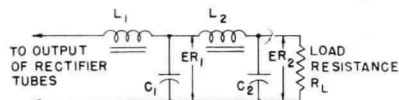


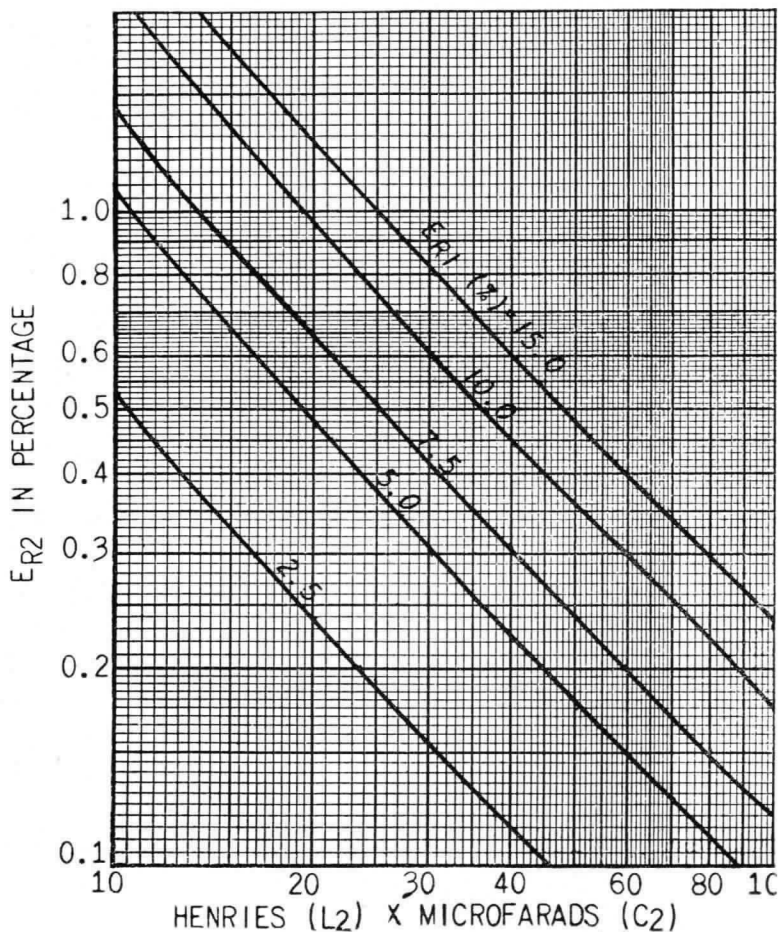
APPLICATIONS (CONT'D)

Double-section Filter



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Fig. 37—Design Chart for Double-section Filter

Selection of Tubes for Rectifiers

In general, the choice of tubes for rectifier service is based on the voltage and current requirements of the load circuit. For high current applications, the gaseous rectifier is recommended, and, for high voltages, the high vacuum rectifier is most desirable. The following points should be considered in the selection:

1. Output voltage required at load.
2. Average current required at load.
3. Peak inverse voltage on rectifier.
4. Peak rectifier current at full load.
5. Effects of nearby fields on gaseous rectifiers.
6. Effects of high-frequency transients generated by gaseous rectifiers.

AMPLIFIER AND OSCILLATOR CIRCUITS

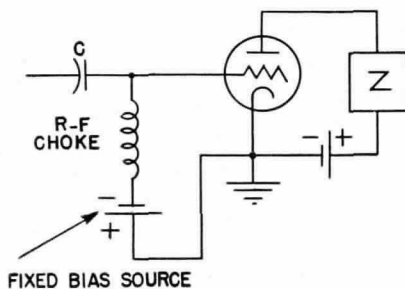
Five important factors are involved in the design of amplifiers and oscillator circuits for radio frequencies:

1. Grid Bias
2. Tank Circuits
3. Interstage Coupling
4. Neutralizing
5. Output Coupling

These, modified by considerations such as power supply capabilities, power output, power sensitivity, frequency range, space limitations, and cost, are the governing parameters the designer must consider.

