise

is Traced Down

Is Alone Susceptible
Thwarts All Attempts
Disturbances

H. Carroll

Editor

disappears when in reality its source is in the set. It happens frequently that a noise develops in the set when the volume is turned up, due to the partial breaking down of insulation in a condenser or some other part. The trouble does not appear at once but comes gradually as the set warms up. When the antenna is removed the noise disappears because there is no longer any volume. If the signal were derived from a phonograph pick-up the crackle would appear, proving that the source is actually in the receiver.

Cornering the Noise

Now we have traced this crackle down to the receiver, but there are many places in this where the cause might be. Is it is in the B supply or in the amplifier? The simplest way of testing this is to try a new B supply, if one is available. The output voltage of this should be the same as that which is suspected. The substitution of the new B supply will either acquit or convict the old supply.

If no B supply substitute is available, it will be necessary to test individual parts by piece-meal substitution of good parts. This is a tedious and long job. To shorten the work those parts which are the most likely to break down should be tested first. Condensers which are subjected to high voltages are the most likely to give way, especially those condensers which are operated near their rated working voltage. In testing for a defective condenser in the filter it is only necessary to have one test condenser, which can be moved about as required. It is simply connected in place of a suspected condenser. It is not necessary to remove both sides of the old condenser, for the condenser is out of the circuit as soon as one side is open.

The capacity of the test condenser should be approximately the same as that of the largest condenser which may occur in the test.

Finding the Noise Outside

Suppose that one of the earlier tests establishes the fact that the source of the noise is outside the receiver, and that it is brought in on the antenna. What can be done to locate it?

Much can be done by merely associating the type of noise made with various electrical devices in and near the house and by considering the time element of its occurrence. Certain electrical devices are used at certain times of the day, and they remain on for a certain length of time. Some click on and off regularly. Others are turned on and kept running for a minute or two, as a sewing machine, for example. Vacuum cleaners are operated about the same way, although they may be kept running for longer periods.

When there is an interfering sound in the loudspeaker, it may pay to turn on and off all the electrical devices in the house. Perhaps it is not any of the devices in the house which is to blame, but it may be a similar one in the next house or apartment, and the test will point to the kind of device which causes the interference. When the kind has been determined, one should find out where such a device is being operated at the time the disturbance occurs.

In congested neighborhoods it may be difficult to find the trouble, if it originates outside the apartment, and it may not be so easy to apply a remedy even if it is found.

Direction Finder

Many sources of noise can be found with the aid of a direction finder. This instrument is simply a loop receiver. If it is portable almost any electrical disturbance can be traced to its source. It is only necessary to tune in the receiver on the noise and point the loop in the direction in which the signal is loudest. The loop then points to the source, provided that nothing intervened between the receiver and the source to deflect the radio waves. Move the receiver to some other location and repeat the observation. The loop will now point in some other direction, but it will still point toward the source of the noise.

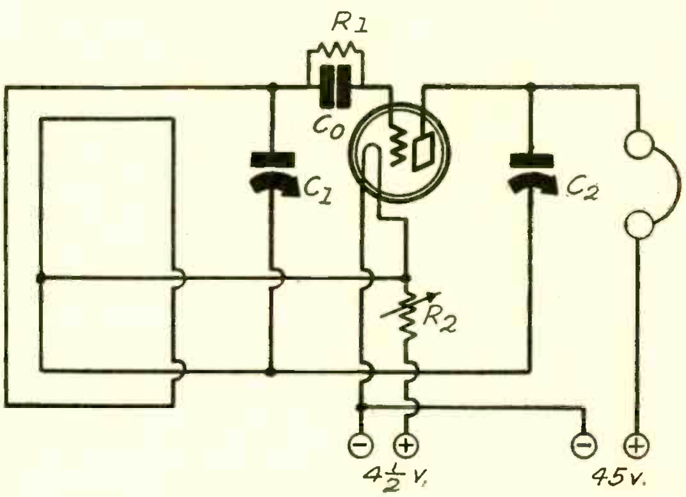


FIG. 2
THE DIAGRAM OF A SIMPLE PORTABLE LOOP RECEIVER WHICH CAN BE USED FOR LOCATING SOURCES OF INTERFERENCE.

Fig. 1 shows the method of locating a noise. The two positions of the loop are indicated by A and B, and the black dot represents the source of the noise. The two lines passing through the loops intersect at the source. If it should happen that the loop points in the same direction at both places it means that the second observation was taken on the line joining the source and the first observation position. The second observation was either closer to or farther away from the source. The intensity of the signals will determine which, for the closer to the source the stronger the signals.

Spurious Directions

It may be that the observations point to something which could not possibly be the source of the disturbance. Reflection of the radio wave or conduction over wire from a distant source may be the reason for the trouble. When this difficulty is met many observations in different places in the same locality should be made. All of them cannot be wrong completely. There will be a general trend which is toward the source.

A simple regenerative, portable loop receiver is shown in Fig. 2. The tube is a 199, requiring a filament voltage 3.5 volts, obtained from three dry cells, and a plate voltage of 45 volts. Co is .00025 mfd. and R1 is a 2 megohm grid leak. The two variable condensers C1 and C2 should be .0005 mfd. units. The loop can be any loop used for broadcast reception which is not too clumsy to carry about. It should have a tap near the center. R2 is a 20-ohm rheostat.

When the receiver is to be used for hunting trouble it makes little difference what the tuning range is. The noise will be carried on all frequencies.

Remedies for Noise

What shall be done when the source of the trouble has been located? It depends on where and on whose property the noise originates. If it is on property of the electrical company, report it. The company will be glad to correct it. If the noise originates in the neighbor's apartment, perhaps the neighbor too, will welcome the information. If the source of the noise is located on your own premises, then it is your place to take appropriate steps to clear it up, not only for your own good, but for the general improvement of radio reception in your vicinity.

It should be remembered that the best place to attack the problem is as close to the source as possible. If a line runs to a noise-making device, a filter should be placed in the line near the device. If a line also runs away from the device a filter should be placed on each side.

[*"Interference Filters" next week, issue of July 13th.*]

Installation Ideas

Taste and Use Decide Position of Components

By Capt. Peter V. O'Rourke

Contributing Editor

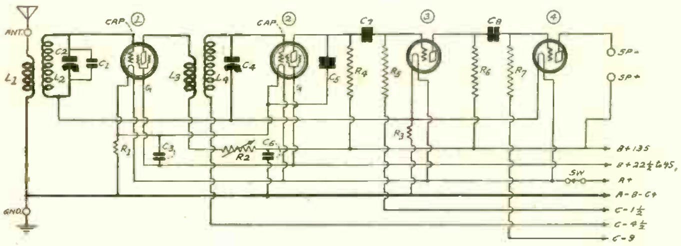


FIG. 1
AN AC RECEIVER MAY BE BUILT IN THIS FASHION WITH FILAMENT TRANSFORMER MADE A PART OF IT, SO THAT A SEPARATE B SUPPLY MAY BE READILY USED.

SEPARATE power amplifiers and tuners are a favorite method of installation with experimenters, especially as the tuner may be encompassed in a small space, for housing in a table model cabinet, and the power amplifier may be placed below in the booth of a console or radio table. How to arrange for these requisites is a question often discussed, with numerous corrolaries.

An AC receiver may be built, if desired, as shown in Fig. 1, consisting of a tuner and audio amplifier, with filament transformer for heating the tubes of the receiver. Then the separate B supply will have a power transformer with the necessary high voltage winding and a filament winding for the rectifier tube. This makes a good combination, especially since the B supply is wholly independent, and may be used with almost any receiver.

Variety of Tube Options

A heightened eye appeal, plus utter separation of the power amplifier and the tuner, is achieved when the audio amplifier is made part of the B supply, and the filament voltages for the receiver also are furnished. This reduces the size of the table model cabinet, if one is used. Variety of tubes is limited, however, unless it is assumed that a power amplifier is to be used with an AC tuner, when the variety is great enough, since AC tubes are becoming standardized. The leaders are *224* for radio amplification, *227* for detector and audio amplification, and 245 for the output, either singly or in push-pull. Where the *226* figures it is usually for audio only, unless the receiver is of some design that may ignore the newer tubes, whereupon a row of 226s may be expected.

The radio frequency side, which includes the detector, is to be judged primarily on selectivity and sensitivity. The audio channel will have nothing directly to do with these. Selectivity should be excellent for utter discrimination among frequencies in these air-crowded days. Sensitivity should be as high as you desire. What your desire will be is what will determine the cost of the tuner.

Where Ultra-Sensitivity Begins

The receivers that are very sensitive bring in plenty of distant stations with great volume, and if you are interested in DX by all means you should provide yourself with a sensitive receiver. One that uses four screen grid tubes for radio amplifier and a *227* or other detector, negatively biased, is the starting-point in the ultra-sensitivity realm. Such a receiver makes most others seem like weak sisters beside it, if the audio channel is a good one.

What the audio should be is again a matter of taste. Good results can be obtained with transformer, impedance or resistance coupling, or combinations of these.

With a highly sensitive tuner, you are likely to deliver a strong voltage to the detector input, so you may use less audio amplification than you've been furnishing to tuners that follow older designs. One stage of high-gain transformer coupling often will prove sufficient, or two stages of resistance-coupling or two of impedance coupling, whereas formerly resistance or impedance coupling called for three stages.

Fig. 1 is the design of the Push-Pull Diamond of the Air, where it is built for operation from an independent B supply. Fig. 2 is a suggested diagram for a B supply, wherein the capacity-resistor filter system is used. A bleeder current is established through the resistor from points 1 to 6, so that the power tube plate voltage, being high, may be taken off at 6, whereas the point from which voltage is dropped through independent resistors is somewhere lower down, so that too high a current will not flow through these resistors any time.

Values of Resistors

What the values of these independent resistors should be can not be foretold for all circuits, as the voltage drop in a resistor depends on the current flowing through that resistor, and the current will depend on the number and types of tubes supplied with B voltage and current and connected to an a individual resistor. However, the plate current drawn by any type tube at standard values of bias is known, or can be measured, and the number of tubes used is known, so the resistor's value can be calculated. By Ohm's law the resistance in ohms equals the voltage divided by the current in amperes.

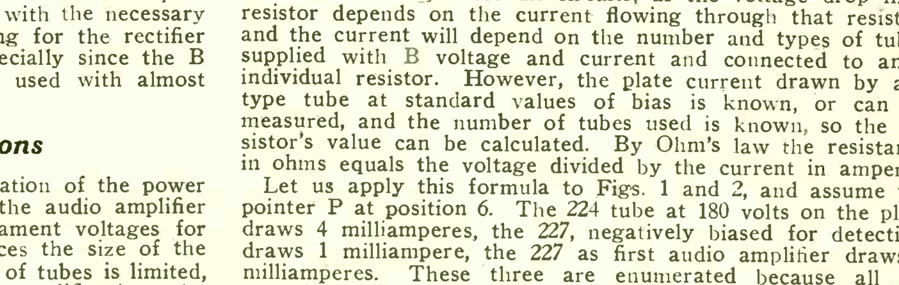
Let us apply this formula to Figs. 1 and 2, and assume the pointer P at position 6. The *224* tube at 180 volts on the plate draws 4 milliamperes, the *227*, negatively biased for detection, draws 1 milliampere, the *227* as first audio amplifier draws 5 milliamperes. These three are enumerated because all are served from the 180-volt tap. The maximum voltage is 300 volts, so the voltage to be dropped is the difference, or 120 volts. Therefore the resistance of the independent resistor, let us say point 5 in Fig. 2, is 120 volts divided by .01 ampere. Hence resistor 5 should be 12,000 ohms. Since it drops 120 volts at .01 ampere it must dissipate 1.2 watts.

Wattage Rating

Following the usual precaution of requiring a resistor of at least twice the rating of the actual wattage, this resistor would be of 3 watts rating. This is low wattage, so almost any resistor of that resistance value would do, 5 watts being a common minimum rating for resistors used for voltage dropping in B supplies.

B+75 is connected to the screen grid of the 224. Assume the resistor terminating at 2 is used. Then the resistance is the voltage drop, 225, divided by .0013 ampere, or about 173,000 ohms. If the pointer is moved down, as advised, say to 200 volts, then the voltages above would be 200-180 and 200-75, or 20 and 125, and the resistors 2,000 and 96,100 ohms.

