Automatic Volume Control without an Extra Tube
Accurate Tuning Condensers and Accessories

**EQUALIZER**

**SINGLE .00035**

**THREE-GANG SCOVILL .0005 MFD.**

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**RIGID AND FLEXIBLE LINKS**

For coupling two ½ inch diameter shafts, use two cat. transformers. Each cat. transformer should be of 1/4 in. diameter and have a 1/3 in. clearance. The shafts should be placed in the transformer so that the clearance is equal on both sides of the transformer. The transformer should be mounted in such a way that it can be adjusted to suit the clearance between the shafts.

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**EXTENSION SHAFTS, TWO SIZES**

Here is a handy set of extension shafts that are available in two sizes: ½ inch diameter and 1 inch diameter. Each shaft is made of steel and is 10 inches long. These shafts can be used to extend the length of condenser shafts to accommodate larger condensers.

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**.00035 TWO-GANG**

A two-gang condenser, like the single type, is supplied with a number of sections on one shaft. In this case, the sections are not equally spaced. The sections are eight in number and are spaced at equal intervals. Each section is provided with a separate set of trimmers.

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**FOUR-GANG .00035 MFD. WITH TRIMMERS BUILT IN**

Four-gang .00035 mfd. condensers are built to provide a wider range of tuning than single or two-gang condensers. Each section is provided with a separate set of trimmers.

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**SHORT WAVES**

Tuning condensers for short waves are especially suitable for filter circuits and short-wave adapters. These condensers are .0005 mfd. (120 nanofarads) in capacity. They are suitable for use with any plug-in set. Order Cat. WB-8-150 @ $1.50. To provide regeneration from plate to grid return, for circuits calling for this, use .0005 mfd. cat. SB-8-250 @ $1.50.

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**One of the newest and best condensers ever made is this three-gang unit, each section of full .0005 mfd. capacity, with a modified straight frequency characteristic. The net weight of this condenser is ¾ lb. Cat. SC-36-1-3 @ $4.50.**

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**H.E.B. is a three-gang condenser of most superior design and workmanship, with an accuracy of at least 99% per cent at any setting — rugged beyond anything you've ever seen. Built by a firm that has pioneered in the fullest extent against any discoloration in the metal. This condenser is the best on the market. It is ¼ inch diameter and extends at front and back, so two of these three-gangs may be used with a single drum that has three center controls. For use of this condenser with any dial of ¼ inch diameter bore, use Cat. XB-5, one for each three-gang. Tension adjustments shown at right, either side of shaft.**

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**OVERALL LENGTH 5 3/4 INCHES.**

**QUANTITY RADIO GOODS CO., 45 West 45th St., New York, N. Y. (Just East of Broadway).**

**Enrolled 25% for merchandise which is not designated postpaid.**

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**SALIENT FEATURES OF THE CONDENSER**

[1] — Three equal sections of full mfd. capacity each.
[3] — Horned semi-frame with rigid frame assembly and separate sections. These assemblies include: miniature coupling between sections.
[4] — Three bearings mounted on the two slugs, between the main shaft and the rear bearings, to ensure uniform contact at all times.
[5] — Both the upper and lower bearing plates are accurately centered between the two bearings.
[6] — Two sets of trimmers are provided for independent adjustment of the trimmers in each section.

**DRUM DIAL**

A suitable drum dial of direct drive type is obtainable for ¾ inch condenser shafts, and will accommodate any over-all length of 5 inches. A return, furnished with each dial.

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**The following manufacturers are advertised:**

- Cat. XH-4 @ 10r
- Cat. K3-2 @ $5c
- Cat. XH-4 @ 10c
- Cat. XH-3 @ 10c
- Cat. KHD-3 @ $1.70
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A New Volume Leveller

By Thomas P. Combing

A SYSTEM of automatic volume control that does not require an extra tube may be adopted in any AC receiver by increasing the negative bias on the radio amplifiers, and by using negative bias or power detection.

While the control is not absolute by this system, neither is it absolute by the extra-tube method. All automatic volume control is a matter of relative uniformity. A certain predetermined volume is established. This never will be exceeded, but it may not be reached by all stations; indeed can not be. The very weak stations are not affected by the control, although the strong ones are, so there is a sort of levelling out, but the weak ones are not brought up to the volume of the strong ones. Not at all.

This reduction in the disparity of the volume is desirable, because tuning through the scale one does not suffer the ear-blasts that prevail when the control is not present. Also, some attenuation is made for that characteristic of tuned radio frequency amplification whereby the amplification is higher at the higher frequencies. Overload of detector and of the audio channel is another item reduced by the control method.

Raising the negative bias of the radio amplifiers above the

(Continued on next page)

LIST OF PARTS

Two .0005 mfd. Hammarlund straight frequency line condensers.
Two unshielded screen grid coils for .0005 mfd. (Screen Grid Coil Co., Cat. 49-70).
Four screen grid coils for .00035 mfd., shielding optional. (Screen Grid Coil Co., Cat. 49-80).
Four Hammarlund -equipment- 100 mµfd.
Seven .00035 mfd. fixed condensers.
One .0015 mfd. fixed condenser.
Three three-in-one fixed condensers, 0.1 mfd (nine capacities).
Two butterfly parallel switches.
One 5,000 ohm biasing resistor with mounting.
One 1.0 meg. grid leak with mounting.
One .00035 mfd. fixed condenser.
Three 700 ohm Electro!36 biasing resistors.
One Electro!3900 ohm flexible biasing resistor.
One Lynch pigtail 20,000 ohm metallized resistor (0.02 meg.).

Four binding posts.
One 50 millihenry RF choke.
One Polo 180-volt power transformer. (Cat. 140 PT).
One voltage divider, 25 watts, tapped one-third way up.
One Polo B choke coil. (Cat. 245-CH).
One 1 mfd. Flechtstein 245 condenser.
Two 8 mfd. electrolytic condensers.
Two 1.0 mfd. bypass condensers, 230 volts DC rating.
One AC toggle switch.
One AC cable and plug.
One National modernistic drum dial, type H, with 2½-volt pilot lamp and socket.
Five UY (five-prong) tube sockets and one UX (four-prong) tube socket.
One 7x21-inch front panel.
One chassis, 19x20 inches.
Six 224 tubes and one 280 tube.

[FIG. 1. AUTOMATIC VOLUME CONTROL BY HIGH-BIASED RADIO FREQUENCY AMPLIFIERS MAY BE INTRODUCED IN ANY AC RECEIVER. THE DESIGN SHOWN IS THAT OF A SUPERHETERODYNE TUNER. THE INTERMEDIATE AMPLIFIER DOES NOT REQUIRE SHIELDING IF THE COILS ARE FOUR AND ONE-HALF INCHES APART OR MORE, CENTER TO CENTER.]

[Diagram showing circuit design and parts list]
(Continued from preceding page)

prevailing values is accomplished by using higher values of resistors for biasing. For instance, with the 224 tubes in the intermediate channel of the Superheterodyne, for 0.005 mfd. bias, it was necessary to use 300 ohms for biasing, affording 1.5 volts negative bias. However, here 700 ohms are shown instead, so that the bias is around 3.5 volts negative.

Determining the bias, is to make the milliammeter needle stand still, so far as possible. But with automatic volume control we are dealing with the carrier intensity, and this amplitude is what we are after. The signal modulation itself may have no effect on the control system, otherwise loud noise would be reduced in volume, soft notes raised, and the tendency would be to have reproduction of all audio at the same volume for each note or word. That is not wanted at all.

Make Your Own Tests

When the bias is increased, the direction of needle deflection is changed. The modulation is positive, or upward. So, without accepting any particular value of resistance, you can make the test yourself. Using a single stage as your guide, tune it in. If at resonance the needle shows a lower reading than the bias until at resonance the needle shows a higher reading. This can be done with a milliammeter in each individual plate circuit, at a time, or a set tester plugged into one socket at a time.

In this connection it is helpful to change over to negative bias detection, so that now we may use leak-off detectors. The reason is that leak-condenser detection modulates downward, and the other type upward, and you want to maintain the latter condition all the more to assist the carrier.

So, in the Superheterodyne, even the modulator, or so-called "first detector," is of the negative bias type. A resistance value of 1,500 to 5,000 ohms will provide modulation in this direction. However, the second detector, the last in the chain, the biasing resistor should be 20,000 ohms, for a coil in the plate circuit, or 50,000 ohms for a resistor plate load.

That reason is, any automatic volume control that attends the performance of the circuit is that the increased amplitude of the carrier increases the bias, which increases the plate current, which increases the volume. So, too, the first detector and the detector undergo increase in plate current, increase in bias, and reduction from what the volume would be otherwise. The action is instantaneous. The effect is blunted, decreased, increased increased increasing the plate current, which would indicate decrease in plate resistance. It is the tendency to increase in current that causes increase in bias, and consequent decrease in current from what it would be were the bias lower initially.

Oscillator Circuit Independent

In the oscillator circuit the usual value of 300 ohms, for 1.5 volts, is used, since the carrier amplitude has no effect on the oscillator, which is independent circuit.

The intermediate frequency amplifier consists of the three tubes to the left of the final detector. The same general types of coils, or indutances, may be used here. The primaries are assumed to have a high inductance, as they have in coils intended for use with screen grid tubes. In the present circuit the oscillator is tuned is a turned-about fashion, since the plate circuits are tuned, while the erstwhile primary is used as the pickup coil in the succeeding grid circuit.

What the intermediate frequency shall be may be determined by the experimenter himself. By using .0035 mfd. as the fixed capacity, and an equalizing condenser of .0001 mfd. (100 mfd.) and coils designed for .0035 mfd. tuning, radio frequency circuits, an intermediate frequency of 500 kc may be employed, or some other frequency close to that. It is not important that the frequency be just 500 kc. It may be 490 or 510 with just as good results.

The frequencies in the broadcast band must be avoided, for reasons of interference and failure of adequate tuning throughout the range of spectrum, but there is no objection obtaining a frequency higher than the highest in the broadcast band. Since 1,500 kc is the highest frequency (200 meters lowest wavelength), a frequency for the modulator is 500 kc (150 meters wavelength), or somewhere between. Probably a lower frequency is easier of attainment with the coils at hand, so a frequency of intermediate frequency of 1,800 kc. Again there is no particular need of a certain frequency being chosen, nor even that you know exactly what the frequency is.

Use of Higher Frequency

To use the higher intermediate frequency, around 1,800 kc, simply omit the .00035 mfd. fixed condenser, and rely on the equalizers to resonate the circuits.

The modulator tuner is a standard antenna coil for the capacity of tuning condenser used, which in this instance was 0.0005 mfd. straight frequency line. If the modulator and oscillator tuning is to be accomplished with single control, then straight frequency line condensers are not only desirable but imperative.

The oscillator coil may be just like the modulator coil, to start with, or the .0005 mfd. fixed condenser, and the higher frequency setting of the oscillator, of the two available, since volume is greater.

Working only the modulator, with earphones in its plate circuit, tune in a local station. Of course the tuning will be deucedly broad, but you will be able to determine, at least, the approximate position of maximum response. Note the setting of the modulator condenser. Since it is assumed or two separate condensers united by virtue of connection to a drum dial, the oscillator condenser's displacement is exactly the same as that of one, of determining condenser.

Now the only work remaining to make the circuits affect the intermediate channel is to remove turns from the secondary of the transformer until the oscillator comes in line of the setting of the modulator condenser (1,800 kc). The coupling is effected by means of a capacity-resistor series circuit from grid to grid. Values of .0001 mfd. and 1 meg., .00025 mfd. and 1 meg. the like may be used. The smaller the capacity, and the higher the resistance, the coupling will have the coupling loose. Also, this method of coupling, used in a Western Electric laboratory Superheterodyne seven years ago, retains the simplicity of the tuned circuits, whereas some other methods of coupling under certain conditions tend to make the two tuned circuits pull together, and act as one, resounding to a single frequency, under which circumstances there would be no reception.