1. Grid Bias—Three basic methods of obtaining grid bias are in common use, and it is important to understand the nature and capabilities of each, since they are not universally applicable.

Fig. 38 illustrates a simple amplifier employing fixed bias. An inductance-capacitance filter is sometimes used to block radio frequency from the bias supply, although it must be carefully designed and placed to avoid parasitic oscillations. An important advantage of the fixed bias system is the protection it offers to circuit and tubes against excessive current in cases where excitation fails.

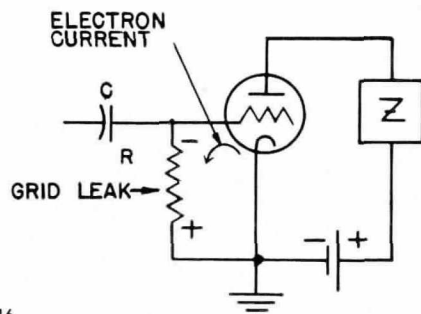


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Fig. 38—Amplifier Employing Fixed Bias

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Fig. 39 shows an amplifier with grid-leak resistor bias. Bias is developed across the grid resistor by the diode action of the grid and cathode, and is proportional to the excitation voltage. Investigation of the biasing action indicates that the value of the grid resistor is not critical, and that it may be determined from the characteristic data by Ohm's Law.



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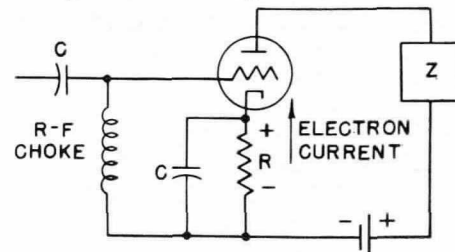
Fig. 39—Amplifier Employing Grid-leak Resistor Bias

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The grid-leak bias generator has important applications in d-c transmission systems where a fixed reference level must be maintained, although the principle is generally modified to include a separate diode bias generator.

The advantages of simplicity are offset by the inability of the system to protect itself against loss of excitation and the resultant excessive plate current. Some over-current protection must, therefore, be included.

Fig. 40 represents a self-biased amplifier. Here, bias is developed across the cathode resistor by the flow of total tube current. The action of the capacitor prevents signal degeneration; it must be large enough to provide, with the cathode resistor, a time constant considerably longer than the period of the lowest frequency to be amplified. Since it is basically a degenerative bias, the self-bias system automatically protects the tube against destructive current overloads. Two disadvantages are evident: first, the effective plate voltage is lowered by the magnitude of the bias developed, necessitating a more generous power supply, and, second, the value and physical size of the by-pass capacitor must be fairly large to maintain gain at low frequencies.



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Fig. 40—Amplifier Employing Self-bias

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Very often, combinations of all three bias schemes are used and compensation for the individual disadvantages of each is achieved.

2. Design of Tank Circuits. The design of tuned circuits for radio-frequency amplifiers and oscillators can be a very complex problem. The wealth of experience, however, which has been gained from many years of radio development has established many simplifications and shortcuts which the circuit designer may employ.

No sharp dividing line is drawn between frequencies at which lumped circuit parameters can be successfully employed and those at which effective design becomes critically dependent upon the use of cavities, tuned lines, wave guides, etc. The change starts somewhere between 150 and 200 megacycles and is fairly complete above 500 megacycles. This section will be concerned with the first group and a later section, ETX-110, will cover the high-frequency problems.

The resonant frequency of a parallel tank circuit is variously given as:

1. The frequency for which the amplitude of the impedance is maximum.

AMPLIFIER AND OSCILLATOR CIRCUITS (CONT'D)

2. The frequency for which the power factor is unity.
3. The frequency for which the power absorbed is minimum for given impressed voltage.
4. The frequency (or frequencies) which occur in the circuit in transient response, i.e., the "natural" frequencies.

