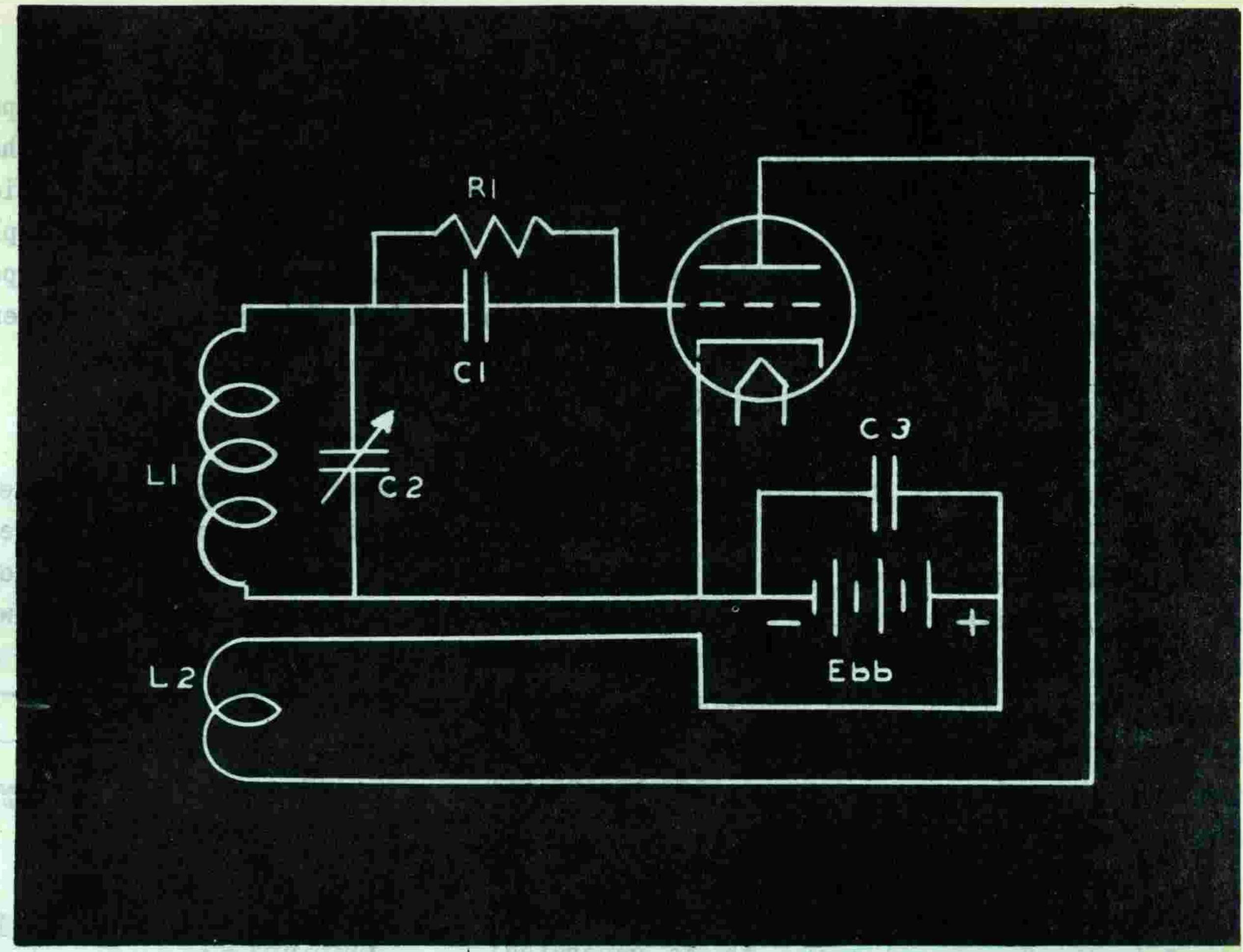

LESSON
28 RA

OPERATION OF A-F AND R-F OSCILLATORS

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OPERATION OF A-F AND R-F OSCILLATORS

INTRODUCTION

Some vacuum-tube amplifiers permit a-c (alternating current) energy of proper polarity and magnitude to be transferred from the plate to the grid circuit of the same amplifier tube. When this occurs so that the a-c variations impressed on the grid circuit result in corresponding a-c variations on the plate circuit, we call the amplifier an oscillator. A vacuum tube oscillator may also be defined as a device which permits d-c (direct current) energy supplied to its plate circuit to be converted into a-c energy.

THE PURPOSE OF AN OSCILLATOR

Without oscillators, the wireless transmission and reception of radio and television programs would be impractical, if not impossible. Motor-driven generators have been known to produce frequencies as high as 25,000 cycles per second. Frequencies of this value might conceivably be used with very serious restrictions for the carrier wave to transmit radio programs. Under no circumstances could a frequency as low as 25,000 cycles per second be used to transmit television programs since these programs, as we shall see when we come to the study of television, require band widths of 6,000,000 cycles per second.

It is the vacuum-tube oscillator which permits r-f (radio-frequency) waves to be generated so that the intelligence in the form of speech, music, and pictures can be carried without wires from the source where the programs originate to the location where the radio or television receiver is placed. Oscillations in signal generators are used to locate and align defective circuits in radio and television receivers. Then too, the superheterodyne receiver circuits employ an oscillator. The incoming radio signal is mixed or combined with the signal generated in the local oscillator to produce a frequency known as the i-f (intermediate-frequency) signal.

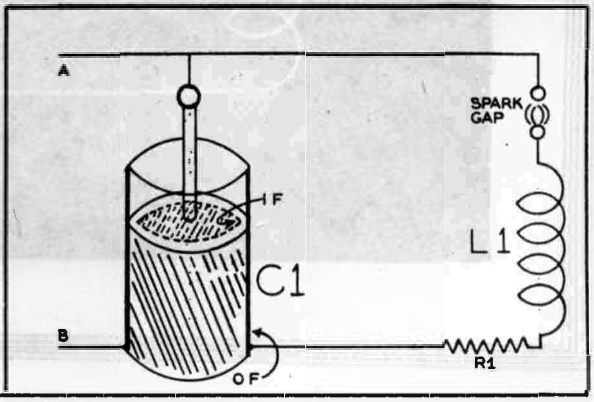

Fig. 1. A simple oscillator circuit consisting of a coil and a Leyden jar acting as a capacitor is shown here.

Vacuum-tube oscillators are also useful in producing dielectric heat. This type of heat is brought about by the intense activity of electrons, atoms, and molecules when these particles of matter are acted upon by h-f (high frequency) currents. High-frequency dielectric heating results in rapid drying operations, preheating of numerous plastic materials prior to molding, rapid cooking of foods, and the welding of plastic sheets by combining heat and pressure in the same operation. Steaks can be cooked in a matter of seconds with the use of h-f dielectric heating.

Although we are principally interested in vacuum-tube oscillators, it is desirable to comment on several other existing types of oscillators. The incadescent lamp which

Thomas A. Edison invented, and which is still widely used, is an oscillator in that it generates very high frequencies in the form of light waves from the electrical energy fed to the lamp. The balance wheel in a watch or clock is an excellent example of a mechanical oscillator. A police whistle generates a-f (audio-frequency) oscillations as a result of air forced through this mechanical device. The doctor regards the beating of a heart as an oscillating action. The chemisttalks ofvaporized metals which subsequently revert back to the solid state of matter as an oscillating or a cyclic condition. All of these different types of oscillators should be kept in mind in your endeavor to grasp the underlying principles on which the operation of an electronic oscillator is based.