FIG. 2
DESIGN OF A SEPARATE B SUPPLY. HOW TO DETERMINE THE VALUES OF THE RESISTORS IN THE CAPACITY FILTER CIRCUITS IS EXPLANED IN THE TEXT. THE ROW OF CONDENSERS AT RIGHT IS 4 OR 2 MFD. EACH. THE VOLTAGE AT POSITION 6 IS 300. THE 280 TUBE IS USED AS RECTIFIER.



POWER AMPLIFIERS

By J. E. Anderson and Herman Bernard

[*"Power Amplifiers," by J. E. Anderson and Herman Bernard, was begun in the June 1st issue. In the June 8th issue loudspeaker coupling devices and battery-operated amplifiers were explained. A special analysis of resistance-coupled audio was included. In the June 15th issue, the exposition was carried forward to the DC supply of A, B and C voltages, e. g., for operation from 110-volts DC obtained from the convenience outlet. Ohm's law was explained in conjunction with the design of a DC supply. Then the part was begun that treats of AC fully, with rectifier and filter analysis exceptionally well set forth. The AC topic was continued last week, June 29th. In the following instalments, the sixth of the series, intimate details on AC type B supplies are set forth. Next week, July 13th, there will be another big instalment. The series will continue each week for several weeks.—Editor.*]

If the resistance is used for a tube requiring a different current, a different terminal voltage, and some other voltage source, the voltage of the source is V volts, the required filament voltage F volts, and the filament current I amperes, the resistance R of the ballast is determined by the formula (V—F)/I=R. If there are several equal tubes, say N, on the same resistor, then the formula for the resistance is (V—F) / NI=R.

Let us apply this to a circuit using—99 types. Suppose a storage battery is used as a voltage source. V=6 volts. The filament terminal voltage is 3.3 volts, which is F in the formula. The current required by each tube is .066 ampere, which is the value of I. Let there be 5 tubes, so that N=5. Substituting these values in the second formula we find that R = (6—3.3) / 5x .066 ohms, or 8.18 ohms. If the tubes require different currents but the same filament terminal voltage let NI in the second formula be the total current, obtained by adding the different currents.

When 5-volt tubes are used on a 6-volt battery, the grid bias is limited to one volt. When 3.3-volt tubes are used on a 6-volt battery, the bias may be as high as 2.7 volts.

In the case of a battery type screen grid tube, the 2.7-volt bias is larger than that which is usually recommended for this tube, the standard bias being 1.5 volts. Several methods are available for avoiding this difficulty. The resistance R may be made up of two units in series, or a single unit with a tap at a suitable point. The tap, whether it be on the single resistor or at the junction of two, should be placed 1.5 volts down from the minus end of the filament, and then the grid return should be connected to this tap. Since the total drop in R is 2.7 volts and 1.5 volts are required, the division of the resistor should be in the ratio of 5-to-4, with the greater portion next to the filament. This proportion is true no matter what the absolute value of R may be, that is, no matter what the number of tubes the resistor serves.

Another method is to put the larger portion of the resistor in the negative leg of the filament circuit, connecting the grid return to A minus, and then putting the smaller portion of R in the positive leg.

Still another method is to connect a potentiometer of about 2,000 ohms across the total value of R, placed in the negative leg, and then connecting the grid return lead to the slider. This may then be set at any place between zero and 2.7 volts.

An easy way to get approximately correct bias for a battery type screen grid tube is to drop 2.7 volts, from 6 to 3.3 volts, in a 25-ohm resistor in the negative filament, and connect grid return to F—(not A) of a 5-volt battery type tube. The negative bias is then 1.7 volts.

There are very few circuits in which a bias of one volt or 2.7 volts is sufficient. In most amplifiers and in all grid bias detectors it is necessary or advisable to make some provision for a higher bias.

The oldest method, if not the simplest, of increasing the bias is shown in Fig. 37B. A small battery E is connected in the grid circuit with its positive terminal to A minus and its negative to the grid return. This gives the tube a bias equal to the drop in the resistance R plus the emf of the battery E. This battery, in whole or in part, may be used to supply bias for other tubes. The resistor method shown in Fig. 37A can be used for battery tubes only, but the method in B can be used for any tube.

If the plate voltage available for a given tube is higher than the required grid and plate voltage combined, the bias may be taken from the plate voltage supply in the manner indicated in Fig. 37C. The grid is returned to the lowest potential point on the voltage divider or the plate battery and the plate return is made to a suitable point of higher voltage. The filament is then connected to a point in between these two points. The bias given the tube in Fig. 37C is the sum of the voltage drop in R and the drop in R1.

The current through R1 is the sum of the plate current in the tube and the current through resistor R2. Suppose the total voltage available is 140 volts, to be divided so that 135 volts are on the plate and 5 volts on the grid. We first determine the value of R2 from the known plate voltage of 135 volts and the current desired through R2. Let this current be 4 milliamperes. Thus by Ohm's law the value of R2 must be 33, 750 ohms.

If the tube is a 201A, the plate current is 6 milliamperes when the grid bias is 5 volts and the plate voltage is 135 volts. Thus through R1 the total current is 10 milliamperes. Now, there is a drop of 1 volt in R, so that the drop in R1 should be 4 volts in order that the total bias be 5 volts. Hence by Ohm's law the resistance of R1 should be 400 ohms. Actually, the effective plate voltage is only 134 volts because the drop in R is subtracted from the plate voltage.

The resistance R2 is not needed in all circuits, and indeed, it is not often used. But it is serviceable when the normal plate current in the tube is very small, such as it is in grid bias detectors and resistance coupled amplifiers. The object of this resistance is to get a larger current through R1 than is afforded by the plate alone, thus permitting a reduction in R, without changing the grid bias. This in turn reduces feed-back.

When R2 is omitted the value of R1 is determined by the plate current alone. We found above that the plate current under the condition specified is 6 milliamperes. If this alone flows through R1 the resistance must be 667 ohms. This is not much different from the value of the 400 ohms obtained when R2 was used. But suppose that the circuit adjustment is such that the plate current is only .125 milliamperes, which is the case in many detectors and resistance coupled amplifiers. Then the value of R1 must be 32,-000 ohms. This would result in considerable reverse feed back and a great reduction in the amplification. The situation would be much worse if a high grid bias were required, as in grid bias power detection circuits.

The method illustrated in Fig. 37C is directly applicable AC circuits, and its use with a heater type tube is shown in Fig. 38A. Whether R2 is used or not depends on the plate current. If it is normally large, R2 may be omitted; if it is normally very small, the resistance should be used. The value of R2 is always determined from the desired voltage on the plate and the desired current through the resistance. Both of these values are arbitrary and may be chosen to suit the tube and its function. R1 is then determined from the total current flowing through it and the desired bias on the tube suitable to the type of tube, its function, and the plate voltage selected.

Since the tube in Fig. 38A is followed by a transformer, R2 would hardly be used except when the tube is used is a grid bias detector. Let the voltage on the plate be 180 volts. The bias

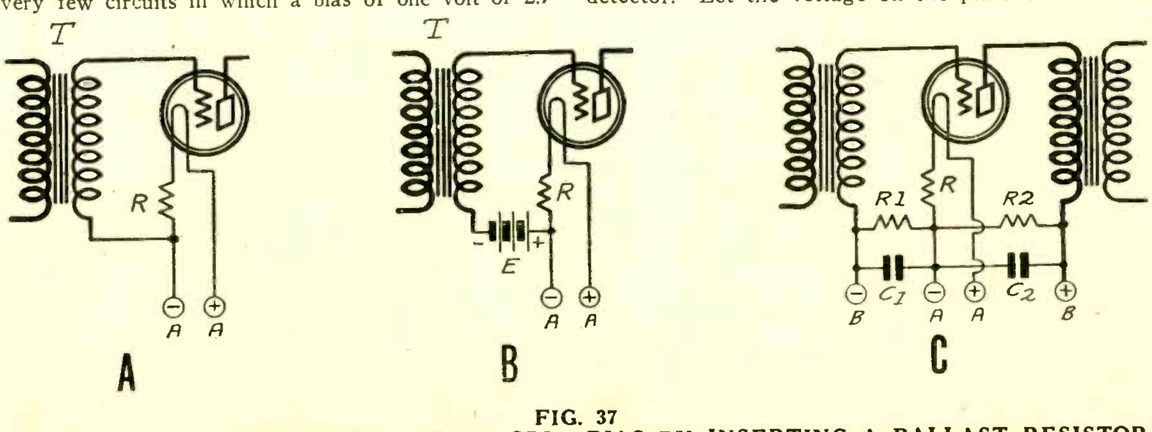


FIG. 37
(A)—METHOD OF OBTAINING A LOW GRID BIAS BY INSERTING A BALLAST RESISTOR R IN THE NEGATIVE LEG OF THE FILAMENT CIRCUIT.
(B)—ADDITIONAL BIAS CAN BE OBTAINED BY CONNECTING A BATTERY E BETWEEN A MINUS AND THE GRID RETURN LEAD.
(C)—A GRID BIAS CAN BE OBTAINED BY UTILIZING THE DROP IN A RESISTOR PLACED IN THE GRID CIRCUIT, THROUGH WHICH CURRENT FROM THE PLATE VOLTAGE SUPPLY FLOWS.

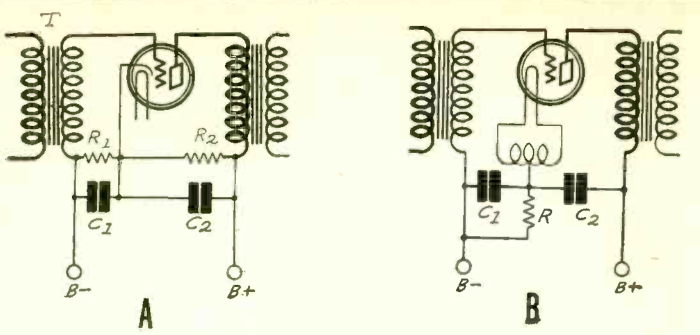


FIG. 38
(A)—IN AN AC TUBE CIRCUIT THE BIAS CAN BE OBTAINED IN A SIMILAR MANNER TO THAT SHOWN IN FIG. 37C.
(B)—IF THE TUBE IS DIRECTLY HEATED BY A TRANSFORMER WINDING THE BIAS CAN BE OBTAINED BY INSERTING A RESISTOR BETWEEN B MINUS AND THE MID-TAP OF THE FILAMENT.

may be taken as 25 volts and the plate current one milliampere. Under these conditions, if R2 is not used, R1 would have to be 25,000 ohms. But if we use R2 and adjust it so that 9 milliamperes flow through it, the total current through R1 is 10 milliamperes. Hence the grid bias resistor should be 2,500 ohms. R2 would have to be 20,000 ohms. Both resistors must be by-passed as indicated.

If the circuit employs a filament type AC tube the bias can be obtained as in Fig. 38B. This is really the same method as that shown in Fig 38A, with the resistor R2 omitted. As in that circuit, the plate resistor may be used in this. It is simply connected from B plus to the mid tap of the filament.

Suppose the plate resistor is omitted in Fig. 38B, and that the tube is a 171A requiring a grid bias of 43 volts and a plate voltage of 180. The total voltage required across the plate voltage supply is then 223 volts. The current through the grid bias resistor R is simply the plate current, which may be taken as 20 milliamperes. By Ohm's law, then, the value of R must be 43/.02, or 2,150 ohms. the plate current in this tube is so high that there is no reason for using the plate resistor to augment the current through R.

Since a filament type AC tube is not suitable for resistance coupled amplification or for detection, there seems to be little reason for using the plate resistor to augment the current in the bias resistor.

The method of obtaining bias shown in Fig. 38B as applied to a push-pull amplifier stage is shown in Fig. 39A. Since the two tubes in a push-pull stage must be equal and operated under identical static conditions, the grid bias resistor in a push-pull stage is just half as large as the resistor used for a single tube of the same type. Thus in Fig. 39A, the value of R should be 1,075 ohms, assuming that the tubes are 171A.

When equal tubes are used in tandem and are used with the same plate voltage, and when they are supplied filament current by the same winding, the grid bias resistor is also half as large as it would be if it were used for a single tube. A circuit of this kind is illustrated in Fig. 39C, R being the bias resistor.

When the circuit is of this type it is useless to use a separate grid bias resistor for each tube, for the two or more used would be in parallel. It is more convenient and economical to use a single resistor.

If two or more tubes are connected to the same filament winding and it is necessary to apply different plate and grid voltages, it is possible to do so. To obtain different plate voltages it is only necessary to return the plate leads to the appropriate points on the voltage divider. To obtain different grid bias on the tubes the resistance R must be provided with tape, preferably sliding. The value of the resistor is determined by summing up all the plate currents that flow through it and by using the highest bias necessary. The taps are then placed so as to provide the necessary lower grid voltages for the other tubes. No current flows into the taps when grid return leads are connected to them, so the determination of the positions is simple. The drop in any portion of the resistor is to the drop in the total as the length of the portion is to the total length. The voltage for any tube is measured from the mid-tap of the filament to the tap, and not from the other end of the resistor to the tap.