The fact that these frequencies differ is primarily based on variations in the types of parallel circuits under consideration. For our purposes, however, frequency differences are so slight (less than 1 per cent), that any definition will suffice. Using the unity power factor relation then:

$$X_L = X_C$$

or
$$f = \frac{10^3}{2\pi(LC)^{1/2}}$$

where,

f is the frequency in megacycles,

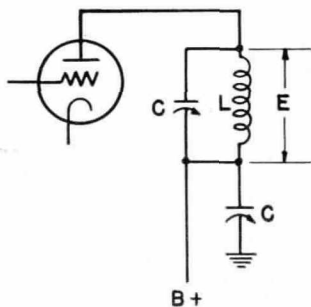
L the inductance in microhenries,

C the capacitance in micromicrofarads.

The operating Q of a circuit is defined as the ratio of the tank volt-amperes to the power supplied to the circuit by the tube. It is, in a sense, a measure of the ability of the resonant circuit to sustain itself. At low Q's the generation of harmonics is severe, and, since these harmonics represent unused power, the efficiency of the system is poor. These harmonics may also be responsible for interference with other radio services if they are radiated and should be minimized on this account.

Too high an operating Q results in excessive losses in the tank due to the large circulating current, and, therefore, needless expenditure of power. A Q between 10 and 15, generally 4π , is used as the design figure.

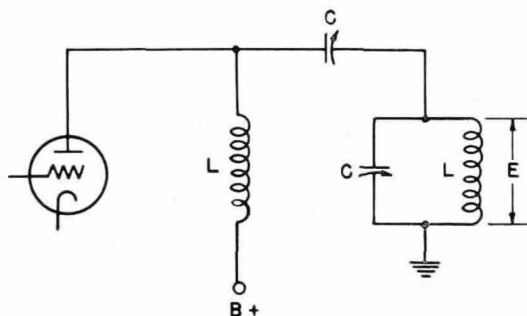
Fig. 41, 42, 43 and 44 illustrates a number of common tank circuits. The voltage E is the radio-frequency voltage developed to ground and is approximately equal to the plate voltage.



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Fig. 41—Tank Circuit with Series Feed

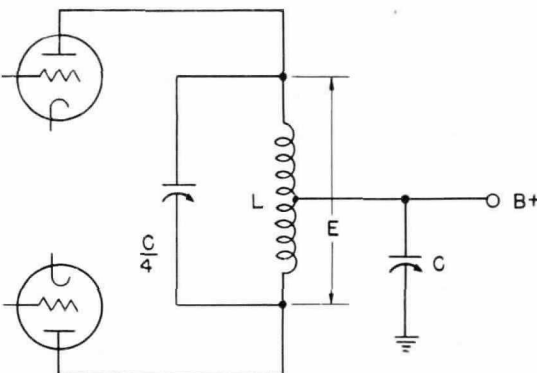
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Fig. 42—Tank Circuit with Shunt Feed

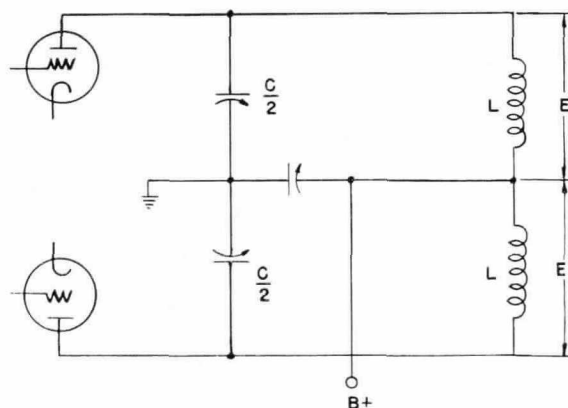
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Fig. 43—Push-Pull Tank Circuit with Series Feed, Single Stator