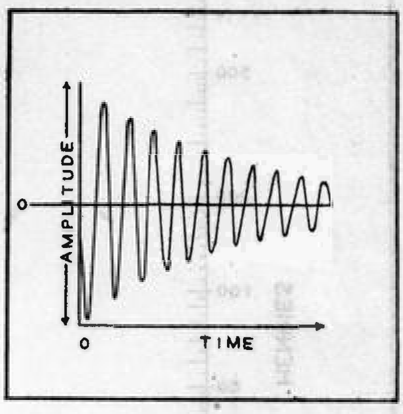

Fig. 2. The output wave from a simple oscillator utilizing a charged Leyden jar as a capacitor.

BASIC REQUIREMENTS OF AN OSCILLATOR

All oscillators that provide a continuous output must fulfill the following basic conditions:

1. The oscillator must have the proper circuit elements to permit sustained oscillations to take place. The most common types of electronic oscillators employ capacitive and inductive elements which fulfill this first requirement.
2. A source of energy must be available to replenish the losses which occur in an oscillating circuit. In most oscillators this consists of d-c energy which is fed to the plate electrode of a vacuum tube. As the energy from the oscillator is delivered to the load, together with a small portion of the energy which is used in sustaining oscillators in the oscillating circuit in the form of heat, additional d-c energy is supplied to the oscillator circuit.
3. A synchronous mechanism or device must be used which makes it possible for the energy to feed back from the plate circuit to the grid circuit with the right magnitude and polarity or phase.
4. The oscillator must be self-starting. Circuit components such as capacitors, inductors and resistors are used in this manner.

A SIMPLE OSCILLATOR

One of the simplest known electrical oscillators consists of high-voltage d-c source, a spark gap, a capacitor, and a coil connected in a series circuit as shown in Fig. 1. The resistor R1 simulates the resistive component in coil L1 and in the capacitor C1. In fact, all capacitors and coils are not perfect coils and capacitors. This means that a practical capacitor can be regarded as being composed of a perfect capacitor in series or parallel with its resistive component connected in series with it. The Leyden jar (named after the inventor) is really a capacitor made from a high grade or quality glass jar with tin foil placed on the outside and inside surfaces as shown in Fig. 1. The Leyden jar is first charged with particles of electricity (about 25,000 volts.)

A slow-motion photograph of the spark discharge which takes place between the spark

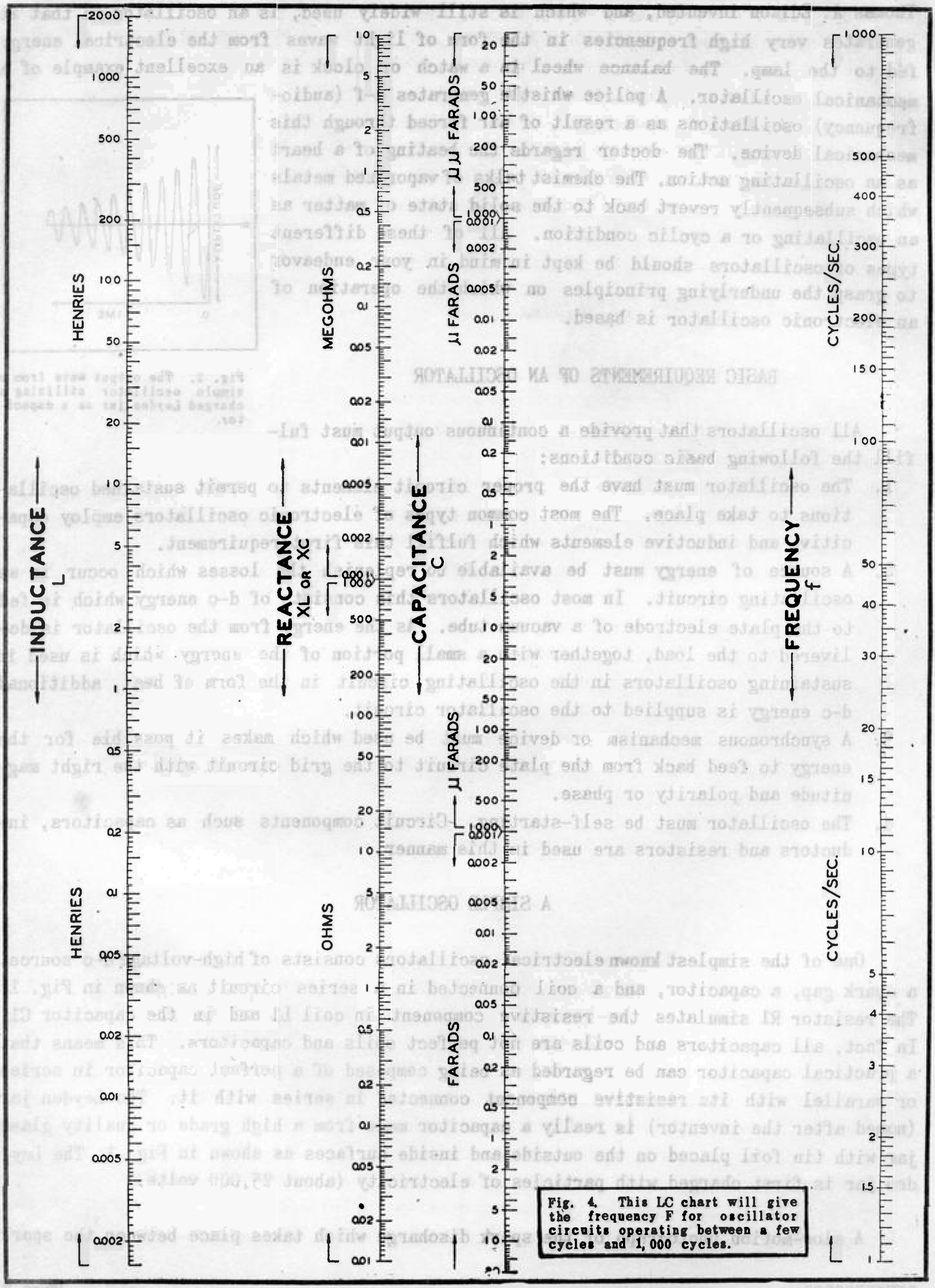

Fig. 4. This LC chart will give the frequency F for oscillator circuits operating between a few cycles and 1,000 cycles.

gap, shows that the spark jumps back and forth several times. The electrons thus flow first in one direction and then in the other direction. Since the Leyden jar was only charged initially at points A and B, the oscillations only continue until the energy is completely expended in the resistive components of the series connected oscillating circuit elements. Energy in a perfect capacitor or a perfect inductance coil is never consumed in the form of heat. The energy is merely stored in the electrostatic field of the capacitor or the magnetic field of the coil. Under ideal conditions, the energy from the Leyden jar capacitor is simply transferred to the inductance shown in Fig. 1. When the energy from the capacitor is fully transferred to the coil, the electronic flow changes its direction, and the energy from the magnetic field of the coil is now sent back to the capacitor where this energy is again transferred from the capacitor to the coil. This continues indefinitely.

