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HIGH FREQUENCY CIRCUIT

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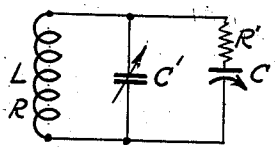


Fig. 1

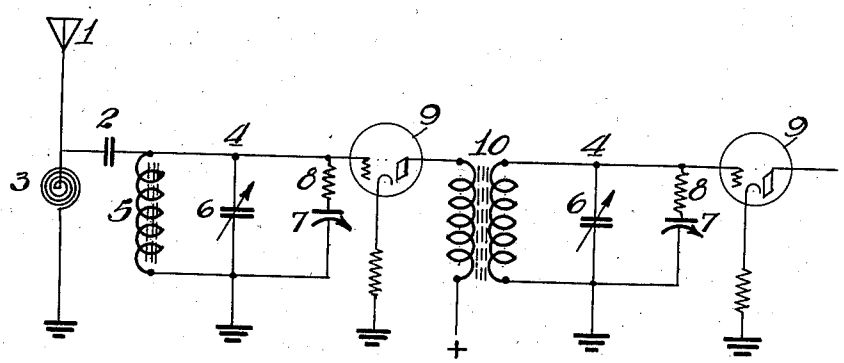


Fig 2.

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HIGH-FREQUENCY CIRCUIT

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6 Claims. (Cl. 250—40)

The invention relates to high-frequency resonant circuits and more particularly to those tunable over a desired range of frequencies by a variable capacitor.

Such circuits usually consist essentially of an inductor of fixed inductance and of a tuning capacitor the capacitance of which may be varied over a considerable range in order to tune the circuits over a range of frequencies.

The selectivity of such a circuit when expressed in terms of band width in kilocycles is a function of L/R, where R is the effective resistance of the circuit at a given frequency and where L, the inductance, is fixed. The circuit resistance, which consists chiefly of the resistance of the inductor, increases considerably with frequency, so that the selectivity of the circuit, expressed in band width, varies in some instances as much as 3 to 1 during variations in frequency of the same order. The decrease in selectivity with increasing frequency is especially marked when an iron-core inductor is employed, since the eddy-current losses in the core cause the resistance of the inductor to increase more rapidly with frequency.

When several circuits tuned by variable capacitors are cascaded together to obtain greater over-all selectivity, the decrease in selectivity with increasing frequency becomes progressively greater, not only introducing distortion of signals at the lower frequencies but also increasing the difficulty of obtaining proper tracking of several circuits throughout the frequency range, since the requirement for accuracy of the capacitors becomes excessively severe at the lower frequencies.

It is an object of the invention to provide a resonant circuit in which the undesired change in selective properties is largely eliminated.

Another object of the invention is so to broaden the selectivity of a resonant circuit employing an iron-core inductor at the lower frequencies of its tuning range as to facilitate the tracking of several of the circuits connected in cascade.

Still another object is to automatically introduce the correct amount of damping in a resonant circuit when the resistance becomes so low that self-oscillations are likely to occur.

The invention will be better understood if reference is made to the accompanying drawing, in which:

Fig. 1 is the schematic diagram of a single resonant circuit embodying the invention; and

Fig. 2 is the schematic diagram of a radio receiving system including two resonant circuits which embody the invention.

Referring to Fig. 1, L is the fixed inductor which has a resistance R, variable with frequency. C is the variable capacitor used for tuning the circuit to a desired frequency, and C′ is an adjustable capacitor of the type usually employed for trimming purposes to establish the initial maximum frequency when capacitor C is at its minimum setting. It is understood that capacitor C′ normally slightly restricts the useful range obtainable with capacitor C, but a trimmer capacitor in each circuit is necessary for uniform performance of several circuits which are simultaneously tuned.

At any frequency the value of the current circulating through the two capacitively reactive branches is proportional to the values of capacitors C and C′. The larger C is, the more current flows through its branch. A suitable value of resistance R′ is inserted in series with variable capacitor C. At the maximum frequency, this capacitor being at its minimum setting, the major portion of the current passes through C′ and the circuit has substantially the resistance R of the inductor, so that the selectivity is proportional to L/R. As the circuit is tuned to a lower frequency by increasing the capacitance of capacitor C, the R of the inductor decreases. At the same time R′ begins to have an effect upon the circuit, and it can be represented by an additional effective resistance

$$r = R' \frac{C}{C' + C}$$

When C becomes greatly larger than C′, the effective resistance r approximates the value of R′. At any frequency, therefore, the resistance of the circuit is increased by the value of r, so that the resultant selectivity becomes proportional to

$$\frac{L}{R + r}$$

Since R decreases as the frequency increases and at the same time r increases, the selectivity tends to remain substantially uniform over the whole frequency range.