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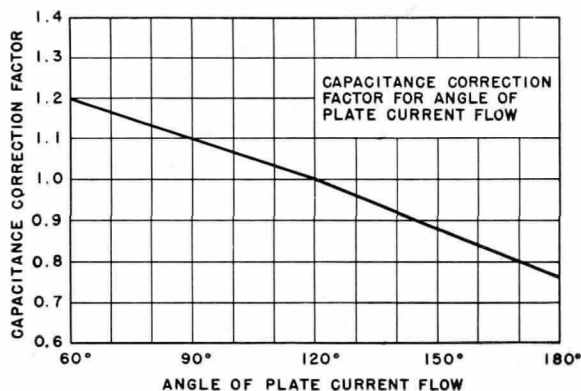
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Fig. 44—Push-Pull Tank Circuit with Series Feed, Split Stator

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Fig. 45, 46 and 47 may be used for determining the optimum design capacitance for a number of operating frequencies and Q's and Figs. 48 and 49 to determine the proper value of inductance for the chosen frequency. Allowances of the order of five to 50 micromicrofarads should be made for the various distributed capacitances which will be encountered in the circuit.

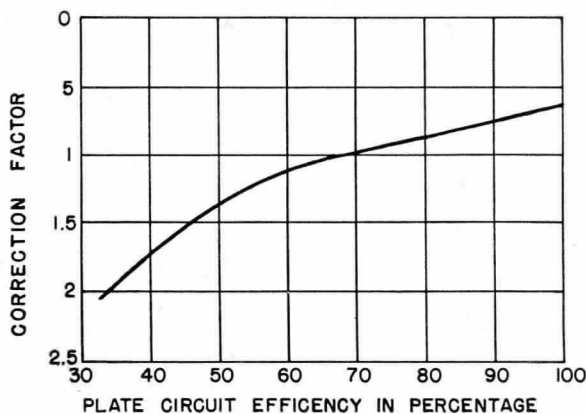
AMPLIFIER AND OSCILLATOR CIRCUITS (CONT'D)



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Fig. 45—Correction Factor by which Capacitance of Fig. 47 Should be Multiplied for Angles of Current Flow Different from 70 Per Cent

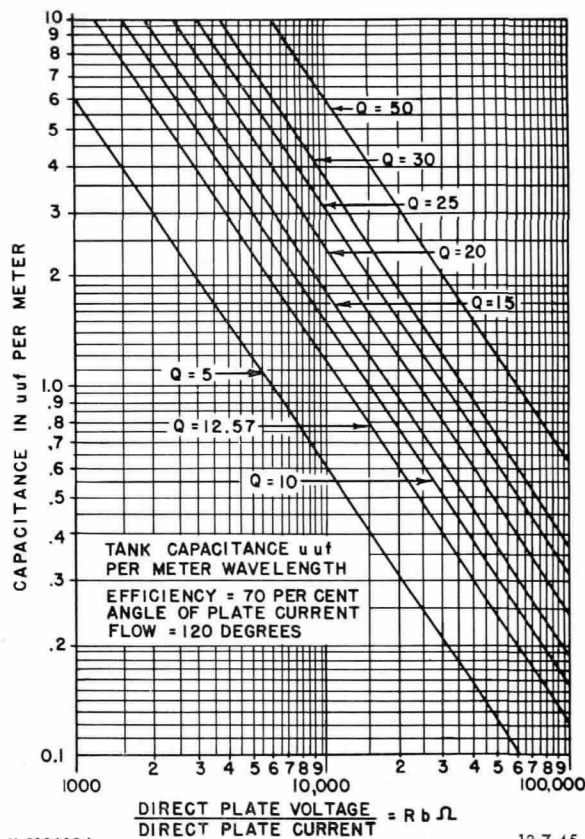


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Fig. 46—Multiply Capacitance Value from Fig. 47 by Correction Factor from this Chart if Efficiency of Plate Circuit is Different from 70 Per Cent

