10w

RADIO WORLD

REG. U.S. PAT. OFF.

The First National Radio Weekly — *639th Issue 13th Year*

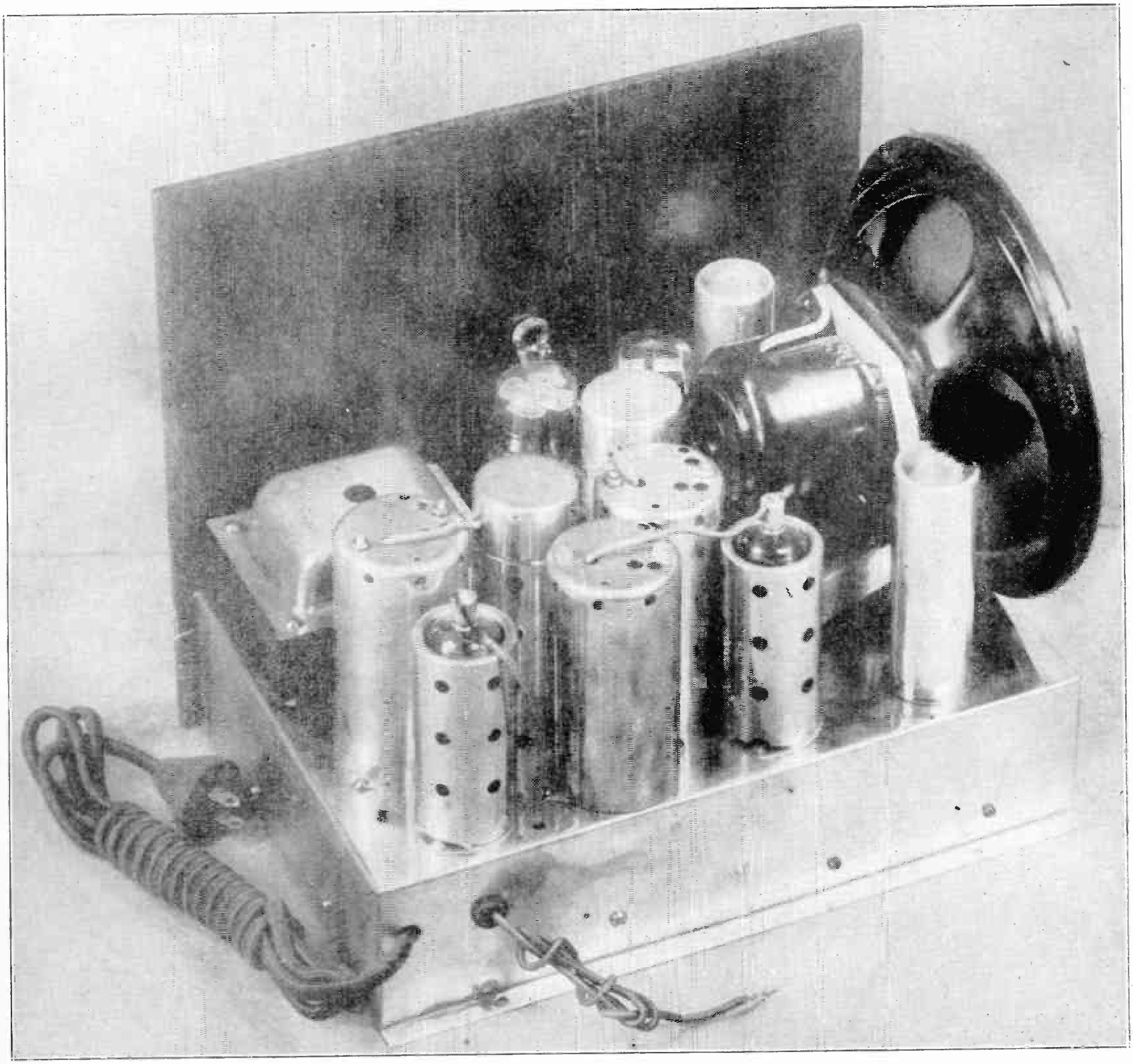
JUNE 23rd
1934

15c
Per Copy

Short-Wave Inductances

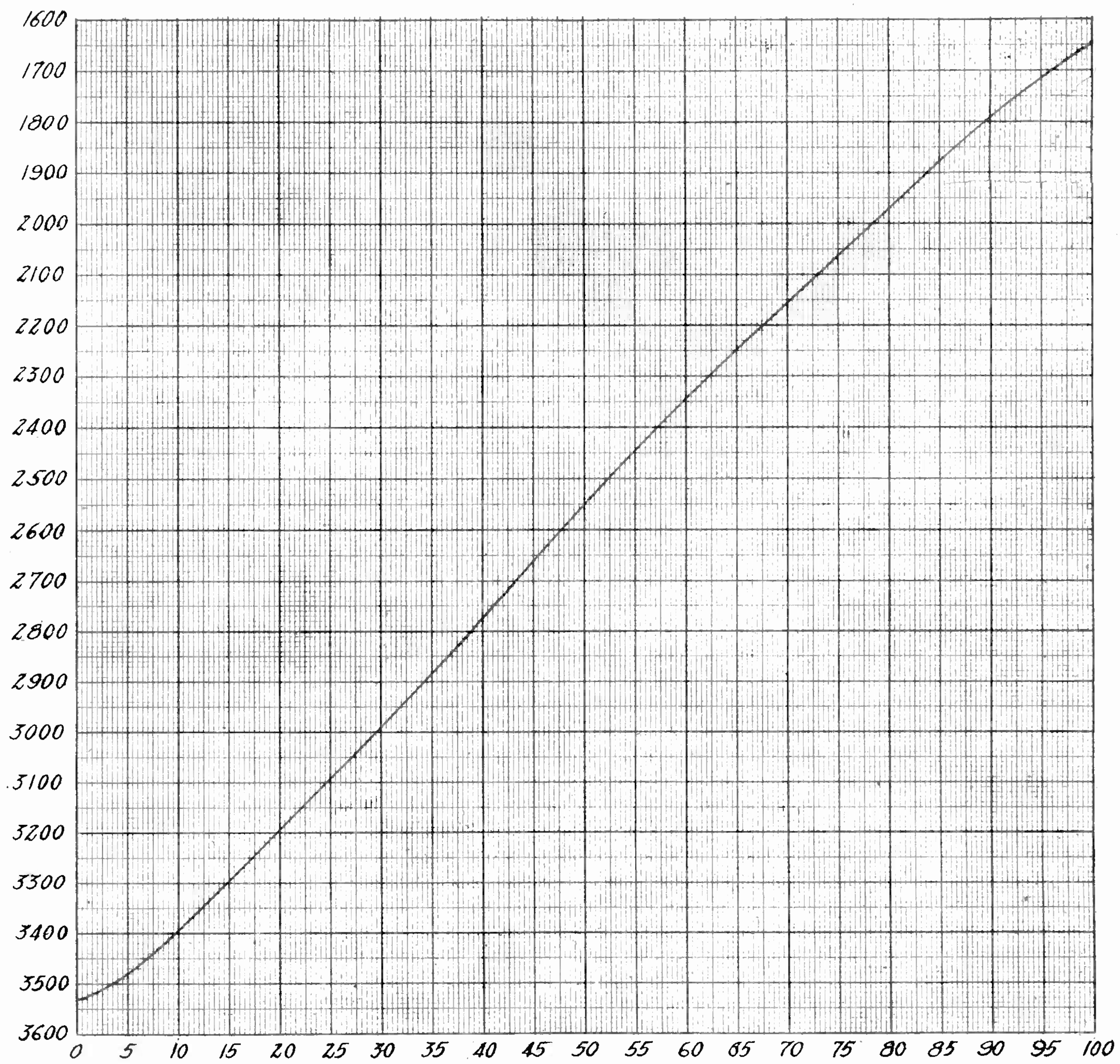
New 12A7 Tube in Midget

A Station-Finder



This time-signal receiver is useful for jewelers, astronomers, power companies, and others especially interested in highly-accurate time and checking low frequencies.

1,645 to 3,530 Kc Chart for Hammarlund 0.00014 Mfd. and Green-Ringed Alden Coil



With this issue is begun publication of a series of charts relating frequencies to the dial settings for the popular Hammarlund 0.00014 mfd. condenser of the single-hole panel mounting type. This is a midline condenser and is not be confused with the straight capacity line small condensers made by the same manufacturer. As so many readers have short-wave sets using the Hammarlund condenser of this midline type, and commercially-wound plug-in coils, the information thus imparted as to where frequencies will come in on the dial is vastly important, especially since all the popular makes of plug-in coils will be charted in connection with this condenser. There are four charts to any series relating a particular condenser to the short-wave coils used. The next two higher frequency brackets for the Alden coils and this condenser will be found on pages 19 and 20, while the highest-frequency band will be given next week, issue of June 30th.

DISPOSAL OF R.C.A. SHARES

Only 7½ per cent of the outstanding common stock of the Radio Corporation of America is now owned by the Westinghouse Electric and Manufacturing Company and the General Electric Company. At the time the Federal consent decree that dissolved the relationship between the electrical companies and R.C.A. was entered into on November 21st, 1932, these companies owned 61 per cent. General Electric Co. distributed to its stockholders on February 20th, 1933, exactly 4,807,321 of its 5,188,755 common shares in the R.C.A., while the Westinghouse Company disposed of 1,334,000 of its 2,842,950 common shares in the R.C.A. to its stockholders. Nineteen months remain in which to dispose of the rest of their holdings.

LITERATURE WANTED

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Joseph L. Berry, 140 Reiman St., Buffalo, N. Y.
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Joseph Gutowski, 31 Main St., South River, N. J.
Wayne Clay, Prop., The Radio Laboratories, 402 East Elm St., Springfield, Mo.
H. C. Boss, 1354 E. Harvard St., Glendale, Calif.

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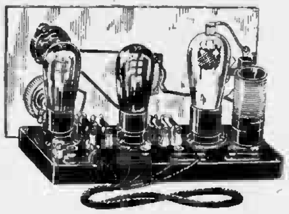
Plants of the Sparks-Withington Company, of Jackson, Mich., are reported by Harry Sparks, vice-president, to be operating twenty-four hours a day, with unfilled orders on its books exceeding those at any time since the fall of 1928. More than 9,000 automobile horns are heing turned out daily; also production is expanding in the refrigerator and radio plants.

* * *

Stewart-Warner Corporation and Subsidiaries—Net profit for the quarter ended March 31, 1934, after taxes, depreciation and other charges, $167,495, which equals 13 cents a share on 1,246,847 $10 par capital shares. This contrasts with a net loss in the first quarter of 1933 of $775,005. Total sales were $4,045,721, compared with $1,462,531.

"JIFFY 3" Short Wave Set



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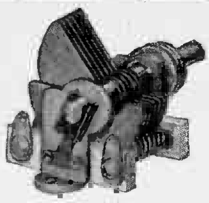

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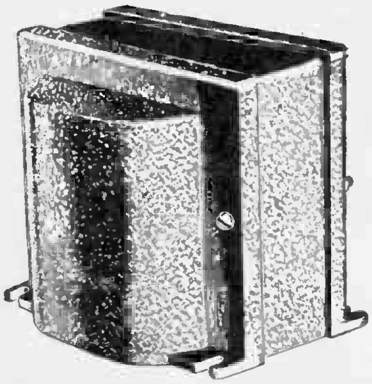

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Secondary Y = 6 amp., 2½ v., ct.
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Issue of June 9, 1934—Two Short-Wave Receivers Using 25Z5; Precision Calibration of High Frequencies; The 19-Tube for Short Waves; Short-Wave Midget; Short-Wave Tuners (Part V of "The Short-Wave Authority").

Issue of June 16, 1934—Finding Frequencies in a Small Short-Wave Set; Tuning Charts for All Plug-in Coils; The Mascot "Two" Short-Wave Set; Types of Receivers Used for Bringing in Short Waves (Part VI of "The Short-Wave Authority").

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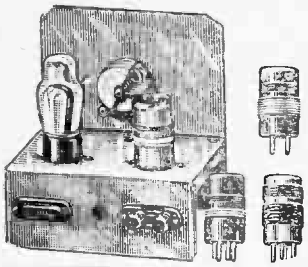

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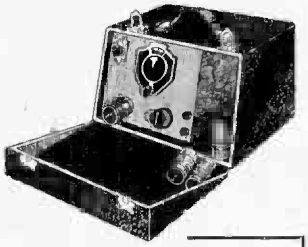

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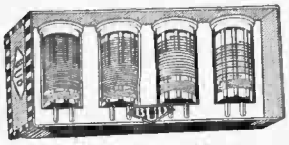

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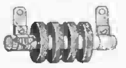

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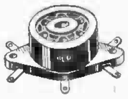

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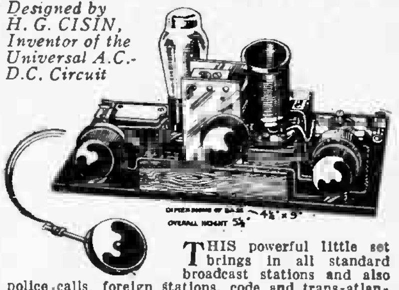

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Roland Burke Hennessy
Editor

Herman Bernard
Managing Editor

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The First National Radio Weekly
THIRTEENTH YEAR

J. E. Anderson
Technical Editor

J. Murray Barron
Advertising Manager

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SHORT-WAVE ASPECTS

of Inductance, Capacity and Resistance

By J. E. Anderson and Herman Bernard

[*This is the seventh instalment of "The Short-Wave Authority." The eighth will appear next week.*—Editor.]

ANY electrical circuit, or portion of such a circuit, has three properties; inductance, capacity, and resistance. A coil is supposed to have inductance exclusively, yet it has both capacity and resistance. A condenser is supposed to have capacity only, but every condenser has also inductance and resistance. And a resistor, supposed to be the seat of resistance only, has both inductance and capacity. A device is called an inductor (coil), or condenser, or a resistor according to the property it is supposed to have predominantly. But it may not have the same property at all frequencies. For instance, a coil may be an inductor at low frequencies, yet may become a condenser at high frequencies. A resistor may also change to a condenser as the frequency becomes high. In dealing with short-wave circuits it is necessary constantly to keep in mind that the properties are distributed.

Inductance

If electric current flows through a conductor a magnetic field is set up about that conductor. The total magnetic flux about the conductor per unit of current is a measure of the inductance. The same applies to an entire circuit. Since there can be no current unless there is a closed circuit, the inductance of a circuit is the total magnetic flux threading the circuit per unit of current. The inductance of a coil can be measured by noting the change in the total inductance of a circuit when the coil is inserted or removed. It can also be measured by substitution, that is, by first inserting the coil under test in a given circuit and then substituting a known and adjustable inductor in its place, adjusting until the known has the same effect as the unknown had when it was in the same position.

