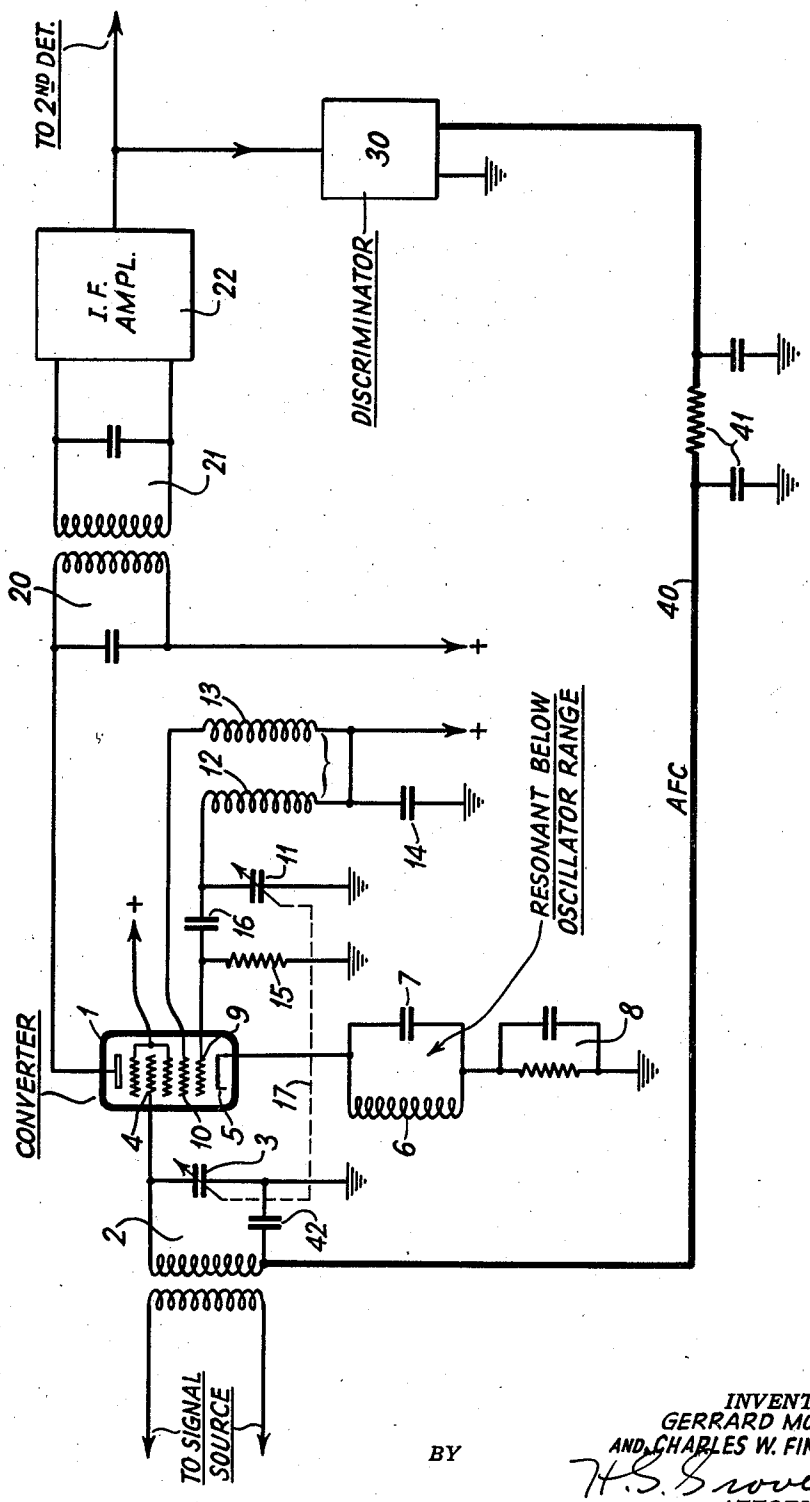
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AUTOMATIC FREQUENCY CONTROL CIRCUIT

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AUTOMATIC FREQUENCY CONTROL CIRCUIT

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Our present invention relates to automatic frequency control (AFC) circuits of the type used at present in superheterodyne receivers, and more particularly to an improved and simple AFC circuit which dispenses with the usual frequency control tube.

There has previously been disclosed an AFC system employing a reactive impedance, as an inductance, in the cathode circuit of a frequency changer tube; the AFC bias being applied directly to the signal input electrode of the tube. In such a system variation of the input electrode potential results in a substantial change in the frequency of the oscillator tunable tank circuit. When utilizing such an AFC system in a receiver tunable over the broadcast band of 500 to 1550 kc., it is essential to provide a wide range of frequency shift at the successive settings of the oscillator tank condenser. For example, frequency shifts of the order of 10–25 kc. are desirable, so that frequency correction of the tank circuit is readily accomplished.

Accordingly, it may be stated to be one of the main objects of our invention to provide an AFC system employing a combined local oscillator-first detector network; a discriminator being used to provide an I. F. frequency-responsive potential which is applied to the signal grid of the said network tube, utilizing an impedance which presents essentially a capacity effect to the oscillator tank circuit and thereby produces relatively wide frequency shifts of the latter as the signal grid potential is varied.