Explaining the Unexplained

The butterfly switch, the volume control and the three circles at the extremities of the inductances in the mixing circuit have not been explained, so here are the words about them.

The switch is simply a device that looks something like the pictorial representation. There are really four leaf-like blades, and each blade contacts a tap on the switch, so that when three condensers are connected to three respective taps, and the switch is turned to engage first one tap, then two taps, then all three or four. The capacitors are connected in parallel and add up. That is an economical way of getting the desired total high capacity by using the sum of the smaller capacities, instead of trying to provide a single large final capacity, in addition to smaller ones.

The same system of switching is used for the volume control. It consists of cutting in capacities in parallel so as to side-track part of the signal. As the reducing volume capacity cut in, the sum of the respective capacities, is .0022 mfd. This is large enough to reduce the volume by about three-fourths. If it is desired to have a softer performance or, all that need be done is to use a larger capacity in the position occupied by the .0015 mfd. condenser.

Leaps-and-Bounds Method

This method of volume control is not gradual but works by leaps and bounds. There are three different steps of volume reduction. That makes a total of four volume levels, including full volume. When the switch is off, that is, the fourth wing of the butterfly is resting on the blank tap, full volume prevails. There is a slight detuning effect when this volume control is used. This offers no disadvantages, since detuning in itself is not a bad thing to reduce distortion, although this detuning is slight it works in the right direction.

The six rings at terminal positions of the coil in the grid circuit of the modulator, and the coils in the grid and plate circuits of the oscillator, represent places where there may be break-out connections to plug-in receptacles, so that short-wave coils may be inserted in circuit. Hence, a single-winding coil in one instance and a double-winding coil in the other would be used.

Not only is the avenue open for the use of plug-in short-wave coils, whereby parallel connection of inductances would become possible, but it is also due to the use of .0005 mfd. straight frequency line tuning condensers, to arrange six coils, three on each side of a tuning condenser, and by a switch cut in the form of a pair of shorting contacts, contact one, and thus cover from 15 to 140 meters and from 190 to 560 meters, merely by turning the switch.

This idea is being tried now in Canada, and if it proves to be satisfactory in all particulars, more data about it will be printed, including constructional details.

The choice of the intermediate frequency has been discussed, but it should be pointed out that if ship interference results on 300 kc (600 meters), turn down the trimmers, and work on 450 kc or thereabouts.
THE winding of coils by the experimenter for short-wave reception sometimes presents a problem, or several problems. Different inductances are to be used, since different frequency bands are to be covered; you hope to be sure that there is adequate overlap, otherwise an important part of the frequency spectrum may be skipped.

The circuit shown in Fig. 1 is a standard one. It is offered in battery-operated form, since 20A tubes may be used, or even 199s, either with only 90 volts of B battery, and some dry cells to heat the filament. The circuit may be built and left thus, not only acting as a short-wave receiver itself, but also as a suitable piece of coil testing and guiding equipment.

Making the First Coil

A good start may be made by taking whatever diameter you intend to use, approximately around 3 inches, and putting on two or three turns for the tuned secondary of the smallest coil. The primary that goes to antenna and ground need cause no concern. It may be from two turns to six turns in either instance. With six turns the signal strength will be greater. Don’t worry about the stepdown ratio. While the ratio is downward, the sensitivity is upward, due to closer coupling.

Now you will find a secondary for the detector coil, of the same number of turns as the other secondary had. The plate winding in inductive relationship to the grid coil, has one turn more than the secondary. The primary may have three turns. If the detector will not oscillate, reverse the connections to the tickler coil, so that the lead that went to plate goes to the stator of the condenser C3 instead. C3 may be 0.00025 mfd. while C1 and C2 may be whatever you have handy, say .00014 mfd., .00005 mfd. C4, .00005 mfd., .00005 mfd. or .00005 mfd., but of course both condensers C1 and C2 must be alike. It is also necessary that each circuit be separately tuned, not gauged, for the coil construction assistance. Besides, the grid returns are different.

Making the Next Largest Coils

When you get the circuit working properly on the smallest coils, as described, await your opportunity to tune in a station, whether it be code or program, that requires engagement of nearly all the condenser capacity, say, a dial setting of 95 to 98 on the condenser setting dial, if there is any disparity.

Now you have a frequency equal to the highest frequency that the next largest coil is to tune to, therefore wind enough secondary turns so that with the smallest antenna coil in circuit, as formerly, the detector coil will afford resonance for the dial setting of from 3 to 5. If the condenser changes capacity hardly at all in this region, use 7 or 9 as your dial reading guide. The fielder for this coil may have one turn for many turns as the secondary, and the primary five to seven turns.

Covering the Broadcast Band

Repeat the process for the third coil. If you desire to get into the broadcast band, repeat the process for a fourth coil. If you are using a very small capacity, .00044 mfd. for instance, you will need five or six coils for each tuned circuit.

Right or Wrong?

QUESTIONS

(1)—The higher the mutual conductance of a tube the better that tube is as a vacuum tube voltmeter whether it is used to measure AC or DC voltages.

(2)—The amplitude of the sound track on a film of the variable amplitude type varies inversely as the frequency of the sound recorded when sounds of different frequencies but equal intensities are compared.

(3)—The mutual conductance of a tube does not vary with the grid bias. For example, it is the same when it is measured at 5 and 6 volts as it is when it is measured at zero and 1 volt.

(4)—The pressure of a phonograph needle on a record is of the order of a few ounces per square inch.

(5)—An electromotive force is the same as a difference of potential or voltage drop in a circuit.

(6)—The only difference between a galvanometer and a current or voltage meter is that the galvanometer is more sensitive than either of these types of instruments.

(7)—If a power transformer has been designed to work on 25 cycles it can be used also on higher commercial frequencies.

(8)—There is no need of shielding radio frequency stages when the tubes are of the screen grid type because the capacity between the plate and the control grid is so low that no appreciable feedback can take place.

ANSWERS

(1)—Right. The value of a tube as a vacuum tube voltmeter, whether it be used as a direct reading instrument or a balance indicator, on AC or DC, is determined by the amount of plate current change for a given change in the grid voltage, and the greater this ratio between the plate current and grid voltage changes, the more sensitive is the meter. This ratio is nothing but the mutual conductance of the tube.

(2)—Wrong. For equal intensities, the amplitude of the sound track remains constant for all frequencies.

(3)—Wrong. It decreases as the bias voltage increases and if the bias is high enough the mutual conductance is zero, for there is no plate current and hence no change in the current. When the mutual conductance is measured as in (1) the average value over the voltage change is obtained. To get the mutual conductance at a point the voltage should be changed by a very small amount in either direction of the voltage at the point in question, and then the plate current change should be divided by the voltage change.

(4)—Wrong. It is of the order of 13 tons to the square inch.

(5)—Wrong. The electromotive force is numerically equal to the total voltage drop in the circuit and both are measured in volts. An electromotive force drives a current through a circuit, but a mutual difference is the product of a current and an impedance.

(6)—Wrong. While it is true that a galvanometer is generally more sensitive, the greater sensitivity is the distinguishing feature. A galvanometer is not calibrated in either amperes or volts.

(7)—Right. It will work more efficiently on the higher frequencies. The main reason for designing a transformer for a high frequency is that it is more economical to do so if that transformer is not to be used on a lower frequency.

(8)—Wrong. Most of the coupling that causes oscillation is magnetic and capacitive coupling through the air. The coupling through the tube is a small part. There is a greater need for shielding the stages of a radio frequency amplifier from one another.

www.americanradiohistory.com
The power amplifier diagram that has greeted one's eyes so often that familiarity may have bred contempt, and which is shown in Fig. 1, still has some points about it that are not generally understood. It is certainly true that good results are obtainable from this power amplifier, and that the gain is sufficient, but it is also true that close attention to a few details that ordinarily pass unnoticed will improve results extensively.

The power amplifier is seen to consist of a stage of single-sided audio and a push-pull output. The first tube is a 227, fed by an Amer-tran de luxe first-stage transformer. This has a turns ratio of 1-to-3. The primary inductance is high, around 200 henrys, so long as the plate current through the primary is low, say, not much more than 1 milliampere.

**Reason for Plate Bend Detection**

It is a good plan, therefore, if you have a tuner that uses leak-condenser detection, to change it over to negative grid bias detection or power detection. Both mean approximately the same thing, the only difference being that with power detection the negative bias and the plate voltages are higher. It is a case of plate bend detection in either instance. However, if you have a tuner that uses leak-and-condenser detection, with grid return to positive, you will avoid this wholesome circuit.

It is because of the core that low plate current is desirable. Core saturation is avoided. It is the presence of the core that causes the direct current through the primary to reduce the inductance.

But it is not true exclusively of the direct current, for the signal current also reduces the inductance. However, that effect will be slight in the first stage, since the signal level is low, the signal current is small, and the inductance is easily high enough even at high final output volume.

One way of keeping the inductance high, even if the direct current is relatively large, is to pass the direct current through an audio choke coil and connect a condenser of 2 mfd. from plate of the detector to P of the audio transformer. Then the B connection of the audio transformer could go to ground. It is not necessary to resort to this method in this stage, since negative bias detection, besides providing superior quality, keeps the direct current low enough.

**Case of the Push-Pull Input**

Next we come to the push-pull input transformer, an Amer-tran 151. This has a turns ratio of 1-to-2½. Here, too, the desirability is just as great to keep the plate current low.

Suppose we investigate the possibility of reducing the plate current so that no filtration, or parallel plate feed, will be necessary. A high plate voltage is not imperative in this stage, as with 90 volts on the plate and 4.5 volts negative bias, the push-pull output stage would overload ahead of the first audio stage. However, the first audio tube's plate current would be 5 milliamperes. We could not reduce the plate voltage low enough to keep the plate current within bounds, unless we made the first audio stage the weak link in the chain.

It is therefore a fact that the input to the push-pull transformer must be filtered, to maintain the precious height of the primary inductance. It is the magnitude of the inductance that enables us to obtain real quality response, especially faithfulness in the low-note region.

Since we are providing a filtered output, therefore we may raise the plate voltage, making it even 180 volts, provided that the negative bias will be 9 or 10 volts, whereupon 10 milliamperes will flow. In fact, the same 1,000-ohm resistor may be used for biasing.

There is no way of avoiding the filtered method if one is to have due respect for the inductance of the primary of a push-pull input transformer to the last stage. And yet in commercial receivers and in many kit-sets as well, the primary carries the plate current, which is high. But that may be due to the fact that the primary inductance is low to start with, so if it is a lot lower, what matter?

**Secondary of the 151**

I do not know of a single commercial receiver that uses parallel plate feed at this important point, and yet it is not only an advantage, it is an acoustical necessity. It is not an electrical necessity, because you will still hear signals well, even if you avoid this wholesome improvement. But you will
**Big Improvement**

Bernard

![Diagram of radio circuit]

**FIG. 2**

FILTERING THE 227 OUTPUT, SO-CALLED PARALLEL PLATE FEED, KEEPS THE DIRECT CURRENT OUT OF THE PRIMARY OF THE PUSH-PULL INPUT TRANSFORMER, WITH CONSIDERABLE ACOUSTICAL IMPROVEMENT.

fare much better by including the improvement in any design you build.

Next we come to the secondary of the push-pull input transformer. It consists of two separate windings, one exactly like the other. The low potential ends adjoin on the terminal strip of the transformer, being brought out to bugs (2) and (3).

The distributed capacity is kept lower by the separate windings, also facility is afforded for a capacity-resistor filter. A 2 mfd. condenser is connected between (2) and (3), while from these two points separate 50,000-ohm resistors go to ground.

This method has a stabilizing effect on the operation of the amplifier, which has been proved many times in actual practice and tests, although the theory of including the condenser is not altogether clear. Nevertheless, the scheme works out as stated and should be followed.