Fig. 45 and 46—Batcher and Moulic; *Electronic Engineering Handbook*, p-216; Electronic Development Associates (O. H. Caldwell, M. Clements); 1944



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Fig. 47—Tank Capacitance Calculator for Class C Amplifiers. Capacitance value is to be multiplied by operating wavelength in meters. Q value is for fully loaded operation and is usually 4 or 12.57. Use Fig. 45 and Fig. 46 to correct for other angles of current flow and circuit efficiency. The circuit resistance scale R_b is in ohms

Fig. 47—Batcher and Moulic; *Electronic Engineering Handbook*, p-215; Electronic Development Associates (O. H. Caldwell, M. Clements); 1944

HOW TO USE CHARTS OF FIG. 48 AND 49

Use of Figure 48:

The chart of Fig. 48 may be used to find:

- (1) The reactance of a given inductance at a given frequency.
- (2) The reactance of a given capacitance at a given frequency.
- (3) The resonant frequency of a given inductance and capacitance.

In order to facilitate the determination of magnitude of the quantities involved to two or three significant figures the chart is divided into two parts. Fig. 48 is the complete chart to be used for rough calculations. Fig. 49, which is a single decade of Fig. 48, enlarged approximately 7 times, is to be used where the significant two or three figures are to be determined.

To Find Reactance

Enter the charts vertically from the bottom (frequency) and along the lines slanting upward

to the left (capacitance) or to the right (inductance). Corresponding scales (upper or lower) must be used throughout. Project horizontally to the left from the intersection and read reactance.

To Find Resonant Frequency

Enter the slanting lines for the given inductance and capacitance. Project downward from their intersection and read resonant frequency from the bottom scale. Corresponding scales (upper or lower) must be used throughout.

Example: The sample point indicated (Fig. 48) corresponds to a frequency of about 700 kilocycles and an inductance of 0.5 henry, or a capacitance of 0.1 micromicrofarad, giving in either case a reactance of about 2,000,000 ohms. The resonant frequency of a circuit containing these values of inductance and capacitance is, of course, 700 kilocycles, approximately.

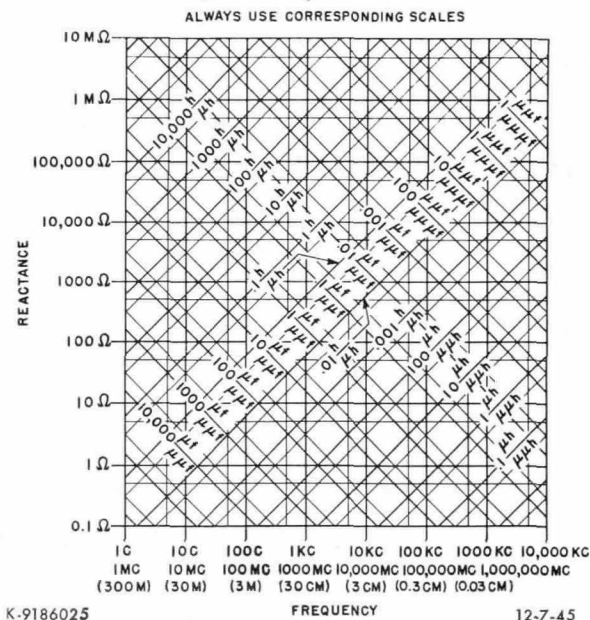
AMPLIFIER AND OSCILLATOR CIRCUITS (CONT'D)