Under practical conditions, the energy transfer from the coil to the capacitor and from the capacitor to the coil ultimately consumes itself as it keeps passing through the resistive components of the coil and the capacitor. In view of this constant expenditure of energy, we must have a ready means of replenishing the dissipated energy. This is the purpose of having a source of energy in the vacuum-tube oscillator. The type of wave output which the circuit in Fig. 1 provides is clearly illustrated in Fig. 2. The reason why the amplitude of the wave diminishes with passing time is the result of the energy partially consuming itself as it passes back and forth through the resistive components of the coil and the capacitor. An oscillator where the expended energy is being replenished results in a wave output as shown in Fig. 3. The oscillator circuit shown in Fig. 1 produces oscillations in cycles per second which depend on the electrical values of the coil and the capacitor.

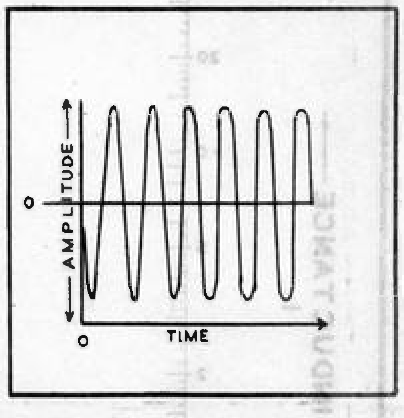

Fig. 3. The output waveform received from an oscillator when the circuit losses are continuously replenished.

HOW THE FREQUENCY OF AN OSCILLATOR CAN BE DETERMINED

Figures 4, 5, and 6 show by means of charts how the frequency can be determined without employing any calculations; that is, when the inductance L and the capacitance C are known. These charts are useful from a few cycles per second to 1,000 megacycles per second. These charts also give the reactance of the inductance or of the capacitance in the event this information is desired. Reactance is indicated by the letters XL for inductive reactance and XC for capacitive reactance.

In Fig. 4 you will find four vertical scales. The first scale at the left is inductance L in henries. The second vertical scale gives the reactance for the inductance as XL and for the capacitance XC. The reactance is given in ohms for the lower half of the scale and in megohms for the upper half of the scale. The third vertical scale gives the capacitance C in farads for the lower section of this scale, in microfarads for the center section of the scale, and in micro-microfarads for the upper section of the scale.

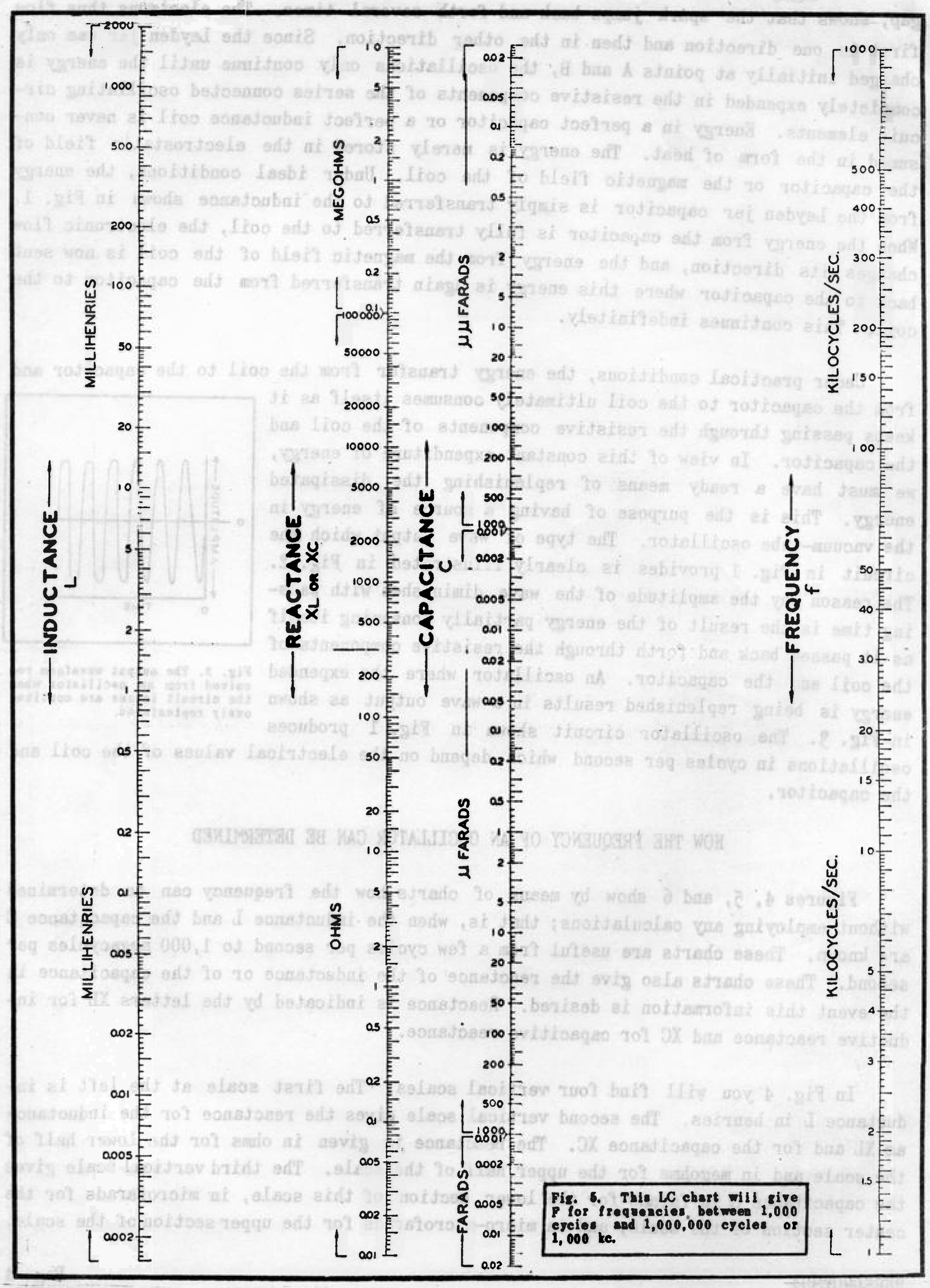

Fig. 5. This LC chart will give F for frequencies between 1,000 cycles and 1,000,000 cycles or 1,000 kc.

The fourth scale shown at the right in Fig. 4gives the frequency F in cycles per second. These charts shown in Figures 5 and 6 have the four vertical scales, the inductance, the reactance, the capacitance, and the frequency. In each case it is important to observe the unit value for length or the portion of the scale which is being used for the respective units: henries for inductance, ohms for reactance, farads for capacitance, and cycles per second for frequency.

With the aid of these charts it is possible to determine not only the frequency but also the amount of circuit capacitance required to obtain a desired oscillator frequency when we know the inductance in a circuit. It is also possible to determine the amount of inductance when we know the frequency and the capacitance. Then we can also determine the amount of inductive reactance in ohms which is presented by the coil in the circuit because we know two circuit properties.

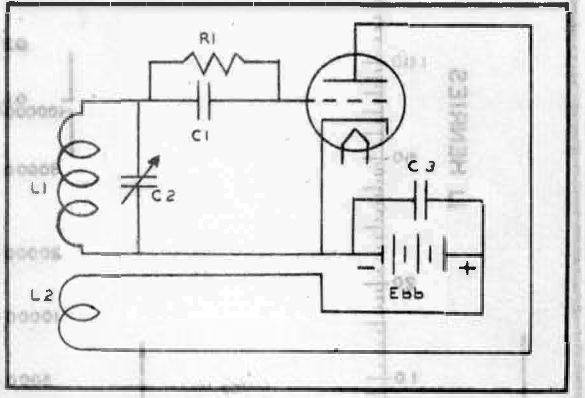

Fig. 7. Circuit diagram of the tuned-grid untuned tickler-feedback oscillator.