In the push-pull stage it is advisable to have “matched tubes.” Under the same operating and voltage conditions the two tubes should draw the same plate current. Since a common resistor of 800 ohms biases both push-pull tubes (and needs no bypass condenser), alternate readings taken with a milliammeter in the individual plate circuits, or plugging-in of a set tester to obtain these readings, will afford a determination of matching. It is therefore true that the matching results only in respect to the direct current. As to the signal current, the matching depends on the push-pull transformer and on the output choke, so these must be of good design and quality.

The output choke is center-tapped. The extreme terminals go to the plates of the 245 tubes, the center tap to B plus maximum. Then a dynamic speaker may be connected to the output binding posts and no direct current, but only signal current, will flow through the primary of the output transformer that is built into the dynamic speaker. Also, impedance matching will be taken care of satisfactorily, since a high impedance is working into a lower one. The choke coil may have a total inductance of 30 henries, 15 henries each side of center, and it is satisfactory if the direct current resistance of the total winding does not exceed 400 ohms.

**Voltages**

The positive B voltages are brought out to binding posts. So are grounded B minus, the detector input to the first audio transformer's primary, and the 2½-volt 16 ampere AC winding of the power transformer. The maximum B voltage is not brought out to a binding post, as it is not used save on the plates of the push-pull pair.

**LIST OF PARTS**

(For Fig. 2)

- One Amer-tran de luxe first stage audio transformer.
- One Amer-tran 151 push-pull input transformer.
- One 1,000-ohm wire-wound biasing resistor.
- One 800-ohm wire-wound biasing resistor.
- Two Lynch 50,000-ohm metallicized resistors (0.05 meg.).
- Two 6 mfd. condensers, 200 volt DC or higher rating.
- Two Polo center-tapped choke coils, 30 henries, Cat. CT-CH. (Center is ignored for the 227).
- Five 1 mfd. condensers, 200 volts DC or higher rating.
- One Polo 245 filter choke, Cat. 245-CH.
- One 245 filter choke, Cat. 245-CH.
- One 1 mfd. Fleckstein condenser, type 245 (for B supply).
- Two 8 mfd. electrolytic condensers with mounting brackets.
- One Multi-tap voltage divider.
- One AC cable with plug.
- One AC switch (normally this is on the tuner).
- One UY (five-prong) and three UX (four-prong) sockets.
- One chassis (4 x 14 inches is large enough).
- Eight binding posts and a speaker output assembly.
- One 227, one 250 and two 245 tubes.

**Detector Bias Constants**

What detector voltage should be applied will depend on the type of detector. For leak-condenser detector, 45 volts would suffice, but as this form of detection is not recommended, either 75, 90 or 180 volts may be applied to the detector. The usual value of biasing resistor for the detector, a 227, under these conditions would be 20,000 ohms (0.02 meg.). Across this biasing resistor a capacity of at least 1 mfd. should be connected.
What About Radiostat?

By A. J. Endson

T HE Stenode Radiostat, recently developed in England, is a superheterodyne type receiver employing a quartz crystal in the intermediate amplifier to obtain a very high degree of selectivity. It was developed by Dr. Joseph Robinson and its purpose is to eliminate interference of the heterodyne type. As a special transmission method, with accompanying receiver, it is also hoped that it will enable the use of many more channels in the spectrum now devoted to broadcasting. For example, it is hoped that a channel may be placed every 1,000 cycles, or closer together. At present there is one channel for every 10,000 cycles in America and one for every 9,000 cycles in Europe.

The basis of the system is the extremely high selectivity of a quartz crystal, a selectivity so great that the transmission band is only 50 cycles wide. A heterodyne type receiver works with the system because a quartz crystal can be adjusted to only one frequency, so that it is necessary to change the frequency of the signal to fit the natural frequency of the crystal rather than to change the natural frequency of the tuned circuit or circuits to fit the signal, as is done in tuned radio frequency receivers.

Sideband Suppression

The first views of this system several months ago raised a world-wide scientific controversy regarding the existence of sidebands. One group contends that no satisfactory broadcast reception can be conducted with extremely sharp sidebands, while another group maintains that it is not only feasible but that it has been done.

A curious cause of reasoning is followed by those who maintain that broadcasting can be conducted with extremely sharp sidebands, such as is represented by the quartz crystal. There are two distinct views of regarding the modulated wave that it is a wave of constant frequency but of varying amplitude. The variation in amplitude occurring at a rate depending on the frequency of the modulating tone. The other is that the modulated wave is composed of three components of different frequencies and invariable amplitude, that is, invariable as long as the depth of modulation is constant. These frequencies are the carrier and the two side frequencies. These side frequencies are equal to the sum of and difference between the carrier and the modulating frequencies.

The variable amplitude view is the natural view of the modulated wave; the carrier and the side frequency view is a mathematical equivalent of the other. Engineers use either, depending on which is the more convenient in particular investigation. It is but a moment's work in mathematical juggling to prove that the two viewpoints are equally correct and nobody who understands the problem ever denies it. Even those who maintain that the side frequency view is untenable admit the equivalence of the two, forgetting or ignoring the inconsistency of their position.

Reduction of Modulation

Those who believe in side frequencies use them to prove that a sharply tuned circuit will suppress the side frequencies remote from the carrier and in that manner reduce the degree of modulation. Those who deny the tenability of the side frequency theory say that a sharply tuned circuit reduces the degree of modulation because a such a circuit will not permit the amplitude to vary as rapidly as it should, especially when the amplitude variations occur at a very rapid rate. Both reach the same conclusion, as they necessarily must if they follow logical reasoning.

Those who sponsor the Stenode Radiostat say that the side frequency theory cannot be used to explain why good broadcast reception can be obtained with a tuned circuit as sharp as that of a quartz crystal because the crystal cuts out completely the side frequencies differing by more than 50 cycles from the frequency of the carrier. So they turn to the variable amplitude theory, and, after having admitted the equivalence of the two viewpoints, say that that is quite adequate to explain the reception.

They say that the sharply tuned circuit reduces the degree of modulation, a fact which they have to admit because of experimental observations, the modulation not being completely suppressed. There is some variation in the amplitude of the carrier wave after it has gone through the crystal. If they did not admit it they would not have anything left. There is enough variation in the amplitude, even at the highest rates of variation, to operate a detector circuit. But that detector circuit must be treated specially. They admit that there is a great deal of frequency distortion, and the high audio notes being relatively suppressed much more than the low. This distortion is compensated for by treating the audio frequency amplifier so as to give a comparatively characteristic.

Stepping to the Moon

Now if the two viewpoints are identical, or even equivalent, how is it possible to explain reception by one and not by the other? How can a mere change of view change the facts in the case?

"To realize the inconsistency of the position let us take an example. We cannot go to the moon because the distance is too great. But suppose the distance were reduced to a step. Then anybody could step to the moon any time. That being the case, there is nothing simpler than to go to the moon. Let us say that the distance to the moon is 200,000 miles. If we define a step as a distance of 300,000 miles. Now we have an easy means of getting to the moon—we just take one step in that direction and we are there. Is it not funny that nobody thought of that before?"

Those who admit the equivalence of the two ways of looking at the modulated wave go back to their views in the end.

If the side frequency viewpoint does not lead to an explanation of reception through a sharply tuned circuit, the variable amplitude viewpoint cannot do either. If the variable amplitude viewpoint can be used to explain it, so can the other. A changed viewpoint will not change the nature of a problem.

Claims for the Stenode Radiostat

The claims for the Stenode Radiostat are that the side frequencies are completely suppressed by the sharply tuned circuit. They are not. They also say that the sharply tuned circuit does not completely tune out the modulation. In that they are right. But if there is some modulation left, the wave that gets through the tuned circuit can be broken up into the components. The amplitudes of the two side frequencies will not be so great as they were before, and that is the only difference. If the two viewpoints are true before the wave has passed through the circuit, they are also true afterward. The tuned circuit has nothing to do with the side frequencies. A changed viewpoint will not change the nature of a problem.

It is a frequency that is exceedingly selective, that it suppresses heterodyne whistles caused by stations operating on frequencies close to the desired frequency and that the quality of the received signals is satisfactory.

One cannot deny that the system is capable of a high order of selectivity. The quartz crystal insures sharpness of response, That it suppresses heterodyne whistles cannot be accepted without reservations. If the circuit suppresses everything differing by more than 50 cycles, then every heterodyne greater than 50 cycles will be cut out. But if the circuit does, it also cuts out all signal frequencies higher than 50 cycles. If there is a little modulation left after the sharp tuner higher than 50 cycles, there is also the other, they are also true afterward. The tuned circuit has nothing to do with the side frequencies. A changed viewpoint will not change the nature of a problem.

Said the Stenode Radiostat is extremely critical. It is in every Superheterodyne of great selectivity, and it must be extraordinarily critical when there is a quartz crystal in the circuit through which the signal must pass.

It has been said that the circuit is subject to frequency variations especially the transmission of this modulation. Many transmitters "wobbleulate" a little in frequency. This "wobbleulation" is often serious on very deep modulation, Naturally, all transmitters would detect such frequency changes. But it is asserted that the Stenode Radiostat will hold due to modulation does not account for this at all. It might go out for a fraction of a cycle of modulation but it would not go out completely on all modulation frequencies and on all modulation depths. It would only account for distortion on the low tones.
The 227 Tube Analyzed

By J. E. Anderson

**FIG. 65**
SCREEN VOLTAGE, PLATE OUTPUT VOLTAGE CURVES FOR THE 227 SCREEN GRID TUBE FOR DIFFERENT VALUES OF GRID BIAS, TAKEN WITH 250,000 OHMS AND 180 VOLTS IN THE PLATE CIRCUIT.

(This is the ninth installment of "Modern Radio Tubes." The first installment appeared August 9th issue, in which the smaller battery type tubes were discussed. Subsequent instalments have dealt with the screen grid tubes, high mu tubes, the new 2-volt battery tubes, and with the 5-volt battery tubes. Last week information was given on the 224 screen grid tube. Next week data will be given on the 226 amplifier tube.—Editor.)

An interesting and instructive set of curves on the 232 screen grid tube is one which gives the relation between the effective plate voltage for different grid bias voltages as it varies with the applied screen voltage.

One such curve was given in Fig. 64 and a set of them is given in Fig. 65. All these curves were taken with a plate load resistance of 250,000 ohms and a plate voltage of 180 volts. The applied control grid bias is given on each curve.

The interesting region on each curve is the upper bend where the curvature is greatest. It gives the control grid bias and the screen voltage which makes the tube most effective as a Superheterodyne modulator when the signal voltage is impressed on the control grid and the local oscillator is impressed on the screen grid, assuming that the circuit has been adjusted as indicated by the data on the graph.

According to these curves, when the control grid bias is zero, there is no positive screen voltage which is satisfactory. When the control grid voltage is 1.5 volts, however, there will be good modulation when the screen voltage is 1.5 volts. When the control grid bias is 2.5 volts, good modulating efficiency will be obtained when the screen voltage lies between 32.5 and 60 volts.

Note that all the curves approach an effective plate voltage of approximately 160 volts, or 20 volts less than the applied plate voltage.

**Region of Instability**

On each curve in Fig. 65 there is a region of instability, where the effective plate voltage may have either of two widely different values. The first curve shows the characteristic when the voltage continued to fall, and the last curve, that for Eg=7.5, shows the course of the curve when the voltage increased with increasing screen voltage. On the first curve a sudden drop occurs at 30 volts on the screen and from then on the voltage decreases slowly, approaching a value of 2.4 volts. Every time this curve was taken the same result was obtained so that this curve represents a relatively stable condition. The second curve represents a stable condition up to about 3.5 volts on the screen. Beyond this point it would either drop suddenly to a low value and approach a voltage of about 2.5 volts, or it would turn upward as indicated in the drawing. All the other curves showed this instability but the stability increased as the grid voltage increased. For example, in taking the two curves for Eg=6 and Eg=7.5 volts no measurement showed a very low value. Undoubtedly, if the measurements had been carried to higher screen voltages, the instability would have shown up for these also, or the trend in the curves would have turned downward. The two curves for Eg=1.5 and Eg=3 were not continued beyond 52.5 and 60 volts because of the instability.