Use of Figure 49

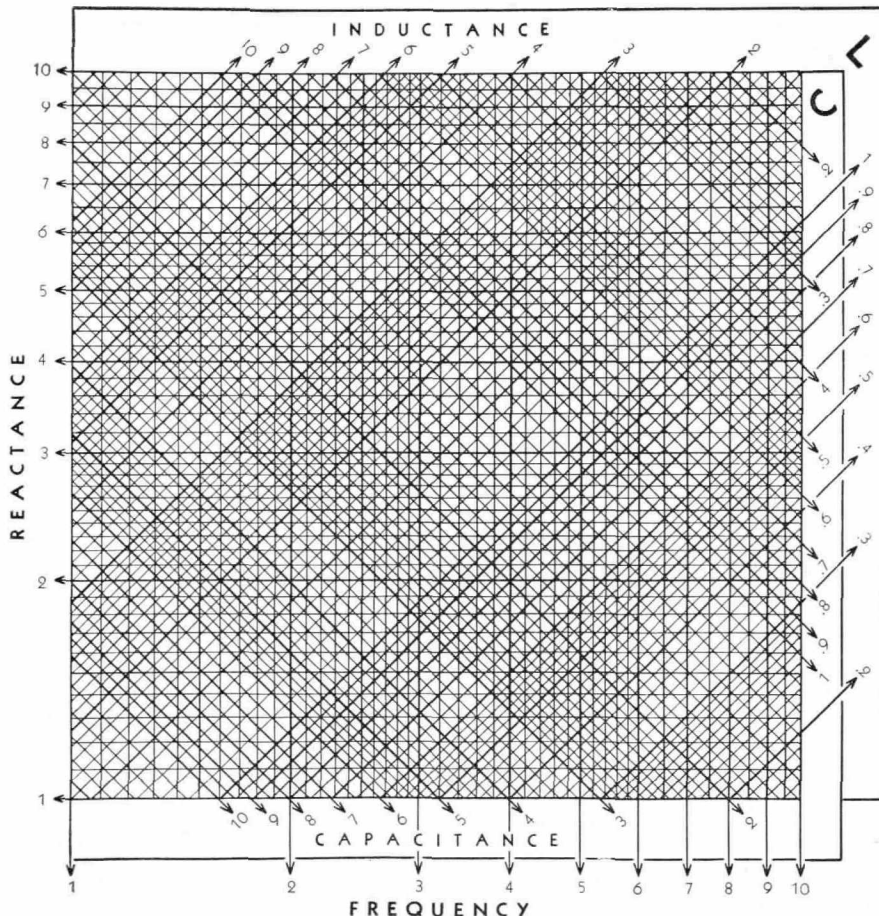
Fig. 49 is used to obtain additional precision of reading but does not place the decimal point which must be located from a preliminary entry in Fig. 48. Since the chart necessarily requires two logarithmic decades for inductance and capacitance for every single decade of frequency and reactance, unless the correct decade for L and C is chosen, the calculated values of reactance and frequency will be in error by a factor of 3.16.

Example: (continued) The reactance corresponding to 0.5 henry or 0.1 micromicrofarad is 2,230,000 ohms at 712 kilocycles, their resonant frequency.

†† Fig. 48—Reactance Chart →



Always obtain approximate value from Figure 48 before using Figure 49



†† Fig. 49—Inductance—Capacitance Chart
†† Fig. 48 and 49. Courtesy of General Radio Company

AMPLIFIER AND OSCILLATOR CIRCUITS (CONT'D)