For certain simple forms of conductors the inductance can be computed with the aid of well-known formulas. If all the factors affecting the inductance are taken into account, the computed inductance will be the same as that obtained by measuring by substitution, assuming that the standard was correct. When the form of the conductor is irregular it is not possible to compute the inductance, but it is still possible to measure it.

In dealing with inductance it is common practice to put a coil in a circuit and assume that the measured or computed value of the inductance of this coil is the total inductance in the circuit. We have just found that this is not the case, for the conductors closing the circuit also have some inductance, and even a condenser has some. Therefore the effective inductance in the closed circuit will be greater than the inductance of the coil alone, and the frequency of resonance if the circuit is periodic will be lower than that computed by using the inductance of the coil and the capacity of the condenser.

Broadcast Frequencies

For frequencies in the broadcast band and for lower frequencies, the difference between the actual frequency of resonance and that obtained by using the computed value of the inductance of the coil is small and usually negligible. But for frequencies much higher than broadcast frequencies, that is, higher than 1,600 kc, the inductance of the connecting leads is often of the same order of magnitude as the inductance of the coil inserted in the circuit. Large errors must be expected. Indeed, it is entirely unpractical to attempt accurate computations at the short-wave frequencies.

One fact that should be kept in mind is that a coil is not always an inductor, but may be a condenser. A coil may be inserted in the circuit for its supposed high reactance, yet the reactance may be low due to the fact that the coil has become a condenser. Instead of inserting a choke in the line, then, we insert a condenser and only aggravate a condition the coil was intended to remove.

The self-capacity of a coil depends on the size of the coil, size of the wire, the separation between the turns, and on the materials used for coil form and wire insulation. In designing an inductance coil, whether it is to be used in a tuned circuit or in a filter, the self-capacity should be kept as low as possible. This will be accomplished by making the coil form as small as practicable, by using air for insulation for the most part, and by separating the turns. A choke coil that is to be used at very high frequency should be wound in sections having a shape somewhat like a coin, the sections should be mounted coaxially with an axial separation of about one-fourth inch, and the sections should then be connected in series aiding. A coil so constructed will have a negligible self-capacity even at frequencies as high as 30,000 kc, yet it may have a comparatively high inductance.

Selection of Inductance

In designing receivers the question of choice of inductance always comes up, and several times for each set at that. Well, how much inductance should be used? We have to know what the function of the coil is before we can answer the question. Is the coil to be used for tuning or for choking?

Suppose that the purpose of the coil is filtering. The first requirement then is that it have as high reactance as possible. But reactance is a direct function of frequency, and therefore we must know the frequency at which it is to function. We then have to make the reactance at this frequency as high as practicable or necessary. In case the coil is to be used in a circuit where the frequency will vary, we usually select the lowest frequency as the frequency at which the coil is to have a certain reactance, for then it will have a higher reactance at all other frequencies, if we assume negligible self-capacity.

A filter or choke coil is usually employed in shunt with some other device, such as a resistor or a condenser. The inductance then will depend on the reactance of this device. The choke should have such a high inductance that when it is connected in shunt with some device there should be a negligible lowering of the total reactance. If the coil is used in series with some other device, the choke should have an inductance so high that

(Continued on next page)

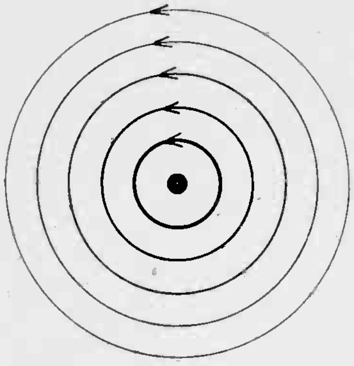


FIG. VII-1
The concentric circles represent the magnetic field about a conductor. The intensity is inversely proportional to the distance from the center. Direction arrows indicate that the current flows toward the observer.

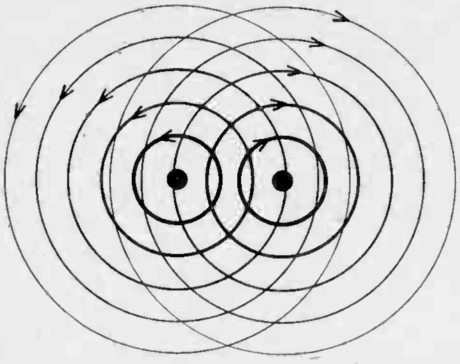


FIG. VII-2
The magnetic fields about two parallel conductors carrying equal currents in opposite directions. The fields partly neutralize each other, making the resulting inductance small, compared to the condition of in-phase currents.

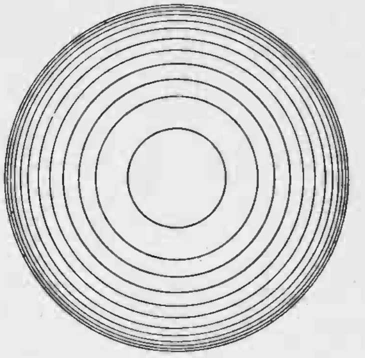


FIG. VII-3
This represents the manner in which the current distributes itself in a wire. Most of the current is near the surface, and the concentration is greater the higher the frequency. This outside concentration is known as the "skin effect."

(*Continued from preceding page*)

the reactance of the other parts in the series is negligible. As an illustration of the use of a choke coil let us take the output circuit of a detector operating between broadcast and audio frequencies. There is a by-pass condenser of 500 mmfd. between the plate and the cathode of the tube and the choke is connected in series with the output circuit, that is, between the plate and the primary of an audio transformer. The audio transformer primary amounts to a condenser at 540 kc, the lowest broadcast frequency, and we may assume it to be 100 mmfd. We then have a choke in series with a condenser, and the reactance of the choke, let us say, is to be 10 times the reactance of the condenser. This reactance is nearly 3,000 ohms and therefore the reactance of the choke should be 30,000 ohms. Therefore the inductance of the choke should be about 9 millihenries. Of course, a higher value may be used.

In the preceding paragraph we considered only the series circuit. We have also to consider the shunt condenser, which we assumed to be of 500 mmfd. Its reactance at 540 kc is nearly 600 ohms. Since the choke we have already selected has a reactance of about 30,000 ohms, all the conditions are satisfied.

Tuning Inductance

When we are to use the coil in a tuned circuit, the inductance must be such that it resonates with a specified capacity at a given frequency. Suppose that we have a variable condenser with a maximum capacity of 350 mmfd. We may assume that coil will have a self-capacity of 5 mmfd. and that the tube preceding the tuner will have a capacity of 10 mmfd. Then the total maximum capacity in the circuit will be 365 mmfd., which is the specified capacity. Now the lowest frequency in the broadcast band is 540 kc, so we shall take that as the given frequency. What should the inductance be? The answer may be found on curves relating the frequency, the capacity, the inductance, or it may be found by substituting in the frequency formula giving the same relation. The answer in this particular case is 238 microhenries.

When the inductance of the coil is as high as the value just obtained the distributed inductance of the circuit outside the coil is negligible and for that reason it is permissible to say that circuit will just tune to 540 kc. But suppose the frequency had been ten times greater and the inductance had been only 2 microhenries; the distributed inductance would not have been negligible in that case.

The Magnetic Field

The magnetic field about a straight wire carrying current is concentric with the wire, is intense very close to the wire, and decreases in intensity directly as the distance increases. This may be represented as in Fig. VII-1, in which central dot represents the cross-section of the wire in which current flows and the circles represent the magnetic field. The first circle is drawn heaviest to indicate at this point the field is strong, and the last circle is drawn with a fine line to indicate that here the field is weak. Circles, of course, do not clearly show how the field varies but they do show the direction of the field. The arrows indicate that the field is produced by a current that is flowing toward the observer.

Fig. VII-2 shows two superposed fields due to two wires placed close to each other. The left-hand system is the same as that in Fig. VII-1 and therefore the current is flowing toward the observer. In the right-hand system the field is in the opposite direction. Hence in this case the current flows away from the observer. The case may be that of two parallel conductors in which the same current flows in both. The two conductors may be the go and return branches of a loop of the same wire.

The inductance of a circuit or a portion of a circuit is the total magnetic field associated with that circuit or part per unit of current. In Fig. VII-1 there is nothing to interfere with the field and the inductance is high. In Fig. VII-2 the two fields mutually interfere and the inductance is less than if there were only one wire. In the limiting case when the two wires coincide the field is zero for that of one wire completely neutralizes that of the other. Of course, it is not possible to make the wires coincide, nor even to touch each other if there is not to be a short circuit. Hence there will be some residual inductance no matter how close together the wires may be.

Bringing Out Leads

Non-inductive resistors are often wound by the go and return method illustrated in Fig. VII-2. Yet it is not the best method for this purpose because as the distances decrease between the wires the capacity increases. Thus we may have either a high inductance and a now capacity or a high capacity and a low inductance, but we cannot have both low inductance and low capacity.

In a spool of wire or solenoid the turns are side by side just as in Fig. VII-2, but the direction of the current is the same in every turn. Therefore the magnetic fields superpose constructively, and the inductance of the coil is increased. It is obvious that the closer the conductors are together the higher the inductance will be for the same number of turns. But the higher will be the distributed capacity.

The self-inductance of a condenser is affected by the manner in which the two leads are brought out. Suppose they are far apart all the way to the binding posts. The leads will have inductance but fields will in part be canceled by the fact that the leads constitute a pair of go and return. But the cancellation will be less when the leads are far apart than when they are close together. In an ultra-short wave circuit the inductance of the leads to the condenser and to the tube often constitutes all the inductance in the circuit, and it is considerable.

Condensers

There are condensers of many sizes, from about 0.5 mmfd. to 50 microfarads, and such wide variations are likely to occur in the same receiver. The very small capacities are used ordinarily for coupling and the very large ones for by-passing where there is danger of audio frequency feedback.

The choice of bypass capacity is based on about the same principle as the choice of inductance for a choke coil. The capacity required depends on the frequency, the impedance across which the condenser is put, and on the thoroughness with which the alternating current must be removed from the by-passed impedance.

Suppose the condenser is connected across the resistor of 300 ohms and that the lowest frequency in the signal current is 540 kc. The condenser is to have such a low reactance that the signal voltage drop is reduced to one per cent. of the value when there is no condenser across the resistor. What should the capacity be? Well, the reduction is so large that we need not consider the resistance at all when the condenser is across it. Assuming that the current in the circuit does not change when the condenser is connected, the ratio of the two voltages is CRw, where C is the capacity in farads, R the resistance in ohms and w is the frequency multiplied by 6.28. The product should equal 100. Hence at 540 kc, C should be very nearly equal to 0.1 microfarad.

This value of by-pass condenser is often used across a 300-

ohm bias resistor for a 58 tube, for example; but the reduction in the radio-frequency voltage is hardly enough to prevent oscillation in some instances, not without additional filtering. Condensers of the order of 1.0 or 2.0 mfd. do the filtering properly across small resistors.

The Coupling Condenser

When a small condenser is used for coupling the required capacity also depends on the frequency and on the impedances surrounding it. While it is customary to say that the small condenser is used for coupling, it would be more nearly correct to say that it was used for uncoupling, at least in some instances. Suppose there are two resonant circuits tuned to the same frequency and that they are not coupled inductively or resistively. A very small condenser is then connected between the high potential sides of the circuit, the other sides of the circuits being at ground potential. Are the two circuits coupled now, that is, will energy be transferred from one to the other? The answer depends on what we mean by circuits. We can call the entire combination one circuit. In that case if there is current in any portion it will necessarily flow in all the circuit. Or we can say that there are three meshes in the complex circuit in which the middle mesh consists of the two tuning condensers and the coupling condenser. On this view the two tuning condensers are the coupling condensers, for they are the elements which constitute common impedances. It seems that the latter view is the more logical and that the so-called coupling condenser aids in the formation in a coupling link or coupling mesh.

Regardless of how the coupling is looked upon the two resonant loops are loosely coupled together if the coupling condenser is very small and closely coupled if it is large. The smaller the condensers in the tuned circuits are, the smaller must the coupling condenser be in order that the coupling should have a specified low value. That is, the required value of the coupling capacity for a specified degree of coupling depends as much on the tuning condensers as on frequency.

The choice of condenser for a tuner in which the tuning is done by varying the capacity depends on the frequency range to be covered. It is usually desirable to have the capacity at any one setting as small as practical, and this requires that the minimum capacity in the circuit be as small as possible and that the tuner does not cover a wire frequency range than is necessary.

Capacity Ratios

The present broadcast band ranges from 540 kc to 1,600 kc, making the ratio of the highest to the lowest frequency 2.96. The capacity ratio in the tuner, that is, the ratio of the maximum to the minimum capacity, should be the square of this, namely, 8.78. About the lowest minimum capacity that can be obtained in a shielded tuned circuit operating between two vacuum tube amplifiers is 25 mmfd., but in most practical cases more is allowed. Let us assume that the minimum is 45 mmfd. The maximum should then be 45 x 8.78, or 395 mmfd. Of the total minimum about 15 mmfd. would be outside the tuning condenser. Therefore the maximum capacity of the condenser alone would be 380 mmfd.

This capacity is larger than the usual tuning capacities in broadcast sets by approximately 25 mmfd. Suppose the maximum capacity of a tuning condenser is 350 mmfd. and that the distributed capacity in the circuit outside the condenser is 15 mmfd. What must the minimum capacity in the circuit be if the present broadcast band is to be covered? The maximum capacity will be 365 mmfd. and therefore the minimum must be 365/8.78, or 41.6 mmfd. That value is easily obtainable and for that reason it is not difficult to cover the present broadcast band with the tuning condenser that was designed for a slightly narrower band.

When the tuner is to operate at only one frequency, as in the case of the intermediate frequency selector of a superheterodyne, highest sensitivity will be obtained if the total tuning capacity is as small as practical; and the smallest possible is the sum of the self capacity of the coil and the tube capacity. If the coil and the tube are shielded, this might be as high as 50 mmfd. Besides this minimum there must be a trimmer with which to effect tuning, and this might have a maximum capacity of 50 mmfd. With the added condenser the minimum capacity might be of the order of 70 mmfd. The tuning coil should have such inductance that it would resonate near this minimum.

Condenser Construction

Any two conductors placed near and insulated from each other form a condenser. One of the conductors may be the earth, so that a single conductor will have capacity.

The capacity of any condenser depends on the effective area of the opposing conductors, the distance between them, and on the dielectric constant of the insulator separating them. The capacity is directly proportional to the area, inversely proportional to the distance between them, and directly proportional to the dielectric constant.