Another important object of the invention is to provide a frequency changer tube having signal and oscillator circuits associated therewith; and there being included in the space current path of the tube, and in operative association with the oscillator circuit, a resonant circuit tuned to a frequency below the oscillator circuit frequency; and means being utilized to adjust the gain of the changer tube thereby to vary the effective frequency of the oscillator circuit.

Still other objects of our invention are to improve generally the simplicity and efficiency of AFC circuits for receivers, and more especially to provide an AFC circuit which is reliable and effective in operation, and is economically manufactured and assembled.

The novel features which we believe to be characteristic of our invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which we have indicated diagrammatically a circuit organization whereby our invention may be carried into effect.

Referrng now to the drawing, there is shown the converter network of a superheterodyne receiver; remaining circuits being schematically represented. The converter tube 1 may be a pentagrid tube; say of the 6A8G type. The input and output circuits thereof are purely conventional; those skilled in the art will readily appreciate the construction of the network. The signal input circuit 2 includes a variable tuning condenser 3; the input circuit is connected between the signal grid 4 and ground. The cathode 5 is connected to ground through a coil 6; the condenser 7 being utilized to resonate the coil to a frequency below the oscillator tank frequency range. A self-biasing resistor-condenser network 8 may be included in series between ground and coil 6 thereby to establish grid 4 at a normal negative bias with respect to cathode 5.

The electrodes 9 and 10 function as the oscillator grid and anode respectively. The tunable tank circuit for the oscillator section comprises the variable condenser 11 and coil 12. The electrode 10 is connected to feedback coil 13, the latter being reactively coupled to tank coil 12. The junction of coils 12 and 13 is connected to ground by a padder condenser 14. The anode electrode 10 may have a positive potential applied thereto from any desired source; the oscillator grid electrode 9 is connected to ground by the leak resistor 15, and the blocking condenser 16 is connected between the high potential side of condenser 11 and the grid 9. The rotors of condensers 3 and 11 may be arranged for mechanical uni-control adjustment; the dotted line 17 designates such tuning instrumentality.

The signals applied to input circuit 2 may be derived from an antenna, after being amplified by one or more tunable radio frequency amplifiers. The signal range may be the broadcast band of 500 to 1550 kc.; or it may be any of the ranges used in a multi-range receiver. The intermediate frequency (I. F.) may be chosen from a range of 75 to 450 kc.; say, for example, the I. F. is 400 kc. The network 20 is, then, resonated to the 400 kc. value; the network being connected in the plate circuit of tube 1. The signal grid 4, as is well known, is electrostatically shielded from the oscillator electrodes by the positive screen electrodes. The I. F. amplifier 22 has its input circuit 21 coupled to the I. F. circuit 20; the amplified I. F. energy is fed to a second detector, and the latter

may provide the direct current voltage for AVC, if desired.

The discriminator 30 may be constructed according to the disclosure of S. W. Seeley in U. S. P. 2,121,103, issued June 21, 1938. The function of the discriminator is to derive from the I. F. output of amplifier 22 a direct current voltage whose polarity and magnitude are dependent upon the sense and amount of the frequency departure of the carrier, at the output of amplifier 22, from the predetermined I. F. value. The AFC bias, that is the discriminator output voltage, is zero when the carrier frequency of the I. F. signal energy is equal to the I. F. By connecting the discriminator output to the signal grid 4, as by lead 40, there is provided a device for varying the gain of tube 1 in response to frequency variations of the I. F. energy carrier. The lead 40 includes the filter 41 for suppressing the pulsating components in the AFC bias; the blocking condenser 42 is connected between lead 40 and the grounded side of condenser 3.

The tank circuit 11—12 is tunable over a frequency range of approximately 900 to 1950 kc.; it constantly differs from the signal circuit frequency by the I. F. value. If the tank frequency departs from that frequency value which produces the desired I. F. value, then the I. F. energy carrier frequency will shift and produce AFC bias. This occurs whether the tank frequency departure is caused by the inter-station tuning process, or by oscillator frequency drift from a desired setting. The AFC bias is applied to signal grid 4 thereby to adjust the frequency of tank circuit 11—12 in a sense to maintain the I. F. value of 400 kc. Since the network 6—7 is resonant to a frequency below the lowest frequency of the tank circuit frequency range, the impedance of the network is essentially capacitative insofar as the tank circuit 11—12 is concerned.

As the potential of grid 4 is made increasingly negative, the frequency of tank circuit 11—12 is found to increase. Conversely, when the grid 4 is rendered less negative, with respect to the normal grid bias value, the tank circuit frequency decreases. This means that the capacitative effect of network 6—7 is varied, with signal grid bias adjustment, in a manner such as to supplement the condenser 11, and in a direction to maintain the predetermined I. F. value. The bias network 8 may be used to establish the normal grid bias value of grid 4; it is recommended that the normal bias value be sufficiently high to prevent the grid 4 being swung positive upon the AFC bias assuming a relatively high positive potential.