In Fig. 39B is shown a method of obtaining the grid bias for various tubes from the voltage divider in the plate power supply. This was used much in the early days of plate power devices, and is still used widely. While it is applicable to all tubes it is used more for battery tubes than for AC tubes.

As will be observed, the point of zero voltage is not taken at the extreme low potential end of the resistor strip, but at a point higher up. The plate voltages are measured from this point upward, and the grid voltages from the zero point downward. The total voltage output of the plate current supply circuit is the voltage difference between C3 and B4. Suppose this is 220 volts. Now if the power tube in the receiver is a 171A the plate voltage should be 180 and the grid should be nearly 40 volts. Thus the total voltage is divided by the point (O) in the ratio 180 volts above and 40 volts below. The point B4 will then be 180 volts higher than the zero point and the point C3 will be 40 volts lower.

Intermediate plate voltages are obtained by tapping the resistor strip at suitable point in the manner already explained. The intermediate grid voltage, likewise, are obtained by tapping the resistance between zero and C3. Sliding taps should be used preferably on this portion of the resistor.

In determining the value of the resistance from zero to C3, it should be remembered that the total current delivered by the rectifier flows through this resistor. The bleeder current alone flows through the portion between zero and B1. The plate currents return from the tubes to the voltage divider at the point (O) and then flow down the grid bias resistor.

Suppose that the total current drawn from the rectifier-filter is 60 milliamperes. What should the value of the resistance be to make the voltage difference between zero and C3 40 volts? Dividing 40 by .06, according to Ohm's law, gives 667 ohms. The tap C1 is placed a distance down from zero proportional to the voltage desired. For example, the voltage at C1 is to be—1.5 volts, the tap is placed 1.5/40 of 667 ohms down, that is, 25 ohms. Again, if voltage at C2 is to be—12 volts, the tap is placed at 12/40 of 667 ohms down, that is, at 200 ohms down. A simple proportion may be used because none of the taps takes any current, so that the same current flows through the entire resistance R. And this current can be obtained by inserting a milliammeter in either the negative or the positive line to the filter. If the taps are movable, the proper voltage can be obtained by connecting a high resistance voltmeter from (O) to either C1 or C2 and then sliding the tap until the meter reads the desired voltage.

Highest Voltage Drop Not Desirable

In all cases where the grid bias is taken from a voltage drop in the plate current supply the voltage used for bias is subtracted from the plate voltage. In some instances the bias is so small that this makes no difference. In other cases the bias is higher but the plate voltage available is high enough to permit the division of the voltage.

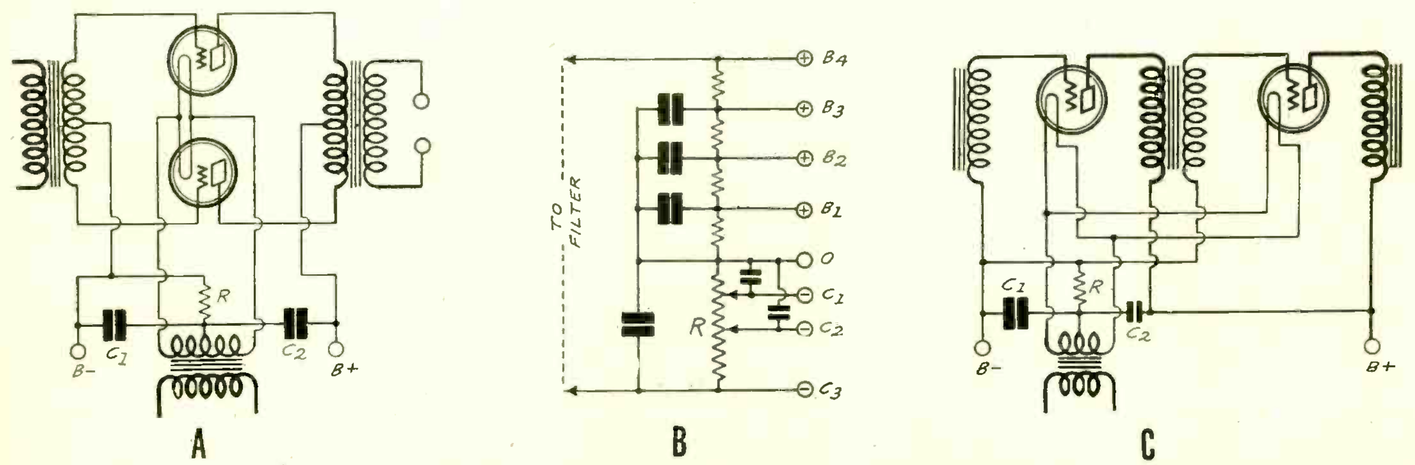


FIG. 39
(A)—IF TWO TUBES ARE USED IN PUSH-PULL THE GRID BIAS RESISTOR IS ONE HALF AS LARGE AS IF IT WERE USED FOR A SINGLE TUBE OF THE SAME TYPE. THE METHOD HERE SHOWN IS THE SAME AS THAT IN FIG. 38B.
(B)—METHOD OF OBTAINING BIAS FROM VOLTAGE DROPS IN THE VOLTAGE DIVIDER OF A PLATE CURRENT SUPPLY CIRCUIT
(C)—WHEN TWO OR MORE SIMILAR TUBES ARE OPERATED FROM THE SAME FILAMENT WINDING AND UNDER SIMILAR CONDITIONS A SINGLE BIAS RESISTOR WILL SERVE ALL.

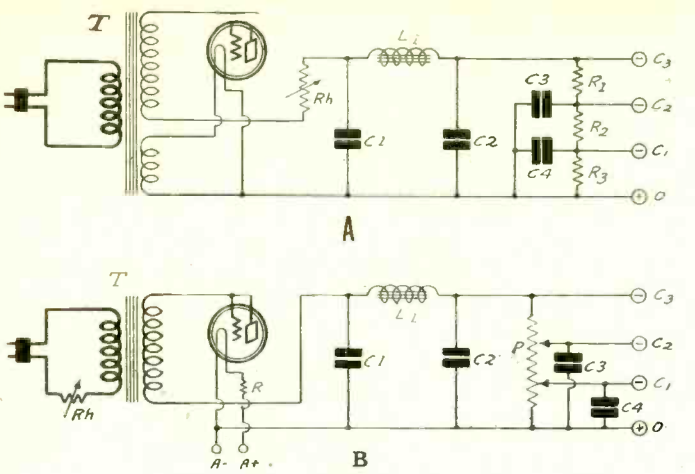


FIG. 40

A. CIRCUIT OF A GRID BIAS SUPPLY SET IN WHICH AN AMPLIFIER TUBE IS USED AS RECTIFIER. IT IS DESIGNED FOR AMPLIFIERS REQUIRING HIGH GRID BIAS

B. THE SAME CIRCUIT AS IN (A) EXCEPT THAT IT HAS BEEN DESIGNED SO THAT THE RECTIFIER TUBE IS HEATED FROM THE STORAGE BATTERY IN THE AMPLIFIER.

But in certain circuits the bias is very high so that when it is taken from the available plate voltage the reduction in this voltage is greater than is desirable. If the total voltage is increased so that both plate and grid voltages have the desired values, the stress on the filter condensers becomes considerably higher. It may be that the extra voltage will make it necessary to use condensers of much higher voltage rating, thus increasing the cost of the plate voltage supply.

Also when the grid bias is taken from a drop in the plate current supply circuit there is a greater power loss than is necessary. For example, consider a circuit involving two 250 type tubes requiring a voltage of 84 volts. The current in each tube is 55 milliamperes, so that the total current through the grid bias resistor is 110 milliamperes, and the power dissipation in the resistor is 9.24 watts. The total power dissipation in the plate circuits of the tubes alone is 49.5 watts. Hence the dissipation is a considerable fraction of the total. The main objection to this power dissipation is that it results in heat.

There is another reason why it is not desirable in some instances to take the grid bias from a voltage drop in the plate circuit, and that is the feed back which occurs through the grid bias resistor. This is such as to lower the amplification when the feedback is from the plate circuit to the grid circuit of the same stage. This is true mainly in single sided amplifiers. If the feed back also gets into the grid circuits of earlier stages, there may be oscillation at audio frequency, or at least distortion.

One way of avoiding these difficulties is to use a grid bias battery. But such a battery for high voltage is usually very clumsy and it rarely gives just the grid bias desired.

Another way is to use a grid bias supply circuit involving a rectifier, a filter, and a voltage divider. In all essentials the circuit is just like a plate power supply circuit but its only function is to maintain certain potentials. It is not required to deliver any power.

In Fig. 40 are shown two such grid bias supply circuits. The upper, (A), is primarily intended to supply the bias in a receiver employing AC tubes, while that in (B) is suitable for receiver usings direct current on the filament, or on part of the filaments.

In each of these circuits a small amplifier tube is used as a half wave rectifier, the grid and the plate being tied together. What type of tube to us as rectifier is of little importance. A little 99 serves just as well as a 250 or a 281. The choice of tube for Fig. 40A would depend on the voltage of the filament winding. If the voltage is 1.5 volts, a 226 should be used; if the voltage is 2.5 volts, a 227 should be the choice; if the voltage is 5 volts, a 201A is the proper tube, or a 99 with a ballast resistor to cut down the voltage.

The voltage of the high winding should be of the same order as the desired grid voltage, or a little less in view of the fact that the rectified voltage will be very nearly equal to the peak voltage of this winding. The primary, of course, should be suited to the line voltage.

The only current that will flow in the filter is that taken by the voltage divider. If the total resistance of this is made very high, the current will be extremely small. For example, the total resistance may well be half megohm. When it is, the voltage across it will be very nearly equal to the peak voltage across the high voltage winding, that is, about 40 per cent. higher than the effective voltage. If the circuit is adjusted so that the voltage from zero to C3 is 84 volts, the current through the voltage divider will be only 168 microamperes.

The filtering is very easily accomplished in this circuit because of the minute current that flows. The capacity of any one of the condensers C1, C2, C3 and C4 need not exceed .5 mfd., and low voltage rating condenser can be used since the voltage will not rise above the highest bias voltage.

The choke coil L1 can be the secondary of an old audio transformer. This can be used without danger of saturation because of the extremely small value of the current that flows through it.

The choice of the resistors in the voltage divider is determined by the voltage drops across any one and the fact that the total voltage drop is to be equal to the highest bias desired. The placement of the taps is simplified by the fact that the same current flows through all the sections.

It may be that the windings on transformer T are such that the voltage across the output is higher than desired. In that event a variable resistance Rh can be put in series with the line as indicated. Naturally the resistance value must be high to cause a considerable voltage drop, since the current through it is small. The rheostat could also be placed in the primary, but if placed there it would have to be smaller because at this point it would also control the filament current in the rectifier tube. The reduction in the filament current is a desirable feature.

It is not likely that a suitable transformer can be found on the market. But there is a way around that. If the filament of the rectifier tube is placed on a winding on some other transformer, and there usually is an extra winding, the remaining portion of T can be an audio transformer, preferably one having a 1-to-1 ratio. When this is used the rheostat Rh can be placed in the primary or where shown without any difference in the effect.

If the receiver has a storage battery the rectifier tube can be placed on it as shown in Fig. 40B. The resistance R is an ordinary ballast suitable to the tube used as rectifier. T can be an audio transformer of low ratio and Rh an adjustable high resistance. The filter circuit in (B) is the same as that in (A).

The voltage divider in (B) is different from that in (A). It need not be, for the two voltage dividers may be used interchangeably. Both are shown merely to illustrate the types. The total resistance of the double slider potentiometer P should be about half megohm. If the potential difference zero and C1 is low, say of the order of 3 volts, P may be made up of a 25,000 ohm and one 500,000 ohm potentiometer connected in series, with a slider on each.

The plus terminal in each of these circuits has been labled zero. It should be connected to the cathode of a heater tube, the mid-point of the filament in a direct heated AC tube, and to the minus terminals of the filament battery. Note that if circuit (B) is used to supply bias for tubes which are on the same battery as the rectifier tube, the plus terminals should not be connected to anything. At any rate, it should not be connected to A plus in the set, for this would short circuit the battery.