A tuning condenser usually is of the air dielectric type, and in such a condenser the capacity depends only on the area of the plates facing each other and the distance between them, for the dielectric constant of air is unity. Naturally, a condenser

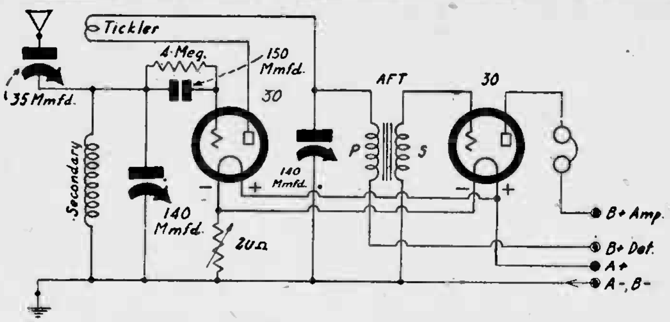


FIG. VII-4

The regenerative detector at left in this figure represents inductance in the secondary and tickler, resistance in the grid leak and capacity in the tuning condensers and grid condenser.

cannot have 100 per cent. air insulation, for the plates must be held firmly at a given distance apart, and this can only be done with rigid insulation. Insulators used for holding the opposing plates at definite distances apart are bakelite, mica, hard rubber, glass, porcelain, quartz, and many other materials that are sufficiently rigid and which at the same time do not introduce losses. In a well constructed tuning condenser possibly only one per cent. of the insulation is other than air, and the solid insulators are placed in weak electric fields so as to minimize losses. The least amount of the solid insulator that will satisfy the mechanical requirements is the best electrically.

In so-called paper condensers the two conductors take the form of thin metal foils and the insulator is a thin strip of paper impregnated with some oil or wax. Two strips of foil and two of paper are stacked up alternately and then rolled firmly together. After the winding the condensers are impregnated with wax.

Paper condensers made in this manner may be either inductive or non-inductive, depending on how the terminals are connected to the metal foils. If the terminals are connected to the ends of the foils, the inductance is comparatively high because then the condenser simulates a coil. But if the terminals are connected to the sides of the foils, and along the entire length, one terminal being brought out at one side and the other terminal at the other side, the inductance is practically zero.

Formation of Electrolytics

If the by-pass condenser is to be used in circuits where only low frequency currents flow, it makes little difference which type of condenser is used, for the inductance is negligible in either case. Cost of the condenser would be the determining factor. If, on the other hand, the condenser is to be used for by-passing high frequency currents, only the non-inductive type will do, for otherwise the condenser might act as a choke.

When extremely large capacities are required it becomes uneconomical to use paper condensers and electrolytic condensers are used in their place. They are made by immersing thin sheets of pure aluminum in certain solutions and passing a current through the solution and the metal sheets. A thin layer of aluminum oxide is formed on the positive plate and this layer forms the dielectric. Because the layer is extremely thin the capacity of the condenser is very large per unit of conductor surface.

This thickness of the film, and therefore the capacity of the condenser, depends on the voltage used in forming the layer. For a very thin film the capacity is very large, but then the condenser cannot be used for high voltages. If the forming voltage is high, the capacity is small, comparatively, because then the film is thick. Such a condenser can be used on high voltages. The highest voltage that can be used depends on the electrolytic and on the kind of metal employed, the limit being between 400 and 600 volts.

Leakage Current

There is always some leakage current through an electrolytic condenser. This is very small if the aluminum electrodes are pure. Very small amounts of impurities, such as other metal particles, will increase the leakage current because no oxide film will form on these impurities. While a high leakage current is detrimental, a small leakage is essential, apparently, to maintain the film of oxide.

The leakage current is a function of the voltage across the terminals of the electrolytic condenser. Thus at 400 volts and below the current may be 5 microamperes per farad while at 500 volts it may be ten times as great. As the voltage increases the increase in the leakage current is very rapid.

Electrolytic condensers have polarity, for the oxide film has formed on the positive electrode. If the polarity is reversed, the oxide film breaks down, and the condenser ceases to function. It is very important that the polarity be observed because

(Continued on next page)

(*Continued from preceding page*)

if the voltage is reversed, a heavy current will flow and this will cause heating in the condenser, which, if prolonged, might end in an explosion.

The capacity of an electrolytic condenser depends not only on the active surface of the conductor and the thickness of the film, but also on the frequency. The capacity is greatest at zero frequency, but it decreases only slowly as the frequency increases. Just the same, the effective capacity of an electrolytic condenser at radio frequency is only a small part of the capacity at low frequencies. Besides, the effective series resistance of the condenser may be high at radio frequencies, whereas at audio frequencies the resistance may be negligible. Because of the low capacity and the high resistance at radio frequencies, electrolytic condensers are not used at these frequencies. When both low and high frequencies are to be by-passed, it is common to connect a small mica or paper condenser in shunt with the electrolytic.

Resistance

If a current I is flowing in a circuit or conductor and energy is lost at the rate of W watts, the resistance is $R = W/I^2$, that is, the ratio of the power lost to the square of the current. This definition is quite general and applies to direct current as well as alternating current of any frequency. The loss need not represent a conversion of electrical energy into heat energy in the wire, for part of the energy may become radiant, when it would not be a loss at all, but only energy absorbed from the source. In certain cases the energy radiated is really lost, because the radiation takes place where it is not desired. As an example, an open transmission line radiates a little energy all along the line, and that is lost because it does not get to the antenna where it could be radiated usefully.

The resistance of wires and other forms of conductors is well known for the metals and most alloys in respect to direct current, but it is not the same for alternating current; and the higher the frequency the greater is the deviation from the direct-current values.

The increase in resistance as the frequency increases is mostly due to what is known as the "skin effect." When the current is rapidly alternating it cannot penetrate into the interior of a conductor because of the formation of eddy currents. The current density decreases very rapidly as the distance from the surface increases. Fig. VII-3 gives an idea how the current density decreases, although the decrease is so rapid at high frequencies that it is impossible to make a true representation.

Penetration of Wire by Current

It is clear that the concentration of the current near the surface of the conductor increases the resistance, for it is the equivalent of decreasing the cross-section of the wire. About 98 per cent. of the total current flows in an extremely thin layer near the surface. That this is the case is brought out by numerical examples. If the conductor is heavy and of copper it can be proved that the current density is reduced to 2 per cent. of its surface value at a depth given by $\mathbf{d} = 26.1/n^{1/2}$ cm, where n is the frequency of the current. Since the current density decreases rapidly, it is obvious that although the current density has been reduced to 2 per cent., the percentage of current deeper than **d** is very much less than 2 per cent. of the total current. If we assume that the frequency is one million cycles, the depth is 0.261 mm; and if we assume that the frequency is 100 million cycles, the depth is only 0.0261 mm.

The penetration depends not only on the frequency but also on the conductivity of the material and on the magnetic permeability. The greater the conductivity the less the penetration. Thus if we had taken silver the penetration would have been less than what we found above, but if we had taken a lead conductor, which has a low conductivity, the pentration would have been much greater. Had we selected iron with a high permeability, the penetration would have been practically zero even at one million cycles. The penetration is greatest in non-magnetic conductors of low conductivity, but the skin effect is the greatest in conductors of conductivity and high permeability.

Use of Stranded Wire

It is clear that mere avoidance of skin effect is not desirable in a conductor when the loss is to be low. Nothing is gained by using a conductor of low conductivity. The only way to avoid the skin effect advantageously is to break up the conductor so that no appreciable eddy currents can flow. Stranding the conductors as is done in Litz wire will break up the eddy currents and will increase the effective conducting area, provided the frequency is not excessive. Unfortunately, it is not practical to use this wire at ultra-high frequencies, for the losses are usually greater with stranded wire than with solid. This is due to the fact that the individual strands cannot be made fine enough to avoid surface concentration of current and to the fact that necessary insulation of the individual strands introduces losses.

Proximity Effect

All the loss of energy from a coil carrying high frequency current does not occur because of resistance in the wire. We have found that loss occurs by radiation. There is also loss in the insulation about the coil, because no matter how good an insulator is, it is never perfect. Losses will also occur because of the proximity of the current-carrying conductor to other conductors. Eddy currents are set up, and wherever a current flows there is loss of energy. If there are many turns in a coil carrying the same current, supposedly, the current in each turn will set up eddy currents in the other turns.

Wherever a high frequency coil may be placed, there will always be other conductors around. In practically all cases where a high frequency coil is used there is also a tuning condenser. It must necessarily be fairly close to the coil, and therefore there will be losses by eddy currents. There will also be shielding around the coil, or between the coil and the operator. If there is any need for a shield at all, there will be eddy currents in the shield when it is put in position, for only the eddy currents make the shielding effective. Losses result. When the entire coil is placed inside a metal shield, large eddy currents flow in the shielding and these add to the losses. The shield around a coil should be as large as space permits, for the larger the shield the lower will be the losses, but the shielding will be equally good.

A Piezo
Using Rochelle Salt

By J. E.

USES of the piezo-electric effect are multiplying rapidly. The two main applications are to frequency control and microphones. For frequency control quartz crystals are used for the most part, but tourmaline is used occasionally for the higher frequencies. For microphones Rochelle salt crystals are used because these crystals show by far the greatest effect.

A noteworthy development in piezo-electric microphone design has been made by the Brush Development Co., Cleveland, O. To get a clear idea of the principle on which the microphone works let us review the properties of the Rochelle crystal. In Fig. 1 we have a section of such a crystal and the three axes of figure, *aa*, *bb*, and *cc*. A slice of the crystal in the form of a parallelopiped has been sketched by dotted lines. This slice lies in the plane of *bb* and *cc* and it is perpendicular to axis *aa*.

In Fig. 2 this slice has been lifted out of the crystal rough. Suppose, now, that an electric force is impressed across the crystal in the direction *aa*. The crystal becomes distorted in the direction of the arrows, that is, so that a square slice would become diamond-shaped.

The method of applying the electric force across the face is to cement tin foil to the two faces and to apply a potential difference to the foils.

Obtaining Flexure

In Fig. 2 a rectangular bar has been sketched in such a direction that the long dimension of the bar is parallel to the elongation of the crystal and so that the short dimension is parallel to the contraction of the crystal. When an electric force is applied to this bar in the direction of *aa* the bar will lengthen or shorten depending on the polarity of the applied force.

Now let another bar be prepared from a similar crystal slice, but in this case let the long dimension be in the direction opposite to that in Fig. 2, that is, at right angles. The long dimension will now point to the opposite corners of the square. This bar, also, will respond to an electric force applied in the direction *aa*, but it will respond the same way when the polarity is opposite. If these two bars are placed side by side and if they are subjected to the same electric stress, one will shorten and the other will lengthen. The strains will be small, even when the stresses are high, but they can be increased enormously by combining the effects of the two bars of opposite polarity.

Let the two bars be cemented firmly together so that mechanically they are one, and let one end of the assembly be clamped so that it cannot move under the applied stress. The other end will be free. Now when the electric force is applied across the crystal in the direction *aa*, one of the components will lengthen and the other will shorten. Since the two bars are cemented together, the only strain will be a flexure. If the combined bar started out straight, it will become curved; and since one end is firmly clamped, all the bending will appear as a transverse movement of the free end. This movement will be very much greater than the elongation or contraction of either component of the bi-element bar. It is this effect that is utilized in sensitive loudspeakers, and it is the converse effect that is applied in crystal microphones.

Construction of Microphone

We have just found that the composite bar bends under an applied electric stress. The converse of this effect is also true, that is, if a bar of this construction is bent by a mechanical

Microphone
Crystal for Conversion
Anderson

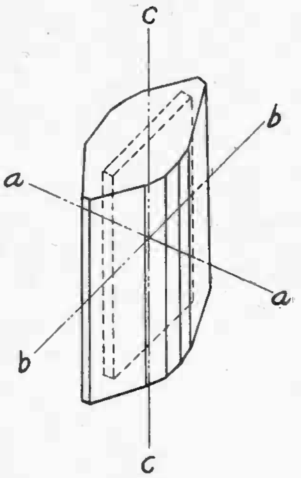


FIG. 1
This represents a Rochelle salt crystal and shows its principal axes of reference. The dotted lines show how a sensitive slab is cut from the crystal.

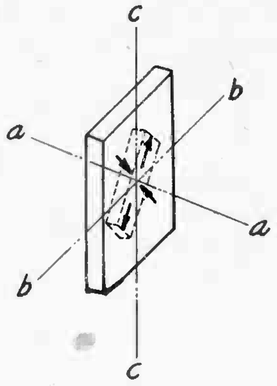


FIG. 2
A bar has been cut from the slab in Fig. 1 in such a direction that the long dimension is parallel and at right angles with the principal strains (arrows).

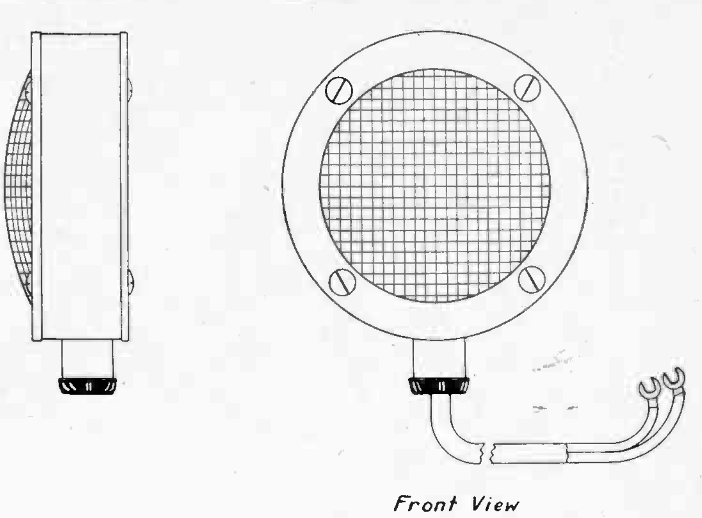


FIG. 4
Front and side views of the completed piezo-astatic microphone of the Astatic Microphone Laboratory. The microphone was kindly supplied by the company.

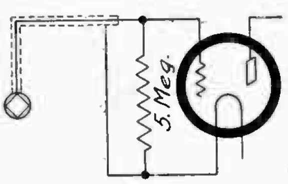


FIG. 6
The input circuit of an amplifier when the piezo-astatic microphone is used. There must be no polarizing voltage on the microphone and a high resistance leak must be used.

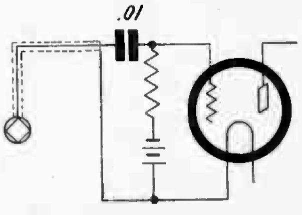


FIG. 7
Another input circuit for a piezo-astatic microphone, which isolates the crystal from the tube and permits the use of a grid bias. A high resistance leak is essential.