A number of problems shall now be presented so that a better understanding of the application of these charts shown in Figures 4, 5 and 6 may be obtained. The procedure is to use a straight edge and lay this straight edge across the four vertical scales of a chart. The straight edge may be a sheet of paper or a ruler. For example, the straight edge may be a sheet of paper which crosses the left hand vertical scale in Fig. 4 at 10, which means that the circuit has an inductance of 10 henries. Then the straight edge crosses the third vertical scale at the point marked 0.01. This means the circuit has a capacitance of .01 microfarads. Now the problem is to determine the frequency at which the circuit will oscillate. In continuing along the straight edge we find that the fourth vertical scale is crossed at the 500 mark. This means that a frequency of 500 cycles will be generated when we have an inductance of 10 henries and a capacitance of .01 mfd. Now it is of interest to point out the fact that the inductive reactance of an inductor having 10 henries will be equal to 0.03 megohms. This is equal to a resistance of 30,000 ohms. Then the capacitive reactance will be equal to the same value. This is a condition which occurs in a resonant circuit. In other words, in an oscillator circuit the inductive reactance is equal to the capacitive reactance at the oscillating or resonant frequency.

The following three problems are now presented to further explain the usefulness of the charts shown in Figures 4, 5, and 6.

PROBLEM 1: Determine the resonant, or generated signal frequency of an oscillator circuit when the oscillator circuit in this problem has a capacitance of 60 micro-microfarads and a coil, which is sometimes called an inductor, of 5 microhenries. To solve this problem, place the straight edge on the number <u>60</u> appearing on the third vertical scale in Fig. 6. Then place the straight edge so that its edge crosses the left hand vertical scale at 5. Then follow the straight edge over to the right hand scale.

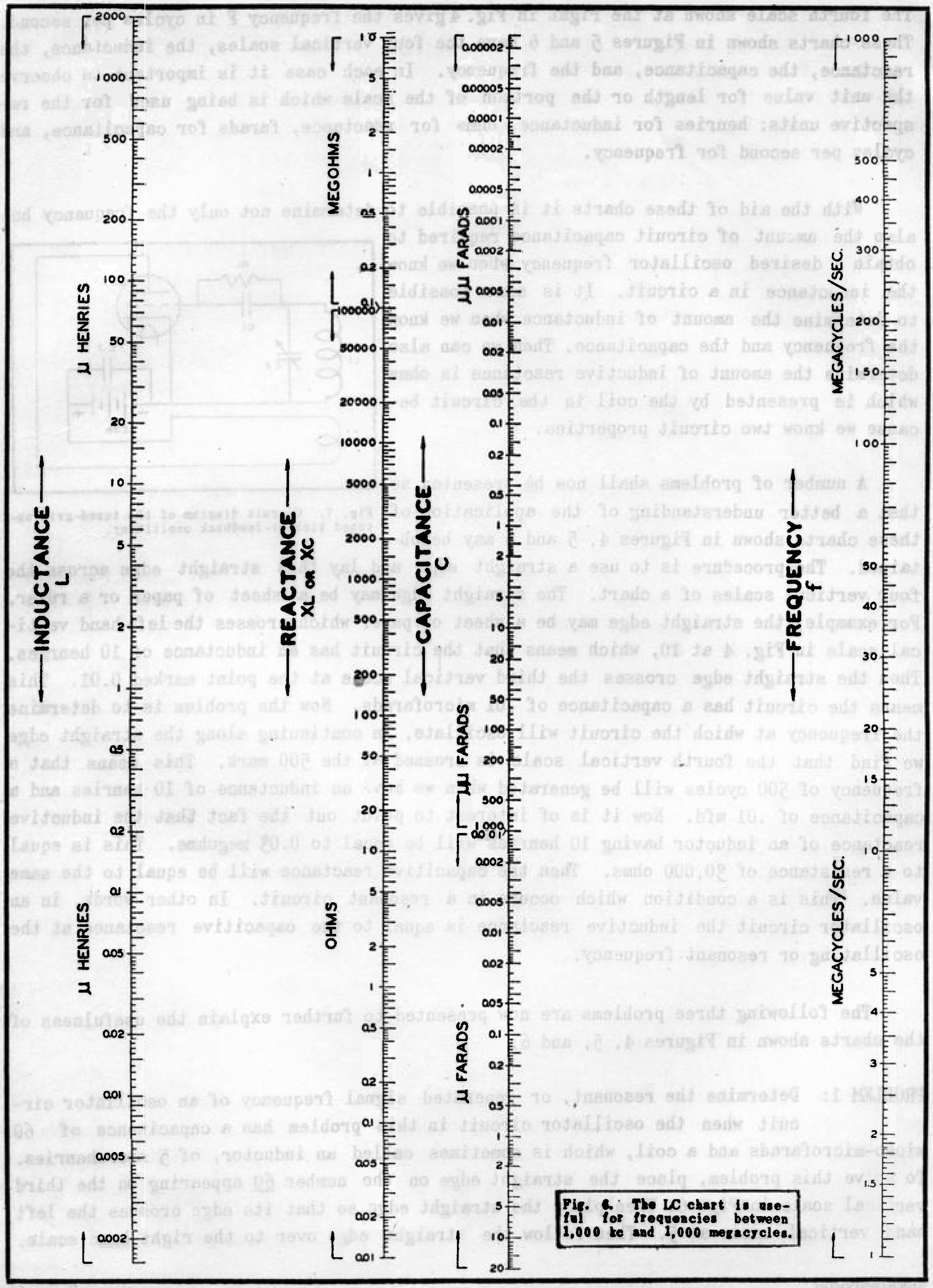

Fig. 6. The LC chart is useful for frequencies between 1,000 kc and 1,000 megacycles.

The straight edge crosses 9.2. This is equal to 9.2 megacycles. We have, therefore, found the resonant frequency of the signal voltage generated by the oscillator to be equal to 9.2 megacycles.

PROBLEM 2: What value of circuit capacitance will be needed in an oscillator circuit to produce a resonant frequency of 1,000 kilocycles when the inductance in the oscillator circuit is equal to 200 microhenries? In this problem, the straight edge should cross the left hand scale of Fig. 6 at 200. Then the straight edge should cross the right hand vertical scale at 1 in the lower right hand corner. Then read the number where the straight edge crosses the third vertical scale. The answer will be 130 micro-microfarads. This is the circuit capacity required with 200 microhenries of inductance.

PROBLEM 3: Determine the value of inductance required to produce a resonant frequency of 600 kilocycles when the capacity in the circuit is equal to 80 micro-microfarads. Using the chart shown in Fig. 5, place the straight edge so that it crosses 80 on the third vertical scale. Then the straight edge should cross the number 600 on the right hand scale. The straight edge will then cross the left hand vertical scale at 9, and this will indicate that an inductance of .9 millihenries will be required.

These charts shown in Figures 4, 5, and 6 can also be used in determining unknown values when using series resonant circuits. This is true because in a series resonant circuit, the inductive reactance is again equal to the circuit capacitive reactance at resonance.

When an oscillator employs inductive and capacitive elements in its circuit, the resulting generated frequency can be computed by using the following formula:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Where the frequency, f, is expressed in cycles per second; the inductance, L, in henries; the capacitance, C, in farads; and π is a constant equal to 3.14. The above formula is rather difficult to handle. Accordingly a graphical solution for determining the value of the frequency for given values of circuit capacitance and inductance is preferred.