The output voltage of either of the circuits in Fig. 40 cannot be measured with any ordinary voltmeter, not even one of 1,000 ohms per volts. The only way to get the correct voltage is to use a vacuum tube voltmeter. And for this the tube to be biased can be used.

Either of the circuits in Fig. 40 takes less room than a dry cell battery giving the same voltage, and it will cost less, last longer and give dependable service whenever it is needed. The power required to operate it is essentially that required to heat the filament.

[*Part VI next week, July 13th*]

Right or Wrong?

(Answers on next page)

(1) A photo-electric cell is a vacuum tube in which electrons are released from the cathode by means of light.

(2) One of the most effective methods of eliminating noise due to electrical apparatus from a radio receiver is to use a high antenna and a good ground.

(3) A condenser type microphone responds twice as well to high frequencies as to low.

(4) Lenz' law states that an induced current produced by relative motion between magnetic fields is such as to oppose the motion.

(5) Ohm's law states that the sum of all currents flowing toward a point of junction of multiple electrical conductors is zero.

(6) The mutual conductance of a vacuum tube gives a measure of change in plate current for unit change in the grid voltage.

(7) If the effect of the direct current in the primary of an audio frequency transformer is balanced out, the low frequencies will be amplified more than when this current is effective.

(8) The ohms-per-volt of a voltmeter determines the current which that instrument will take at full deflection.

(9) The object of the air gap in transformer and choke coil cores is to prevent magnetic saturation by the direct current which flows through the winding.

(10) The advantage of using core materials of high permeability is that a smaller quantity of it may be used in a core for a given purpose.

A Circuit

Description of the

By Tim

A BROADCAST wave is a radio frequency wave because it is an agitation in the ether at super-audible rapidity, say, at more than 500,000 times a second. The emission of the wave by the broadcasting station is called radiation. But radiation may carry no intelligence. It may be a radio frequency of a form varying only at a given number of cycles a second, and unaffected by anything that would even slightly change that frequency. If so it is called an unmodulated wave. But if varying intensities of electrical impulses are mixed with the carrier, thus slightly but continuously changing the frequency in a manner corresponding to frequencies of the new ingredient, then it is a modulated carrier. In broadcast reception we are interested in modulated continuous waves.

Broadcast waves are alternating current and alternating voltage. The purpose of a receiving aerial is to intercept these waves. The aerial is mostly a capacity adjunct, with the ground as the other plate of the condenser. The aerial is a playground for all waves ever radiated, but broadcast receivers are only sensitive enough to pick up signals at about the time of their transmission. A wave, once radiated, never stops going, but it almost instantly becomes so feeble that we have no instruments with which to intercept or measure it, but we assume it to be as imperishable as matter, and to continue on its way at 186,000 miles a second.

The object of the tuner is to enable the reception of a desired frequency. Therefore the tuner is a radio frequency discriminator, enabling us to select the desired frequency and reject the undesired frequencies. Hence the term selectivity.

The radio waves that use your antenna-ground system as their playground have a coil of wire connected in parallel, one end to aerial, the other to ground. Physical connection to earth is not essential. Even the roof of a building is approximately at ground potential, especially if physically connected to ground by metallic conduction, as by a standpipe. The batteries are at ground potential without necessarily being connected to a cold water pipe or radiator. So is a power transformer. The electrical line is grounded on one side, even if AC. So there are antenna and ground at all hazards.

Coil's Field Without Limit

This coil of wire, called the antenna winding, offers some odd obstruction to the radio waves, although it receives all waves, a certain band of frequencies better than other bands. The opposition is not the same as that of a resistor to direct current. It is complex, because the wire has a phenomenal quality called inductance, a property that causes the coil to behave like a magnet when current is passed through it. If the current were direct and steady, the manifestation of magnetism would be steady. But the radio wave is alternating, and the alternations are duplicated in this magnetic field which is that restricted area in which the magnetic lines are substantial. The field is actually without limit, and is possibly eternal, but it quickly passes beyond our scope of measurement.

The magnetism arising from the passage of current through a coil or over the surface of the coil is called electro-magnetism, and the coil as an electro-magnet is distinguished from a permanent magnet, such as a horseshoe magnet, and from other forms of magnets.

This field around the coil is an agitation in the ether, too, lines of force emanating from the coil in concentric circles, so that every line or force sent out returns again. So all the waves intercepted by the antenna and set flowing in the antenna coil duplicate in the field of this small coil their behavior elsewhere. The field about the coil rises and falls twice for each cycle of the frequency of each wave, and as there are countless waves in the circuit, all rising and collapsing at different times, we

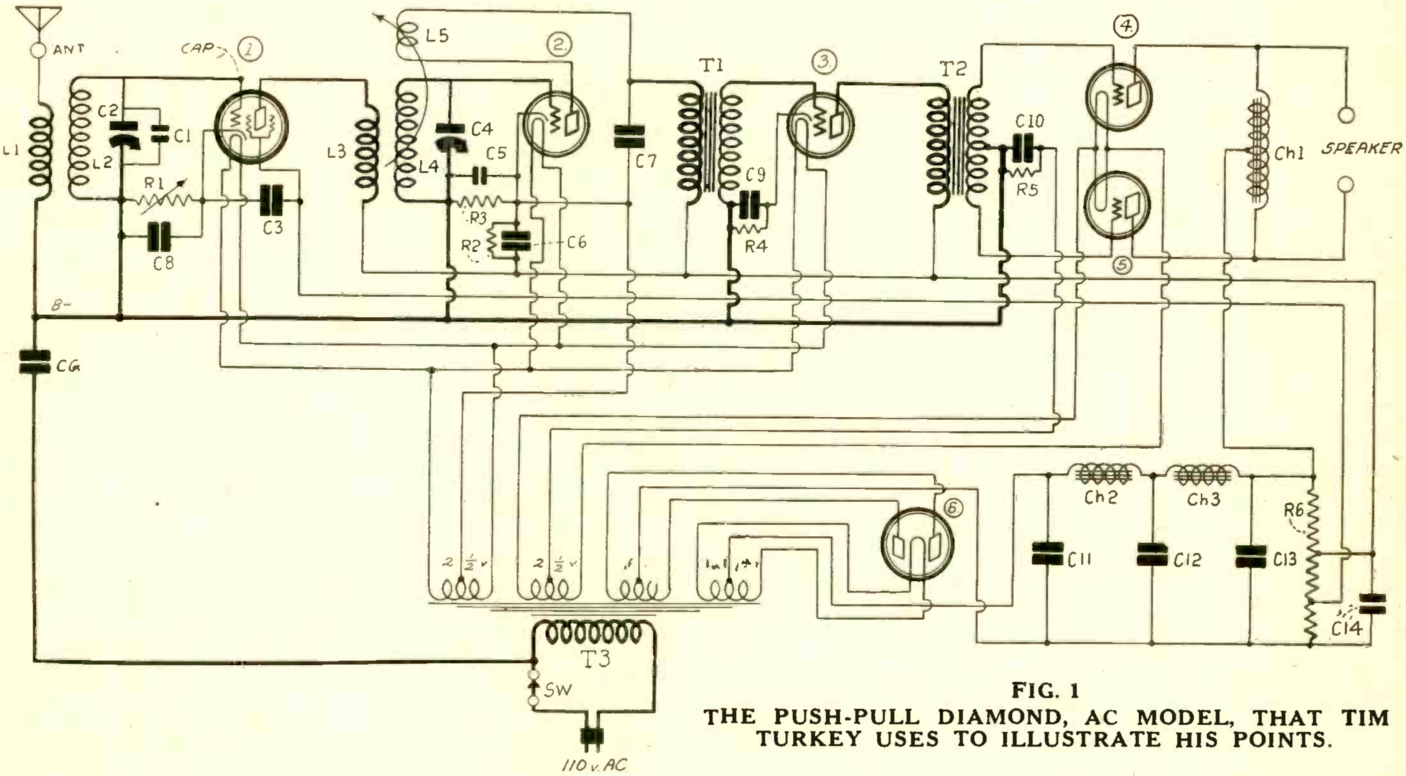


FIG. 1
THE PUSH-PULL DIAMOND, AC MODEL, THAT TIM TURKEY USES TO ILLUSTRATE HIS POINTS.

Right or

(See questions o

(1) Right. Light energy releases the electrons from the cathode just as heat energy releases them from the filament or cathode in an ordinary vacuum tube.

(2) Right. This is often the only means of lowering the noise-to-signal ratio that can be applied to a radio receiver.

(3) Right. High frequency sounds are reflected from the diaphragm and that doubles the pressure. At low frequencies there is no reflection. The change from no reflection to full reflection is gradual as the frequency of the sound changes.

(4) Right. If a bar magnet, for example, is thrust into a coil in a closed circuit, a current will flow in the coil, and the direction of the current is such as to oppose the motion of the magnet. This is general and is the basis of all electric machines and transformers.

(5) Wrong. This is Kirchhoff's law. It states simply that no electricity can accumulate at a point. Current flowing away from the point are considered negative. The law can be stated also that the sum of all the currents flowing to the point is equal to the sum of all the currents flowing away.

(6) Right. For example, if the mutual conductance of a

in Action

Entire Performance

Turkey

reach an infinite number at once. So from this amazing assortment of waves, of which, however, only about a few hundred have any recognizable field strength, the tuner must make its selection at our bidding.

To enable this process to function easily, we have another coil in very close proximity to the antenna coil. The first coil we call the primary. The other coil we call the secondary. It has a larger number of turns of wire than the primary, and the number of turns is so proportioned that if we connect an adjustable tuning condenser across the secondary we are able to tune in from 200 to 600 meters by turning the condenser. We can tune in that way because the proximity of the secondary to the primary enables the secondary to acquire a copy field of its own, for the voltage and current of all waves in the primary are duplicated in the secondary, because of electromagnetic coupling, called mutual induction.

How Tuning Is Effected

By making the condenser variable, we have a storage tank that takes in and discharges electricity at assignable periods depending on the capacity setting to which it is turned, when the condenser is connected across the coil. The capacity receives its charges from the coil connected to it, and the amount of capacity determines the rate of charge and discharge. When that rate is equal to a certain frequency the circuit is resonant to that frequency. A resonant circuit offers infinite impedance to the tuned frequency, and the higher the impedance the greater the voltage across it, so the favored frequency passes into the first vacuum tube in Fig. 1.

The radio frequency fluctuations or alternations are in the grid-to-filament circuit of the tube at a resonant frequency now. The changes in grid voltage, still maintained at the tuned radio frequency, which may be from 1,500,000 cycles down to 550,000 cycles per second, cause corresponding fluctuations or alternations in the plate circuit of the tube, but on a magnified scale, because the tube is worked as an amplifier. This plate current is present because of plate connection to the B battery or B eliminator, which makes the plate positive in respect to grid and filament.

Plate Current Follows Resonant Frequency

Since the plate and the grid are coupled inside the tube, the electrons flowing from filament to plate and the plate current flowing from plate to filament even against the electrons, the plate current rises and falls at the resonant frequency, for again current is flowing in a conductor, consisting largely of capacity and inductance, and the plate current, direct at all times, is made to change in intensity corresponding to the resonant frequency.

If that frequency is 1,000,000 cycles per second (300 meters), then the plate current changes 2,000,000 times a second. It starts at zero, rises to maximum amplitude, falls to zero, this for the positive alternation, then drops to maximum at the negative alternation and rises to zero. Each half-wave is called an alternation, and two succeeding alternations constitute a cycle. So the plate current changes from zero to maximum twice each cycle, once in performing the positive alternation, again in performing the negative alternation. The plate current does that, although direct reading meters are not available to disclose this to the eye. The meters used in plate circuits are milliammeters for direct current reading, and these read the peak current.

Carrier Wave Is Discarded

A corresponding input is made to the detector as was made to the first tube. But the circuit here is different. We want to hear the speech and music. The frequencies we have been dealing with are above audibility. They are radio frequencies with a mixture introduced in them, by virtue of sounds made before a microphone, sounds converted into electrical impulses corresponding to the frequency and intensity of the original sound waves, and which pulses were mixed with the carrier, so that they altered the fringe of the carrier to the extent of this modulation.

We want only the modulation henceforth. We want to discard the carrier now. This we do by unmixing the two mixed parts, forming the tube circuit for detection, which is the suppression of all save the fringe that represents the audio component. Some radio frequency will be in the detector plate circuit, but a condenser helps to bypass this, and the succeeding parts are not equipped to favor passing radio frequencies. We are now in the audible realm.

