Oct. 4, 1938. W. A. SCHAPER 2,131,976

IMAGE SUPPRESSION SYSTEM

Filed May 17, 1937

Fig. 1,

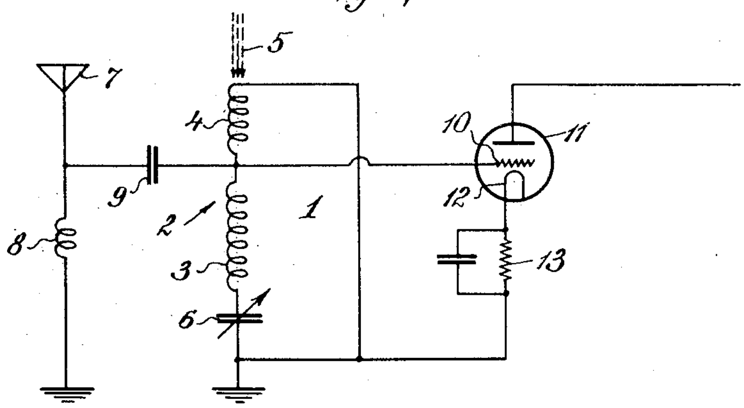

Fig. 2,

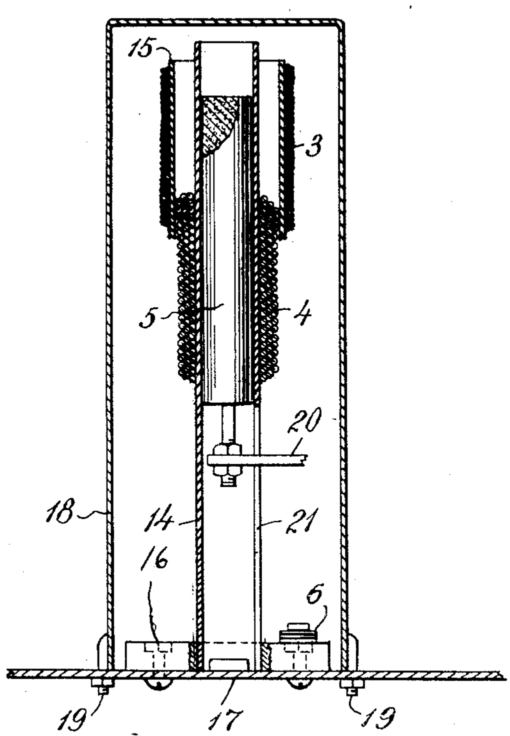

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IMAGE SUPPRESSION SYSTEM

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9 Claims. (Cl. 250—40)

This invention relates to high-frequency circuits and more particularly to those employed in receiving systems of the superheterodyne type, wherein the signal passes through one or more circuits tuned to the signal frequency, is combined with locally produced oscillations, is demodulated to produce a beat frequency, is then further amplified at the beat or intermediate frequency, is finally demodulated to produce an audio-frequency current and is then rendered audible. More particularly, the invention relates to circuits intended to suppress certain undesired responses in superheterodyne receivers.

When a radio receiver of the superheterodyne type is tuned to a desired signal, a spurious response may be obtained from a second signal which is higher (or lower) in frequency than the desired signal by twice the intermediate frequency of the receiver. The undesired signal is commonly called the image-frequency signal, and its frequency is called the image frequency. Thus for every desired signal there is a corresponding image-frequency signal which, if present and of sufficient strength, may cause an undesired response. For example, if a particular desired signal has a frequency of 600 kilocycles and the intermediate frequency of the receiver is 450 kilocycles, the local oscillator being adjusted to a frequency higher than the signal frequency, the image-frequency signal will have a frequency of $600+(2\times450)$ or 1500 kilocycles. The ratio of the input voltage of image frequency required to produce a given output, to the signal voltage required for the same output, is called the image-frequency ratio of the receiver.

In a superheterodyne receiver, that portion of the system through which the signal passes without a change in frequency usually includes an antenna circuit and one or two variably tuned circuits with or without a thermionic amplifier tube, and is commonly called the "preselector". One method of increasing the image-frequency ratio is to employ, in the preselector, additional resonant circuits tuned to the signal frequency so that a satisfactory degree of attenuation of the undesired image-frequency signals is obtained. Such an arrangement, however, increases the cost of manufacture of the receiver and requires additional chassis space.