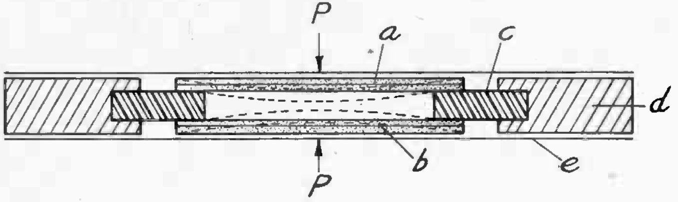


FIG. 3
This shows the construction of the Brush sound cell, a sensitive microphone based on the use of composite crystals made of two simple slabs having opposite polarity.

force, an electric difference of potential appears across the opposite faces. If the mechanical force is due to the pressure of a sound wave, there is a relation between the intensity of the sound and the generated electric potential. In other words, we have a piezo-electric microphone.

The structure of such a microphone is shown in Fig. 3. There are two of the composite, or bi-element, bars (1) and (2). They are held apart by separating and damping details (3), which are set in the mounting pieces (4). On each side of the assembly is a membrane (5), which seals the unit from the outside air. The air pressure acts in the direction P, bending the composite bars inward, as shown by the dotted lines. The bending produces a voltage across the opposite faces in each composite plate. The two are connected in parallel. This assembly is called a sound cell, and is a miniature microphone of comparatively high sensitivity. Many of these cells can be combined.

In Figs. 4 and 5 are the front and side views, respectively, of the model D-104 piezo-astatic microphone of the Astatic Microphone Laboratory, Inc.

The piezo-astatic microphone is very sensitive provided that it is used under the proper conditions. The first condition is that it must work into a high impedance, for the impedance of the crystal microphone is very high. The second condition is that there should be no polarizing voltage across it.

Fig. 6 shows one way of coupling the microphone to an amplifier. The grid leak acts as a load of high value. A resistance of five megohms is indicated, but actually the resistance across the microphone is less because of stray leakage also because of grid current. It should be pointed out that this is not the best arrangement because if there is grid current this will flow through the leak and there will be a voltage across it, which means that this voltage will also be across the microphone. However, the grid current is extremely small.

An improved connection is shown in Fig. 7. Here a stopping condenser of 0.01 mfd. is connected in series with the lead between the microphone and the grid and a grid bias battery is connected in series with the grid leak. By this method the proper grid bias can be applied to the tube without impressing any voltage on the microphone. The 5-megohm grid leak is so high in value that even on the lowest audio frequencies there will be no appreciable reduction of the output by the series condenser.

(Continued next week)

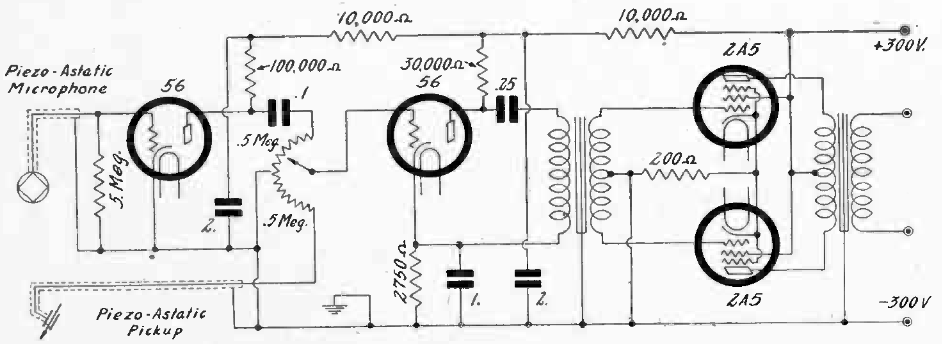


FIG. 5
A suitable circuit for use in a public address system when the microphone is the piezo-astatic instrument shown in Fig. 4 and when the phonograph pick-up is constructed on the same principle.

Methods of Sim

of Signal Generators for Steadine

By Herma

THE manufacturers of test oscillators, or signal generators, as these instruments are now being called, strive for a high degree of accuracy and some of them also for frequency stability. The prospective purchaser does not always know what these claims mean. For instance, is frequency stability something quite apart from accuracy? Does a certain percentage of accuracy mean that it applies only to the high-frequency extreme of tuning any particular band, as is the similar case with meters, where the percentage accuracy applies to the full-scale deflection only? And in addition, or by way of further elucidation, how are frequency stability and a certain percentage of accuracy achieved?

First, an accuracy of 1 per cent. means that the frequency can be read to an accuracy of 1 per cent. at any frequency in the range, or, if there are more than one range, any frequency in any of the ranges may be read that closely. Thus the application of this rating differs entirely from the percentage accuracy rating applied to meters.

Second, frequency stability means that the oscillator, when tuned to a particular frequency, maintains that frequency. How well it maintains it seldom is stated. The device may be described as "unusually stable." That is simply a statement that it is not wobbly due to any cause.

Two Causes

The two principal causes of instability are the inherent instability of the radio-frequency generator, or oscillator itself, and the wobbly output caused by poor forms of modulation. Grid blocking, which by including a large leak value stops the plate current at audio periods, constitutes one of these forms of poor modulation. When the output of a set is read with a meter, and the modulated signal-generator's carrier is introduced in the tuner, the meter needle will not stand still.

Starting with frequency stability, the first goal, it is achieved by making the tube behave as a pure resistance. A convenient method of checking for frequency stability is to put a d-c milliammeter in the signal generator plate circuit, tune the generator over its full frequency ratio, any band, and note the behavior of the needle. If the oscillator is stable the needle will stand still. Often one will find that the needle stands still for frequencies represented by the higher capacities of the tuning condenser settings, but will change abruptly for lower capacity settings.

This test is as good as any for a prompt and reliable determination, although devoid of absolute values. The reason it is good is that all variable factors that might be present would show up in the plate current condition, and if there are no variable factors, that is, the needle stands still, the tube behavior is like that of a pure resistance. It will be remembered that a pure resistance is one that has no inductance or capacity.

One of the simplest stabilizing devices, although not a perfect one, is the grid-leak-condenser combination. This has been used for all the years of broadcasting, though not for that purpose, and amounts to diode-biased detection, where the grid to cathode circuit is the input to the triode as well as constituting the diode.

Stabilization Methods

Alone, the leak-condenser method falls short at the higher frequencies, usually, which is the region where most oscillators oscillate most violently. To correct for this several means of auxiliary or complementary stabilization may be used. In Fig. 1 is shown the typical oscillator, with so much stabilization as leak and condenser contribute. In Fig. 2 a high resistance is used for grid leak, a moderate capacity grid condenser, and a high resistance in series with the plate, but bypassed. The relationship of the grid leak, grid condenser, plate series resistor and bypass condenser from series resistor to cathode determines the stability. The values must be correctly chosen. In Fig. 3 a high value of leak is used, but the grid condenser is adjusted to some low value, usually under 50 mmfd., for stabilization. As stated, plate current indication will serve as guide of frequency stabilization.

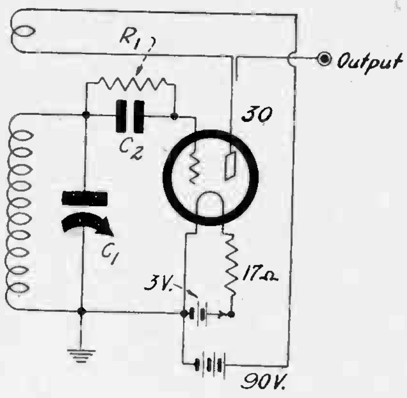
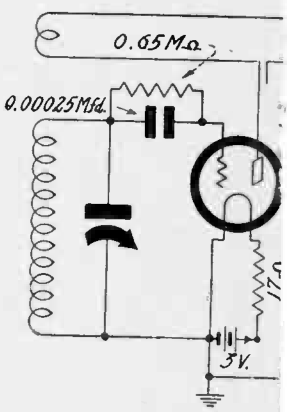


FIG. 1

A standard tuned-grid oscillator without any special stabilization, though possessing the incidental stabilizing effect of leak and condenser.



FI

Stabilization intr proportioning of and fixed bypass values apply onl The tuning cond

Taking Fig. 2, which was constructed for covering part of the broadcast band, with a capacity of 0.00014 mfd., when the grid condenser was 0.00025 mfd. and the grid leak 0.65 meg. (650,000 ohms), the 30 tube was stabilized with 0.225 meg. (225,000-ohm) series plate resistor and 0.0005 mfd. bypass condenser, for frequencies between 460 and 1,000 kc. At 1,100 kc instability set in, but the oscillator was not intended for more than 2-to-1 frequency coverage, and was calibrated only as such, for use as a station finder by fundamentals and harmonics, therefore the instability in the unused region may be ignored. If it were necessary, other values could have been selected for extending stabilization from 1,100 to 1,200 kc, the high-frequency extreme of the tuning.

Modulation Downward

The stabilization method, of course, is something of a damper, especially in view as the tendency of a circuit to oscillate greatly at high frequencies of tuning in any band (low capacity settings) is overcome. The object is to produce levelling. Building up the lower frequencies to equal the amplitude of the higher ones is not so easily accomplished, and practically all methods work the other way. Hence the output is less for some frequencies than without stabilization, but for all frequencies should be the same.

The grid-leak-condenser circuits "modulate downward," meaning that the greater the amplitude of oscillation, the less the plate current. So the direction of change, if any, may be noted by considering the needle action in reverse. The plate current decreases with increased oscillation intensity because the grid current increases and more negative electrons accumulate at the grid, that is, the greater the oscillation amplitude, the higher the negative bias on the grid due to the leak.

The stabilization of the plate circuit, as is accomplished in Fig. 2, for the higher frequencies of tuning that otherwise would be unstable, is due largely to the high d-c resistance of the series resistor. If the tube resistance in the plate circuit is 10,000 ohms, and the series resistor 22.5 times that, the total resistance is relatively stable, because the fixed element is large compared to the tube. Thus, the higher the resistance in series with the plate, the better the stability, from a theoretical viewpoint, because then the nearer the total comes to being a pure resistance. However, if the resistance is too high the oscillation amplitude is too low, and besides unless there is a bypass condenser, the circuit will not oscillate, and if this bypass condenser is too low the selectivity will be poor indeed at the higher

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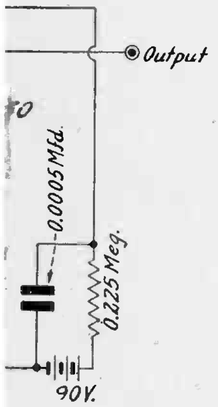

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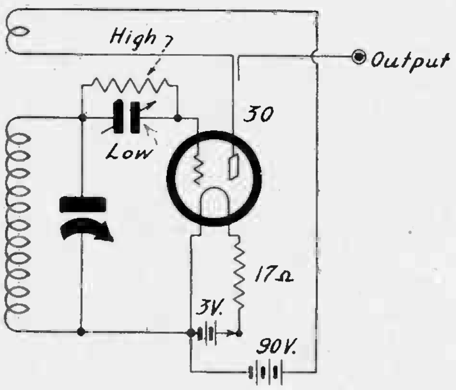

FIG. 3
If a high-resistance leak is used, of the order of a few megohms, the plate current kink at the higher frequencies may be removed by grid condenser adjustment.

frequencies of tuning any band, and if the condenser is too high the time constant will be in the audio-frequency region that results in modulation of the same type as is present when grid blocking is introduced. With such modulation, either grid or plate type, the output is wobbly.

Air-Dielectric Condensers

The method used in Fig. 3 requires an air-dielectric condenser for the grid condenser, as the compression type will not retain its capacity constant, and the fixed type would require too great an assortment to select from, and besides would not stay put, because, even if molded, it permits creeping of plates and mica dielectric inside the space left for the condenser.

With a high grid leak, and no condenser, the circuit might not oscillate, as the resistance constitutes a damper. The greater the condenser capacity across the leak, the less the damping effect, within reasonable limits of capacity, say 0.001 mfd., and reasonable resistance value, say, 2.0 meg. The higher the frequency, the more effective any particular capacity in this position, so the capacity is made small enough to permit the leak to act as a damper at the high frequency part of the tuning of a band, and take the kinks out of the plate current curve.

Another point to consider is the size of the tickler and the degree of coupling to the secondary. If the tickler is made so large that at the high-frequency end it stops oscillation, due to the tickler behaving as a choke, a few turns may be removed until oscillation at this extreme is restored, and then some aid is gained toward stabilization, although this alone is a critical method and not one easy to use. As an adjunct, however, it is helpful. Then any of the other methods may be used additionally, as the tickler already renders some help, since it tends somewhat, though not completely, to act as a choke where damping is desired, in the higher-frequency brackets.

Effect on Frequency

An unbypassed series resistor in the grid circuit, between the regular leak-condenser combination and the grid, will serve as astabilization agency, as will an unbypassed resistor in the plate leg. The reason is the same as before, that the damping effect is greatest at the higher frequencies. At the lower frequencies it is not substantial. However, these resistors would have low values, say, 1,000 ohms or so for the grid circuit, 10,000 to 20,000 ohms for the plate circuit, considering the 30 tube only, and the d-c voltages as in Figs. 4 and 5. Other tubes might require different values.

The introduction of any of these resistances and condensers changes the frequency from what it would be for the same tuning condenser and coil without these additions so any calibration made on the basis of particular inclusions must not be deemed to hold strictly if the parts are altered or omitted. The capacity change of the condensers, if of the fixed mica dielectric molded type, is not of any importance in this regard, though a resistor's of more than 10 per cent., such as might arise from use and age, is important. Occasional checking of the resistance value is advisable, if a particular calibration is to be followed.

Using standards as bases of comparison, we run a curve, or create a dial calibration for direct-reading, and as the standards are accurate, including broadcasting stations, if such are used, the particular frequencies may be registered accurately, and then since we have frequency stabilization we will generate a certain frequency at one setting and, leaving the setting thus, the frequency always will be the same, say, to one part in 100,000 or even better.

Unstable Change

Even if the oscillator were unstable, the change in frequency scarcely ever would extend beyond the audio range, that is, for a frequency of 1,000,000 cycles generated, the change would not exceed 10,000 cycles, or one part in 100. It can be seen that frequency stabilization improves the stability a thousand-fold.

The percentage of accuracy referred to by manufacturers has nothing to do with the accuracy just mentioned. If there is a change of 100 cycles out of 1,000,000 cycles, then the frequency stability is 0.0001, or one one-hundredth of one per cent. (0.01 per cent.). As stated, this factor is never mentioned, except in precision apparatus of the costly kind, as used in elaborate research.

Since the electrical part is stable now, the question arises as to what can be accomplished in the mechanical part. That mechanical part may be considered to consist of the dial mechanism, the plotting of the curve, the ability to read the curve closely, or the plotting of the direct-reading scale and the ability to read that scale closely. To these matters the accuracy mentioned by manufacturers pertains, and it can be seen to be a mechanical aspect. Frequency stability does not enter here, because whether the oscillator is stable or unstable, the difference can not be read on the dial or curve. However, the output reading will be constant, which is important, if stabilization is present, even if the tested circuit is highly selective.