What have we now? A steady, unvarying current, or a fluctuating current? The rectified component is a fluctuating signal current. It doesn't fluctuate the same way that radio frequency does, however. Most obvious is the fact it is slower, much slower, for it is audible, and we know it can't exceed 10,000 cycles a second. We adults scarcely can hear frequencies higher than that. It is not an alternating current, however, for it does not reverse its polarity. It is an unsteady or changing direct current, always flowing in the same direction. It is called a pulsating direct current. It falls to zero and rises to maximum positive, but it never goes negative.

Audio Transformer Passes DC?

Now, it is direct current. And first thing we do is to put an audio transformer in the circuit, with primary connected to B plus detector and to the plate of the detector tube. It is well known that a transformer will not pass direct current. How is it that the signal goes through, even being stepped up by the transformer and then by the next tube, the process being repeated until the final or power tube is reached? Have audio transformers started passing direct current recently?

Since the detector plate current, although direct current, is pulsating, and since the primary of the audio transformer is a coil of wire, and possesses inductance, or the property of being an electro-magnet when current is passed through it, the pulsations in the plate current, due to the reconverted speech and music, set up a varying magnetic field, and the same phenomenon of magnified duplication by mutual inductive coupling is repeated at audio frequencies as took place at radio frequencies. The lines of force, or electrons in transit, rise from zero to maximum height, return to zero, and—do they swing negative? They do.

Now It Can Be Told

How can direct current turn out to be alternating current? The audio transformer is no machine for doing it. An alternator is not a type of machine for making the same type of change. A rotary converter is, however. How would we ever have AC electricity in the wiring of our homes if machines could not readily give us alternating current? Nature supplies us with almost no alternating current, except interference, like static and lightning. We have to make our own AC or go without.

Wrong?

(…n preceding page)

tube is 1,000 micromhos, a change of one volt on the grid will change the plate current 1,000 microamperes, that is, one milliampere. This applies to the tube alone and not when there is a load impedance in the plate circuit.

(7) Right. The direct current reduces the effective inductance and therefore it reduces the amplification. This effect is greater the lower the frequency.

(8) Right. That is true regardless of the range of the voltmeter. If the instrument has 1,000 ohms per volt it takes one milliampere at full scale. If it has 200 ohms per volt, it takes 5 milliamperes. If it has 50 ohms per volt, it takes 20 milliamperes.

(9) Right. The air gap introduces a high reluctance in the magnetic circuit and prevents a high flux.

(10) Wrong. That is an error which many designers have committed. The reverse is generally true. More of the material should be used because it has a higher permeability. The advantage is that a given inductance can be obtained with fewer turns. If the permeability is high there will also be less iron loss in the transformer.

REVERSE TRANSFORMER WINDING

If a circuit squeals, either at radio or audio frequencies, a simple remedy that often works is to reverse the connections on one of the windings. Which one, does not matter.

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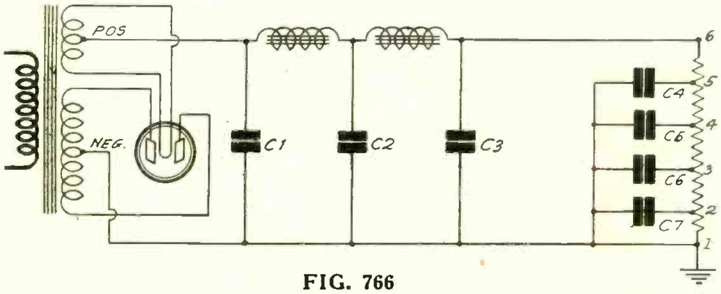


FIG. 766
THE SIMPLEST B SUPPLY, USING FULL-WAVE RECTIFICATION.

WHAT is the simplest B eliminator I could build, using full-wave rectification? What would the output be? Several intermediate voltages are desired.—J. M. P.

See Fig. 766. The power transformer has two windings. The one on top in the diagram is 5 volts for the filament of a 280 tube. If this winding is center-tapped, take the positive lead from this tap. If there is no center tap, use either side of the filament for positive. The difference is immaterial. The high voltage winding will largely govern the output voltage. The other important voltage factor is the total current drawn. The greater the current the less the voltage. If the high voltage winding is 600 volts across extreme terminals, with center tap, use this tap as negative and connect the extreme terminals to the rectifier plates. Thus you will get about 300 volts up to 100 ma. You should not draw more than 100 ma. from this tube anyway. The voltage divider may be 10,000 ohms, with suitable taps. The current through this resistance alone, not counting current drawn by receiver tubes, is only 3 ma. This is called the bleeder current. Each tap on the resistor should be bypassed with 2 mfd., preferably 4 mfd., except the tap, 2, if that is used for connecting to A minus to make 1 the bias for the last audio tube. Then C7 is 4 mfd. C1 is 2 mfd., C2 and C3 are 4 mfd. each. These three should be of the 600-volt AC working voltage rating.

* * *

I DESIRE to build a B supply of special pattern, so that the AC cable will plug into the wall, as usual, at one end, and at the other end will plug into a convenience outlet in the B supply, to serve the filament transformer and the power transformer. Is this all right?—A. B.

No. When you plug into the wall outlet you might easily leave the male plug exposed at the other end. Thus a connection between the exposed plug's prongs would short the 110-volt AC line. Your method is a violation of the Underwriters' specifications. You can build a male plug protruding from the B supply, and have a female plug to feed from the AC cable, but the standard method of permanently connecting the AC cable at the power supply, and using a male plug at the other end of the cable for connection to the wall outlet, is preferable.

* * *

HOW can the voltage of an A eliminator be controlled? I built an A supply, to work from direct current. The imput is 110 volts DC. The tube filaments of the receiver draw 2 amperes. But I get different filament voltage readings on a good voltmeter. Especially does the reading go off when I remove a tube. What can be done to correct this?—C. F. Z.

Fool-proof versatility of design in a DC eliminator has not reached the same state as in AC, probably because the market is not large enough to warrant the large expense of research work. Your supply is one where the voltage at the filaments depends on the current flowing through a limiting resistor. Evidently from your letter you get correct reading of voltage, that is, 5 volts for each of eight .25 ampere tubes, when the 2 amperes are flowing. But if you put in a tube assumed to draw .25 ampere, but actually drawing .5 ampere, or you remove one tube, you change the voltage, decreasing it one-eighth in one instance, increasing it one-eighth in the other. Hence you read 5⅛ or 4⅞. Under other conditions the change might be greater. You should not remove any tube from a set served by a DC A eliminator when the power is turned on, nor should you turn on the power unless all tubes are in circuit. A double circuit breaker would help cure the trouble, or a single circuit breaker at least would prevent application of a dangerously high filament voltage. This single relay would be in the circuit where all filament current flows and would shut off the power before tubes could be injured. Also, it may be advisable to have both sides of the line switched, so that you have to work two switches, or one double pole double throw switch, which amounts to the same thing, to turn the power on and off. Then no shorts can occur due to accidental grounding of an exposed side of the 110-volt line through the A supply.

* * *

I AM using an AC receiver, with 226 tubes as radio amplifiers and first audio. I wonder if I have biased them correctly? The current flowing through the three different biasing resistors seems to be the same, as measured by a good milliammeter, whether I connect the meter in the first or second radio or in the first audio stage. I simply open the resistor and insert the meter to complete the connection. This I assume is the correct way. I get a reading of 15.2 milliamperes for the first and second radio stages and the first audio stage, so these tubes, adding up the currents, must be drawing 45.6 milliamperes, which seems astonishing. I forgot to mention that each stage has a separate resistor for biasing. The first is 100 ohms, the second 200 ohms, the third 400 ohms, as I figured the progressive stages would require greater bias.—J.H.C.

You are heating the filaments of the three 226 tubes from a single winding of the filament transformer or power transformer. Therefore these filaments are in parallel, just as are the filaments of three battery type tubes when connected thus to the A battery. Hence the biasing resistors are in parallel, also. Instead of having separate biases you have the same bias for all three stages, and the resistance is equal to the reciprocal of the sum of the reciprocals, that is 1 divided by (1/100 plus 1/200 plus 1/400). This is 57 1/7 ohms. Omit all the resistors save the 100-ohm one. Leave grid returns at negative of the B supply, as at present. Since the filaments and biasing resistors are in parallel, the 15.2 milliamperes constitute the total plate currents of the three tubes united in the parallel circuit consisting of filaments, biasing resistance of 57 1/7 ohms, and transformer secondary. You must have connected the meter in the wrong place.

* * *

SOME audio amplifier designs that I have seen lately call for a large output tube like the 250, but ahead of it is only a modest tube, such as the 227 or perhaps a 224. This strikes me as strange, since the negative bias recommended for the 250 at a plate voltage of 450 volts is 83 volts. Particularly am I puzzled because the 224 does not call for a high negative bias, but only about 1 to 1.5 volts, even at 180 volts applied to the plate. How can distortion be avoided, if the preceding audio stage is so conservatively biased, whereas the last stage takes such a very large bias? The grid should swing positive, should it not, and distortion result?—A.T.C.

The bias on the 250 is 83 volts negative, let us say, therefore the bias on the grid of the preceding tube should be 83 divided by the product of the step-up of the audio coupler and the amplification factor of the preceding tube. Assume transformer coupling and a ratio of 1-to-3, primary to secondary. Also assume a 227 tube with 135 volts on the plate and a negative bias of 9 volts, required for that plate voltage. Is this enough? The mu of the 227 is 9 and the step-up ratio of the transformer is 3, so the bias on the 227 would not have to exceed 83 divided by 27, or about 3.5 volts. To take care of any possible difference due to computation of the root mean square voltage swing as distinguished from the DC voltage, multiply by 1.41 to establish a safety factor. That gives 4.935 volts. So 5 volts in practical use would be sufficient. Now consider the 224 tube. Suppose the plate voltage is 180, as recommended, and the bias 1.5 volts. The coupling device, let us suppose, is a resistance stage, for that does not increase the volume, as a coupling function, but merely utilizes the amplification factor of the tube. The factor of the 224 under operating conditions may be assumed to be 100. Lest that be considered optimistic, let us say the factor is 60. Then the negative bias on the 224 would have to be in excess of 83/60, or 1.39 volts. Multiply by 1.41 as a safety factor and you get 1.9599 volts. But as DC voltages alone have been considered the precaution of multiplying by 1.41 need not be taken, or, if you choose to take it, you can operate the tube at 2 volts negative bias. In audio amplification it is well to increase the bias a little beyond the usual recommendations for the 224, as these recommendations do not in general apply to audio circuits. If you will calculate the voltage drop in biasing resistors, by multiplying the biasing resistor's resistance by the current, you will probably find that the circuits provided ample bias for the tube preceding the final audio, even if the power tube was a 250, or two 250s in push-pull.

* * *

IS THERE any general criterion of quality? When one says a receiver has fine tone quality, how can one assign definite values, or rather, are there not definite values that can be assigned instead of the general descriptive phrase that has come to be meaningless?—A. K.

There is no general criterion, as the method of determination has not been standardized. What method is used will determine to some extent what the result will look like on a curve or other graph. The test at all hazards is bound to be a rather difficult one, and beyond the average experimenter's ability to apply. A standard input might be provided, with modulation, and the result measured as to quantitative response at various assigned audio frequencies, and as to qualitative results by oscillograph test. The nature of the reproducing device, if any is used, would have to be stated explicitly. The Institute of Radio Engineers is attempting to establish standards for this type of testing. Whether results obtained by public ears as compared with private meters will coincide is hard to say, since appreciation of tone quality seems to be a state of educated existence not possessed by all, or so many badly distorting receivers would not grace so many homes.

* * *

IS THERE any dispute as to who invented the vacuum tube? I understand that Fleming, the Englishman, gives Dr. De Forest no credit at all, and I never read or hear about Dr. DeForest giving much credit to Fleming, either. What did Edison have to do with it, if anything?—C.J.

The question as to who invented the vacuum tube is like the question as to who invented radio. No one person did. Edison discovered that when a positively charged body (which we now call the plate) was placed inside an evacuated bulb in which a filament was burning, that current would flow in this extra circuit from this body to the filament. The positive voltage was obtained in his test from the positive side of the filament. He found that when this extra body was made negative that no current flowed. Years later others explained the reason for this, when the theory of electrons had become fairly well established. Fleming constructed an evacuated glass envelope containing two elements, a plate and a filament, thus utilizing the phenonenon that Edison had discovered and which is now known as the Edison effect. Dr. DeForest's great contribution, and it was really a great one, was the third element or grid. This he placed between the filament and the plate, to control the flow of electrons. Fleming's valve was a rectifier only. DeForest made amplification possible by the use of a tube. DeForest's tube could be made to detect and also to oscillate, and the oscillation, enabling agitation of the ether by radio waves, made it practical to send out modulated radio frequency waves, without which we could have no broadcasting. From these facts you may decide for yourself who invented the thermionic valve or radio vacuum tube.