One of the objects of my invention is to provide a simple and effective means for increasing the image-frequency ratio of a superheterodyne receiver. Another object of the invention is to provide an image-suppression arrangement for a superheterodyne receiver which is inexpensive and does not require complicated additional apparatus.

The arrangements of the present invention are particularly adapted for use in receivers in which the resonant frequency of the variably tuned circuits is adjusted by varying the inductance in the circuits. Variable inductance devices suitable for this use are disclosed in my United States Patent No. 2,051,012 on Permeability tuning means. The employment of such variable inductance devices, together with the arrangements of the present invention, provides a receiver which not only is capable of substantially uniform performance over a wide range of signal frequencies but also has a substantially constant image-frequency ratio.

The invention will be better understood by reference to the drawing, in which:

Fig. 1 is a schematic wiring diagram of one advantageous embodiment of the invention; and

Fig. 2 is an elevation, partly in section, of a variable inductance device suitable for use in the circuit of Fig. 1.

Referring to Fig. 1 of the drawing, resonant circuit 1 comprises variable inductor 2, which includes coils 3 and 4 and movable magnetic core 5, and adjustable capacitor 6. Antenna 7 is grounded through choke coil 8 and is connected to the junction of coils 3 and 4 through capacitor 9. Grid 10 of vacuum tube 11 is also connected to the junction of coils 3 and 4. Cathode 12 of vacuum tube 11 is grounded through biasing resistor 13. The junction of coil 4 and capacitor 6 is grounded.

In operation, resonant circuit 1 is tuned to the frequency of the desired signal by means of movable magnetic core 5. The portion of the voltage of signal frequency which is developed across coil 3 and capacitor 6 in series is applied to grid 10 of vacuum tube 11. By means of adjustable capacitor 6, resonant circuit 1 may be aligned with the other variably tuned circuits of the receiver, this adjustment preferably being made at or near the high-frequency end of the tuning range.

Coil 3 and capacitor 6 form a series circuit which is resonant at a frequency higher than the signal frequency. Since coil 3 and capacitor 6 in series are connected directly across the input to vacuum tube 11, they form a series trap circuit which, at resonance, has an impedance equal to the resistance of coil 3 which may be made very low. By proper choice of coil 3, the series resonant frequency of coil 3 and capacitor 6 may be made substantially equal to the image frequency which is to be suppressed. If coil 3 is properly related to movable core 5, this relationship between the series resonant frequency and the signal frequency may be maintained substantially unchanged throughout the range of signal frequencies. Thus a high degree of image-frequency suppression is realized due to the low-impedance path for image-frequency currents which is provided by coil 3 and capacitor 6 in series.

By way of example, the resonant circuit 1 may be tunable over a range of signal frequencies between 540 and 1600 kilocycles. If the intermediate frequency is 450 kilocycles and the local oscillator is adjusted to a frequency higher than the signal frequency, the image-frequency range will extend from 1440 to 2500 kilocycles. Thus while the signal frequency has a maximum-to-minimum ratio of 2.97, the ratio of the maximum to the minimum image frequency is only 1.736. These frequency ratios correspond with inductance ratios of 8.8 and 3.0, respectively. Since the resonant frequency of circuit 1 depends upon the effect which magnetic core 5 has on both coils 3 and 4, whereas the frequency of series resonance of coil 3 and capacitor 6 is dependent only upon the effect of the magnetic core upon coil 3, the desired relations are readily obtained by properly proportioning coils 3 and 4 with respect to core 5.

As the core 5 is inserted into coils 4 and 3, in effect the junction of coils 4 and 3 is electrically shifted downward, in such a maner that coil 4 becomes an increasingly larger part of the total inductance in circuit 1 and coil 3 becomes an increasingly smaller part of the total inductance, but at the same time the inductance of coil 3 increases at the proper rate to provide attenuation of the undesired image-frequency signals.