THE BASIC TYPES OF OSCILLATOR CIRCUITS

All of the basic types of oscillator circuits can be divided into two distinctive groups. These groups are divided into two frequency ranges. Oscillators producing signal voltages within the range of 10 to 25,000 cycles per second are known as audio-frequency (a-f) oscillators. Then, oscillators producing signal voltages within the range of 25,000 to 500,000,000 cycles per second are known as radio-frequency (r-f) oscillators.

The various types of oscillator circuits which we shall presently discuss in this lesson can be made to provide the same efficiency and power output when associated with a particular tube. The ultimate selection of a particular type oscillating circuit for application in some radio, television or electronic equipment rests principally with the design engineer. Therefore, oscillator circuits should never be changed in a set unless, of course, the original circuit cannot be made to oscillate with a tube known to be in a good condition.

In each of the following basic types of oscillator circuits we may refer to the expressions tank circuit and/or LC circuit. These expressions are given to the frequency-controlling circuit which generally consists of a coil and a capacitor. We will also refer to the excitation voltage. This is the voltage which is fed back from the plate circuit and applied to the grid circuit of the same vacuum tube. Essentially, this feedback voltage, when properly applied, actually provides the excitation voltage to the amplifier circuit, thereby producing and sustaining oscillations.

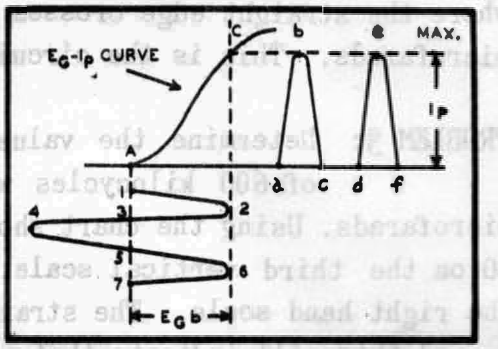

Fig. 8. Graph illustrating how the plate current increases as the a-c grid voltage swings from zero to its maximum positive and negative peaks.

THE TUNED-GRID UNTUNED TICKLER-FEEDBACK OSCILLATOR

In the circuit shown in Fig. 7, current flows in the tickler coil L2. Coil L2 induces a voltage into coil L1. When these two coils are wound in the same direction on the coil form, oscillations will be sustained. Coil L2, therefore, provides the necessary feedback to enable oscillations to take place. This type of feedback is often called inductive or magnetic feedback, since there is electromagnetic coupling between coils L1 and L2. The frequency-determining circuit in Fig. 7 consists of essentially capacitor C2, since the grid to cathode capacitance is low, and coil L1. The chart presented in Figures 4, 5 and 6 would be directly applicable to this circuit in determining any one of the three quantities when two of its values are known, namely — frequency, capacity, or inductance. By adjusting capacitor C2, a range of different frequencies may be obtained from the oscillator. This type of oscillator circuit, as is the case with all oscillators, operates as a class C amplifier with self-excitation being furnished to the amplifier to sustain oscillations. The tickler coil L2 furnishes this self-excitation through inductive coupling into the grid circuit of the vacuum tube. The oscillator circuit shown in Fig. 7 is referred to as a tuned-grid and untuned tickler-feedback oscillator since the grid circuit of the oscillator is tunable with the capacitor C2 while the feedback is obtained through the untunable tickler coil.

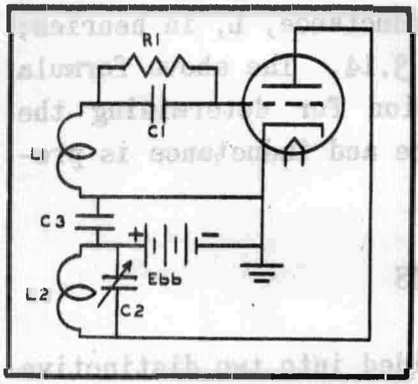

Fig. 9. The tuned-plate untuned grid-feedback oscillator circuit is shown here.

The tickler coil L2 only provides feedback for less than one-half of a complete cycle of the desired signal voltage. When electric energy is introduced into the tank circuit which consists of L1 and C2, this tank circuit has an inherent characteristic which supplies the missing portion of the cycle to the grid of the vacuum tube. This characteristic is called the fly-wheel effect of the tuned or tank circuit. Because of this characteristic, it is not necessary to supply energy for a complete cycle to the tank circuit of an oscillator to sustain oscillations. Consequently, since energy need only be supplied for a small fraction of a cycle, less than half of the complete cycle, the oscillator aswell as the classCamplifier, which operates on exactly the same characteristic, functions at the highest possible efficiency.

It has been stated that an oscillator must be self-starting. In Fig. 7 it is the resistor (grid leak) R1 which makes this possible. It functions in the following manner after the cathode has reached its operating temperature.

1. When the plate-supply battery voltage is first applied, there is no grid current flow, since the voltage drop across the resistor R1 is zero.
2. When the grid bias is zero, the plate current flow through the tickler coil L2 becomes high.
3. The flow of plate current through L2 causes a voltage to be induced in the tank circuit L1-C2 of the oscillator, thus starting oscillation. Once started, these oscillations continue until the plate supply voltage is removed.

As the plate current of the tube in Fig. 7 increases, the current through the coil L2 likewise increases and causes the introduction of a voltage across L1. The upper terminal of L1 will become positive causing a further increase in the plate current of the tube. The a-c voltage at the upper end of L1 will be applied to the grid-cathode circuit of the tube to the capacitor C1, this capacitor offering low reactance to the a-c in the circuit. When the grid of the tube is positive with respect to the cathode, then electrons will flow from the cathode to the grid. These electrons will flow through the resistor R1 and naturally, through the coil L1 back to the cathode. There will appear a d-c voltage across C1. Since R1 is in parallel with it, the voltage will also be across the resistor R1. The grid end of the resistor R1 will be negative with respect to its left end. This d-c voltage across R1, therefore, automatically applies a bias voltage to the grid-cathode circuit of the tube, the relative amount of bias voltage being dependent upon the amount of coupling between L1 and L2 and the value of R1 and also the value of the battery Ebb. The value of R1 is generally 15,000 to 50,000 ohms.

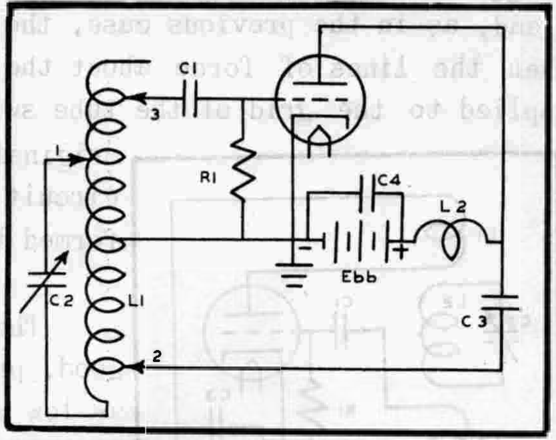

Fig. 10. The shunt-feed Hartley oscillator circuit is shown here.

After the tube in Fig. 7 has reached its average operating bias voltage across R1, which is after a few of the positive alternations of the a-c voltage across L1, then the tube will begin to operate as indicated by Eg-Ip curve shown in Fig. 8. The operating point will fall at A. Then, as the a-c grid voltage develops across L1-C2, the tank circuit, the grid voltage will swing from point 1 in the positive direction to point 2, and, at the same time, the plate current will swing up on the Eg-Ip curve to the point C. This, then causes the plate current to vary from the point a up to the point b. This is indicated as the maximum Ip.