* * *

IN building a resistance-coupled amplifier, need I put a separate condenser at each stage from A— to B+, where the same B+ lead is used for all tubes in the amplifier, including detector?—C. L.

No. These condensers would be in parallel anyway. Use a large capacity in single construction, as C2 in Fig. 767. Use 8 mfd. or more. An electrolytic condenser of still larger capacity is suitable. The single condenser is more economical than a group of smaller capacities reaching the same total. You may use three resistance coupled stages instead of the two shown.

* * *

IN building an AC receiver, using screen grid tubes, type 224, a 227 as detector and as first audio, and 245s in push-pull as the last audio stage, I find that I do not get the correct voltages on the filaments. Do you think there is something the matter with the tubes? I am using a power transformer that has a 600-volt center-tapped secondary, and three filament windings: 2.5 volts for the push-pull stage, 2.5 volts for the heater type tubes and 5 volts for the filament of the 280 rectifier. It is a manufacturers' model that I picked up at a price on radio bargain-hunting expedition.—T. J. Y.

There is nothing the matter with the tubes, from your statement, but instead you are overworking the power transformer, at the filament voltages of the heater type tubes particularly. Check up carefully and determine whether you are getting the right voltage, 2.5 volts, on the 245s, for the chances are that such is really so. Then check up on the 224s and the 227, which supposedly are connected to one winding, and note whether these tubes alone show too low a reading. Feel the transformer after the receiver has been operating for an hour. Is it warm? It may even be hot if you are overloading it excessively. Power transformers are designed to carry a certain load, and although a 10 per cent. overload is not serious, a 20 or 30 per cent. or greater overload certainly is. If you will notice where you get the lower reading, and leave the meter in circuit when you take out a heater tube in the same transformr leg, probably you will read a higher voltage with the tube out. If so you have doubly verified the fact that you are overloading the transformer. There are few transformers on the market that will stand even 8 amperes on the 2.5 volt winding intended for heater tubes, so be sure to get a transformer that is rated by a reputable concern to stand the drain you intend to put on it—1.75 ampere for each 227 or 224 tube at 2.5 heater volts. Five such tubes would call for a winding rated at 8 amperes at least, preferably 9 amperes.

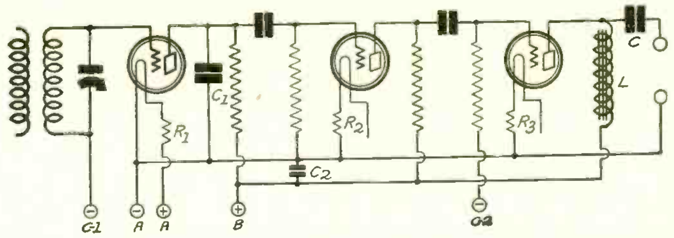


FIG. 767
A SINGLE CONDENSER, C2, OF SUITABLY LARGE CAPACITY, FROM A TO MAXIMUM B PLUS, IS AS EFFECTIVE AS A GROUP OF SMALLER CONDENSERS OF EQUAL TOTAL CAPACITY, AND COSTS LESS.

* * *

IS there any method of tuning that will increase the frequency range (not the distance range necessarily), without plug-in coils or alteration of capacity ratios?—P. M. B.

Yes. A coil may be constructed with fixed winding, a rotatable winding connected in series, the rotatable coil actuated by the same mechanism that turns a variable condenser that is connected electrically across the total winding. A conventional primary may be introduced for coupling. Thus the turning of the condenser gives the usual capacity variation, while the rotating coil, with its shaft connected physically to the condenser shaft, increases the fixed inductance at series-aiding position, does not affect it at all at neutral, and decreases the total inductance at series-opposing position. The variation is carried on steadily and automatically and the frequency range may be increased in a manner determined by the inductive and capacitative constants. This system was invented by Herman Bernard and after long experimentation has been reduced to practice. Circuits embodying this method will not be ready until August or September.

The Thrill Box

Tunes from 15 to 550 Meters and Gets DX

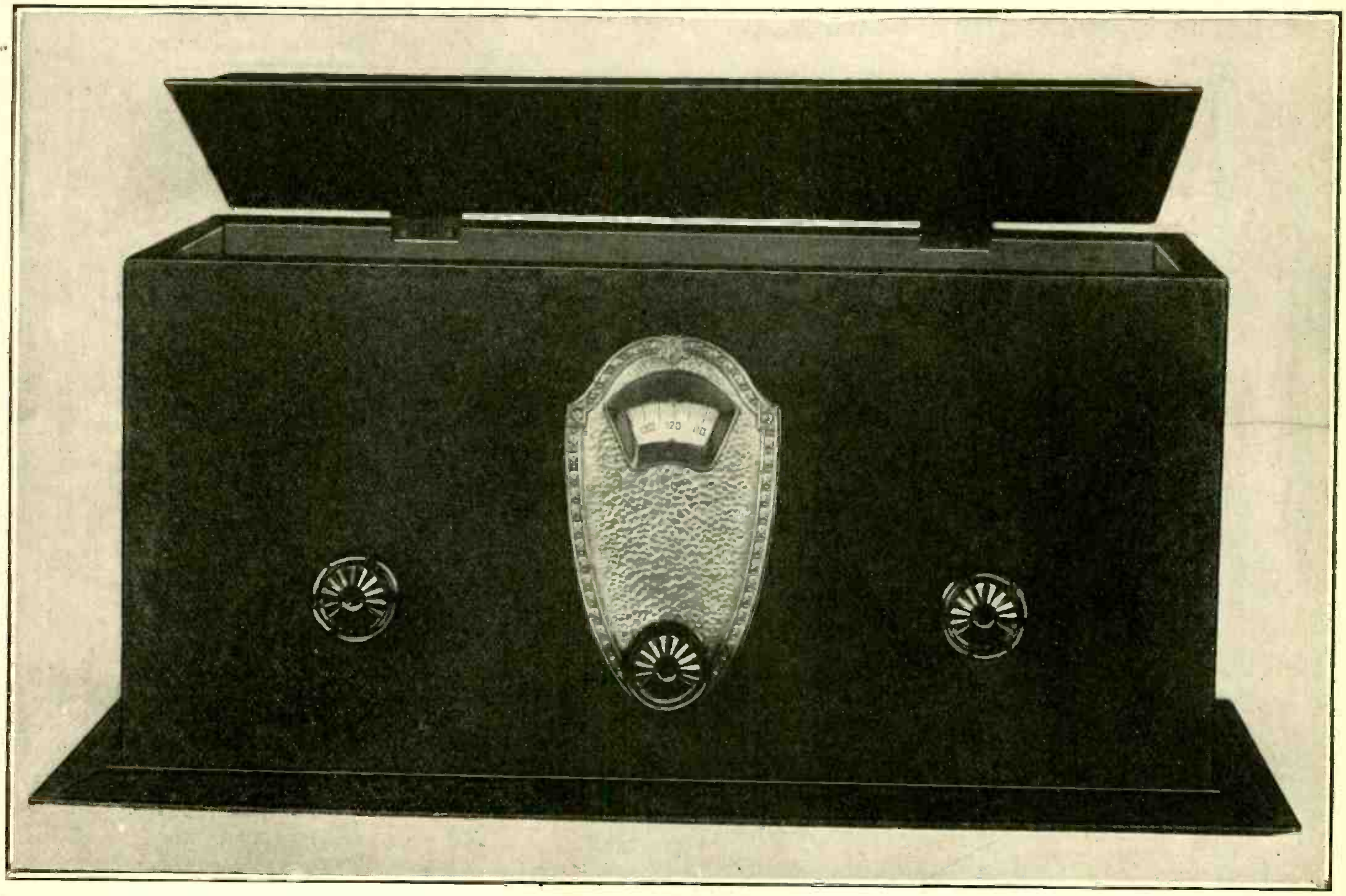


FIG. 2
FRONT VIEW OF THE NATIONAL THRILL BOX

[Part I of this article was published last week, issue of June 29th. Part II, the conclusion, follows.—EDITOR.]

LET us look at the circuit diagram of this short wave receiver called the Thrill Box, to discover how sensitivity and selectivity have been obtained.

In the antenna circuit is a choke coil L1, so designed as to offer a high impedance to any radio frequency signal in the wide band which the circuit is designed to cover, and that is from about 15 meters up to 550 meters, thus including the broadcast band.

The signal voltage developed across the coil L1 is impressed on the control grid of a 222 type screen grid tube. In the plate circuit of this tube is a coil system, L2, L3, L4, designed so as to make the screen grid tube work efficiently. This three-circuit tuner is of the plug-in type, and there is a set of six of these coils available for covering the entire band mentioned above.

Note the peculiar arrangement of the tuning condenser. It is a three-in-one affair. The object of this is to extend the range into the broadcast band when using the largest tuning coil in the set. The variable section C1 of this condenser is in two parts, one of eight plates and the other of 18 plates. The smaller section alone is used for tuning in the short waves. C2 is a fixed condenser permanently connected across the larger portion of C1. A tiny switch Sw2 is provided for cutting in or out the larger section of the condenser, and this switch is easily accessible.

The tickler L4 is fixed in position on the three circuit tuner, and the amount of regeneration is controlled with an adjustable resistance R3 connected in parallel with it. This operates both by shunting the feedback around the coil and by introducing damping into the tuned circuit. It is of a type which operates very smoothly so that there is no difficulty in controlling the regeneration even when the circuit is on the verge of oscillation.

A .001 mfd. condenser C6 is connected across the input to the audio amplifier to provide the necessary low impedance at radio frequencies.

Returning to the screen grid tube, we note a resistance R1 in the negative leg of the filament circuit. This has a value of 15 ohms and provides a bias of nearly 2 volts for the control grid. We also note two .5 mfd. condensers C4 and C5 on the output side of the tube. These serve to maintain the screen and plate voltages constant with respect to radio frequency fluctuations and to minimize feedback. Large values are used to make them effective.

The detector is a 200A type. This is used because it is an exceptionally sensitive detector when followed by a high impedance coupler. The grid leak resistance R4 is 6 megohms and the grid condenser is the usual .0025 mfd.

There is a common ballast resistor R2 of 1 ohm serving all the tubes in the set, placed in the negative lead to the battery. The drop in this resistor provides the bias on the grid of the first audio tube, which is a 240 high mu type tube.

The final tube is a 171A power tube, provided with 180 volts on the plate and a total grid bias of 46 volts. A 45-volt C battery is used and the extra volt comes from the drop in R2.

The audio coupler is a special development and is known as the National SW-4 Duo-Coupler: It contains two separate couplers in one case, each being of the resistor and auto-transformer type. The two couplers are not identical, but each is designed to work most efficiently with the tube which precedes. That is, the first section works best when preceded by a 200A detector and the second when preceded by a high mu tube.

A pilot light associated with the dial is connected across the filament circuit on the receiver side of switch SW1. This is not shown in the drawing, Fig. 1.

It will be observed that the loudspeaker is connected directly in the plate circuit of the power tube. This suggests that the speaker used should be of a type which has a transformer built in such as a dynamic. Of course any speaker can be used if a suitable filter be placed between it and the set. Even if no filter is used there is little harm done to the speaker because the grid bias is little higher than the usual. The circuit was operated for several hours with a cone speaker directly in the plate circuit without any ill effects.