To explain the actual operation of the AFC circuit, let it be assumed that a signal carrier of 1000 kc. is desired to be received. Assuming, further, that the tuner 17 is being adjusted to adjust circuits 2 and 11—12 to 1000 kc. and 1400 kc., respectively, when the oscillator tank circuit has been resonated to 1390 kc. (assuming the tuner has been previously set to receive stations below 1000 kc.) I. F. energy of 390 kc. will be produced in circuit 20. The discriminator 30 is constructed so that for I. F. carrier departures below 400 kc. the AFC bias is negative; whereas for departures above 400 kc. the AFC bias is positive. It will now be seen that when the AFC bias goes negative, the frequency of network 11—12 increases towards 1400 kc. The constants of network 6—7, and the bias range of grid 4, are chosen to shift the frequency of circuit 11—12 sufficiently to secure the desired I. F. value.

Shifts of 24 kc. were obtained at the low frequency end of the broadcast band, and 12.3 kc. at the high frequency end. This was accomplished when 6—7 was tuned to 440 kc. Network 6—7 is tuned below the oscillator band, and preferably below the desired signal band. It serves to produce a quadrature current in the cathode electrical stream. When the bias of grid 4 is changed this quadrature current is changed, and the effect of tube 1 in shunting circuit 11—12 is varied. For example, when grid 4 is sent negative by the discriminator bias, the quadrature current of cathode 5 is changed, and the shunt across circuit 11—12 produced by this quadrature current is changed. The frequency of 11—12 is increased by this process.

By way of illustration the following circuit constants are given, it being understood that these values are in no way limiting:

Coil 6=	3 millihenries
Condenser 7=	100 mmf.
Condenser 14=	450 mmf.
Condenser 16=	100 mmf.
Resistor 15=	50 megohms

While we have indicated and described a system for carrying our invention into effect, it will be apparent to one skilled in the art that our invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of our invention, as set forth in the appended claims.

What we claim is:

1. In a frequency changer circuit provided with a tube having an oscillator section and an associated oscillator tank circuit, a signal input electrode in said tube, an intermediate frequency output circuit associated with an output electrode of the tube, a signal input circuit coupled to the signal input electrode, a capacitative impedance, disposed in the space current path controlled by the signal electrode, operatively associated with the tank circuit, and means for varying the potential of said input electrode thereby to cause said impedance to adjust the tank circuit frequency, said capacitative impedance comprising a network tuned to a frequency below any frequency to which the tank circuit may be resonated but above the said intermediate frequency.

2. In a frequency changer circuit provided with a tube having an oscillator section and an associated oscillator tank circuit, a signal input electrode in said tube, an intermediate frequency output circuit associated with an output electrode of the tube, a signal input circuit coupled to the signal input electrode, a capacitative impedance, disposed in the space current path controlled by the signal electrode, operatively associated with the tank circuit, and means for varying the potential of said input electrode thereby to cause said impedance to adjust the tank circuit frequency, said capacitative impedance consisting of a resonant network tuned to a frequency below the oscillator tank circuit frequency range.

3. In combination with a tube having a cathode and plate, a signal grid, oscillator grid and oscillator anode electrode disposed between the cathode and plate, a tunable signal input circuit connected between the signal grid and cathode, a tunable oscillator circuit operatively associated with the oscillator grid and anode, an intermediate frequency output circuit coupled to the plate, a discriminator coupled in said interme-

diate circuit to produce a variable direct current voltage, means applying the variable voltage to the signal grid, and a network in the cathode circuit resonant to a frequency below the oscillator frequency range.

4. In combination with a tube having a cathode and plate, a signal grid, oscillator grid and oscillator anode electrode disposed between the cathode and plate, a tunable signal input circuit connected between the signal grid and cathode, a tunable oscillator circuit operatively associated with the oscillator grid and anode an intermediate frequency output circuit coupled to the plate, a discriminator coupled to said intermediate circuit to produce a variable direct current voltage, means applying the variable voltage to the signal grid, and a network in the cathode circuit which is resonant to a frequency which is less than the lowest frequency of the oscillator frequency range but is higher than the intermediate frequency.

5. In a superheterodyne receiver of the type employing a combined local oscillator-first detector network provided with a tube having at least a cathode, an output electrode, a signal grid, an oscillator grid and an oscillator anode, an oscillator tank circuit reactively coupling said oscillator grid and anode to provide an oscillator section, said tank circuit including means for adjusting its frequency over a relatively wide range of frequency values, a signal input circuit coupled to said signal grid and cathode and including means for tuning it over a signal frequency range which differs from said oscillator range by a predeetrmined frequency value, an output circuit coupled to said output electrode tuned to said predetermined frequency, a discriminator, responsive to frequency departures of signal energy in said output circuit from said predetermined frequency, for developing a direct current voltage whose magnitude is dependent on the amount of departure, means for applying said voltage to said signal grid, and a resonant network, tuned to a frequency below the oscillator frequency range, connected in the space current path of said tube to simulate a capacitative reactance in such relation to said tank circuit that the tank circuit frequency is supplementally adjusted by said discriminator voltage.

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