The region of instability is of no practical interest because the circuit would be adjusted so that the operating point would fall on the left of the lower bend in the curve.

No matter what mutual characteristics are taken on a screen grid tube, this peculiarity always appears, and it imposes a limitation on the adjustments of the circuit. Take, for example, the curves in Fig. 70. At the top of each curve, with the exception of that for a screen voltage of 6 volts, there is a sudden jump in the curve, and the operating grid bias must be high enough to put the operating point to the left of that jump. The limiting points have been indicated by circles on this graph.

**FIG. 75**
GRID VOLTAGE, PLATE OUTPUT VOLTAGE CURVES FOR THE 227 TUBE FOR THREE DIFFERENT PLATE BATTERY VOLTAGES AND 250,000 OHMS IN THE PLATE CIRCUIT.

The 227 has a heater and cathode structure like the 224 screen grid tube. That is, it is of the indirectly heated type and it may be used on either DC or AC. The heater terminal voltage should be 2.5 volts, when the heater current will be 1.25 amperes.

This tube may be used either as a detector or as an amplifier and it may be loaded either with a transformer or a resistance. For amplification it may be used either in radio or audio frequency circuits. For detection it may be used with either grid bias or grid leak and condenser, and when bias is used it may be either moderate for small signal detection or higher for power detection.

When detection is accomplished by means of grid leak and condenser, the grid return should be made directly to the cathode and the condenser should have a capacity of about

(Continued on next page)
THE CIRCUIT OF A GRID BIAS DETECTOR USING THE 227 TUBE. THE BIAS MAY BE SUPPLIED EITHER BY A BATTERY OR A VOLTAGE DROP IN A RESISTANCE.

The values in this table are correct when the load on the detector is a resistance of 250,000 ohms. When a low resistance transformer or audio choke coil follows the tube, the grid bias may be a little higher, but not more than one or two volts. When the tube is used as amplifier with resistance coupling a suitable load resistance is 250,000 ohms, although lower values may be used if desired. The curves in Fig. 75 show the performance of the 227 tube when working into a 250,000 ohm resistance, for three different plate battery voltages as indicated. From these curves it is possible to get the amplification on any grid bias as well as to get the optimum bias for detection and amplification. Indeed, the values in the grid bias table above we obtained from them, interpolation having been used to get the bias values for voltages for which no curves are given.

Let us examine the curves to see what the performance of the detector amplifier is.

Suppose we use 180 volts in the plate circuit. Then we may, without incurring excessive distortion, permit the plate voltage to rise to 150 volts, where the grid bias is 20 volts. We may also permit the grid bias to go to zero, where the output voltage is 11 volts. Thus a grid voltage change of 20 volts produces a change of 149 volts in the output voltage. Therefore the amplification is 7.45 times. The grid bias would be adjusted to 10 volts.

Reducing the Distortion

There is considerable distortion with this adjustment, for the amplification of one peak of the signal wave is 8.5 and that of the other is only 6.4 times. If we wish to reduce the distortion we may do so by reducing the grid bias. Let us assume that the tube is fed a 245 power tube, which requires a signal amplitude of 50 volts. The double amplitude must therefore be 100 volts. At zero bias the plate voltage is 11 volts and at 11 volts the plate the grid bias is 12 volts. Hence we may bias the tube by only 6 volts. The two signal peaks of each wave are now amplified 875 and 792. This not only represents a considerable improvement in the quality but an appreciable increase in the amplification. If the grid bias is reduced, the amplification will increase slightly and the distortion will decrease, but the output voltage will not be enough to load up a 245 power tube.

If the plate battery voltage is 135 volts, the amplification will be about the same as when the battery voltage is 180 volts, provided low bias values are used. This is evident from the fact that the two curves run parallel. If we must get maximum output from the tube with 135 volts in the plate circuit, we may allow the plate voltage to rise to 15 volts, which would require a bias of 7.5 volts. The mean amplitude of the output wave would be 56.4 volts, which is sufficient to load up a 245 power tube. However, the distortion is much greater than it should be and therefore it would be better to limit the output voltage to 96 volts, where the bias is 10 volts. This would permit a mean output amplitude of 44.4 volts, which is ample to load up a 171A power tube. The mean amplification of the two sides of the wave is 8.88 times. The grid bias would be 5 volts.

Low Plate Voltage Inadvisable

When the plate battery voltage is 90 volts, the output voltage midline is allowed to rise to 77 volts. This would require a grid bias of 4 volts. The voltage amplification would be nearly 8.2 times, and the output would be more than enough to load up a 120 or 231 power tube. If the best quality is to be obtained from a resistance coupled amplifier having several 227s in tandem it is clear from the curves in Fig. 73 that a 227 with plate battery voltage should be used and that the bias should be no higher than that demanded by the signal level. Thus it is better to use 180 volts in the plate circuit than any lower voltage, and the grid bias on any particular tube should be less than the amplitude of the signal voltage impressed on the tube.

Suppose that the power tube is a 245, which requires a bias of about 8.5 volts. We may, as we found above, use a bias on the 227 of 6 volts. We also found that the amplification was approximately eight. Hence we need an input to the second 227 from the power tube of 6/8 of a volt, and we may bias the tube by one volt. This arrangement will give as little distortion as is possible under the circumstances and at the same time the two 227s will give an amplification of about 70 times. If the detector is used so that the output voltage is 0.75 of a volt, we will need only two 227 amplifier tubes between the detector and the power tube.

The schematic diagram in Fig. 75 shows the arrangement used in taking the curves and the meaning of the plate voltage Ep.

CHARACTERISTICS OF 227

| Filament voltage, maximum | 2.5 |
| Filament current, amperes... | 1.75 |
| Amplification factor... | 9.0 |
| Plate voltage maximum... | 180 |
| Plate resistance, ohms... | 9,000 |
| Mutual conductance, microhms... | 1,000 |
| Base, standard UY... | or four-prong. |

The recommended plate voltage when the tube is used as detector with grid leak and condenser is 45 volts.

The circuit diagram in Fig. 76 shows a grid bias detector using the 227 tube when a battery or other external source of voltage is employed. While the circuit in Fig. 77 shows an arrangement by which a suitable grid bias is obtained from the B supply. In either of these circuits CI may have a value of 0.1 mfd. and C2 a value not greater than 0.0005 mfd.

The resistances R1 and R2 in Fig. 77 depend on the bias desired and on the value of the plate voltage applied, that is, the total voltage across R1 and R2. When the tube is adjusted for detection the normal plate current is so small that it may be neglected in comparison with the current that flows through R1 and R2, or the values of these resistors may be chosen so that this holds. Let us assume that the total voltage is 202.5 volts, which is to be divided so that the plate gets 180 and the grid 22.5 volts. Then the drop in R1 is to be 22.5 volts and that in R2, 180 volts. We might arbitrarily assign a value of 10 milliamperes to the current flowing through the two resistors. This gives us 2250 ohms for R1 and 18,000 ohms for R2.

In case it is necessary to conserve the current, we might assign 5 milliamperes, which gives us resistance values just twice as high. Perhaps the best way of applying this scheme is to make R1 and R2 a single potentiometer of about 30,000 ohms, con-
necting the slider to the cathode. When this is done the best detecting efficiency can be found by simply moving the slider until the output is greatest.

The performance of the 227 as a power detector is illustrated in Fig. 78. The tube is working into an audio transformer and the curve includes the step-up of the transformer. The plate voltage is 180 volts and the grid bias is 25 volts. The curve shows that the detection is practically linear up to an input voltage of 30 volts, peak value. When the input amplitude is 30 volts the peak voltage on the first audio tube is about 60 volts. As the input is increased beyond 30 volts, the curve falls rapidly, due to the fact that the grid of the detector tube takes current. Clearly, it is not permissible to impose on a voltage higher than 30 volts if the selectivity of the circuit is to be preserved. Since the output of the detector under the conditions represented in Fig. 78 is not sufficient to load up a 245 power tube, it is necessary to interpose an amplifier between the detector and the power tube. The extra amplification thus obtained will reduce the required amplification in the tubes preceding the detector. If we assume that the amplification in the extra audio stage is 7.5 times, which it will be if resistance coupling is used between the 227 and the power tube, we need an input of only 6.7 volts to the 227. Fig. 78 shows that this will be obtained if the signal amplitude impressed on the 227 detector is about 7.5 volts.

**Plate Current Curves**

In Fig. 79 we have a family of plate voltage, plate current curves for the 227 tube, covering grid bias voltages up to 32 volts. One load line for 18,000 ohms and a plate battery voltage of 180 volts is drawn across the curves. This line is drawn for convenience in drawing other load lines, parallel to it, for the computation of the output power. Since the 227 is not a power tube the computation is not carried out. Neither are load lines for high resistances drawn because Fig. 75 shows more clearly the performance of the tube in resistance coupled circuits. The curves in Fig. 79 can be used for estimating the plate current when the effective plate voltage and the grid bias are known, or for estimating the grid bias when the effective plate voltage and the current are known, or for estimating the effective plate voltage when the grid bias and the plate current are known. The curves also permit the determination of the amplification factor of the tube. For example, at 8 milliamperes and 13.5 grid volts the plate voltage is 160 volts and at 4 milliamperes and 18 grid volts the plate voltage is 200 volts. Thus a change in the grid bias of 4.5 volts causes a change of 40 volts in the plate voltage, at constant current. Hence the amplification factor is 40/4.5, or 9. The rated amplification factor is 9.

**Controlling Volume in 224**

The screen voltages usually recommended for a 224 do not always give the best results. Some means of adjusting the voltage is therefore desirable. A simple way is to return the screen lead to the slider of a potentiometer to an input of about 30,000 ohms which is connected across 75 volts. By this means it is possible to vary the applied screen voltage between zero and 75 volts and thus find experimentally the voltage which gives best operation. Incidentally, this arrangement is also the best volume control that has been found for circuits incorporating the 224 tube.

It is important never to attempt to get the required screen voltage by connecting a high resistance in series with either screen lead or with the common screen return lead. This will not give a definite screen voltage for it will vary with the signal as well as with the value of the heater current. Moreover, if a common resistance is used there will be coupling among the tubes and this will either upset the stability of the circuit or else reduce the amplification. Even when the potentiometer arrangement as suggested above is used, it is necessary to use individual radio frequency choke coils in each plate and screen return lead, and to by-pass each with a condenser as shown in the sample circuit. Besides this, it is necessary to use a large condenser from the slider of the potentiometer to ground. This condenser is not shown in the circuit because there is only one screen lead involved and the potentiometer is omitted.

The 20-ohm potentiometer across the heater is used as a means of eliminating hum. The slider is connected directly to the cathode of the 227 detector tube and to the negative end of the bias resistor for the 224. If a potentiometer of this value is not available, a center-tapped resistance of approximately the same value can be used in place of it, or else a center-tap of the 25-volt heater winding. The adjustable potentiometer is the best arrangement although it is not as convenient as either of the other methods.
How to Get Better Reception

By John C.

THE antenna as a form of signal pick-up circuit is one that will be popular for many years to come, because when real reception results are wanted, especially those from distant places, this form of signal voltage generator, insofar as the receiving set is concerned, is the best.

Loop-antenna operated sets are either very sensitive signal detectors or can be made so, but even these work much better on extremely weak or distant reception when the loop is properly coupled, (as for instance like the coil arrangement called the loose coupler,) to an antenna. The reason for this is that when a loop-operated set is made sensitive enough to respond to a very weak signal, it is perhaps a hundred times more sensitive to more relatively local disturbances, and this condition, added to the effect of the non-proportional magnification of so-called set noises, or tube noises, often results in warring reception.

Therefore the antenna properly used provides the best means of increasing the signal strength over and above the noise level.