Dial Index

One of the considerations in respect to the dial is that it should have an indicator devoid of parallax. No matter from what angle you read the scale, the reading should be the same. If the index is far enough removed from the scale, and there is no other guide between, when the reading is taken from the left it is one value, at center another, and at right another. If there is only slight possibility of parallax, conditions are well enough satisfied if the reading is taken exactly from the center, as one would do naturally.

Suppose the oscillator is direct-reading, that is, the frequencies are imprinted on the scale. It is then a problem to coincide the tuning system to the scale. This may be done by such methods as the designer originally intended. A trimming capacity is one method, but the trimmer must be an air-dielectric condenser. Another method is to use different values of grid condenser until the correct one is found. Another is to select the proper series resistor. All such tests are made for the highest frequency to be tuned in for a particular band. The variable factor for the low-frequency setting, since the capacity will be always the same for any particular dial position, is the secondary inductance, and the making of the coil to proper closeness of inductance is taken for granted, if the oscillator is to have any respectable rating at all.

By using utmost pains it is possible to have a direct-reading

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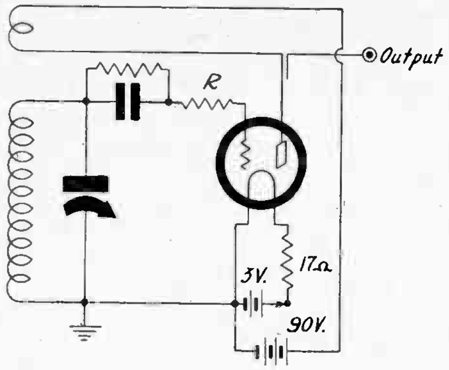


FIG. 4
An unbypassed series resistor R in the grid leg, outside the tuned circuit, will create stabilization also. Try values of 1,000 ohms up.

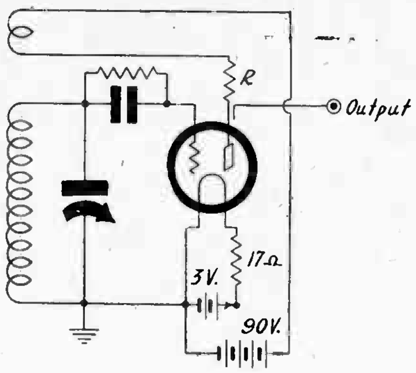


FIG. 5
Also a series resistor R in the plate leg, unbypassed, offers stabilization possibilities. Values of 10,000 ohms up should be tried.

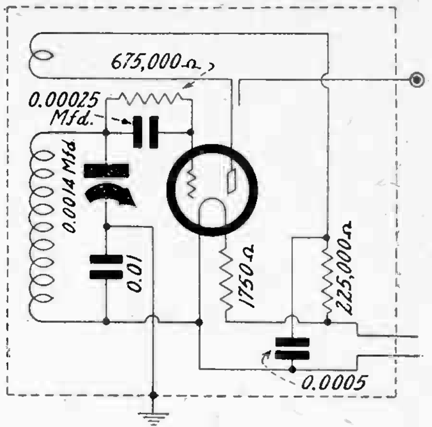


FIG. 6
An a-c-operated signal generator, with hum as modulation, serves as a station-finder. This is an adaptation of Fig. 2.

dial scale, and use commercial condensers, and accurate inductances, to attain a production accuracy of 1 per cent. By some refinements, particularly of close adjustments that take the time of experienced engineers, this accuracy may be doubled, but it is an expensive process, and requires the occasional discarding of a tuning condenser, meaning practically the tearing down and rebuilding of an oscillator that could go out as one of an accuracy of 1 per cent.

Figs. 2 and 6 were built with special pains and the accuracy was ½ per cent. By devoting a few hours more to testing and adjustments, the accuracy might be improved to ¼ per cent. The frequency generated was so stable that during two hours of testing the change did not amount to more than 100 cycles out of 1,250,000 cycles.

Perhaps the easiest external test to make to confirm stabilization is to zero-beat the signal generator with a broadcasting station. This usually requires a vernier dial, or very close handling of a knob for direct actuation, as getting zero difference of frequency is no rough and ready matter, despite the facility with which the advice is given to "zero-beat with a broadcasting station."

For those not familiar with the process it will be detailed.

As you tune an oscillator to the frequency of a station, since the station itself is sending out an oscillating voltage or current, you have an instance of two oscillators.

If the local oscillator or signal generator is not quite in tune, but approximately so, there will be a difference in frequency small enough to be in the audio range. Thus, turning the dial from right to left, approaching the station frequency, you begin to hear a high-pitched squeal, the pitch declines until it becomes zero, and then, continuing in the same direction, as you move the dial slowly the pitch rises again and keeps rising, because the difference is increasing, although due to the generator working in the other frequency direction, and finally the difference is too great to hear, that is, becomes radio frequency.

That central point between the audible high-pitched extremes, that point where there is no difference in frequency, represents zero beat.

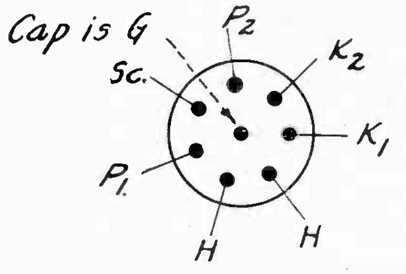
Now if you will zero beat with a station, since the station frequency is accurate to plus or minus 50 cycles, and since you would be using a receiver which, in all likelihood, does not pass 50 cycles, but does pass 100 cycles, if you left the oscillator going for an hour, and could not hear any beat, you would be safe in assuming that your oscillator during that period did not change its frequency more than 100 cycles out of n cycles, where n represents the frequency of the broadcasting station in cycles.

The behavior of Figs. 2 and 6 was exactly that of an oscillator so stable as to be comparable to the stability of a crystal-controlled oscillator that did not have a temperature oven, for instance, the crystal method used in single-sideband superheterodynes.

No modulation is present in any of the oscillators, Figs. 1 to 5 inclusive, but a.c. may be used as modulation, as shown in Fig. 6, which is an adaptation of Fig. 2 to this extent.

Since the stabilization is not difficult, it is suggested that the time is ripe to introduce stabilization in the local oscillators of superheterodynes, particularly those that include the short-wave spectrum. The trimming condenser must be air-dielectric, remember, that the higher the frequencies to be tuned in, the more important is this precaution, while the stabilization attained for one band will have to be checked for its continued existence on other bands. In general it has been found that the stabilization is a function of the capacity and resistance, and not of the inductance in the tuned circuit, therefore the methods have real and extensive possibilities.

The 12A7 for Midget Sets



Bottom view of a small seven-hole socket to be used for insertion of the 12A7 tube, which combines a half-wave rectifier for B supply, and a pentode output tube. For the pentode P1 is the plate, Sc is the screen, G is the control grid, connected to cap of tube, while K1 is the cathode. The rectifier consists of P2, plate, and K2, cathode, and is to be connected in series with the line, for transformerless use, or to a secondary of a power transformer for a-c use alone.

Since in the last audio stage only "harmless" audio frequencies are present, a rectifier tube may be combined in the same envelope as the output tube, as is done in the 12A7, which Kenrad makes. Thus one fewer envelope may be used in a rectifier, although electrically there will be the same number of functioning tubes. However, as soon as duplex tubes become popular the fact isn't even mentioned that there are two tubes in one envelope, and the mechanical and electrical count becomes one. One envelope, one tube.

On this basis a pretty good four-tube set can be built, consisting of two stages of tuned radio-frequency amplification, a detector and the 12A7. Also, practically any small circuit can be changed to encompass the space economy offered by the new tube.

Biasing Resistor

The rectifier is the same as any other half-wave type. The pentode is the same as other pentodes as to general application, although the plate current may be less, so that the biasing resistor for the power tube may be around 800 to 1,000 ohms. The value is not critical, and even less than 800 ohms may be tried.

Across the biasing resistor should be placed a large-capacity condenser. Such a type is obtainable in electrolytic form at 30 to 50 mfd. for low voltage rating (around 30 volts rating, normally). The actual applied voltage never will be more than half that.

Choke Option

The same filter may be used for this rectifier as for others.

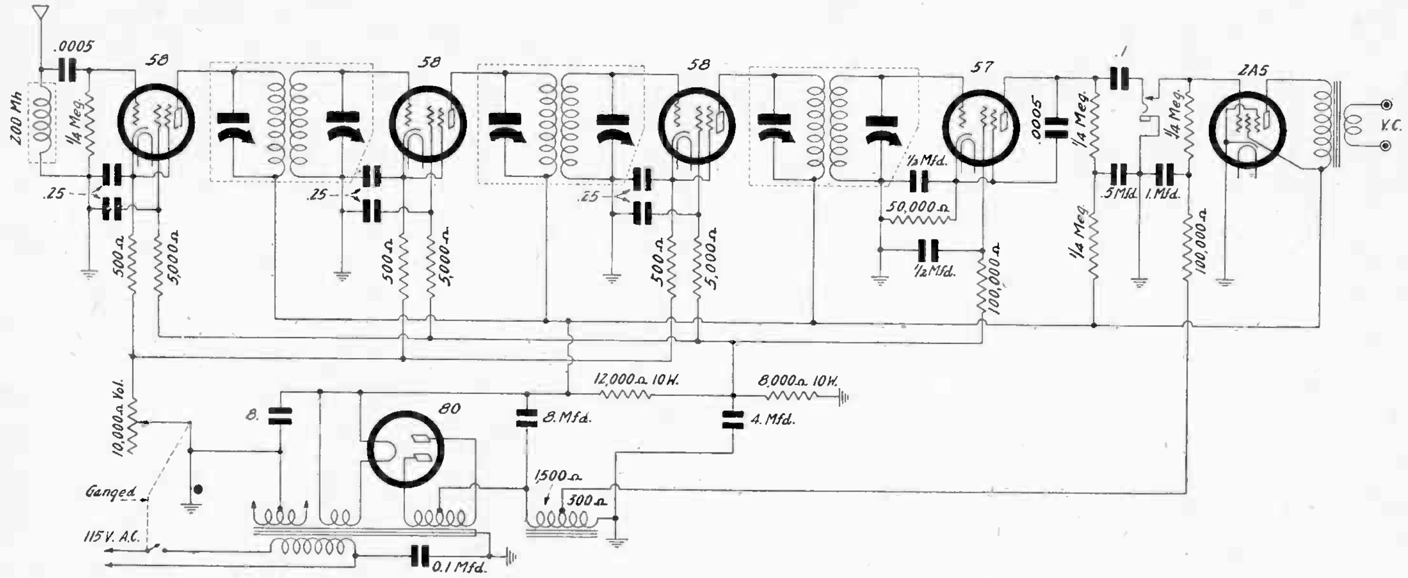
Of course the electrical independence of the two tubes must be preserved, as it is when the cathodes are used independently. The choke for the B supply may be in either the negative or the positive leg, but if in the negative leg then take the precaution to insulate the condenser nearer the rectifier cathode from possible chassis or ground connection, since this first condenser is between B minus and cathode, and B minus is not grounded in negative-leg-choke systems.

A Time-Signal Receiver

Device Provides Accurate Check of Line Frequency

By Alan Mannion

Mannion Radio Laboratories



A six-tube a-c-operated set for bringing in the time signals from NAA, Arlington, Va. This is a tuned-radio-frequency set of the fixed-frequency type. The transmissions are on two different frequencies, but only one of them need be selected. There are various uses for the signals besides just telling time for time's sake.

SINCE the early days of radio there has been available a highly accurate service through the daily time-signal transmissions from NAA, Arlington, Va. This service is correct to the degree of accuracy of the Naval Observatory, and is therefore suitable for the setting of chronometers and the adjustment of other high-precision time apparatus. The signals are broadcast daily over two channels as follows:

Type A2

113 kc (2,653 meters) Greenwich Civil Time: 02:55 to 03:00, 07:55 to 08:00, and from 16:55 to 17:00.

Type A3

690 kc (435 meters) Greenwich Civil Time: 02:55 to 03:00 and from 16:55 to 17:00.

Checking Line Frequency

It is not generally realized that these time-signals also provide a means of checking line frequency to a very high degree of accuracy. This need has become increasingly great within recent years due to the use of synchronous clocks in homes. The speed of synchronous motors depends upon the frequency of excitation. It follows that any variation in frequency will cause a corresponding variation in clock speed. The increasing use of electric clocks makes necessary a far greater accuracy of line frequency than do most other commercial usages. Variation of a fraction of a cycle from true frequency of 60 cycles causes much less variation in power transformer secondaries than that caused by a slight change in line voltage. This is not so in the case of a chronometer with a synchronous motor. The changes in line voltage, even when amounting to several volts, will not cause the clock to gain or lose, whereas any change in frequency, however slight, if consistently neglected, will cause a decided variation from accurate time.

It follows therefore that the accuracy of clocks in consumers' homes will be no greater than the accuracy of frequency adjustment at the local power plant. Every power company has a master clock so constructed as to keep accurate time when the line frequency-average is exactly 60 cycles. Here is where the time signal receiver provides a needed service to the company. If the master clock can be compared to Naval Observatory time, *and kept accurate to that standard*, all the clocks on the power lines will be equally accurate. This of course postulates clocks without individual physical defects.

Checked Thrice Daily

The receiver pictured was designed and constructed for one of the largest power companies in the East. It was responsive to the first frequency listed, 113 kc. This is usually referred to as the "2,600-meter time-signal." This company supplies current for tens of thousands of home clocks, as well as those in more public use, and an accuracy of one-thirtieth part of a second is maintained in checking the master clock. Three times a day this master clock is checked with the time-signal transmissions and adjustments made in generator speed to bring the frequency back in line, should variations occur.

The diagram shows an untuned input followed by three stages of tuned-grid, tuned-plate, radio frequency amplification. This makes six tuned circuits in all. Since the input is untuned, variations in antenna length, leadin capacities, etc., will not cause serious detuning of the receiver. This allows a very accurate alignment at the wanted frequency right in the laboratory, and no adjustments are required in installation. A long, high aerial should be used.

The detector is a 57, selected for its high signal sensitivity, and biased for power detection. Its output is fed into a 2A5 power amplifier, the coupling being resistive. A dynamic speaker, though not required, may be economically used in this circuit, since it does duty as a filter choke, and also as a means of providing bias for the output tube. Filtering must be good if this receiver is to be used in the same building with the power generators. Thoroughness in this respect pays dividends.

Adjusting the Tuner

Each tuned circuit consists of a 20 millihenry and a 120 (max.) mmfd. variable condenser. They are constructed similarly to i-f transformers, the choke coils being mounted on ⅜-inch dowel rod, and spaced about 1¼ inches apart. The proper band-pass effect may be obtained experimentally by changing this distance.