After the a-c grid voltage has reached its maximum positive value at point 2, then, there being no further increase in plate current, the lines of force about the coils L2 and L1 will drop to zero. This causes the a-c grid voltage to change from the point 2 to the point 3. When the electromagnetic lines of force about the coils collapse, then the grid voltage swings from the point 2 to the point 3 and since the circuit operates like a fly-wheel, the a-c voltage applied to the grid-cathode circuit will continue to swing from point 3 to point 4. From this point 4, the circuit continues to fly around and back to the point 5. At this point 5, the plate current again flows as the grid to cathode voltage swings in the positive direction and over to point 6. It will be observed that the plate current started to flow when the grid voltage reached the point 5. This is indicated by the point d. Then, when the a-c grid voltage has reached the point 6, the plate current has again reached the maximum value at the point e and, as in the previous case, the instant the plate current reaches its maximum value, then the lines of force about the coils L2 and L1 collapse again and the a-c voltage applied to the grid of the tube swings once more from the point 6 to the point 7, the original starting point, and so on. Oscillations in this circuit continue at the rate determined by the tank circuit formed by L1-C2.

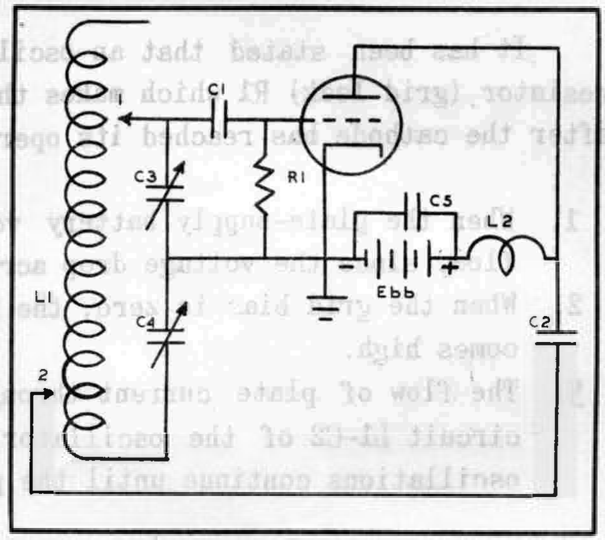

Fig. 11. The Colpitts oscillator circuit.

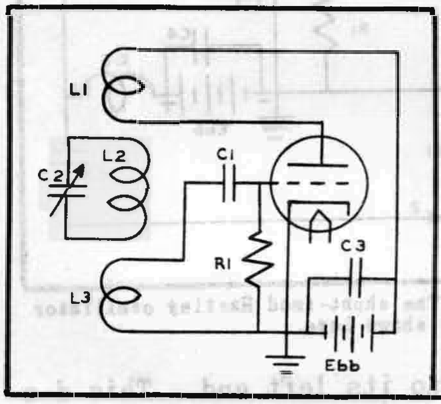

Fig. 12. The Meissner oscillator circuit.

The frequency stability of this type of oscillator is good, provided the losses in the tank circuit are kept down as low as possible. This means that low-loss coils and capacitors should be utilized in the LC circuit. Low-loss coils have large diameter (copper) wire and coil forms which absorb very little r-f energy. As the losses in the tank circuit increase, the frequency stability of an oscillator becomes poor and the exact frequency generated by the oscillator circuit no longer follows the LC circuit values shown in the charts presented in Figures 4, 5 and 6. Changes in filament (cathode) and plate supply voltages as well as changes in the temperature of the parts in an oscillator circuit can cause frequency unstability or frequency drift.

The capacitor C3, which is placed across the battery in Fig. 7, has the function of by-passing radio-frequency energy around the battery Ebb. If it were not used, the battery may be ruined with the passage of r-f energy through it. Furthermore, the battery resistance would be introduced into the circuit, thereby further lowering the frequency stability of the oscillator circuit.

THE TUNED-PLATE AND UNTUNED GRID-FEEDBACK OSCILLATOR

When the frequency determining or tank circuit is in the plate circuit of the vacuum tube and the grid circuit is untuned, the oscillator is known as a tuned plate and untuned grid-feedback oscillator. This circuit is shown on Fig. 9.

The coil L2 in the tuned-plate circuit is inductively coupled to the coil L1 in the grid circuit. These coils are again wound in the same direction on the coil form so when coupled together as shown, the phase relationship of the a-c voltage applied to the grid will be correct and oscillation will take place. Again, the amount of the feedback voltage can be regulated by changing the coupling distance between the grid and plate coils.

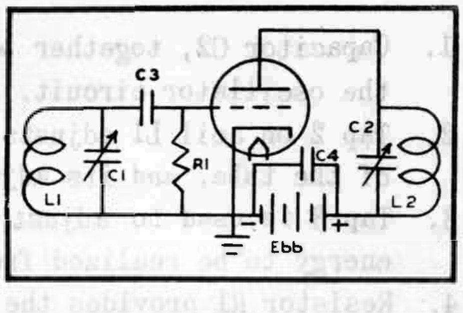

Fig. 13. The tuned-plate tuned-grid oscillator circuit.

In this oscillator, the tank circuit has been placed in the plate circuit. In the untuned-plate tuned-grid oscillator, the tank circuit was placed in the grid circuit. The tuned-plate and untuned-grid oscillator, like the preceeding ones, all operate as self-excited class C amplifiers. That is, they supply their own energy for the purpose of sustaining oscillations.

It is interesting to note that the grid resistors shown as R1 in each one of the oscillator circuits shown in Figures 7, 8 and 9 are connected across the respective grid-coupling capacitors C1. These resistors are sometimes connected between grid and cathode. This method of connection places a resistive load on the oscillator, as the value of R1 is then connected across the winding L1 of the r-f transformer formed by L1 coupled to L2. This load tends to make the oscillator give a more constant output voltage over a range of frequencies as the value of the tuning capacitor across the tank circuit is changed. However, too low an ohmic value of R1 will cause an unstable frequency to be generated. Therefore, R1 should be across C1 for best results. The ohmic value of R1 should be between 15,000 and 100,000 ohms.

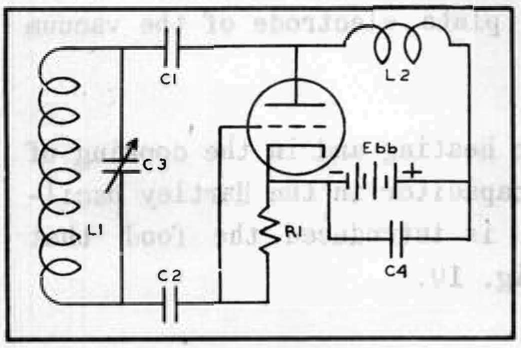

Fig. 14. The ultraudion oscillator circuit.

THE HARTLEY OSCILLATOR

The Hartley oscillator circuit was developed by Mr. Hartley in the early days of radio and is often used in test equipment. This circuit is easily identified by its tank circuit consisting of a single capacitor and a tapped coil as shown in Fig. 10. The d-c voltage supplied to the oscillator may be either applied using the series-feed or the shunt-feed method. In the first instance, the d-c supply voltage and the r-f load are in series with each other in the plate circuit. In the case of the shunt-feed method, the d-c voltage supply load and the r-f load in the plate circuit are in parallel with each other. Since the series-feed circuit places its tank circuit at a high d-c potential with respect to the filament of the tube, it must be insulated from the chassis, and an insulated shaft on the variable capacitor must be used. For this reason the series-feed method of supplying d-c to the plate of the oscillator circuit is seldom used. Practically all oscillators are fed by means of the shunt-feed method.