Loop-Antennas Should Be Kept Clean.

The effect of surface dust is always comparable to a theoretical case set up when you make the surface of an insulated wire carrying a high frequency current weakly conducting. This is, when you do this the wire tends first of all to be surrounded with a conducting layer, which if the layer does not touch the "insulated" conductor underneath, forms a source of capacity leakage.

But if on the other hand the surface layer becomes sufficiently moisture-laden, the chances of the conductor being weakly grounded are not remote by any means.

The Outdoor Antenna

The most favorable reception season is advancing now and all who have outdoor antennas will do well to see that they are in good order.

Radio frequency currents tend to travel toward and along the exterior surface of a conductor. If this is true, what size or diameter should the live conductor of an outdoor conductor have? The answer is that it should be as large as the supporting strength of the mast or other points of suspension will permit. This might lead some of the readers to picture a copper wire of say 1/4 inch outside diameter, which if it were used as an antenna of say 125 feet long would mean that the sag with 100 pounds tension would be very noticeable indeed. In order that the sag should not be any greater than that customarily observed with eight-gauge aerials the tension would have to approach 1500 pounds. But desirable as this size of copper conductor would be from the view point of low surface resistivity, the weight would be too great, so there must be a compromise.

A number of manufacturers put out "antenna kits" at a variety of prices, but these are usually "skinny antennas". When these are new the surface resistivity is lower than is the case when the more expensive kits are used, and at the end of six months or a year in the open the span has increased surface resistance to such a degree that reception is not as good as it used to be. The customary replacement of one or more tubes follows. This does not always clear up the trouble.

Mapping Service Area.

Those who correct reception faults do the best they can in cases where reception is weak but they are hopelessly beaten if weak reception is in any way due to antenna pick-up deficiency that is not traceable to any readily observed electrical or mechanical defect. All this is directly due to the fact that there is no standard of signal input measuring device.

What is needed is an instrument that will read in direct units the standard (or sub-multiple standard) micro volts per meter, the present accepted way of defining signal strength.

The local service area of broadcasting stations that serve the community in or near where you live is plotted more or less regularly by those whose business it is to know what this area is. The basis of arriving at the determination of this area is the establishment of a series of points radially distributed about the location of the transmitting antenna, where the carrier-wave is of uniform intensity. These points are noted on a regular geographical map and are linked by an imaginary line, which when the map is complete forms an irregular circle. Several of these irregular circles form a "complete" map, and the individual ones are the connected points where the signal voltage is the same, and therefore they are called equipotential lines, or field lines.

When the final results of a series of field strength measurements carried out over an average radius of say 100 miles yields the information that certain areas of reception are being slighted, i.e., the signal voltage is too low to operate receivers satisfactorily, it becomes necessary to effect certain changes in the transmitting antenna. With these corrections made the largest number of local listeners wants are satisfied, provided another dead spot has not been created by the aforesaid adjustment.

Improvement Sought

More than one experimenter would like to know how to improve on his present receiving antenna system, particularly if some desired stations do not come in with sufficient volume. The type of receiving antenna that is most commonly used is a length of 7-strand twisted conductor with individual wires Nos. 22 to 24 B. & S. gauge hard drawn copper.

A TYPE OF ANTENNA WHICH TO STUDY THE EFFECT OF DISPOSITION IN THE FIELD OF A GIVEN TRANSMITTER.

Stranded wire has been used for this class of antenna because it is more elastic than a solid conductor and also because it possessed more actual surface area than a solid wire of equivalent copper carrying capacity, and by the line of reasoning previously referred to also was more desirable for high frequency use than the solid conductor. But experience has shown that the conventional antennas have a handicap that is not fully realized, and it is that after oxidation* of the individual strands has taken place the strands have had some comparatively high series resistance (dc as well as high frequency, AC) "inserted" in between them with the result that the desirably low cross-sectional area resistence is increased.

It has been previously pointed out that RF currents tend to...
**Ult from An Antenna**

Williams

**FIG. 3**
HOW THE EFFECT OF CHANGED INCIDENT FLUX IS OBSERVED.

flow toward the surface of a conductor, but this does not presuppose that they do not penetrate to any depth at all. On the other hand, some depth of penetration is undoubtedly achieved, which makes it desirable to consider cross-sectional resistance. It may be added that “surface” current flow of those high frequency alternations encountered in radio transmission and reception tends to be more manifest as the frequency increases, but the relative elusion over the broadcast band need not cause the experimenter any special concern.

No 6 to No. 9 Solid Wire Antenna

The important feature of this present discussion is the compromise. Since all copper conductors are subject to oxidation, as previously pointed out, and there is a relatively serious effect of this coating in the case of stranded conductor, it has been found by trial extending over a long period that the best antenna conductor for average use that is not unduly expensive and is cheapest to maintain in satisfactory working condition is solid copper or phosphor bronze wire that is equivalent to between No. 6 to No. 9 B. & S. gauge. This wire may be readily cleaned with fine sand paper regularly and thus the surface resistance may be kept at the lowest value.

The next important step before considering the points of suspension of the antenna is where to put insulators, and perhaps also decide what they shall be made of. The primary function of antenna insulators is to act as virtual points of suspension and conductor terminals. They are supposed to determine the horizontal and vertical length of the antenna wire span.

Insulation as an absolute concept is invalid, because there is no real dividing line between conductors and insulators. A conductor is merely a path of low electrical resistance whereas if the path of current flow acquires very high resistance it becomes progressively a poor insulator then as the resistance reaches enormous values the path becomes a good conductor.

But in the main insulators are known as such because they present very high resistance to relatively low potential differences.

**Potentials Analyzed**

The opposite ends of a perfectly horizontal span of wire are at the same potential at all times, when there is no branch circuit connected to the span at any point, but since a lead in wire is necessary if we are to make effective use of the antenna span the above condition is modified.

Also, it is modified when dust-bearing moisture is precipitated on the wire and in a more or less continuous coat over the insulators and other supporting media which if of metal, may be grounded.

But most good insulators have a smooth hard and non-porous surface that does not harbor dry dust or wet dust to any special degree, so that successive rains and winds effectively clean the

*Oxidation is the name given to the chemical process whereby atmospheric oxygen combines with a substance. The product formed is called an “oxide.” Thus copper wire that is exposed to pure atmosphere plus the effect of heat from the sun acquires a coating of copper oxide in a comparatively short time. Of course physical contact with the oxygen is prerequisite to the formation of the coating.*

**FIG. 4**
A TYPE OF ANTENNA THAT IS NOT EFFICIENT.

The product formed is called an “oxide.” Thus copper wire that is exposed to pure atmosphere plus the effect of heat from the sun acquires a coating of copper oxide in a comparatively short time. Of course physical contact with the oxygen is prerequisite to the formation of the coating.

*Continued on next page*
In Fig. 2 we have a case that does not look especially promising to start with because of the relative position of the transmitting antenna and the receiving one, but as we are studying situations where the first case must be taken, it is assumed that there are no other sources of radiation affecting the receiving system, so that the only observable effects will be those that come from the transmitter shown.

According to what we have learned from Fig. 1, direct radiation in this case should result in no observable signal voltage at the receiving antenna, a conclusion that is entirely within reason if signals of these were suppressed being due to the consistency where the radiated flux axis must always be at right angles to the conductor axis, but we are to find out whether this is strictly true.

All conductors have some size, and because of this, some observed facts relative to Fig. 2 are not as readily shown in the case where the appearance of Fig. 2 would not have been due to the use of a detector more sensitive than, say, a three-circuit tuner.

Here the radiations are seen to advance directly across the conductor, and parallel to its axis. Relative to Fig. 2, some questions have been asked about the pickup qualities of certain "shaped" antenna conductors, the principal questions having to do with leakage and induction effects, due either to the manner in which the particular antenna wire is suspended, or the resultant effect of close proximity of the wire to the house, etc.

Specific cases demand specific answers so the only way to handle this class of quizzes is to answer various letters personally, a much more satisfactory arrangement.

Most of the questioners are interested in knowing what antenna arrangement would provide the most signal, a very logical inquiry, since most of us are interested in getting all the signal we can, but the disposition of the antenna wire has been so consistently ignored in the inquiries that Fig. 2 was deemed a good starting point. In all the following, to simplify matters, the assumption of a uniform radio frequency output from the transmitting antenna is made. Let us see what we can learn from the next picture, in which a different state of things is apparent.

**Antenna Voltage and Incident Flux**

Since it has been pointed out that the disposition of the antenna conductor in the field of the radiated AC flux is important, it does not require any stretch of the imagination to extend this idea to some desired frequency, no matter where you happen to live. But in many instances it would be highly impractical to concentrate on one frequency alone so it becomes necessary to consider a point that seems difficult for some experimenters to realize.

Substantially the same rule holds for radio reception as the case of Fig. 1, and the idea is carried over to Fig. 4, where we see the receiving antenna located at an angle to the inducing flux, which, let us pretend, corresponds to an actual case. What voltage will be developed in this antenna relative to what would be expected if the wire were straight and the flux or wave front? Obviously one-half, because the wire is exactly halfway between its zero coupling and maximum coupling positions.

The two dotted lines are now of interest, and we will proceed to use them, but only one at a time. This antenna is located on top of a flat roofed roof, the supports and building will wood also, and there is no leakage of any kind. The object of adding one of the dotted-line conductors is to add to the pickup, so let's see whether we gain anything. The procedure is to shift one input meter lead, so that one end of one of the dotted line extensions is included in the circuit. If an increase of signal voltage is noted, then safe assumption is that the span was not parallel to the wave front in the first place. If no additional signal input is detected it can only be surmised that the orientation was correct in the first instance as it would be impossible to register a decrease, with the present arrangement.

**FIG. 5**

THE STRAIGHT-WIRE ANTENNA.

**FIG. 6**

A HORIZONTAL COMPARISON-VIEW OF THE TRANSMITTING AND RECEIVING ANTENNAS.

The addition of the other dotted-line wire would merely repeat what has been already shown, with the added proviso that if the dotted lines were extended the final results might not be any different.

Fig. 4 is another variation of flagrant disregard for the laws of induction, an example of which can be seen in any time ato apartment houses.

**DX Reception**

DX reception, wherever one is located, usually occurs from no more than two distinct cardinal points, that is, the regular reception of DX so that it is understandable during the time that regular local broadcasting is in progress, is certain limited, and therefore it would seem in the light of the above to be a good plan to try to find out what these best DX reception directions are and accept them for DX reception, say at least two, and have things so arranged that it is easy to switch from one to the other, and by this means it will be found that results as complete to this will be gained.

A moment's consideration of Fig. 4 should show this, but in case it does not, read slowly from here on.

If we think that a horizontal wire does not develop an emf in the antenna, it is also true that if the antenna is connected to a load circuit that is in turn connected to ground, a current will flow, depending principally on the impedance of the load circuit.

In this case let it be supposed that some such load is in the circuit here. How will its presence affect the observed reactions? The case here is best modified by the local re-radiation of one of the solid arms of our system, by the presence of a magnetic field that was manifested only when the load was applied, and this AC field acting at right angles to the one of the other arm has the effect of partly neutralizing it, and indeed if the field was of maximum intensity the resultant current would be reduced exactly one-half.

So the horizontal right angle antenna is actually poorer than a straight wire system of length equal to that of one of the arms, where the conditions are as previously noted.

One of the difficulties of analyzing antenna behavior is the fact that not one in a hundred antennas is so erected that all the variables affecting its performance can be readily observed. For instance in the case where a signal is more readily picked up when an iron roof is in the proximity of the antenna system, it is likely that some of the signal is picked up from the roof directly by induction, although the only positive proof of this would be to remove the metal sheet and re-observe the results.

**Raising the Antenna**

Again a case somewhat the opposite might be found to be the effect. In other words, suppose it was found necessary to raise the antenna vertically, say ten feet from the roof in order to increase the signal voltage a certain desired amount. It would then have been found that the initial trouble was excessive capacity loss, so it is seen that the individual conditions have to be measured every time to give satisfactory answers to individual problems.