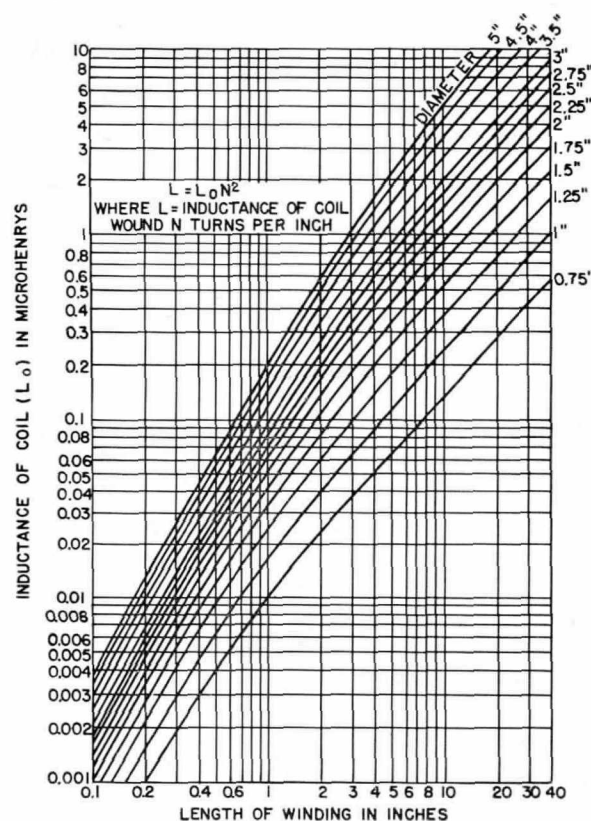
Tank Inductance

The design of the tank inductance can be carried out with the aid of Fig. 50. From the desired inductance, L , the value of L_0 is determined by:

$$L_0 = \frac{L}{N^2}$$

where N is the number of turns per inch to be used. The winding length, s , is established from the graph and the total number of turns is simply the product, Ns . Fig. 50 may also be used for the inverse operation, i.e., determining the inductance from the dimensions of a given coil.

It is important to remember that coupling circuits will, in general, have important effects on the apparent capacitance and inductance of a circuit and these effects must be included in the tank circuit design calculations.



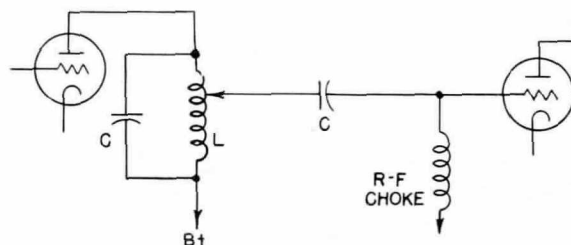
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Fig. 50—Inductance of Coils Wound One Turn per Inch (from Nagaoka's Formula)

3. Interstage Coupling. Interstage coupling in radio-frequency amplifiers may be effected by either capacitive or inductive coupling. In capacitive coupling, energy is fed from one stage

to another through a d-c blocking capacitor. As shown in Fig. 51, the coupling can be made a fraction of the total output of the first stage by tapping the plate tank. The circuit has the advantage of simplicity, but may be the cause of spurious resonances.

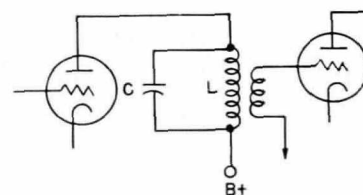


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Fig. 51—Amplifier with Capacitive Coupling

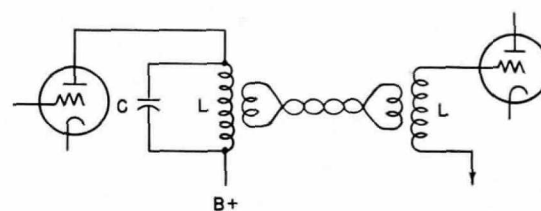
Inductive coupling (Fig. 52 and Fig. 53) may be either direct, or through transmission lines. If direct coupling is used, mechanical problems may result from the necessity of maintaining short leads. Transmission lines, such as the link coupling, allow reasonable separation of components. The link consists of a twisted pair terminated at each end by a few turns inductively coupled to the plate and grid tanks. For maximum transfer of energy the coils must be placed at the current maxima of the tanks. Other forms of inductive couplings, parallel lines, coaxial lines, etc. are practical and often used.



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Fig. 52—Amplifier with Direct Inductive Coupling



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Fig. 53—Amplifier with Link Inductive Coupling