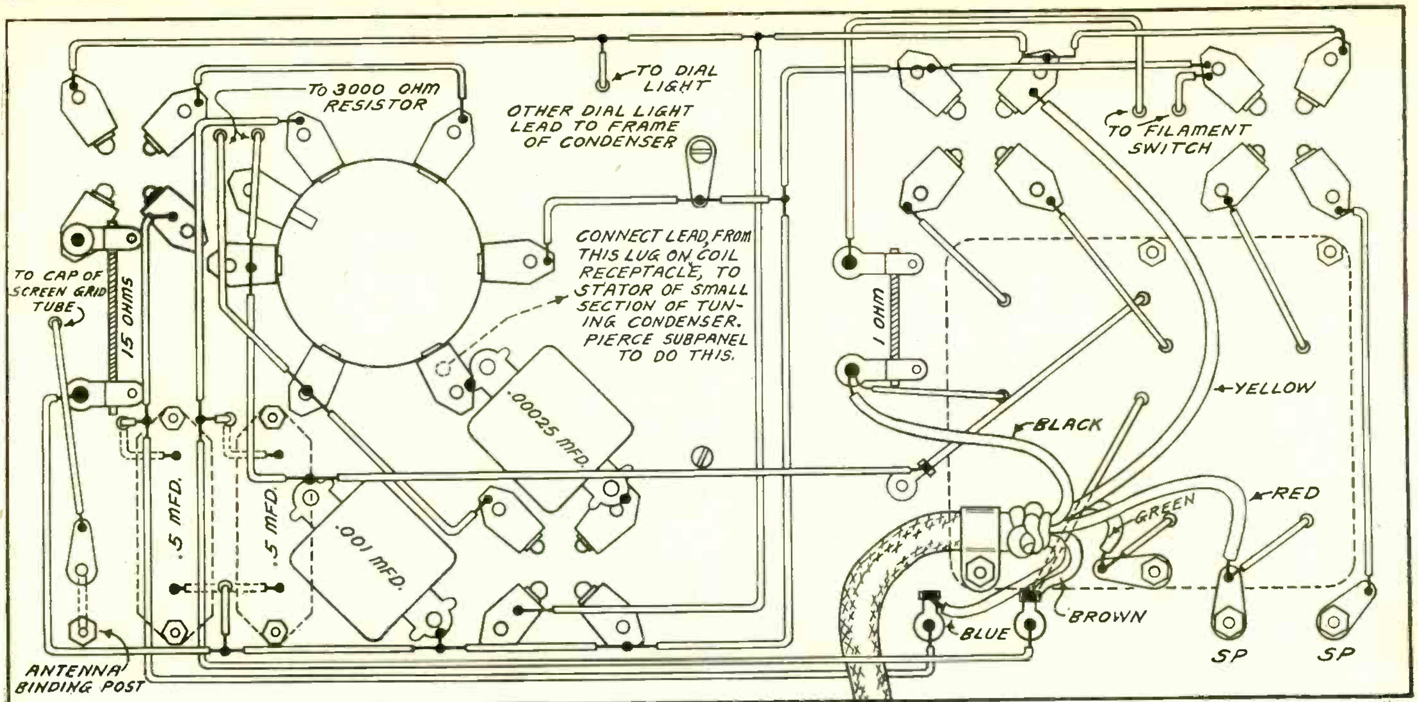
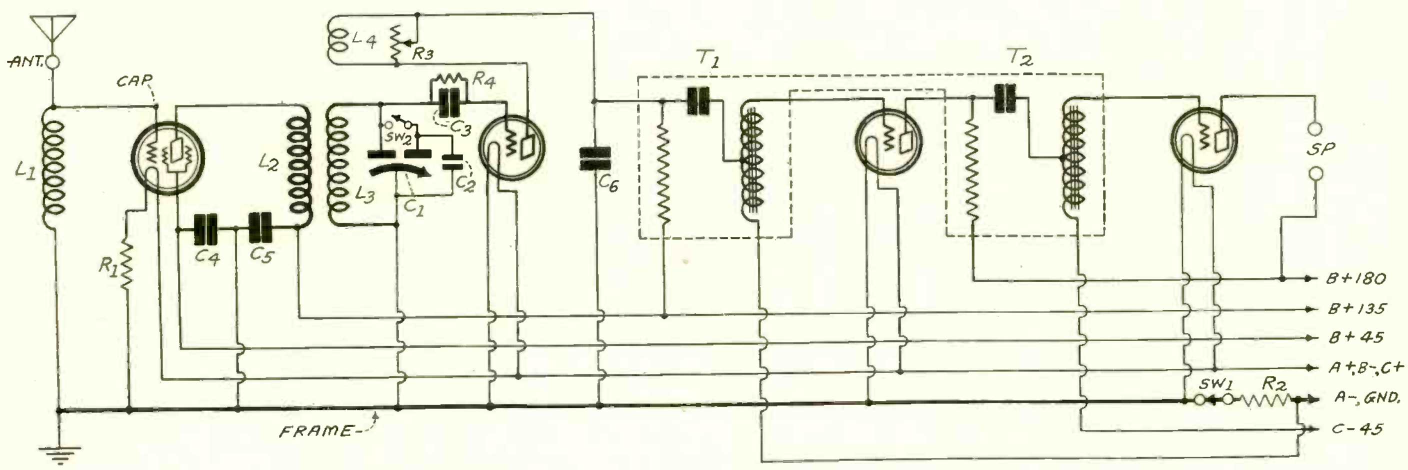


FIG. 3
PICTURE DIAGRAM OF THE WIRING OF THE SHORT WAVE RECEIVER



SCHEMATIC CIRCUIT DIAGRAM OF THE WIRING

If the greatest sensitivity of which this short wave receiver is capable is to be realized, the various voltages must be adjusted carefully. If a B supply unit is used it is not safe to rely on the marked voltages on that device, for they may be off more than 50 percent., due to the current being other than the anticipated value. And if the screen and plate voltages are as much off, the receiver will not bring in the stations it would if all the voltages were as specified. This matter of voltage adjustment cannot be emphasized too strongly.

Best results will be obtained if batteries are used for supplying the screen and plate voltages, because the circuit has been designed for voltages which batteries readily give, and because the internal resistance of batteries is low as compared with the internal resistance of B supply units. If a B supply unit having very good regulation is used and if the voltages initially are adjusted to those specified, the results will be practically the same as if fresh batteries are used, and better than if old batteries are employed.

Cures for Excess Oscillation

If the circuit breaks into oscillation abruptly before the volume is loud when tuning in on a moderately distant station, the voltage supply is undoubtedly the cause. Likewise if the circuit motorboats the B supply is a fault. Motorboating usually starts coincidently with oscillation in the RF circuit, but it may occur whether or not the RF circuit is oscillating. If this trouble should occur, don't blame the receiver, for it is not at fault. The plate votlage supply is unsuitable for the receiver.

B supplies containing electrolytic condensers of large capacity, such as the National Velvet B, usually give no trouble. Other units not containing such large filter capacities often are very troublesome. In most instances motorboating can be stopped in any receiver by adding more capacity to the filter. Not all the taps need be by-passed with additional condensers, but just where a condenser is most effective depends on the receiver as well as on the B supply. With a certain B supply of poor regulation the short wave receiver motorboated whenever the receiver broke into RF oscillation. This was remedied by connecting a 6 mfd. condenser across the 135-volt tap.

It should be remembered that motorboating at a low frequency in any receiver is an indication that the receiver is capable of good quality, especially on the low notes, and that it also indicates the B supply unit has poor regulation and is inadequately by-passed.

The wiring of the Thrill Box is illustrated on this page. A life-size blueprint, showing this wiring, is supplied with the parts. The Thrill Box also is obtainable in built-up form, and with such a model goes a sticker disclosing that that very set brought in a foreign station. At present such models are tested out particularly for 5SW, Chelmsford, England. The Abbott Laboratories, that do the wiring, affix the certificate of foreign reception.

LIST OF PARTS

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

PLAN IS AFOOT FOR A FEDERAL STATION GROUP

Washington.

The establishment of a station owned and operated by the Federal government is under consideration. The operation of stations by cities has given rise to the suggestion that the United States should have an official station. When the Senate reconvenes on August 19th Senator Nye (Rep.), North Dakota, will ask the Interstate Commerce Committee to consider a bill for such creation.

The station would be erected in Washington and would be under the direction of the Secretary of Commerce. It would be available for use in the dissemination of information by governmental agencies and, during political campaigns, would be open to speakers for any political party without charge.

Wants to Reach People

Senator Nye explained that it is his idea that the Government should not "give away the air" completely, as it has already parted with all other channels of communication and transportation. There should be some agency left through which the Government may reach the people without going through a privately controlled, and possibly monopoly controlled, channel, he said. While the bill provides for the establishment of only one broadcasting station to begin with it also gives the Secretary of Commerce authority to establish additional stations. Authorization is given also for the Secretary to make arrangements for chain broadcasting by linking up the Government station with privately owned stations.

Not to Buck Private Concerns

It is not his idea, the Senator said, to set up the Government as a commercial competitor of the private stations. There would be no sale of time for advertising or other purposes over the Government station, he said; it would be merely an agency for the dissemination of information.

N. Y. and Chicago Public Shows Next

The Radio World's Fair at Madison Square Garden, New York City, and the Chicago Radio Show are the next two national radio events. Unlike the recent Radio Manufacturers Association trade show, these radio expositions will be open to the public.

All exhibition space in Madison Square Garden, New York City, and the Coliseum, Chicago, has been taken by manufacturers of radio sets and apparatus. The New York exposition will be held September 23d to 28th, inclusive, and the Chicago show October 21st to 27th, inclusive.

A THOUGHT FOR THE WEEK

THE theme song has become so important a part of radio entertainment and is meeting with so tremendous a sale among sheet music buyers that music publishers are wondering how long the happy days will last. At any rate, they are grateful at last to radio for helping the talkies and soundies to give real life to their hitherto moribund shipping departments.

Station Licenses Are Extended

Washington.

Licenses of broadcasting and point-to-point and mobile radio stations were extended by the Federal Radio Commission.

The licenses of broadcasting stations, expiring on July 31, 1929, were extended until October 31st, subject to the observance of the customary commission regulations regarding their renewal. All existing licenses for stations other than broadcasting stations, as well as construction permits of all classes which expire at any time from June 15th to September 10th, were extended to October 1st, 1929.

RADIOPHONE FOR LEVIATHAN

Washington.

Establishment of a radiophone service between land and the United States Liner "Leviathan," by which persons anywhere in the United States may communicate directly with passengers while the vessel is on the high seas, or in dock, has been authorized by the Federal Radio Commission.

The Commission has allocated to the American Telephone and Telegraph Company, which will operate the service, four high frequency channels for its land station, located at Deal, N. J., and three frequencies for the "Leviathan." These channels will be employed in the "Two-way" telephone communication system to be operated by radio.

Engineers of the A. T. & T. said that every one of the 18,000,000 telephones in the United States will be available for direct connection with the "Leviathan," whether she is at her dock in New York, in mid-ocean, or at her destination at Southampton, England.

Hoover to Have Station at His Summer Camp

Washington.

A radio transmitting and receiving station, will be installed at President Hoover's camp on the Rapidan River, in Virginia, about 75 miles from Washington, for use in emergencies, the Department of the Navy announced.

Traffic with Washington from the camp normally will be handled over a special telephone line, which might be subject to interruption, in which cases the temporary wireless station will handle traffic direct to the Navy communications office. An Army field set, with a 20-watt transmitter, will be installed.

The station, to operate on 300 to 600 kilocycles, will use the call letters A6L.

BITTAN APPOINTED

The Van Horne Tube Corporation has appointed D. R. Bittan metropolitan sales representative, with offices at 14 Warren Street, New York City.

BOARD TO WORK ALL SUMMER

Washington.

The Federal Radio Commission will conduct its work all through the Summer, but will not resume public hearings until September 3d.

BOARD ORDERS STATIONS QUIT IN SOS CLASH

Washington.

Three new regulations governing procedure of broadcasting stations, and relating to the authority to subpoena witnesses for attendance at hearings were adopted by the Federal Radio Commission.

The first specifies that broadcasting stations must give absolute priority to radio communications or signals relating to ships or aircraft in distress and cease broadcasting during such times when interference may be caused with the reception of such distress signals. A table of distances to be observed in such cases is specified.

The second relates to the procedure governing issuance of subpoenas. It specifies that they may be issued, requiring attendance of witnesses from any place in the United States at any designated place of hearing, by any member of the Commission, its secretary, or by any examiner appointed by the Commission.

The third order specifies that all construction permits and licenses for relay broadcasting shall be issued under conditions requiring Commission authority before a station may rebroadcast programs. It orders that stations engaged in relay broadcasting shall report at least quarterly as to the results of the undertakings.

Americans to Fore at Melbourne Show

Washington.

Melbourne's fifth radio show was the most successful ever held in that Australian city, in the opinion of the committee and firms who took part in it recently, the United States Trade Commission at Melbourne, S. R. Peabody, informed the Department of Commerce. He said:

"The exposition of radio products was the largest of its kind yet held; there were over 65 stands, with about 36 exhibitors. Most prominent stands were the American, Netherland and Australian. Dealers reported sales most satisfactory at the exposition, and financial returns also were said to cover expenses. More than 60,000 persons are estimated to have visited the exhibition."

U. S. Experts to go to World Conference

Washington.

President Hoover approved the House joint resolution appropriating $27,500 for the expenses of the participation of the United States in the meeting of the International Technical Consulting Committee on Radio Communication to be held at The Hague, beginning September 19th.