The principle of oscillation for the Hartley oscillator circuit is very similar to that presented for the tuned-grid and untuned-plate oscillator. With reference to the Hartley oscillator circuit shown in Fig. 10, the following facts should be considered:

1. Capacitor C2, together with tap 1 on Coil L1, controls the resonant frequency of the oscillator circuit.
2. Tap 2 on coil L1 adjusts the effective plate-load impedance in the plate circuit of the tube, and its adjustment has little effect on the resonant frequency.
3. Tap 3 is used to adjust the grid-excitation voltage which permits maximum output energy to be realized from the oscillator circuit.
4. Resistor R1 provides the operating grid bias voltage and also makes the oscillator self-starting.
5. Capacitor C3 is a blocking condenser which permits the r-f energy to flow through it and at the same time blocks the plate supply voltage Ebb from shorting, that is, discharging through the lower portion of the coil L1.
6. The coil L2 prevents r-f energy from entering the battery circuit and is, therefore, called an r-f-c. This radio-frequency choke coil offers a very high impedance (high reactance) path to the r-f energy, but hardly any resistance to the d-c voltage passing through it on its way to the plate electrode of the vacuum tube.

The Hartley oscillator circuit is used for dielectric heating and in the cooking of foods with r-f energy. When so employed, the single-tank capacitor in the Hartley oscillator circuit consists of two metal plates between which is introduced the food that is to be cooked. This capacitor is identified as C2 in Fig. 10.

THE COLPITTS OSCILLATOR

The Colpitts oscillator circuit differs from the Hartley oscillator in that the tank circuit has a single coil with two frequency-controlling capacitors C3 and C4 as shown in Fig. 11. The principle of operation of the Colpitts oscillator is identical to the principle of the other oscillators already discussed in this lesson. In adjusting the Colpitts oscillator circuit the following procedure should be followed:

1. Tap 1 along with series capacitors C3 and C4 should be adjusted in selecting the

operating (resonant) frequency of the circuit. The ratio of the capacitance of C3 to C4 controls the feedback voltage. The use of less capacity at C4 reduces the feedback voltage.

2. Tap 2 controls the amount of grid excitation, which in turn controls the output of the oscillator. Colpitts oscillators are used quite often in induction-heating applications where metal rods or objects to be heated are introduced in the inside of the single tank coil of the Colpitts oscillator. Metal rods can be heated to a cherry red within a matter of a few seconds by this process. Tempering of objects made of iron is also done in this manner.

THE MEISSNER OSCILLATOR

The Meissner oscillator circuit has an isolated (separate) tank circuit, C2-L2. This oscillator circuit may be considered as an oscillator circuit with two tickler coils, one in the grid and one in the plate circuit of the tube. The coupling between L1 and L2 as well as between L2 and L3 is adjusted for the proper amount of feedback to sustain oscillations. In principle, the Meissner oscillator functions like other types of oscillator circuits previously discussed in this lesson.

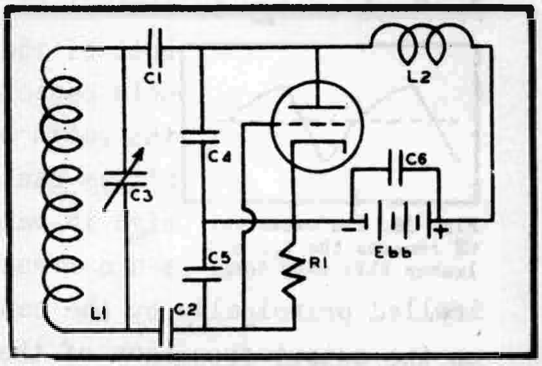

Fig. 15. The ultraudion oscillator circuit is shown here with the interelectrode capacitances symbolized.

THE TUNED-GRID, TUNED-PLATE OSCILLATOR

The tuned-plate, tuned-grid oscillator secures its feedback through the grid-plate interelectrode capacitance of the vacuum tube. The circuit arrangement for this type of an oscillator is shown in Fig. 13. When the plate circuit of a tuned-plate, tuned-grid oscillator is tuned so that the plate circuit results in positive reactance, oscillation takes place. Another way of saying this is that oscillation will take place when the plate circuit C2-L2 is tuned to a slightly higher frequency than the grid circuit L1-C1. This causes the voltage to lead the current in the plate load circuit, as a parallel resonant circuits characteristics always are controlled by the item in the circuit having the lowest reactance. The inductive reactance will be low when the capacitive reactance is less than required. It should be emphasized that the grid and plate circuits are not tuned to the same frequency as a condition for oscillation. When properly adjusted, this particular type of oscillator circuit offers very good frequency stability as a result of its high plate-load impedanee.

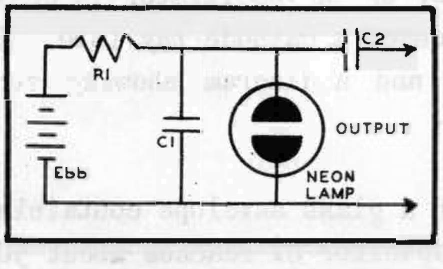

Fig. 16. Circuit diagram for a neon lamp sweep generator.

THE ULTRAUDION OSCILLATOR

The ultraudion oscillator circuit also makes use of the interelectrode capacitances in a vacuum tube for feedback coupling. The ultraudion circuit is shown in Fig. 14. The tank circuit is shown as L1-C3. The capacitors C1 and C2 serve as r-f coupling and d-c blocking capacitors. L2 is used as a radio-frequency choke (r-f-c). It is possible to show that the ultraudion oscillator circuit is very similar to the Colpitts oscillator circuit. This is done in Fig. 15. Here the capacitors C4 and C5 have been added to show the placement of the interelectrode capacitances in the circuit. The capacitor C4 represents the plate-to-cathode capacitance while C5 represents the grid-to-cathode capacitance. You will recall the Colpitts oscillator circuit shown in Fig. 11 had the two capacitors C3 and C4 connected in series and across the tank circuit. These capacitors are replaced by the capacitors C4 and C5 in Fig. 15 because capacitor C2 in Fig. 11 is a coupling capacitor and also serves to block the d-c in the plate circuit. It will be seen that there is a marked resemblance between the equivalent ultraudion and the Colpitts oscillator circuits. The degree of feedback energy is controlled by the ratio of these two interelectrode capacities. Since both of these capacitors C3 and C4 are fixed in value, a small variable capacitor is often connected across capacitor C4. In this way the ratio between the grid-to-cathode and the plate-to-cathode capacities can be varied. The coupling capacitors C1 and C2 are rather high in value, thereby producing very little impedance to the flow of a-c current through them. The frequency of the tank circuit is controlled principally by the capacitor C5. All other capacitors have little or no effect on the output frequency of the oscillator circuit. The r-f-c coil L2 and capacitor C6 prevent r-f energy from entering the battery circuit. The passage of d-c energy to the plate circuit is not hindered by the use of the coil L2.

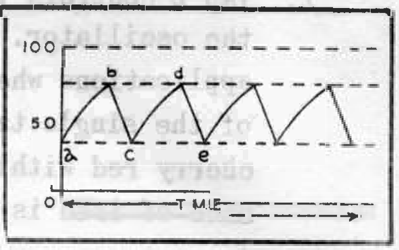

Fig. 17. Sawtooth output voltage across the capacitor C1 is shown here.