In general, when erecting an antenna system over an iron or other metal roof, always aim to construct an arm so that effective height of the antenna will insure a minimum of troublesome leakage effects.

One correspondent was anxious to know whether it would be correct to lead his 'lead-in' wire along the shingled roof on insulators, then down over the eaves, and side of the house to the lead in tubing, answer here is, always use the shortest lead-in route that will insure the best insulation, and in any case keep the lead-in wire at least two feet away from wooden structure, to avoid surface leakage in wet weather, and as for metallic surface a good plan is to make three feet the minimum separation.

A brief consideration of Fig. 5 may help to decide the answer to the question of antenna length, because here we have no special problem in sight, at least not yet.

As a practical consideration to start with, it is reasonably safe to state that the length of antenna conductor is not more than half of the story, since the height above the earth, or ground, has to be considered as well as the set itself.

(Continued next week)
September "Proceedings"

By Brunsten Brunn

P. A. B. MARS, G. W. Kerwick and G. W. Pickard report
work on the development of frequency-stabilized oscillators.

At one stage of their work, they developed a frequency-stabilized oscillator for
aircraft use, and it has been found satisfactory for this purpose. It should also be found useful in other applications
where a constant frequency is demanded. One of the advantages
of the circuit is its extreme flexibility, and seems to pre-
clude its use as a primary frequency standard.

Many variations of the fundamental circuit are given but all do depend on the rearrangement of the disturbances of the
period of the selected frequency. Another name for selective reentrant circuit
might be selective regeneration. The main principles of the circuit are selective feedback, loose selective coupling between
the tubes in the amplifier, and plenty of amplification to make
up for the feeble feedback and the loose coupling.

Interpolation Methods for Use With Harmonic Frequency Standards

describes methods of measuring frequencies by interpolation
between known harmonics of standard frequencies or known
harmonics of such frequencies. The subject is discussed under
the following classifications:

I.—Direct beating methods, wherein the beat between known
and unknown frequencies is utilized directly to operate fre-
quency indicating or measuring devices.

II.—Direct interpolation methods in which the fundamental
frequency of an interpolation oscillator is utilized to
be in turn with the unknown and the adjacent known harmonic
frequencies.

III.—Harmonic interpolation methods which are an extension
of the principles of (II) permitting an interpolation oscillator
of limited fundamental frequency range to be employed in the
measurement of frequencies lying both above and below this
range.

IV.—The principle of (III) points to a means for covering a
wide range of unknown frequencies through the use of a low-
frequency narrow-range oscillator fitted with harmonic produc-
ing circuits. A greatly open-out interpolation scale may be
obtained.

Precise and Rapid Measurement of Frequencies

N. P. Case, Department of Engineering Research, University
of Michigan, Ann Arbor, Mich., outlines a precise and rapid
method of measuring frequencies from five to two hundred
cycles, the second, which is also an extremely simple method. It
depends on the fact that a condenser charged to a given
voltage f times a second and then discharged through a re-
sistance, the mean voltage across the resistance is proportional
to f. This voltage is balanced against the voltage drop in a
slide-wire potentiometer. The slide wire is first calibrated
against a known frequency and subsequently other frequencies
can be directly from the setting of the potentiometer on
the wire when the circuit is balanced for the unknown fre-
quency. The accuracy of the method is better than 0.1 cycle
per second.

A Note on the Mathematical Theory of the Multi-Electrode Tube

Those who revel in mathematical theory will find much pleas-
ure in reading this paper by Peter Caporse, RCA-Victor,
Calden, N. J., and they may find some practical information
about multi-electrode tubes. As an exercise in mathematical
analysis the paper is splendid; as a practical study of the prop-
certies of vacuum tubes it leaves much unexplained, although
the symbolism contains expressions of the properties.

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Advertising Department

Radio World, 145 West 45th Street, New York, N. Y.
Simple Mathematics

By Manning Manwaring

used here in somewhat the same fashion as it was previously,
except that this circuit contains no steady "internal" emf that
caracterized the network of Fig. 2, where this emf was
furnished by a battery.

Measurements of mechanical work that is done by or on
mechanical devices must be in some way able to give an indication
of the ratio of the mechanical equivalent of the supplied energy
to that of the mechanical work done by the rotating body.

Here are a few cases when the measurement of the desired
quantity in question involves to a certain degree knowing some-
thing about the special properties of the particular device. The
most important part of this circuit scheme is the armature of
two motors, and the specific properties of the armature that
influences the result of measurements is called armature reaction,
and it will be necessary to go into an explanation of this effect
very briefly.

The field coils that provide the magnetic flux in which the
armature conductors rotate are seen and are also observed to
be wound in opposite directions, thus providing the requisite
counterbalancing when a magnetizing current flows through
the coils. The armature conductors are, of course, properly arranged
and connected to a commutator against which the brushes B
make contact with the armature. The armature, therefore, will
not seriously interfere with the free rotation of the armature.

When the armature and field coils are connected as shown
to the storage battery and the switch is closed, the armature
rotates because its fluxes react with the fluxes already present
in the polar air gap set up by the field coils, and since the
armature is free to move the strong flux reactions over-
come the bearing friction, and it starts to rotate.

The circuit network as portrayed includes a line voltmeter
shunted around the battery and two ammeters A1 and A2. Ammeters
with field coils and the armature, while A1 is in series
with the field coils A1. At this point the heavy flywheel
is mounted so that the motor will turn it, and there is no extra
bearing friction added to the motor armature by this addition.

The necessary assumptions are as follows: the motor is of
reasonable size, and therefore a 1/4 horsepower motor was selected.

Since a horsepower is 746 watts, the motor is a 186-5 watt
design theoretically, but with the convenience of a 186-
5 watt motor, and since watts are the product of volts
and amperes, let us assume that the line voltage is 23.25 volts,
and that the line current, motor running freely under the stated
load, is 8 amperes. Under these conditions the motor is requiring
its rated input of 186 watts, and the armature is taking
just enough current (or power) to supply the frictional and
winding losses of the system, as indicated by the result of
the reading of A1 ammeter minus the reading of A2 ammeter.

With everything running normally, let us apply some uniform
friction force to the outer edge of the flywheel and observe the
behavior of the ammeters A1 and A2. With the point of the
flywheel and inspection has probably shown the reader by now
that it did not obey Ohm's law particularly well as friction was applied to the fly-
wheel and inspection has probably shown the reader by now
that it did not obey Ohm's law until it became stationary, or
in other words, it did not appear to obey it at all. Let us see whether it did
or not. If it had been possible, we could have connected a
center zero voltmeter to the motor terminals and run the motor
nearly to find out whether it acted any
differently as a generator than as a motor.

We would have found that the voltmeter did deflect differ-
ently, in fact, that its deflection in the latter case would have
been opposite to that of the case when the device was used as
a motor. But when the armature was running as a motor the
conductors that compose it were rotating in precisely the same
way as they were when it was stationary. The obvious conclu-
sion is that when the motor armature rotated, its conductors
developed an emf that tended to oppose the emf applied to the
motor.

The equation that expresses this condition is

\[ E_A - E_W = R_e \]

in which \( E_A \) = Applied line voltage,
\( E_W \) = Back emf of motor,
\( I \) = Indication of \( A_1 \) ammeter, and
\( R_e \) = Effective resistance when armature is freely rotating
under load.

It is clear that when the armature is clamped the result is a

(Continued on next page)

FIG. 4
HOW TWO LAMPS ARE COMPARED, I. E., A SIMPLE
PHOTOMETER MEASURING CIRCUIT.

[This article is a continuation of a discussion which appeared in
the September 27th issue of Radio World, in which resistor
networks, battery charging, and elementary lamp measuring devices
utilizing forms of resistance measuring circuits as a basis of making
test comparisons were described. The following article takes up
the principle of the photometer and other measurement topics.—Editor.]

THE standards by which electrical apparatus is measured has
to conform to a degree with that of the standard devices
chosen to represent the major characteristics of its particu-
lar kind. Thus two lamps are compared, the choice may be
on the basis of comparative current drawn or of the degree of
illumination obtained, and it is safe to say that the likelihood
of them being similar is remote. Usually one or the other is
used and more often it is the wattage that is checked against
the illumination in terms of filament input wattage to the lamp
which is a standard one and whereby the relation between
the lamp's light output and the light "input" of the measured
source are compared.

These devices are employed by those whose business it is to
measure light conditions in industrial plants, and especially
where a quick and reasonably accurate survey of illumination
requirements is required.

A Photometer Circuit

Fig. 4 is really the basis of the device previously outlined,
but being a laboratory measuring instrument rather than
to a device to measure external illumination as the "foot-
candle meter" is its description, or rather the points of interest
about it so far as we are concerned are confined to the
difference between the circuits which can be observed readily
by inspection.

The essential circuit arrangement is a network containing a
"standard" lamp, and this lamp's filament has an ammeter in
series with it, while a voltmeter, is shunted across the filament.

The lamp is previously calibrated in terms of foot-candles per
unit power input expressed in watts at various voltages other
than "standard" voltages, that is, for conditions other than
standard, a table is supplied for the standard lamp whereby a
constant check on its illumination is available at all times.
The supplied table also indicates the maximum allowable input
permissible without ruining the constants of the lamp.

The other circuit is essentially similar to the standard one
except that no table is necessary and a controlling resistance
called a "comparator" is used to adjust the lamp under measure-
ment to any desired condition of illumination.

The uses of the photometer circuit are principally those of
determining the illumination efficiency of lamps and their
relative power consumption.

The meters of the two circuits are identical in deflection
characteristics, and where only one set of them is available
the use of two double throw, double pole switches makes it
possible to employ one set of meters in both circuits.

There are many instances in the art of measurement where
electrical circuits are employed for the measurement of quanti-
ties of non-electrical in origin and not all of them depend on a
change in resistance as the basis of comparison from which
values are derived.

A Measurement of Mechanical Work

The case in Fig. 5 is one where a 1/4 horsepower motor is
equipped with a flywheel load, this type of load being the best
kind for the conditions under consideration. Ohms law will be
Bottles of Nothing

OW bottles full of nothing act to pick up radio broadcast programs was explained in a talk from WGY, recently, by Hans I. Manning, physicist of the General Electric Company research laboratory. Speaking on "What Price Emptiness," Mr. Manning said:

"I've never heard of anyone going to the store and asking the clerk for the dollar's worth of emptiness, and getting it. Great many people spend a great many dollars each year buying empty space."

"Whenever you buy certain kinds of incandescent lamps, you are purchasing a little bit of emptiness wrapped up in a glass container. X-rays enable medical doctors to study and repair human anatomy, and X-rays are helping other kinds of doctors to study the anatomy of the atom—and, described in its simplest terms, an X-ray tube is simply two pieces of metal placed inside a glass bottle full of emptiness.

Vacuum bottles provide us with electric eyes better in some respects than human eyes. All in all, you buy millions of dollars' worth of vacuum devices each year—and yet the price paid for such use of kinds of emptiness is surprisingly low when you think of the cost of learning how to make the kind of emptiness required—and then, how to make containers full of nothing do the jobs they do.

"Radio—whether sending of programs or the reception of music and speech—is not at all the profound mystery it used to be. Certainly, radio is intimately connected with these containers of weirdly rendered vacuum tubes. Without them, radio as we know it to-day would be impossible.

Unfamiliar Names

"Most people have felt the wonder, the awe-inspiring mystery of the devices that permit ready and instantaneous communication over the entire surface of the world. Many people, at some time or another, were curious about the how and why of radio. But usually our talk of work claimed that the business of radio is accepted, like a lot of other puzzling things, as a matter of course.