The circuits may be approximately lined up using a modern service oscillator. The i-f range of these oscillators usually extends down to 113 kc. The final adjustment must be done with the aid of the time-signal itself. This is not difficult with an output meter.

The construction of these modernized time-signal receivers may boost the service man's reduced summer income. Local watchmakers and power companies may mean new customers. Astronomers have use for the same device.

When aligning the receiver to the time signal, an output meter may show dips in the pulses between beats, which are exactly one second apart. By observing the maximum swing of the needle on each beat, resonance is easily established. A long tone is sent exactly on the hour, followed by NAA in Continental: dah-dit, dit-dah, dit-dah. The beginning of this tone is the checking cue.

[Other illustration on front cover.]

The Triplett 4686

Universal Tester, With Facilities for Measuring High Alternating Currents

By Jack Tully

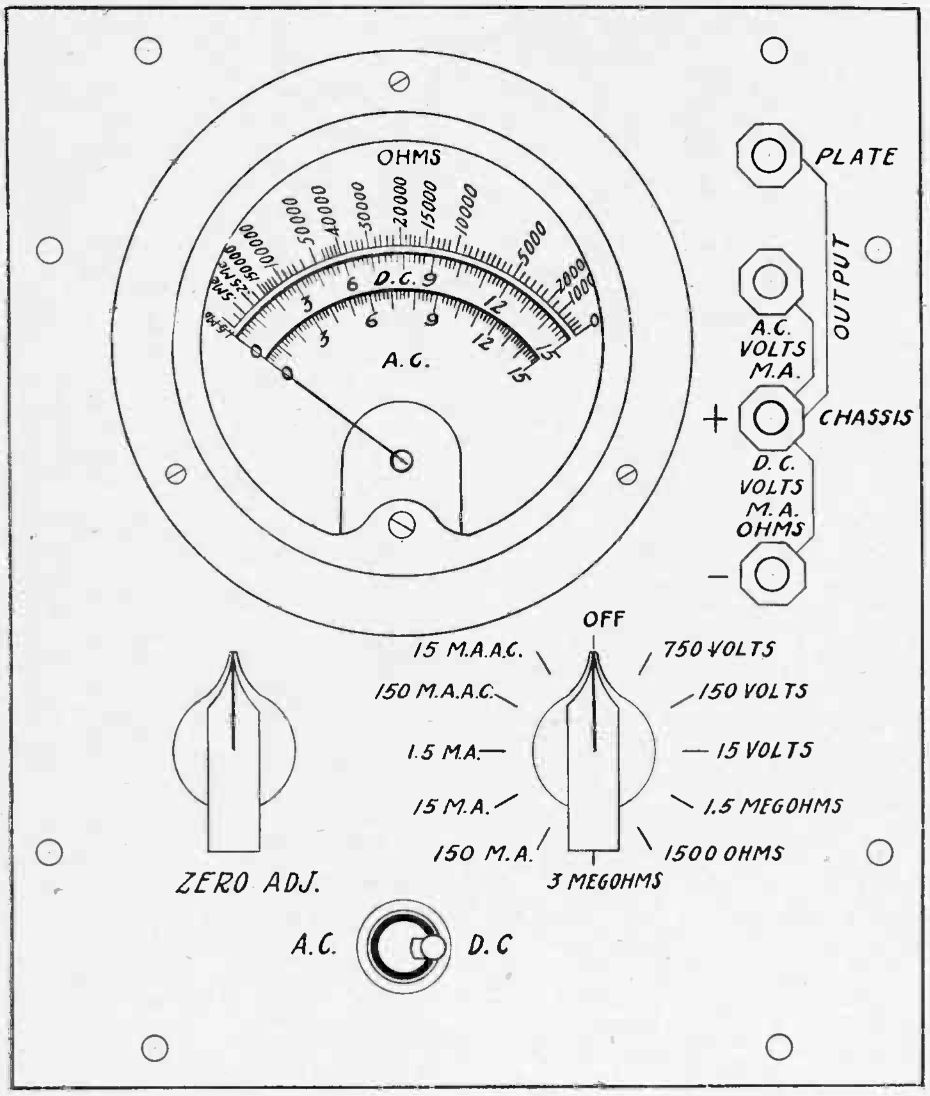


FIG. 1

A drawing of the panel of a universal meter. The instrument measures alternating and direct currents and voltages, output power, and resistance. The instrument has an exceptionally wide range in all its applications.

IN previous issues we have shown many circuit testers, some of which have been of the universal type. Nearly all the testers have inclosed provision for measuring medium values of resistances, but none has contained means for measuring alternating currents higher than one milliampere. Now we have a simplified universal tester that measures alternating and direct currents and voltages as well as resistances of different ranges in the Triplett Universal Model 4686.

In most testers the switch which converts the circuit from one service to another is usually very complicated, which follows an attempt to make the tester fool-proof. No switch, however simple or complex, can make the circuit such. By the introduction of a two-way switch by which the circuit can be adapted for a-c or d-c measurements, the general selector switch, and hence the circuit, can be greatly simplified.

An idea what the tester will measure can be gained from Fig. 1, which is a drawing of the panel. First it will be noticed that the dial contains three scales, one for resistance, at the top, one for direct current, in the middle, and one for alternating current, at the bottom. A knife-edge pointer sweeps over these scales in such a manner that it is possible to read all the scales with equal accuracy.

Details of Circuit

For the details of what the tester will do we have to examine the dial of the selector switch. There are twelve stops on the switch, one of which is neutral. That leaves eleven different positions for measurements of as many different things. But the eleven live steps are for each of the positions of the two-way switch for a-c or d-c. Hence there are really 22 possibilities.

If we turn the selector switch in the clockwise direction, we first come to the 750-volt stop. This is for either a-c or d-c provided that we apply the unknown voltage at the proper terminals. The ones to use are clearly marked. At the second step in the same direction we come to the 150-volt stop, which is also for either a-c or d-c according to the position of the two-way switch and the terminals used for the application of the unknown. The third stop is like the other two, but the voltage to be measured on it is only 15. These three voltage ranges, a-c and d-c, are sufficient for the measurement of all voltages that are likely to occur in a radio receiver or public address amplifier.

Resistance Ranges

The three steps following the voltage steps are for resistance measurements. These are for 1,500 ohms, 1.5 megohms and 3 megohms. The scale, it will be noticed, runs from zero to 1.5 megohm. Therefore when the switch is on the first resistance step, the scale is to be read directly in megohms, or in ohms, depending on where the needle points. If the switch is on the second step, the correct resistance is obtained by reading the scale and dividing by 1,000, whereas when the switch is on the third resistance step the readings must be multiplied by 2.

The useful range of the resistance meter is from less than one ohm to 3 megohms, and that certainly covers all practical cases. While there are resistances greater than three megohms, they can seldom be measured accurately with any meter available, and frequently they do not retain the values while in service. Hence there is little object of measuring them.

Current Ranges

In turning the selector switch to the left from the neutral position we first come to a stop for 15 milliamperes alternating current and after that we come to a 150 milliampere a-c stop. In either of these positions the two-way switch must be set on a-c and the unknown must be applied at the a-c terminals.

After the a-c stops we have three d-c stops, for 1.5, 15, and 150 milliamperes direct current. Of course, the d-c terminals and the d-c setting of the two-way switch must be used when direct current is being measured.

In the diagram is a terminal post marked "plate," and between this post and the post marked "chassis" is a line marked "output." This indicates that the two posts in question are to be used in making output measurements on power stages. The post marked "plate" and the one directly below it are connected together with a condenser of 0.5 mfd. This makes it safe to connect the plate of the output tube to the terminal marked "plate" when measuring the a-c component of the output of the tube. Since the output of the power tube is alternating current, the two-way switch must be set on a-c when a measurement of output is made.

A Full-Wave Rectifier

Since the meter employed is of the d-c type, a rectifier is necessary to convert a-c to d-c when alternating current is measured. The rectifier used is of the copper oxide type and is full-wave. The rectifier element is not built into the meter

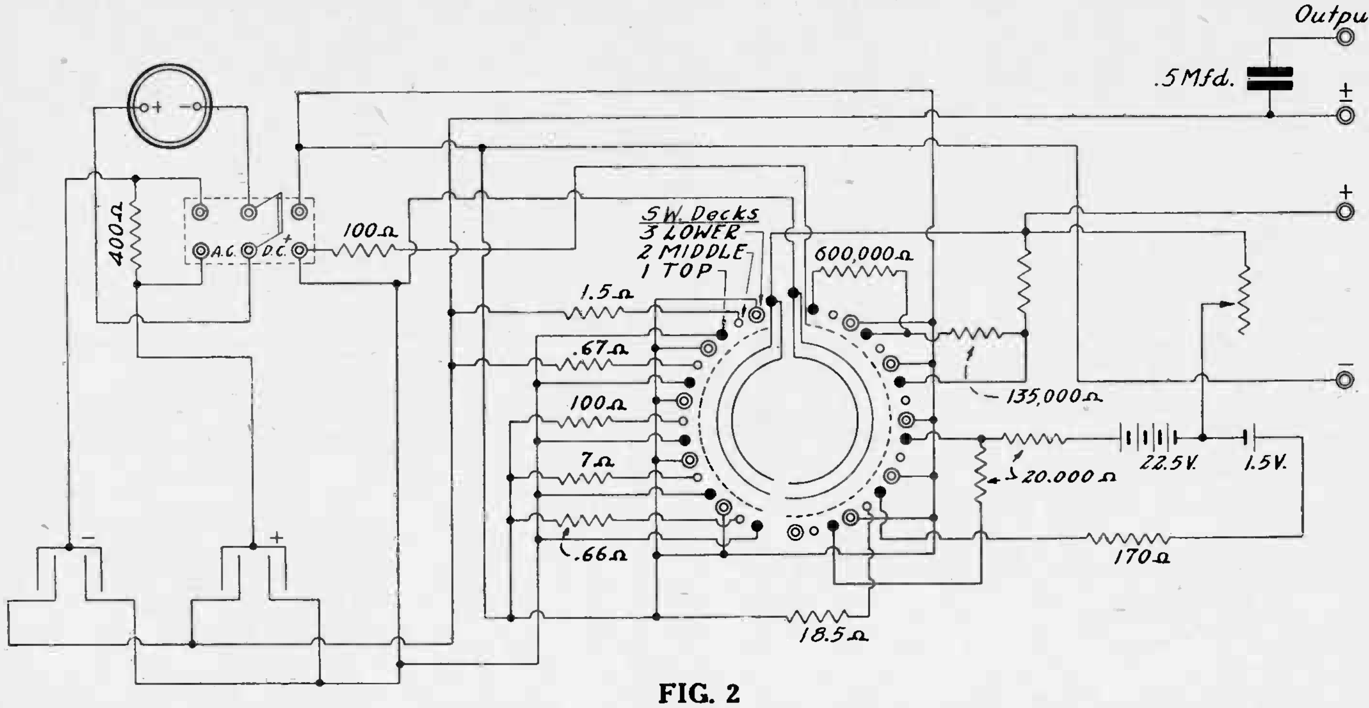


FIG. 2

The circuit diagram of the universal tester, the panel of which is shown in Fig. 1. A full-wave dry rectifier is put into the circuit by means of a two-way, two-pole switch when alternating current is to be measured.

as is customary, but is external. A much larger unit can therefore be used, for there is plenty of room in the box housing the tester.

Aside from the knobs and other devices on the panel of the universal tester so far mentioned, there is a knob marked "zero adj." It is to be used in connection with resistance measurements to bring the needle to zero resistance, or maximum current, when the terminals for the unknown resistance are short circuited.

For those who are interested in the wiring of the tester we are reproducing the circuit diagram in Fig. 2. The rectifier connections appear at the lower left corner of the figure and the two-way switch directly above it. The selector switch looks somewhat complex in the circuit diagram, but some of the apparent intricacy vanishes when it is noticed that there are three decks, and that the stop-points on each are distinctly marked.

The resistance meter accessories are on the extreme right on the diagram with the batteries indicated. But these batteries are not included in the assembly of the universal meter. Leads are provided for making connections to these batteries, two leads for each battery. Just above the batteries is the zero adjuster rheostat.

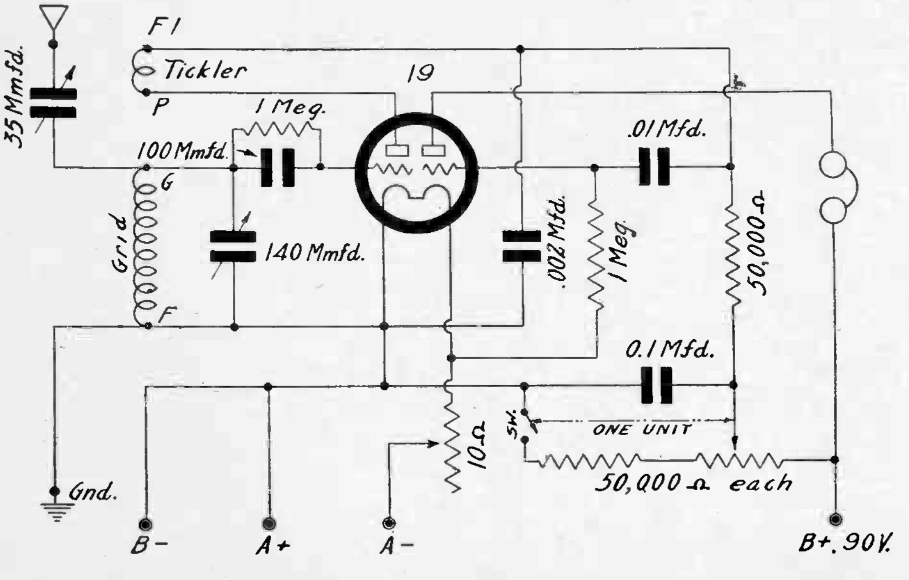
The four terminal posts shown on both the circuit diagram and the panel drawing are tip jacks. One of these, which is connected to the chassis, is colored red while the other three are black. Long leads for making connections are provided, and they have colors corresponding to the colors of the jacks. Tips on the leads of course fit the jacks.

There are two bakelite mounting strips for the various resistors. On the lower strip, which is held at one end by the rectifier unit and at the other by one of the terminals of the milliammeter, are mounted six high resistors. These are covered by a fibre insulator and then the second bakelite strip is mounted on the first. This second strip holds nine shunts and other small resistors.

The Duo-Amplidyne Uses New 19 Tube

By **HERMAN COSMAN**
Try-Mo Radio Corporation

Several years ago a German tube manufacturer turned out multi-element tubes which acted as two or more stages of amplification. Many in the industry on this side of the Atlantic were disposed to scoff at the idea, but those who scoffed have come to pay homage to the idea, especially when the idea has been clothed in modern garb.