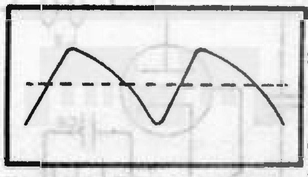

Fig. 18. The capacitor C2 removes the d-c and leaves this wave form.

NEON LAMP SWEEP OSCILLATION

In certain devices a voltage output from a generator or an oscillator is desired which will cause an electron beam to sweep across the face of a cathode ray tube. Such an oscillator is often called a sweep-circuit generator and a diagram showing such a circuit is presented in Fig. 16.

The neon lamp consists of two metal plates sealed in a glass envelope containing a small amount of neon gas. When the voltage across the capacitor C1 reaches about 50 to 60 volts, as shown at b in Fig. 17, the neon gas ionizes and acts as a short circuit (good conductor) across the capacitor, thereby allowing the capacitor to discharge. When this takes place, the voltage across the capacitor and the lamp decreases to the voltage at point C, a value where the gas ceases to be ionized and this, then, removes the short across the capacitor and the action starts all over again. The output wave, or signal, for this type of generator is shown in Fig. 18 after passing through the output-coupling capacitor C2 shown in Fig. 16. Because of the shape of the output wave, the neon lamp sweep oscillator or generator is often called a saw-tooth generator.

Neon oscillators are generally operated at audio frequencies. In other words, frequencies below 25,000 cycles are generated.

THE GRID-TUNED INDUCTIVE-COUPLED OSCILLATOR

Although most superheterodyne sets utilize a single tube for the oscillator and mixer circuits, such an arrangement proves to be unsatisfactory at the very high radio frequencies (above 56 mc) as required for television reception. Accordingly, separate oscillator and mixer tubes are employed in a television set similar in arrangement to that shown in Fig. 19. The oscillator shown in Fig. 19 is of the tuned-grid tickler-feedback type. The grid tank circuit L1-C2 is the frequency-determining circuit. This oscillator receives its feedback energy from the tickler coil L2 in the plate circuit. By means of inductive coupling between L1 and L3, from L3 to L4 by conductors and again by inductive coupling between L4 and L5, energy is transferred from the oscillator tank circuit to the mixer circuit L5. This is an efficient means of coupling the output of a high-frequency oscillator to another circuit.

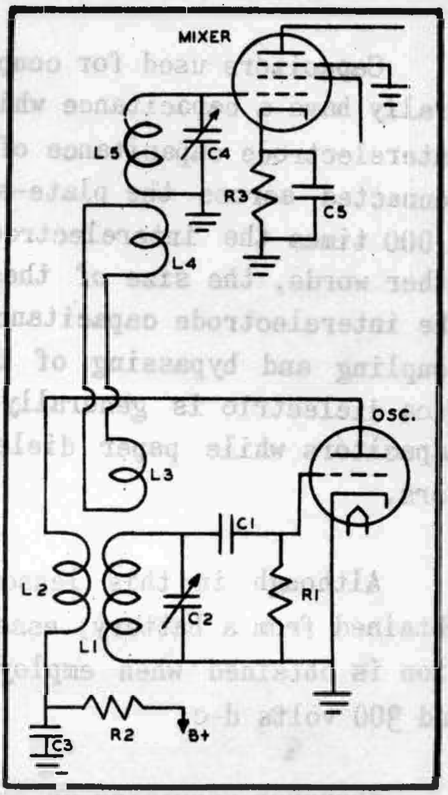

Fig. 19. The grid-tuned inductive-coupled oscillator circuit.

The oscillator-mixer circuit can be further modified as shown in Fig. 20. Here the oscillator circuit is coupled to the mixer circuit capacitively through a small capacitor C4. This capacitor may be just one inch of two parallel wires. Sometimes, instead of using a capacitor between the oscillator output and the mixer, the capacitor action is obtained by merely wrapping the insulated oscillator output lead around the grid lead wire of the mixer tube. This same type of coupling can be utilized with other types of oscillators.

SUMMARY

At least ten different types of oscillator circuits have been explained, each having its individual characteristics. They are listed below.

1. The tuned-grid untuned tickler-feedback oscillator.
2. The tuned-plate and untuned grid-feedback oscillator.
3. The Colpitts oscillator.
4. The Hartley oscillator.
5. The Meissner oscillator.
6. The tuned-grid, tuned-plate oscillator.
7. The ultraudion oscillator.
8. The grid-tuned inductive-coupled oscillator.
9. The grid-tuned capacitive-coupled oscillator.
10. The neon lamp sweep generator.

The Colpitts, the Hartley and the Meissner oscillator circuits were developed many years ago by these men who pioneered in radio. Although triode tubes were used in many of the oscillators discussed in this lesson, it is possible to use a screen-grid or a pentode tube and obtain excellent results. The feedback voltage in this case will be less due to the higher amplification factors of these tubes.

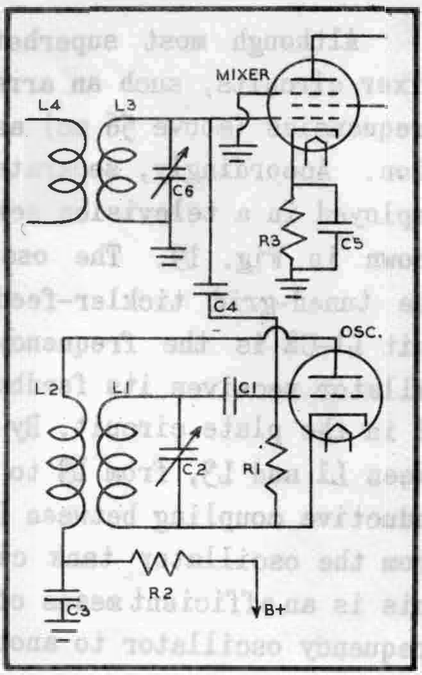

Fig. 20. The grid-tuned capacitive coupled oscillator circuit is shown here.

Capacitors used for coupling and blocking purposes generally have a capacitance which is from 200 to 500 times the interelectrode capacitance of a tube. The bypass capacitor connected across the plate-supply voltage may have 1,000 to 5,000 times the interelectrode capacitance of a tube. In other words, the size of these capacitors is dependent upon the interelectrode capacitance of a tube to insure efficient coupling and bypassing of the signal voltages developed. Mica dielectric is generally used in coupling and blocking capacitors while paper dielectric is used in bypass capacitors.

Although in this lesson the plate-supply voltage was obtained from a battery, essentially the same type of operation is obtained when employing another power supply capable of developing between 100 and 300 volts d-c.

Whenever servicing an oscillator that does not operate properly, first have the tube tested. Then be sure it receives its required operating voltages and try connecting a bypass capacitor across each bypass capacitor associated with its supply voltages. In the event the oscillator coil or coils have been replaced, then check the polarity of the coils or windings as if it were a transformer. The grid and plate ends of the respective coils should be at the opposite ends of the coil form. In other words, at a given instant the grid end of the grid coil or winding will be positive while the plate end will be negative with respect to each other. This is maintaining the proper phase relationship for oscillations. Of course, if the grid end is connected to the end of the grid coil or winding nearest the plate coil or winding, and if both coils or windings are wound in the same direction on the coil form, then the plate end of the coil or winding should be nearest the grid end of the grid coil or winding.

— END OF LESSON —