Fig. 2 of the drawing shows a variable inductance device suitable for use in the circuit of Fig. 1. Coil 4, which may be of the three-layer, bank-wound type, is wound on vertically disposed tube 14, within which magnetic core 5 slides freely. Coil 3, which may be a two-layer bank winding, is supported on tube 15, which is mounted concentrically with tube 14, in such a manner that the lower portion of coil 3 overlaps the upper portion of winding 4. Insulating base 16, in addition to providing a suitable means for mounting tube 14, also supports adjustable capacitor 6 which is conveniently arranged to be adjusted from below the chassis 17 to which base 16 may be attached. Shield can 18, surrounding the variable inductance device, is attached to chassis 17 by means of spade bolts 19. External means not shown, may be employed to impart vertical motion to magnetic core 5 through lever 20, which protrudes through slot 21 in tube 14.

In one successful embodiment of the invention, the following constants are employed:

Coil 3________56.3 microhenries; 10/44 SSE wire
Coil 4________77.5 microhenries; 30/44 DSE wire
Capacitor 6___50–125 micromicrofarads
Choke coil 8___2 millihenries
Capacitor 9___7 micromicrofarads

It will be understood that the scope of the invention is not limited to these particular values, nor to the particular mechanical form shown in Fig. 2 of the drawing. Various modifications will occur to those skilled in the art and may be incorporated without departing from the scope of the invention, which is defined in the appended claims.

I claim:

1. A high-frequency network having inductive and capacitive elements connected to form series and parallel circuits resonant at materially different frequencies, and means including a magnetic core movable relatively to said inductive elements to tune said circuits over wide ranges of frequency while maintaining a substantially constant difference between the resonant frequencies of said circuits.

2. A high-frequency network having inductive and capacitive elements connected to form a series circuit and a parallel circuit, and means including a magnetic core to tune said series circuit over a first range of frequencies and simultaneously to tune said parallel circuit over a second materially different range of frequencies while maintaining a substantially constant difference between the resonant frequencies of said circuits.

3. A high-frequency network having inductive and capacitive elements connected to form a series resonant circuit and a parallel resonant circuit, and a magnetic core movable relatively to said inductive elements, said core being of such nature and so related to said inductive elements that movement of said core simultaneously tunes said circuits over materially different wide ranges of frequency while maintaining a substantially constant difference between the resonant frequencies of said circuits.

4. A high-frequency network including inductance coils and a capacitor arranged to provide series and parallel circuits resonant at materially different frequencies, and a magnetic core movable relatively to said coils, said coils and said core being so related that said movement alters said resonant frequencies while maintaining their difference substantially constant.

5. A high-frequency network including a capacitor and a first inductive winding connected to form a series resonant circuit, a second inductive winding connected to said first inductive winding and to said capacitor to form a parallel resonant circuit, and a magnetic core movable relatively to said windings to tune said resonant circuits over two different ranges of frequency, said core and said windings being so chosen and so related as to maintain a substantially constant difference between the resonant frequencies of said circuits.

6. A high-frequency network having inductive and capacitive elements, and means including a magnetic core movable relatively to said inductive elements to simultaneously secure relatively high resonant response to any selected carrier within a range of frequencies and relatively low response to a carrier displaced from said selected carrier by a substantially constant frequency difference.

7. A high-frequency network having inductive and capacitive elements, and means including a magnetic core movable relatively to said inductive elements to provide maximum parallel resonant impedance to any desired carrier within a range of frequencies and minimum series resonant impedance to a carrier displaced from said desired carrier by a substantially constant frequency difference.

8. A high-frequency variable tuning device including an adjustable capacitor, a pair of coaxially mounted and serially connected inductive windings, and a magnetic core movable relatively to

said windings, said core being such as to tune a parallel circuit including both of said windings and said capacitor over a first range of frequencies and a series circuit including one of said windings and said capacitor over a second materially different range of frequencies while maintaining a substantially constant difference between the resonant frequencies of said circuits.

9. A high-frequency variable tuning device including an adjustable capacitor, a first inductive winding having three layers, a second inductive winding having two layers, and a movable cylindrical magnetic core, said core being coaxial with respect to and movable relatively to said windings, said first and second windings and said capacitor forming a parallel resonant circuit, said second winding and said capacitor forming a series resonant circuit, and said core being of such nature and so related to said windings that movement of said core simultaneously tunes said circuits over materially different wide ranges of frequency while maintaining a substantially constant difference between the resonant frequencies of said circuits.

WILLIAM A. SCHAPER.