Fig. 2 shows the application of the invention to a radio receiver which employs two resonant circuits arranged in cascade. Such an arrangement is commonly employed in radio receivers of the tuned radio-frequency type, and in the radio-frequency portions of superheterodyne receivers. The antenna 1 is grounded through high-impendance choke coil 3 and is coupled through a

capacitor 2 to the first circuit 4 including iron-core inductor 5, an adjustable trimmer capacitor 6 of small capacitance and a variable tuning capacitor 7. A resistor 8 is in series with capacitor 7 and tends to broaden the selectivity when the capacitance of capacitor 7 is increased for tuning to the lower frequencies. The circuit 4 is in the grid circuit of thermionic tube 9, the plate circuit of which includes the primary winding of coupling device 10. The secondary winding of coupling device 10 is the inductor of the second resonant circuit 4. The tuning capacitors 7, 7 of the tuned circuits 4, 4 are preferably mechanically ganged together to facilitate simultaneously tuning the two circuits to resonance at the same frequency. The second resonant circuit 4 is in the grid circuit of second thermionic tube 9, which may operate otherwise than as an amplifier. For example, second tube 9 may, in a superheterodyne radio receiver, function as the modulator.

In an embodiment of the invention according to Fig. 1, the following components are satisfactory:

Inductance L=200–250 microhenries
Capacitance C'=10–30 micromicrofarads (adjustable)
Capacitance C=10–450 micromicrofarads (variable)
Resistance R'=1–5 ohms

A low-loss iron-core inductor of a type suitable for use in circuits such as those shown herein has a resistance of 10 to 15 ohms at 1400 kilocycles, and of about 2.5 to 5 ohms at 600 kilocycles, depending on the amount of iron, the size of the wire and the size of the shielding container. The variation of the resistance and the selectivity between 600 and 1400 kilocycles may be from 3 to 5 times, or 9 to 25 times when two circuits are used in cascade. The insertion of a resistance R' of about 2 ohms will barely affect the selectivity of the system at 1400 kilocycles because the resistance of the inductor is of a high order and because the added resistance is ineffective when the tuning capacitor C is near its minimum value. On the other hand, the same resistance is high compared with the resistance of the inductor at 600 kilocycles, and will almost double the width of the selectivity curve when the tuning capacitor is near its maximum value. In this instance, therefore, the undesired selectivity variation of from 3 to 5 times is now reduced to about 2 times in one circuit, or about 4 times with two circuits. A still larger value of resistance R' will produce greater compensation, but values over 5 ohms are likely to produce an undesired broadening of the selectivity at the higher frequencies, with results detrimental to good performance.

The invention is not limited to the devices as described, but may be equally well applied to systems other than radio receivers which employ resonant circuits tuned by variable capacitors. It will be understood that other reactive elements having high-loss components may be employed instead of the resistance R' to produce substantially the same desired improvement in the uniformity of selectivity over a wide range of frequencies.

Having thus described my invention, what I claim is:

1. In a high-frequency resonant circuit tunable over a range of frequencies and including an inductor, a main tuning capacitor, and an auxiliary tuning capacitor, means including a resistor in series with said main tuning capacitor of such value as to substantially compensate for variation of the resistance of said circuit with frequency.

2. In a high-frequency resonant circuit tunable over a range of frequencies and including an inductor having a ferro-magnetic core, a main tuning capacitor and an auxiliary tuning capacitor, means including a resistor in series with said main tuning capacitor for maintaining the total resistance of said circuit substantially constant over said range of frequencies.

3. Means for tuning a high-frequency resonant circuit having a magnetic-cored inductor while maintaining the resistance of said circuit substantially constant, said means including an adjustable capacitor and a network comprising a variable tuning capacitor and a resistor in series, said adjustable capacitor and said network each being in shunt with said inductor.

4. In a high-frequency resonant circuit tunable over a range of frequencies and including an inductor, a main tuning capacitor and an auxiliary tuning capacitor, means including a resistor in series with said main tuning capacitor for maintaining the total resistance of said circuit substantially constant over said range of frequencies.

5. Means for tuning a high-frequency resonant circuit over a range of frequencies, including an inductance, a capacitor of relatively small capacitance and adjustable by an amount only sufficient to align said circuit at a single frequency and a network consisting of a variable tuning capacitor in series with a resistor, said variable tuning capacitor having capacitance values adequate to tune said circuit over said range, said adjustable capacitor and said network each being in shunt with said inductor.

6. In a high-frequency resonant circuit tunable over a range of frequencies and including an inductor having losses which increase with frequency, a main tuning capacitor and an auxiliary tuning capacitor, means for substantially compensating for said losses, said means including a resistor in series with said main tuning capacitor, whereby the selectivity of said resonant circuit remains substantially constant over said frequency range.

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