"And for the general lack of understanding of radio—for real misunderstanding sometimes—lies in the unfamiliar names so constantly used by those who talk or write about radio programs. Who would know that a grid is simply an abbreviation for a well-known and familiar word gridiron, and that it means a small piece of metal, placed inside an exhausted bulb to do the same sort of job for electric, or electron-currents, that the faucet in the kitchen sink does for the flow of water through the pipe, that is, let a little bit of water out when a little is wanted, and a lot of flow when much is needed? Who would suspect the name of an electrodynamic speaker means simply a new and infinitely better way of making something move—move more powerfully and more accurately. Names don't explain things, so why should names like kilocycles, Superheterodyne, radio frequency or screen grid mean anything definite to the great majority of people?

"Actually, all these things do mean something, and in reality the meaning isn't nearly so difficult or puzzling as the names seem to indicate. The job I've set out to do is simply that of taking apart some of these mysterious words to see what they're made of and then putting them back together only in such a way that they do make sense. Naturally, such a job can't be done in a few minutes—but perhaps we can make a start tonight.

"Everyone knows that broadcast programs are not sent out from the station at sound. Just step out on the back porch and try talking, or even yelling—sending sound—over to Australia or down to the Antarctic! So what the station sends isn't sound.

"You wouldn't really expect it to be, any more than you'd expect the trolley conductor to say 'good morning' to you when he puts the car back together. Then, there is the real mystery why the sound would be the kind of sound you'd expect—cold, dead, and flat, and vacuum tubes make it possible.

"Vacuum tubes, of course, make it possible for broadcasting stations to produce the right kind of bumps in space. Incidentally, sending stations are not the only things that make bumps in space. When a spark like lightning jumps from cloud to earth or back again, the bumps produced in space are likely to reach your radio set and cause you to say unkink things about static, whatever that is.

"Now let's look at the other side of the picture for just a moment. The disturbances are in some way made to carry energy coming to the set from far away places control other energy, supplied by batteries or by the house current in your home.

"You see, the energy received from any broadcasting station is much too small to make a loudspeaker operate—you, yourself, must supply that energy but the incoming radio waves must be made to control your local supply. Again vacuum tubes are essential for this. Let's try to paint this picture over again.

"Imagine a nice expensive vase resting peacefully on the piano. Along the street comes a truck, or on the nearby track a train or trolley car, and bumps are made in space—those so-called ether waves—reach your home possessing very little energy. So a receiving set, essentially, is just a gadget that will pick up these minute spaces. Those disturbances are in some way made to carry energy coming to the set from far away places control other energy, supplied by batteries or by the house current in your home.

"Now let's look at the other side of the picture for just a moment. The disturbances are in some way made to carry energy coming to the set from far away places control other energy, supplied by batteries or by the house current in your home.

"Now let's look at the other side of the picture for just a moment. The disturbances are in some way made to carry energy coming to the set from far away places control other energy, supplied by batteries or by the house current in your home.

Mathematics for Experimenters

(Continued from preceding page)

low resistance network, where the armature and field from the two branches, and then these considered separately are merely two cases where $R = E/L$ holds for the two branches and $A_2$ indicates the total load as before. The efficiency of the motor as a "door" of work depends upon the maximum mechanical force the motor can develop without getting excessively warm.

Reverting once again to Fig. 4 is not out of order, when it is recalled that the most important features of electric illumination tests is that the supply voltage shall be constant, and in some cases it is extremely important that the current shall be uniform also, especially in the case of low voltage lamps where the current flow is a considerably larger fraction of the supply voltage than is the case in illustration. The temperature of the control resistor should not be over 30 Centigrade.

This steady state of current flow is usually attained by the use of storage batteries supplementing the generator or merely the storage of a non-generating available.

The standard of illumination are compared by the use of two semi-transparent screens, each placed so as to be readily visible in a dark box while the two screens are equidistant from the two light sources and the comparator of the right hand circuit is adjusted until the illumination of the two screens is the same. In summary to view the screens with one eye so as to eliminate the influence of any optical defect of the person making the test.

FIG. 5

A CASE WHERE TWO CIRCUITS REACT TO PRODUCE MECHANICAL WORK. INITIALLY THERE IS NO INTERNAL EMP BUT WORK IS DONE WHEN IT APPEARS.
The capacity of a large condenser can be measured in the same way as a resistance by an application of Ohm's law, but to do it it is necessary to have a source of AC voltage of known value and to have a current meter that measures alternating current. For the most part, the voltage that is often used is the voltage of the lighting circuit may be as low as 115 volts, unless a meter is available for measuring it accurately. The condenser to be measured is connected in series with the line and also in series with the AC voltage source. The ratio of the known voltage and the amperage indicated by the meter gives the reactance of the condenser at the frequency of the line voltage. The reciprocal of this ratio is proportional to the capacity and the factor of the proportionality is 0.2332F, where F is the frequency of the line voltage. Hence the rule is: Divide the indicated current in amperes by the voltage of the line and divide this quotient by 0.2332F, and the result is the capacity of the condenser in farads. Multiply by one million to get microfarads.

Let us take an example. Suppose the voltage of the line is 115 volts, effective value, the indicated current is 1.75 milliamperes, and the effective value, the frequency of the line voltage 60 cycles per second. Therefore 0.2332F equals 377. Dividing 0.175 amperes by 115 volts we get 0.00152 ohms, and dividing this number by 377 we get 0.0000404 farad. Multiplying by one million we get 4.04 microfarads.

* * *

**Principle of the Ohmmeter**

On what principle does the direct reading ohmmeter operate?

I understand how Ohm's law works but it is not clear to me how it is applied in the direct reading instrument.—C. T.

It works on the principle that the current through a resistor is inversely proportional to the resistance if the voltage in the circuit and current remains constant. In every ohmmeter a battery of fixed voltage is used and the scale of the ammeter is calibrated on that basis. There is also a fixed resistance in series with the meter which is necessary for the protection of the meter. This meter will indicate zero when the terminals for the unknown resistance are shorted the meter reads full scale. That point is therefore marked zero resistance. All other resistances are shown in series with the known resistance, and the pointer is deflected accordingly. It is possible to calibrate the meter without the use of standard resistances provided that the scale is visible at the same time that the current scale is visible. Suppose we use a battery of 1.5 volts and we employ a milliammeter having a sensitivity of 1.5 milliamperes. We must put a resistance of 1,000 ohms in series permanently as a protection for the meter. Now if we add 1,000 ohms the current reading will be 0.75 milliamperes, so that point is marked 1,000 ohms. If we put 2,000 ohms in series, not counting the first 1,000 ohms, we get a current reading of 0.5 milliamperes and therefore we mark this 2,000 ohms. In the same way we can determine points for any other resistances we choose. For the calibration we do not need any resistance at all, except the 1,000 protector resistance, because we can assume that we have any resistance whatever and then calculate the current and mark the point suitably in terms of resistance. In calculating the resistance we always add the permanent resistance but we do not take it into account in calibrating the scale.

* * *

**Output Voltage of 232**

Is it possible to get enough output voltage from a 232 screen grid tube to load up a 245 power tube without serious distortion?

If so, what are the conditions that should be imposed on the screen grid tube?—K. Y.

It is quite possible to get enough output from the 232 to load up a 245 power tube without a great deal of distortion. The conditions that should be imposed on the tube, besides the screen bias, are set forth in the curves shown in Fig. 62, page 8, Sept. 27th issue. The screen voltage should be 225 volts, the plate battery voltage 202.5 volts or more, the load resistance 250,000 ohms, and the grid bias -1.25 volts negative. The signal input amplitude to the screen grid tube may be 0.75 volts.

* * *

**Scanning Line Standards**

HOW many scanning lines per frame are used as standard in our local laboratories? What is the standard now used will be adopted finally?—A. B. H.

Most transmitting stations in this country now use 48 lines per frame, and this is the standard adopted temporarily by the Radio Manufacturers Association. However, there are still some that use 24 lines, 30 lines, 50 lines, and 60 lines. One might say that there is no standard. There is little likelihood that 48 lines will be adopted ultimately as the standard because it is not capable of line enough definition of the picture. Possibly 60, 72, or even 100 will be used.
Ohm's Law Again

I WANT to tap a voltage divider so that I get voltages of 45, 67.5, 90, 135, and 180 volts. The total voltage across the voltage divider is 300 volts. Will you kindly tell me where to put the taps so as to get the desired voltages? That is, tell me the values of the resistances between adjacent taps—R. G. H.

The problem is indeterminate because you have not specified the currents which will flow in the various resistance sections, nor have you given any information on which to form an estimate of the current. The placement of the taps is essentially an application of Ohm's law, and to apply that law it is necessary to know two of the three quantities involved.

Results with Short-Wave Converter

I BUILT one of the short-wave converters which you described a short time ago, and I have been using it with a superheterodyne. I am not getting satisfactory results. What do you think is the reason?—L. A. J.

You did not say which converter you built nor with which superheterodyne you tried to operate it. It is possible that there is not enough radio frequency amplification in the superheterodyne. That is the usual reason why converters of the superheterodyne type do not work well with broadcast superheterodynes. One will be able to select the band that may be better to skip the radio frequency amplifier and the oscillator in the superheterodyne and couple the converter to the intermediate frequency in the superheterodyne is of the order of 100 ke or higher.

Effect of Silver Plating

W HAT is the advantage of using silver plated wire for tuning inductances? Does it make the selectivity of the coils greater or is silver used for decorative purposes?—T. C. F.

High frequency currents are concentrated near the surface of the wire and therefore if the surface layer of the wire is the best possible conductor, the selectivity of the coil will be high, that is, the resistance will be low. Of course, the thickness of the surface layer of the silver is very small so that the gain in selectivity is not great. The coil made of silver plated wire looks much better than other bare wire and it does not corrode like other wire. Hence the advantage is not only lower resistance but better appearance and permanence.

Effectiveness of Grid Suppressors

H OW is it possible to suppress oscillation in an amplifier by putting a grid resistor in the grid lead when no current flows in the grid circuit? If there is no current flowing through the suppressor there is no voltage drop in it and hence it will not appear. We either have to abandon the theory that no current flows in the grid circuit or else find some other explanation for the effectiveness of grid suppressors. Or so it seems to me, at least.—A. E. L.

That's right. We have to abandon the theory that no current flows in the grid circuit at radio frequency. There is a small current flowing because of the effective input capacity of the tube. This capacity may be 5 mmd, or more and this is sufficient to account for the current that flows through the suppressor. At very high frequencies the current through 5 mmd. may be quite high, and at broadcast frequencies it may also be considerable, especially at the higher frequencies in this band.

Band Coverage Facts

W HAT are the conditions for the coverage of the broadcast band with a tuning condenser? Some broadcast receivers tune from below 550 kc to well above 1,500 kc while other receivers fail to cover the band by a wide margin. What determines whether a condenser does or does not cover the band?—E. S. N.

The determining factor is the ratio of the change in capacity of which the condenser is capable to the minimum capacity in the tuned circuit when the condenser is set at minimum. This ratio must be 0.44 or greater. Thus if the capacity of the tuning condenser can be changed by .0035 mfd., the capacity in the circuit when the condenser is set at zero should be 77.6 mfd. or less if the band is to be covered. If the capacity of the tuning condenser can be changed by only .0003 mfd., the minimum capacity cannot be larger than 54.5 mfd.. It is very difficult to design a circuit so that the minimum capacity is as low as that, especially if the coils are shielded, and it is for that reason that with .0003 mfd. tuning condensers the broadcast band can seldom be covered.

Curves for the 240 Tube

I F you have a characteristic curve of the 240 tube showing its performance in a resistance coupled circuit, please publish it. Or if you have published it recently, please refer to the issue in which it appeared.—V. A. V.

One of the curves in Fig. 853 is for the 240 tubes. As stated on the graph, the curve is for a plate battery voltage of 140 volts and a load resistance of 420,000 ohms, the measured value of a resistor rated at 500,000 ohms. The curvature at the top of the curve for the 240 tube is due to the fact that AC was used on the filament and that the grid drew current when the grid voltage with respect to the mid-point of the filament was less than 3.5 volts. The bias for amplification should be 5.5 volts since that point falls at the point of symmetry of the curve.
Vatican Takes Over Marconi's Broadcaster

Vatican City.