Preparations are being made for the sending of a delegation, composed of radio experts from the various Government services. As the United States is in charge of matters relating to the International Radio Union until the next international Radio conference, to be held at Madrid in 1932, considerable responsibility rests upon the American delegation to The Hague conference.

WCFL INFERIOR, UNRULY, BOARD SAYS IN COURT

Washington.

Reasons for its denial of the application for full time, a cleared channel and 50,000 watts power, WCFL, operated by the Chicago Federation of Labor, were filed with the Court of Appeals of the District of Columbia by the Federal Radio Commission.

The statement, drafted by Paul D. P. Spearman, of Commission counsel was filed in reply to the Federation's petition appealing from the Commission's decision denying the request. The station sought the 770-kilocycle channel, now assigned to WBBM, Chicago, and KFAB, Lincoln, Nebr., as the first step in a national chain of broadcasting stations interconnected by short waves for rebroadcasting.

Consequences Listed

The Commission's statement set forth that the granting of the application would result "in unjust and unwarranted discrimination against the rights of one State and in favor of another; that it would result in an inequitable distribution of the transmitting facilities between the States within the Fourth Zone, in violation of the 1928 amendment to the radio act of 1927; that stations WBBM and KFAB were and are rendering a greater and higher class public service than Station WCFL; that Station WCFL has broadcast programs which are against public interest; that Station WCFL has operated in violation of law and in disregard of the reasonable regulations of this Commission; that Station WCFL has used only a very small portion of time it has at its disposal for broadcasting labor programs; that its record does not justify a greater amount of time or power for broadcasting such programs."

Patent Medicine Ads

The Commission set forth that to accede to WCFL's request would mean closing KLAB, Nebraska, which is indicated as a better type station than WCFL. The Board's counsel said of WCFL:

"This station has given as much, or more, time to the advertising of medicine of questionable value than it has to the furthering of the interests of organized labor. This station broadcast sponsored programs and advertised the sale of securities, without announcing or divulging the sponsor of such programs in violation of Section 19 of the radio act of 1927."

Hoover Hears Labor

Washington.

President Hoover's influence to obtain an exclusive wavelength for WCFL, Chicago, was sought by William Green, president of the American Federation of Labor, and John H. Walker, president of the Illinois Federation of Labor, who visited the White House.

Mr. Green said that the American Federation of Labor was interested in the matter because the Federation regards the Chicago station as the one labor station where an effort is being made to obtain an exclusive wavelength. At present, he said, the Chicago station is obliged to divide time with a station at Seattle, Wash. The Chicago station may now use the wavelength each day until sundown, a time, Mr. Green said, when laboring men are at work.

Literature Wanted

THE names and addresses of readers of RADIO WORLD who desire literature on parts and sets from radio manufacturers, jobbers, dealers and mail order houses are published in RADIO WORLD on request of the reader. The blank at bottom may be used, or a post card or letter will do instead.

RADIO WORLD,
145 West 45th St., N. Y. City.
I desire to receive radio literature.

Name ....

Address ....

City or town ....

State ....

N. H. Chown, 544 I. W. Hellman Bldg., Los Angeles, Calif.
James Coughlan, 63 Elm Point Ave., Great Neck, L. I.
Chas. V. Kase, 511 Washington Ave., Belleville, N. J.
Lester Winterer, P. O. Box 28, Hawthorne, N. Y.
Fred Huykman, 363 No. 8th St., Paterson, N. J.
J. W. Williams, Box 487, Texon, Tex.
William Wallace, Box 431, Wallaceburg, Ont., Can.
W. C. Bond, Meaford, Ont., Can.
E. L. Rudebock, 12 Brighton Ave., East Orange, N. J.
Albert Wells, 11 Fifth St., Waterford, N. Y.
R. E. Stover, 652 Englewood Ave., Detroit, Mich.
Everett Dare, 1813 So. Carroll St., South Bend, Ind.
J. W. Summers, 1061 62nd St., Oakland, Calif.
Wm. Koury, 4061 Grand Ave., Detroit, Mich.
Robert Gralia, 1305 Christian St., Philadelphia, Pa.
Walter F. Bozarth, Williamsburg, Va.
P. B. Sawyer, 332 Owen St., Portsmouth, Va.
Peter A. Lazarnick, 170 Portage Ave., Winnipeg, Can.
F. G. Taylor, Box 76, Union City, Tenn.
E. C. Grenshaw, 323 S. 6th St., Union City, Tenn.
R. T. Carr, Pine Bluff, Ark.
E. L. Gould, P. O. Box 1811, Atlanta, Ga.
N. L. Streator, 205 Soquel Ave., Santa Cruz, Calif.
Joe Pristash, 839 Clarence Ct., S. W., Cleveland, Ohio.
M. F. Michael, 42 Canedy St., Fall River, Mass.
Francis Livingston, 1594 Humber St., Memphis, Tenn.
Robert Boyle, P. O. Box 501, Waterford, N. Y.
Edwin N. Sims, 51 Sixth Ave., Verdun, P. Q., Can.
Frank J. Biernat, 13101 Carondolet Ave., Chicago, Ill.
C. Fred Vollmer, P. O. Box 175, Bucyrus, Ohio.
John W. Coates, Jr., 69 N. Main St., Miamisburg, Ohio.
F. Gonzales, 1722 E. 119th St., Los Angeles, Calif.
William S. Hays, 1825 Druid Hill Ave., Baltimore, Md.
Mr. Otto E. Elwert, 481 N. Pasadena Ave., Pasadena, Calif.
Everett Hanaan, 518 So. Glasgow Dr., Dallas, Texas.
A. J. Jarosik, 4171A Shaw Ave., St. Louis, Mo.
H. W. Boulter, 209 Academy St., Hampton, Va.
R. M. Currier, 418 N. W. 5th St., Abilene, Kans.
W. A. Blazier, McCook, Nebr.
Rhodes Boyken, 311 Farley Bldg., Birmingham, Ala.
Otis Jones, 215 13th St., Knoxville, Tenn.
Myron Gordon, 524 No. Main St., Port Chester, N. Y.
Cameron Mill, Carrollton, Ky.
L. K. Nieman, 1503 High St., Beatrice, Nebr.
W. A. Gladhill, 1600 Champigny St., Montreal, Que., Can.
John McKiever, 489 Hudson Ave., West New York, N. Y.
E. R. Wentz, 399 Woodrow, Beaumont, Texas.
Ulysses L. Burroughs, 3640 Caldwell St., Omaha, Nebr.
H. O. Stephani, 26 Dickerman St., New Haven, Conn.
Leo G. Leish, 10 Academy St., St. Catharines, Ont., Can.
P. A. Roberts, 11 Florence St., Woodforss, Maine.
Stephen M. Miles, 186 Chittenden St., Akron, Ohio.
W. A. Heckman, c/o W. N. Kratzer Co., Arsenal Sta., Pittsburgh, Pa.
Oscar Rathsam, 658 W. 43rd St., Chicago, Ill.
A. F. Day, Sergent, Ky.
B. J. Barnhart, Apt. 4, 1107 Charles St., McKees Rocks, Pa.
Robt. J. Orr, 3503A Nat. Bridge, St. Louis, Mo.
G. T. C. Chatto, Box 34, Pine Falls, Man., Can.

TALKIE GROUP BUYS INTEREST IN RADIO CHAIN

Half interest in the Columbia Broadcasting System has been purchased by Paramount-Famous-Lasky Corporation, according to a statement by W. S. Paley, president of the Columbia System. Commenting on the transaction he said:

"Developments in both the aural and visual entertainment fields, not only scientifically but in production, distribution and merchandising problems, have been drawing a closer and closer parallel for the past year or eighteen months until they have reached such mutuality as to be almost common ground. Scientific developments have served to introduce sound into motion pictures and a reasonable prospect for vision into broadcasting.

"We hear a lot about television but not many know a great deal about it. One thing is certain, however. It is coming. Whether it be in two years or five, it is sure to come. And with this amalgamation of interest we are prepared for it. Columbia can lean on Paramount for the new problems entailing actual station presentations in full costume, to be broadcast, and Paramount knows it has an outlet in presenting its television features to the public."

Programs Over Wire Delight New Zealand

Washington.

New Zealand promises to equip the entire country with installations for getting programs over telephone wires, Charles F. Kunkel, Assistant U. S. Trade Commissioner at Wellington, reported to the Department of Commerce. The said:

"The carrier system has been so well received by the public wherever it has been installed so far that its extension to all suitable lines in the entire country is indicated by plans. Carrier equipment requires adjustment for the particular section of the line to be used as conditions vary infinitely. Trial alone can determine the adjustments necessary."

NEW RESISTANCE FOLDER

A new folder on resistance in radio, ranging from an adjustable grid-leak, of 1/10 to 10 megohms to a super-power variable resistor of 250 watt rating, has just been issued by the Clarostat Manufacturing Company, Inc., 291 North Sixth Street, Brooklyn, N. Y. A copy will be sent to any interested person upon request. Mention RADIO WORLD.

CORTLANDT PANEL ENLARGES

Cortlandt Panel Engraving Company, 165 Greenwich Street, New York City, has expanded again. This concern furnishes panels of all kinds and for all standard circuits. It also drills and engraves to order, any size or quantity. The new facilities also take care of the making of aluminum shields and cans of all kinds.

LERNER WITH LANDAY

Meyer Lerner is in charge of service and installation at Landay Brothers store on Cortlandt Street, N. Y. City. Harry H. Moore is store manager.

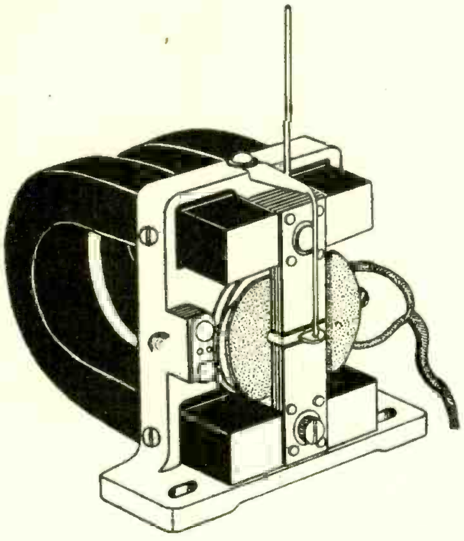
Quick Action Classified Ads

Radio World's Speedy Medium for Enterprise and Sales

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

New Junior Model

POLO UNIT $4



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

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

HAVE AN EXPERT PUT YOUR SET IN SHAPE!

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

COMPLETE PARTS for the New, Highly Selective

SCREEN GRID DIAMOND

(Four-Tube Battery Model)

Exactly as Specified by Herman Bernard

$29.00 Net

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

KELLY TUBES

Prescribed for the

Screen Grid Diamond

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

KELLY TUBE COMPANY
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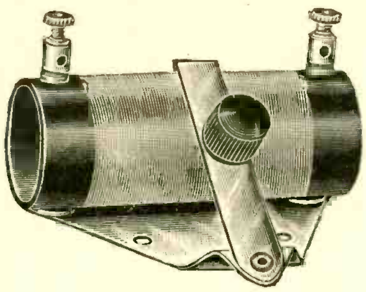

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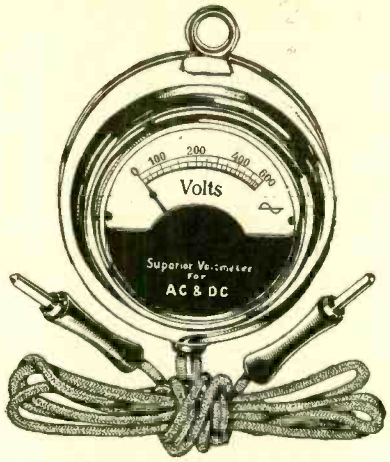

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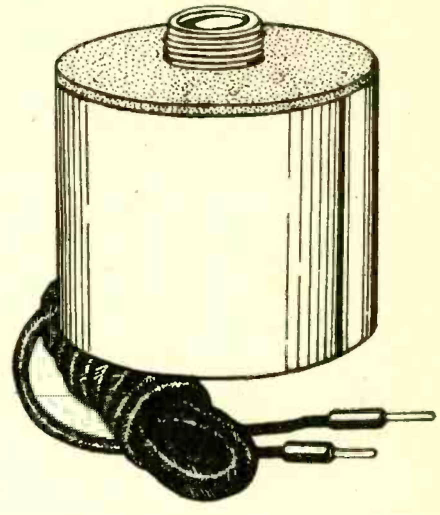

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