Mechanically this set, produced by Try-Mo Radio Corporation, has only one tube, but electrically it has two tubes, with a high degree of regeneration.

The radio industry is fortunate now in having several multi-element tubes in which the terminals of the elements are available for use in a large number of different combinations. One of these new tubes is the 19, a two-volt tube of the filament type. The 19 consists of two equal triodes in one bulb. That is, it has two plates and two grids.

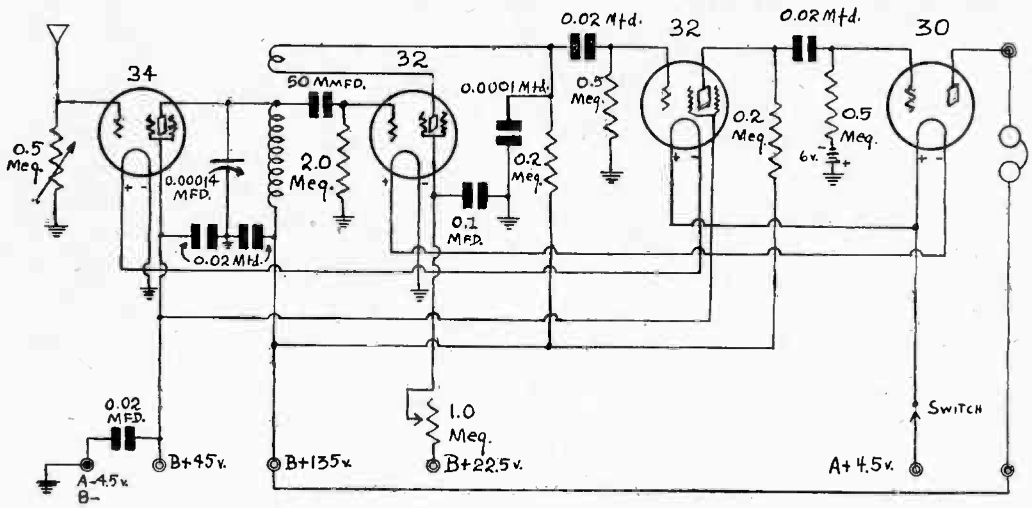
In what way does this help the designer of radio receivers? In answer to this question we call attention to the diagram which represents the circuit of a short-wave receiver. Not a one-tube receiver, however, but a two-tube set having a regenerative detector and one stage of resistance-coupled audio. One of the elements in the 19 envelope is used for the regenerative detector and the other for the audio amplifier.

The set is complete in all respects, although there is only one tube.

Plug-in coils are used for changing the frequency coverage, and each coil requires a four-contact socket, for it has only two windings, the tuned and the tickler. The antenna is connected to the high potential side of the tuned circuit through a 35 mmfd. variable air condenser.

The regeneration is controlled by varying either the filament current or the plate voltage, preferably the latter. A 50,000-ohm potentiometer is provided for this purpose. As indicated on the diagram, this is ganged with the filament switch.

Radio University



An untuned r-f stage may be used for short waves, the load being a resistor, fixed or variable.

Untuned R-F Stage

HOW CAN the tuned detector circuit be kept free from the effects of antenna capacity, inductance and swinging aerial, without an extra tuned stage?—K. C.

By using an untuned stage. A resistor will serve the purpose. However, there is some sacrifice, as the antenna capacity across the resistance becomes a serious attenuator of signal intensity as the radio-frequency carriers exceed 15 mgc or so.

* * *

Oscillation Frequency

IS IT POSSIBLE to determine accurately by computation what will be the resonant frequency of an oscillator? I have particular reference to short waves, where the inductance is small compared to the capacity.—P. O.

There is no known method of accurate computation of practical inductance for short waves, because of limitations imposed by the receiver or oscillator. The capacity and inductance of the leads in the set are a serious uncertainty, therefore there is no stable basis of computation. Assuming low frequencies, the resonant frequency of an oscillator may be computed closely, of course, but this need not necessarily be the frequency of oscillation. The oscillator may oscillate at other than the resonant frequency, and usually does, the slight difference being due to a phase shift.

* * *

Current-Fed Line

FOR A TRANSMISSION LINE input, should the receiver be voltage-fed or current-fed?—K. L.

It is usual to have a voltage-fed transmission line. This is the method employed in telephone and power line practice. Of course audio frequencies are involved. However, for short-wave use, it is well to consider the possibilities of a current-fed line, because the frequencies are so high. Take the power line example. Any stray capacity to ground is negligible in the light of a frequency of 60 cycles. But the same capacity to ground in a transmission line from antenna used for short-wave reception is serious. Therefore it is suggested that a step-down r-f transformer be used with antenna connected to the large primary and the transmission line to the small secondary. There being negligible transformer loss, the power in primary and secondary is the same, but the voltage has been reduced in the secondary, perhaps to a few per cent. of the primary voltage. The secondary current has been increased proportionately to the voltage decrease, since the power is approximately the same in both branches. Hence the current is very large compared to the voltage, and this would constitute a current-fed line. The loss due to capacity to ground would be smaller than in the voltage-fed transmission line because the percentage of current through this capacity to ground is much less than in the example of a voltage-fed line. A point needing watching, however, is the loss in the resistance of the transmission line. Since the current is large, if the transmission line has even a small resistance, the drop in this resistance will be a ratable factor.

* * *

Unusual Tube Uses

WHEN A TUBE is used in other than its orthodox manner, as is sometimes done by unusual connections of grids and screens, is it permissible to consider the tube as functioning in its originally intended manner, and apply the specifications of an orthodox installation, or must one start anew, and where is this information obtainable?—J. K. C.

The tube characteristics as given in commercial charts apply only when the connections are as stated in the chart, which are the orthodox connections. When a departure is made from the usual method the operation of the tube is quite different. In general, no data are available as to the characteristics of the tubes in these special uses, and the experimenter would have to run his own curves. For instance, consider a 58 tube. It usually has the control grid independent, the suppressor tied externally to the cathode, the screen and plate independent, the heater independent. If the tube is subjected to automatic volume control, and the suppressor is tied to the grid return, which is negative d-c side of the a-v-c circuit, the plate resistance declines with increase in signal amplitude and increase in a-v-c voltage, a method used for automatic tone control, as the circuit is less selective on strong signals, and thus locals come in with excellent quality, whereas distant stations, from which quality is not so generally expected, are subjected to greatly heightened selectivity, where selectivity is needed most. The curves for this performance are obtainable from tube manufacturers. Consider now the 58 used in an oscillator, with feedback in the screen circuit, suppressor tied to cathode, and the formal plate having a load resistor connected to B minus, whereby some current will flow through this resistor, and the oscillation voltage may be taken therefrom through a condenser, the "plate" acting as an electron-coupled pickup element. This constitutes the tube a quadrode, as the plate that would make it a pentode really isn't a functioning part of the tube proper. The information on this type of operation of the tube is not now obtainable from the tube manufacturers.

* * *

Difference in Aerials

WHY CAN NOT the same antenna conditions be used for transmission of short, medium and long waves, and why must special attention be given to short-wave installations?—K. L.

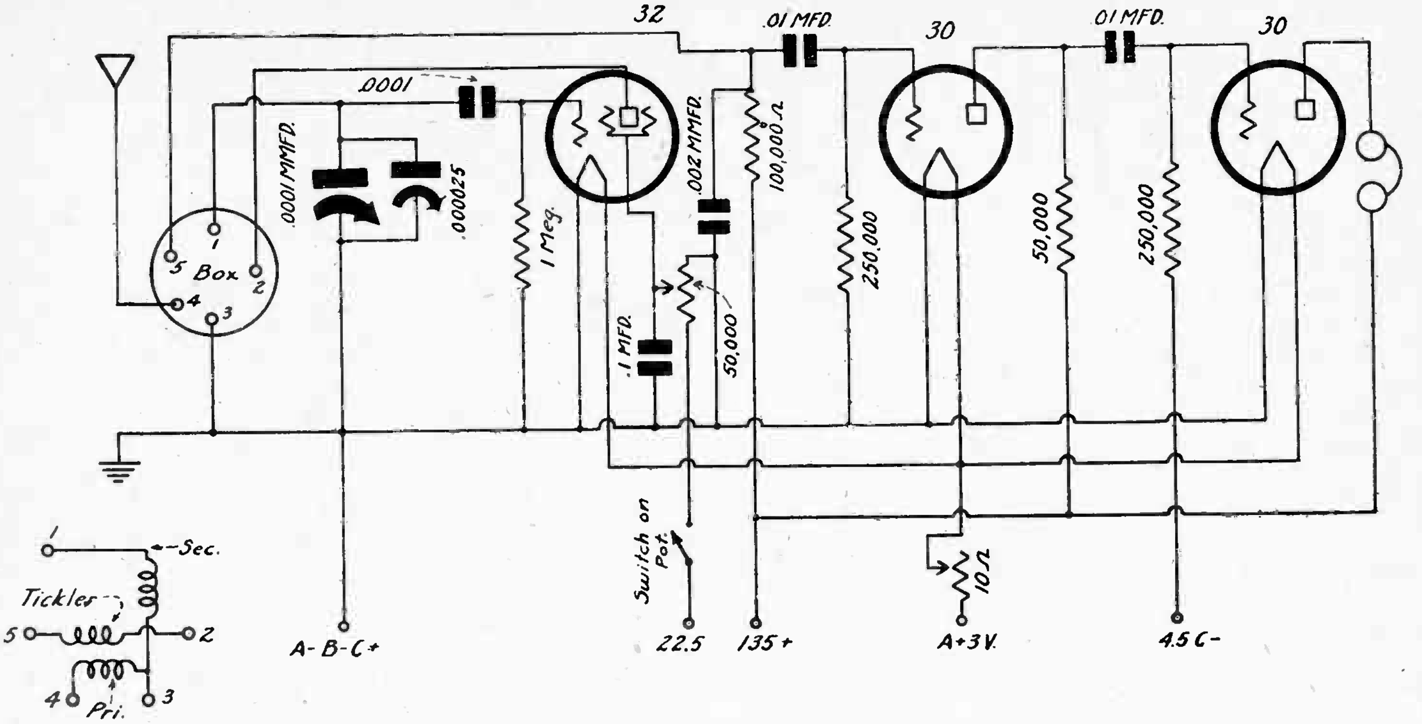
The same antenna can not be used for the same reason that not everybody can wear the same size shoe. Short waves may be compared to children with little feet, long waves to giant adults with large feet. The proper antenna is selected so that the shoe will fit the foot. Stated technically, the whole antenna system should be sensibly related to the wavelength, and that is true of reception as well as propagation. Another way of stating this is to say that for efficient radiation the dimensions of the circuit should be comparable to the wavelength or frequency. For short waves very short aerials are as efficient as very long ones are for long waves. Hence the difference in aerial installations is simply a recognition of a scientific fact, or obedience to nature.

* * *

The "R" Rating

HAS THE "R" RATING a scientific standard, and if so, will you please state what that standing is?—T. W.

The "R" rating has no scientific standing, and is simply a method of stating approximately the comparison of reception, being better than no method at all, but devoid of accuracy. The rating is expressed as R1 to R9, where R1 represents the worst conditions of reception and R9 the best. Hence a statement that "signals were R9" means they were excellent. As to the relative values encompassed by the R's of lesser magnitude, the meaning depends as much on what the expressor intended it should be as it does upon what the recipient of the information thinks that the expressor meant. When a system is related to a more definite basis it is of improved value. The Bureau of Standards, Department of Commerce, United States Government, sends out standard frequencies, and encourages reports on reception. The Bureau states: "The data required are approximate field intensity, fading characteristics, and the suitability of the transmissions for frequency measurements. It is suggested that in reporting on intensities, the fol-



A battery-operated short-wave receiver using drawer-type plug-in coils.

lowing designations be used where field intensity measurement apparatus is not used: (1) hardly perceptible, unreadable; (2) weak, readable now and then; (3) fairly good, readable with difficulty; (4) good, readable; (5) very good, perfectly readable."

* * *

Drawer-Type Coils

HOW ARE the drawer-type plug-in coils used in a circuit? Are they shielded? —U. D. C.

The drawer type coils are contained in a shield box, usually copper, and have base pin connections at the far end to be inserted in a tube socket used as coil receptacle. A diagram herewith shows a regenerative detector circuit, with screen-controlled regeneration, where the drawer-type coil has six connections, two being common to ground, therefore a five-pin base, and five-hole socket, are used. The primary, secondary and tickler are identified and the numerals refer also to the bottom-view socket connections.

* * *

Television Carriers

IS IT A FACT that television is bound to be on very high frequencies ultimately, and if so why?—K. C.

When television becomes a commercial fact it will be on ultra frequencies because of the necessity of a wide band width to pass all the picture detail. On low frequencies that band width for modulation is impossible, as the necessary picture modulation band width would have to be equal, on the broadcast band, to that whole broadcast band itself, or more. But if the transmission or carrier frequency is very high, say, 75 mgc, then a band width of a few hundred kilocycles, or more, becomes entirely practical. There has been very little dissent indeed from the statement that ultra frequencies will be used for television.

* * *

Temperature Oven

WHAT IS a temperature oven used for? Does it improve the accuracy of an oscillator very much?—K. L.

For general work an oscillator need not have a temperature oven, as the object is to maintain an even temperature, preferably well above normal room temperature, to hold the capacities and inductances constant. The oven is used in oscillators of a very high order of precision. The heating device may consist of series-connected carbon-filament lamps, and in conjunction there is a thermostat control. The thermostat acts as a relay and it may consist of two closely-adjacent metals of different co-efficients of expansion, so that when the heat rises to a certain value a switch this relay controls is opened and the heating devices are turned off, until the chamber falls to a certain other temperature, when the switch is turned on again automatically.

* * *

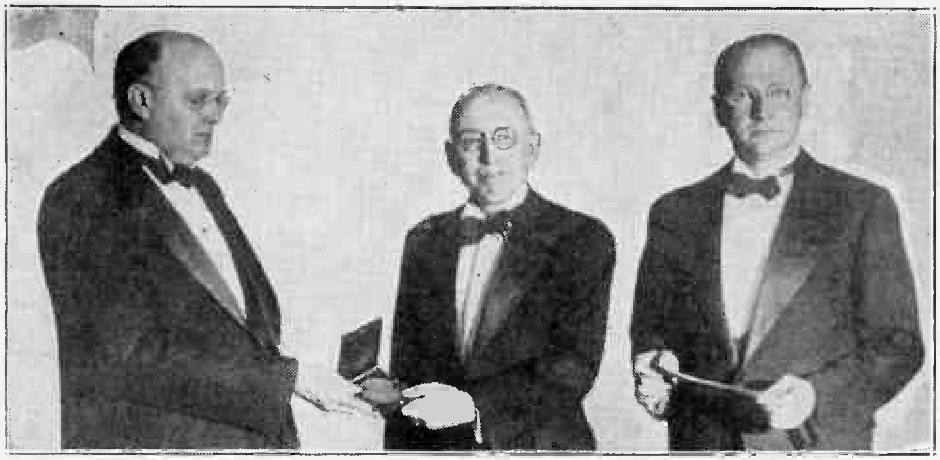
Super-Regeneration

WHAT IS the super-regenerative circuit, is it as sensitive as it is said to be, and if so, why is it not used for receptions of other than ultra frequencies?—H. E. D.