The high-power broadcasting plant erected here by the Marconi Company has been formally taken over by the Pope. This plant, which was constructed under the personal supervision of Senator Guglielmo Marconi himself, is now one of the most powerful transmitting stations in Europe. In accepting the plant His Eminence bestowed high praise on Mr. Marconi, who was the first to utilize radio waves for practical communication. The plant was officially connected to the Vatican Radio by Father Gianfranceschi, the chaplain-scientist of the Noble Arctic expedition in 1928.

bass can build up the bass in compensatory manner.

Automatic Volume Control

Automatic volume control will become popular with some of last season’s receivers, but this year the inclusion of such controls is almost as the rule in the better grade sets. The general method used is to couple an extra tube to the detector, because the radio frequency voltage at the grid is highest here, and to have this extra tube so biased that increases in carrier intensity produce corresponding increase in current flow in the tube. Hence any biasing resistor through which this current flows provides increased bias with increased carrier intensity, hence decreases the volume as the original amplitude increases. This resistor may be the common bias for RF tubes. Thus is a leveling effect produced. Some receivers have automatic volume control built into an extra tube. One way of doing this is radio frequency amplifiers on a higher negative bias than commonly prevails. This, with whatever detector is used, in radio and detecting circuits seems the general effect of increased bias with increased carrier amplitude.

Time Clock Tuning

Automatic clock tuning is beginning to show itself used in a tin clock and switch, and motor, whereby it is possible to set the tuning switch by tuning the receiver. At the output of the amplifier is connected the engraving head, which is a sort of inindented phonograph pickup. The needle of the head makes indentations on a blank record consistent with the audio fluctuations emitted by the output tube or tubes, as this blank is moved by a regular turntable.

There are two types of blank records. One type is used grooved records, as some track is necessary to keep the needle in concentric motion. The other system has a blank label to the turntable, and thus the recording head is caused to travel at the same speed of rotation as the turntable and to move concentrically over the surface. The records are 6 inches and 10 inches. The 6-inch record will play for about 1 minute and 15 seconds and the 10-inch record about 2 minutes and 25 seconds.

Tone Control Popular

Tone control consists of turning a knob or a switch so that certain audio frequency regions of tonal response will be accentuated. Thus, if one is listening to a speech, the fullest response in the high audio frequency region will be sought, so that the sibilants will be crisp and speech will be most intelligible. This is done by turning the control to “treble” or “brilliant.” In the same way, music may be accentuated to bring out only the violins or the piccolos. Also, the middle register may be accentuated, or the bass. A middle register tuning is recorded by the listener, while a fourth position, representing cutting the tone control out of circuit, is present.

The purpose of the tone control is to enable the operator to have the reproduction tuned to his taste. He can make the combination one tuned to his own liking without crashing the piccolos. Also, the middle register may be accentuated, or the bass. A middle range tuning is recorded by the listener, while a fourth position, representing cutting the tone control out of circuit, is present.

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National's Thrill Box

The short-wave receiver, known as the Thrill Box, was displayed in AC and battery-operated forms. The AC model is a twelve-station set, and has a very compact cabinet. The B supply, and operates without hum. The reception of unmodulated stations, however, is not remarkable for its clarity. The MB-30, designed by James Millen and Prof. Glenn H. Browning, also uses the MB-20 short-wave tuning condenser and coils, a Velvetcne push-pull power amplifier and special laboratory testing and measuring equipment, and is complete for $95.00.

Crystal Room Attracts Many

The Crystal Room was in full blast during this show. This consisted of a glass-enclosed studio designed by the National Broadcasting Company and the Columbia Broadcasting System used the Crystal Room as their own exhibit. The Crystal Room was displayed as a feature that drew large crowds, some of whose members never before had seen a broadcast actually on the air. Other stations contributed to the exhibition of talent.

Some of the two treats to some members of the crowd was to see how talks are made. In connection with this a public stunt was carried out by a talkie program company whereby the actors were made up to look like members of vocal quartets of show visitors, with the promise that winners would get at least a temporary job in Hollywood.

www.americanradiohistory.com
Washington.

...granting authority 20 present...Company, testified 30,000...channels to Broadcasting Spectrum, ninety...Federal...October 1, 1930...WOR, Newark, N. J., operated by a...store,...Detroit, has been...2,000 watts, it...WOR,...watts...WJZ is...National Broadcasting Company, and this fact was...as well. Some facts about the...WJZ's steady day-and-night service area was...miles radius, and estimated that the additional...20,000 watts would increase this to a...32-mile radius. The present dependable...be added, by 6,500,000 persons, whereas the...would bring the well-served population up...WJZ, Detroit, Mich., operated by the...radio service area is spotty, because to the north and north-...sent signals are attenuated, due to...Lost $544,219

To the south, southwest and west...city limits is sought, or 20 miles, said Walter K. Hoffman, chief engineer of the station, that $3,800,000 persons in Michigan can not be served adequately with the present...If the 30,000-watt petition is granted the...the city limits is sought or 20 miles, said Walter K. Hoffman, chief engineer of the station, that $3,800,000 persons in Michigan can not be served adequately with the present...WASHINGTON

WABC, New York City, outlet of the...Commission, stating that the site is now open to it, and asking approval. In this communi-...WABC, New York City, outlet of the Columbia Broadcasting System, which station had been granted a...site, which is not far from Wayne Township, Passaic County, N. J. The Columbia System has sent a...a request to the Federal Radio Commission...We wish to point out that within a...of the proposed site there are only twelve homes, of which five have receiving sets; one-mile radius, 142 homes, seventy-three receiving sets; one and one-half miles, 417 homes, 210 receiving sets; one and one-half miles, 736 homes, 390 receiving sets; two miles, 1,210 homes, 974 receiving sets. These computations were made after the...and 700,000 per...WABC, with transmitter at Crossbay Boulevard, Queens County, N. Y., operates on 5,000 watts.

NEW CORPORATIONS


The station reported an operating loss of $344,219 for the ten years ending August 1930, and stated its loss last year was $69,000.

WASHINGTON

High radio frequencies are now being employed in experimental medicine in the creation of artificial fevers with a view of determining their possible therapeutic and corrective properties, reports Dr. C. B. Jolliffe, chief engineer of the Federal Radio Commission.

The subject is being studied in private laboratories with considerable success, he stated. It has been found possible, he continued, to heat the internal organs of experimental animals without affecting the external tissues and the skin, and thus obtain the diathermic benefits of the impulses.

The possible hazard to the human con-...visit to the Naval Research Laboratory, at Bellevue, D. C., according to Capt. W. W. Curtis, chief of progressive medicine of the Navy. So far no ill effects have been detected, he said.

Experiments will be continued by the Navy to learn the therapeutic value of ultra-high frequencies, said Dr. Bell, but without devoting its attention either to preventive side at present. Frequencies as high as 60,000 kilocycles have been used to produce artificial fevers, according to Dr. Bell.

According to reports to the Federal Radio Commission, some spectacular demonstrations of the possibilities of ultra-high frequencies have been made.

Thus tomatoes have been cooked inside the pots without heating the can itself other than by conduction from the heated contents, and eggs have been boiled inside a glass jar without directly heating the glass container.

It is possible by means of special apparatus to concentrate the effect of the...waves to a given spot.

Lodge's London Talk

Heard on Chain Here

Sir Oliver Lodge, famous English physicist and socialist, in a talk in London, which was rebroadcast in America over the Columbia Broadcasting System, cited recent trends in science as evidence of the existence of the spirit apart from the body.

"I believe," said Sir Oliver, "that this...is continuous and that death is not a break in its continuity, but a..."in sloughing off of the material body. We go to a spiritual body, a body which we have, though it makes no difference to a large percentage of us. We shall continue in the spiritual body when the material body has been left behind."

In radio Sir Oliver is known as the...invention of tuning. Those who read the...ers on radio will discover that he used "tuning" for selecting a frequency to the exclusion of others. Synchronized circuits are tuned circuits.

SECRET SYNCY is SOUGHT

The Hague.

The Dutch postal officials are considering an invention between The Hague and the Dutch East Indies by which it is hoped that secrecy in transatlantic radio-phone talks may be obtained. At present any amateur with a suitable set can listen in to the conversations.


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A SHIELDED radio frequency transformer for use as antenna coupler or as interstage coupling, for screen grid circuits. The coil is wound on a 1% inch diameter bakelite former with No. 26 stranded wire, primarily on the outside, separated from the secondary by an insulating wrap 1/16-inch thick. The metal shield is placed over the primary, forming a complete loop. This metal shield prevents high-frequency pick-up. The shield is grounded through the coil former and a short wire lead attaches to the shield bottom. The four leads emerge through an insulated hole in the shield bottom. The coil assembly is already mounted on a shielded wooden base, which is fastened to the chassis. These coils are illustrated.

Precisely Matched for Gang Tuning

O NE primary lead-out wire from the coil, for single stage connections, has a braid shielded lead against stray pick-up when the stand alone is soldered to a ground connection. The windings are 6 inches long and are color identified. The wire terminals of the windings themselves, and the terminals, are soldered to copper rivets. Each coil comes entirely assembled inside the shield, with each coil 1% inch in diameter and 3% inches high. High impedance primaries of 60 turns are used. Secondaries have 20 turns for .00005 mfd. and 70 turns for .00005 mfd.

Junior Model Inductances

The Series B coils have the same inductance and the same shields as the Series A, but the primaries, instead of being wound over the secondary, are wound on separate, insulated bases, resulting in lower coupling. The braid shielded coil forms longer, and is fastened to the shield bottom plate by means of metal clips. The clips are not soldered. Order Cat. B-BH-3 for .00005 mfd and Cat. B-BH-5 for .0005 mfd.

Electricity in winding and spacing is essential for coils used in gang tuning. These coils are specially suited for gang condensers, because the inductances of all are identical. For the shielded base, the winding is identical. The coils are matched by a radio frequency oscillator. The color scheme is as follows: shielded wire used for antennas or plates; red for ground or B plus. (These colors are due to the same coil for antenna coupling or interstage coupling.) Blue is for grid and yellow is for grid return. For four units, the Cat. No. is A-44-BH. For .0005 mfd. Cat. No. is A-44-BH-8.

For a stage of screen grid RF, either for battery type tube, 222, or AC, 224, followed by a grid-leak condenser detector, no shielding is needed, and higher per-stage amplification is attainable and useful. This extra-high per-stage gain, not practical where more than one RF stage is used, is easily obtained by using dynamic tuners. Two assemblies are needed. These are furnished with condensers erected on a socketed aluminum base. Each coil has its tuned winding divided into a fixed and a moving segment. The moving coil, actuated by the condenser shaft itself, acts as a variable-meter, which bucked the fixed winding at the low wavelengths and aids it at the high wavelengths, thus being self-neutralizing and maintaining an even degree of extra-high amplification throughout the broadcast scale.

For AC operation (224 RF and 224 or 227 detector), use Cat. BT-L-AC and BT-R-AC. For battery or A eliminator operation (222 RF and any tube as detector), use Cat. BT-L-DC and BT-R-DC.

For the antenna stage and BT-R for the detector input, BT-L consists of a small primary, with suitable secondary for the .0005 mfd. condenser supplied. BT-R has two effective coils; the tuned combination leading in the RF plate circuit, the inside fixed winding in the detector grid circuit. This combination is stated as the "antenna type." This is done as follows: Turn the condensers until plates are fully excited, then have the moving coils parallel with the fixed winding. Turn the highest wavelength station receivable—50 meters—shielded coil until the moving coils half-way round and return to bring in the station. The setting that represents the "station" that station is the correct one. If gain tuning is used, use a 4:1 step switching condenser across the variable. Then adjust the equalizer for a low wavelength 1500 meters or less.