The super-regenerative circuit is one set up for oscillation, but into which another oscillating frequency, much lower than the first, is fed, this auxiliary frequency being usually close to an audio value, and the purpose is to interrupt the high-frequency wave to prevent oscillation at the high frequency. In this way the sensitivity is pressed far beyond what it would be were oscillation or regeneration present, because the limiting factor has been substantially removed, that is, the saturation point of the tube has been moved over a long way. However, the squelching of the oscillation tendency has the effect of introducing a low parallel resistance in the tuned circuit, hence the selectivity is low always, which is a limiting factor for all radio frequencies except the very highest, when it is necessary to have a receiving system that is not selective, so that the signal will not disappear due to transmitter instability.

(*Continued on page* 19)

ZWORYKIN AND HOOPER HONORED



Acme

Capt. S. C. Hooper, director of communications, United States Navy, is shown in center receiving from Dr. C. M. Jansky, Jr., president of the Institute of Radio Engineers, a medal for outstanding contributions to radio. At right is Vladimir K. Zworykin, of the RCA-Victor Company, similarly honored for outstanding contributions to television. The awards were made at the recent Institute convention in Philadelphia.

Station Sparks

By Alice Remsen

GUY LOMBARDO is now broadcasting over an NBC network direct from the Starlight Roof of the Waldorf-Astoria, New York. Watch your local papers for time, if you like to dance to the seductive strains of Guy's orchestra. . . . Xavier Cugat, who was formerly at the Starlight Roof, is leaving for Europe; after a tour of the principal foreign cities, Cugat will return to the Waldorf in August. . . . At this very moment of writing, I am listening to Al and Lee Reiser, the famous two-piano team; they are playing a special arrangement of Bill Paisley's lovely tune, "Beautiful Dreams," on the Lover's Lane program. The boys, as usual, are doing a good job. . . . Jessica Dragonette is going in for dancing these days; even while on vacation, she will keep up her dancing lessons; she says it helps to develop rhythm, and is also good exercise. . . . Muriel Pollock and Vee Lawnhurst are still using their twenty fingers on two pianos; early mornings on WEAF; the girls are clever and have done, and are still doing, plenty of good work together. . . . Ben Bernie and all his lads are back in Chicago, after a sojourn on the West Coast and wayside points. The Pabst Blue Ribbon program will emanate henceforth from the NBC Chicago studios. . . .

May Singhi Breen and Peter de Rose have another birthday party behind them, their eleventh anniversary on the air. This time the party had a sponsor, the Kraft-Phenix Cheese Corporation, and it was broadcast as the feature of Paul Whiteman's Music Hall program. Deems Taylor, noted composer, and master of ceremonies of the program, interviewed the "Sweethearts of the Air," and Paul Whiteman and his orchestra played eleven of the song hits written by Mr. de Rose. May, of course, swung her ukulele into action and scored a hit with her playing of the theme melody of "Inspiration," a symphonic number written for ukulele by her composer-sweetheart-partner-husband. . . . Robert Simmons, young NBC tenor, has plenty of work to do now that he is taking the place of Frank Parker with the Revelers and on other of Parker's programs, while the latter is on the Coast with Jack Benny. . . . Eddie Albert, the "he" of the "Honey-mooners" program, was once a prize-fighter, but not for long; he left the fistic world in time to preserve all his features intact. Eddie has quite a presentable nose, and his ears are okay too; at least, so Grace, the "she" of the program, thinks. . . . Irene Beasley has been added to the Fitch program each Sunday at 7:45 p.m. over WEAF; Irene replaces Wendall Hall for eight weeks, during the latter's vacation. . . . Everett Marshall won a $500 consolation prize in the Irish Sweepstakes. . . .

Very glad to hear Emil Velasco, with his orchestra over WABC several times weekly, from the Grill of the Hotel Taft, New York. . . . Melodic Strings, a feature of the Canadian Radio Commission, will be heard regularly over the nation-wide WABC-Columbia network in an exchange series between CBS and the Canadian group. This is the second season for this series. Each Tuesday at 10:30 p.m. EDST. . . . June 28th will bring a spectacular drama of twenty crowded years of history to the Columbia microphones. Mark this date on your calendar: Monday, June 28th, 8:00 to 9:00 p.m. WABC and network. . . . The Oxol Trio, a feature of the WABC-Columbia network for the past four years, will continue on a new summer schedule, Mondays and Wednesdays at 5:45 p.m. EDST. . . . The latest gag of Gracie Allen's is that she is a direct descendant of Rob Roy, the historic Scottish chieftain. . . . Walter Tetley, the fourteen-year-old Columbia radio star, will sail across the Atlantic very soon to keep a series of theatrical engagements in England and Scotland.

A THOUGHT FOR THE WEEK

THE NEW NRA DEVELOPMENTS regarding price-fixing, etc., are interesting in themselves as well as in their probable effect on the various markets affected. But has it ever occurred to you that price-fixing, discounts, cost sheets and all the varied paraphernalia that go toward arriving at money conclusions do not have anything to do with the desire to listen in on programs? When all is said and done, all the technical, marketing and financial problems in radio are reduced to the question of whether folks still have ears that function, and intelligence that enables them to listen to symphonies or to jazz with discrimination and understanding. Remove the urge to listen to programs and whatever is left doesn't amount to a hill of beans so far as radio fans are concerned. That is to say, the essential of the whole problem of radio is whether our millions of listeners-in continue to want to turn the dials in preference to indulging in any other entertainment activities.

And all that's smack up to the interest and value of the programs presented.

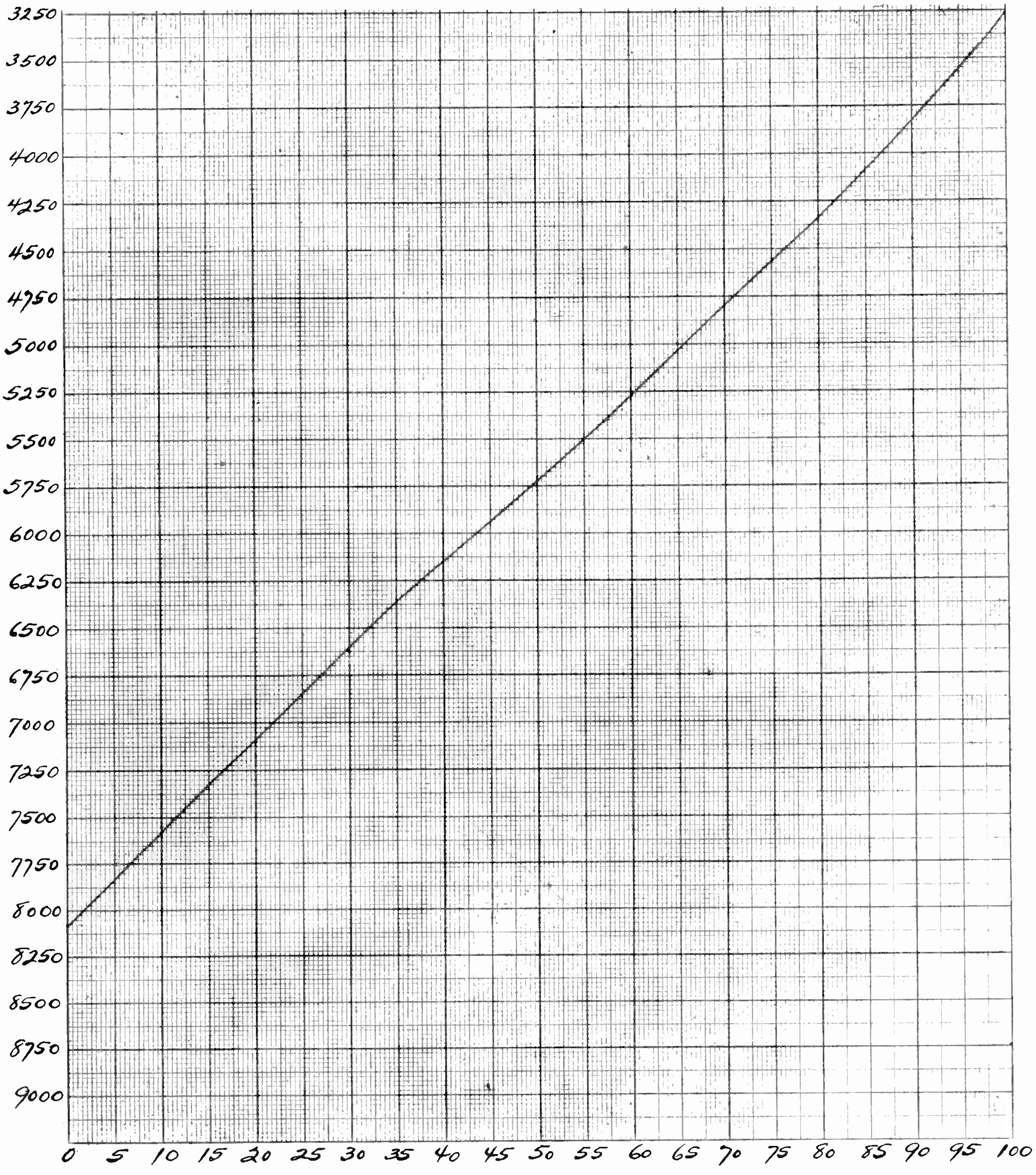
BROADCAST STATION CHANGES

Alterations and corrections to the edition dated January 1, 1934, and to supplement No. 1, of "Radio Broadcast Stations in the United States," prepared by the Federal Radio Commission.

Call Letters, Studio Location, Alerations and corrections.

KARK—Little Rock, Arkansas. Power 500w-LS, quota units 0.5.
KFBL—Everett, Wash. Licensee, Lee E. Mudgett.
KFDY—Brookings, S.D. Frequency 780 kc.
KFGQ—Boone, Iowa. Frequency 1310 kc.
KFPY—Spokane, Wash. Issues being determined by Court of Appeals, District of Columbia.
KFYR—Bismarck, N.D. U, quota units 1.25.
KGHL—Billings, Mont. S. A. Exp., frequency 780 kc.
KGIR—Butte, Mont. Issues being determined by the Court of Appeals, District of Columbia.
KLRA—Little Rock, Ark. C.P. power 2½kw-LS, quota units 1.25.
KMED—Medford, Ore. C.P. power 250w-LS, quota units 0.3.
KOIN—Portland, Ore. C.P. power 2½kw-LS, quota units 1.25.
KOOS—Marshfield, Ore. D, quota units 0.1.
KPCB—Seattle, Wash. S.A. Exp., Frequency 710 kc, U, quota units 0.4.
KRGV—Harlingen, Texas. C.P., T and studio, Weslaco.
KRKD—Los Angeles, Calif. Licensee, Radio Broadcasters, Inc.
KRLD—Dallas, Texas. S.A. Exp., operate simultaneously with WTIC, U, quota units 2.0.
KSEI—Pocatello, Idaho. Strike out S.A. Frequency 890 kc, Issues being determined by the Court of Appeals, District of Columbia.
KSLM—Salem, Ore. C.P., permittee, Oregon Radio, Inc., Power 100w, frequency 1370 kc, D, quota units 0.1.
KSO—Des Moines, Iowa. Frequency 1370 kc, power 100w, night, quota units 0.3.
KTHS—Hot Springs National Park, Arkansas. S.A. Exp. operate simul. with WBAL on 1060 kc, daytime and S.H. night, quota units 4.17.
KTRH—Houston. Texas. Frequency 1330 kc, power 1 kw, U, quota units 1.0.
KWCR—Cedar Rapids, Iowa. C.P., power 500w-LS, quota units 0.5.
KWJJ—Portland, Ore. S.A. operate on 1040 kc.
KXYZ—Houston, Texas. S.A. Exp. power 500w, quota units 0.6.
WBAK—Harrisburg, Pa. Strike out all particulars.
WBAL—Baltimore, Md. S.A. Exp. operate simultaneously day with KTHS; operate S.H. to 9 p.m., Eastern Standard Time; operate synchronously with WJZ on 760 kc, 2½ kw power, from 9 p.m., Eastern Standard Time, quota units 3.75. Strike out S.A. Exp.
WCAL—Northfield, Minn. C.P. power 2½kw-LS, quota units 0.09.
WCBC—Lansing, Mich. C.P., call letters changed to WJIM.
WCHS—Charleston, W. Va. Licensee, Charleston Broadcasting Corporation.
WDNC—Wilmington, N.C. T and studio, Durham, Frequency 1500 kc.
WEED—Greenville, N.C. C.P., T and studio, Rocky Mount.
WESG—Elmira, N.Y. S.A. Exp., Frequency 1090 kc.
WGCM—Mississippi City, Miss. Studio, Gulfport.
WHAD—Milwaukee, Wis. Strike out all particulars.
WHET—Dothan, Ala. Licensee, John T. Hubbard and Julian C. Smith, d/b as Dothan Broadcasting Company.
WHN—New York, N.Y. Power 1 kw, quota units 1.0.
WHP—Harrisburg, Pa. U, quota units 0.8.
WIBA—Madison, Wis. Quota units 1.0.
WISN—Milwaukee, Wis. Power 500w-LS, U, quota units 0.5.
WLAP—Louisville, Ky. T and studio Lexington, frequency 1420 kc.

3,000 to 8,000 Kc Chart for Hammarlund 0.00014 Mfd. and Alden Yellow-Ringed Coil



Radio University

ANSWERS to Questions of General Interest to Readers. Only Selected Questions Are Answered and Only by Publication in These Columns. No Correspondence Can Be Undertaken.

(*Continued from page* 17)

Vernier Control

IS IT necessary to have a vernier for short-wave tuning?—J. C.

The tuning condenser should be equipped with a vernier dial, unless the dial itself is extremely large, e.g., is a drum around 30 inches in circumference. The necessity of small change in condenser rotor position for a relatively large change of the tuning knob is to enable tuning thereceiver accurately to a station, and that stations may not be unknowingly passed over.

* * *

Effect of Ground

WHY IS IT that when I attach a ground wire to my short-wave set, while body capacity in tuning is reduced, the signal strength of the station does not increase?—H. X.

This is due to the fact that the short waves travel the sky route, hence the ground lead, which might pick up waves traveling close to the ground, has nothing in the short-wave category to deliver.

8,000 to 14,000 Kc Chart for Hammarlund 0.00014 Mfd. and Alden Red-Ringed Coil