

Feb. 13, 1940.

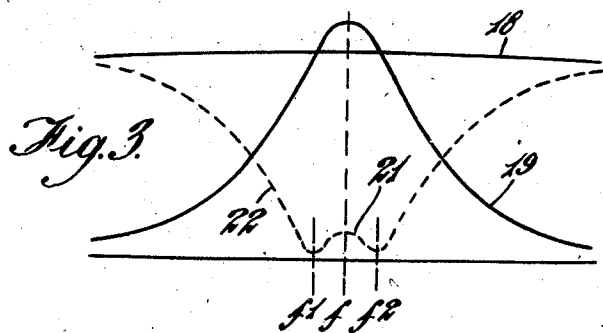
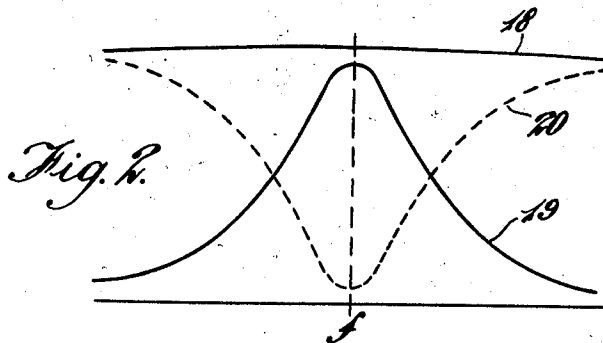
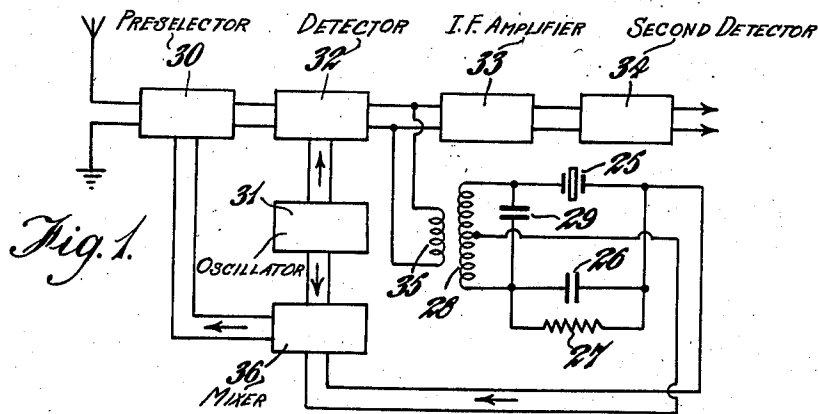
J. ROBINSON

2,190,243

RETROACTIVE VALVE APPARATUS

Filed Aug. 8, 1939

2 Sheets-Sheet 1



James Robinson
By
Watson, Cole, Grindle & Watson
ATTORNEYS

Feb. 13, 1940.

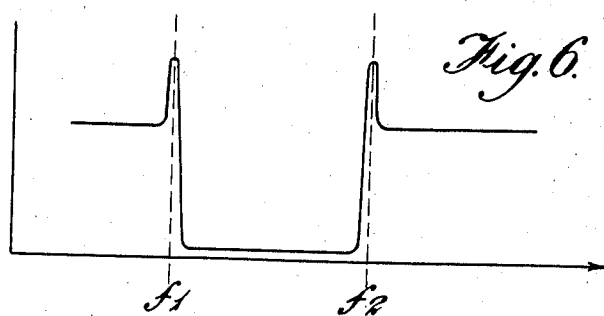
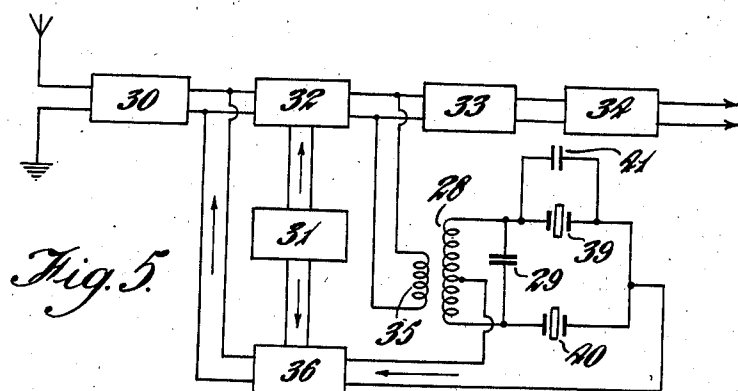
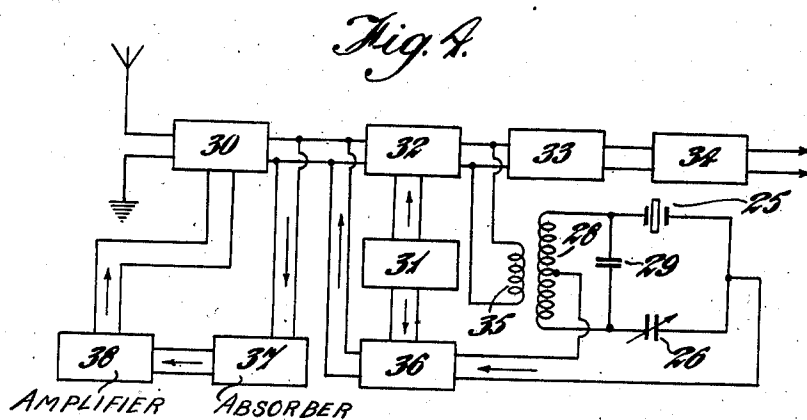
J. ROBINSON

2,190,243

RETROACTIVE VALVE APPARATUS

Filed Aug. 8, 1939

2 Sheets-Sheet 2



James Robinson
B
Watson, Cole, Grindle & Watson
ATTYS.

UNITED STATES PATENT OFFICE

2,190,243

RETROACTIVE VALVE APPARATUS

James Robinson, London, England

Application August 8, 1939, Serial No. 289,059
In Great Britain December 14, 1937

6 Claims. (Cl. 250—20)

This invention relates to retroactive valve apparatus. In such apparatus it has been proposed to apply retroaction through frequency selective means such that negative retroaction is obtained for some frequencies of an applied band so as to attenuate the signals of these frequencies and to produce no substantial effect or to produce positive retroaction for applied signals of other frequencies within the band.

The present invention is concerned with a retroactive valve apparatus for an applied band of frequencies, for example, as described in my British Specification No. 466,415, in which there is provided a frequency changer comprising a valve oscillator and mixing device, to which mixing device wave signals and local oscillations are applied, and retroactive means for applying a portion of the beat frequency signal output derived from the frequency changer to the oscillator to change the signal amplitude as applied to the mixing device. In this manner there is obtained an effective increase in selectivity which may be further increased by employing a highly selective device such as a piezo-electric crystal circuit in the said retroactive means. According to the present invention the retroactive means aforesaid is such as to provide substantial negative retroaction for a major part of the band of frequencies and a small negative, zero or small positive retroaction (referred to collectively herein as a less negative retroaction) for a narrow intermediate part of said band of frequencies at the input of the frequency changer.

It will be understood that by negative retroaction is meant retroaction in which the phase difference between the applied signals and the signals fed back is more than 90° and by positive retroaction is meant retroaction in which the phase difference is less than 90° .

In the preferred form of the invention the retroactive means aforesaid comprises a bridge circuit having a selective circuit or device in one arm and a resistance in the opposite arm. Thus, signals passing the resistance arm of the bridge are opposed to signals passing the resonant arm, so that the resultant response of the bridge circuit is small at or near the resonant frequency and is large for higher and lower frequencies. The frequency selective device of the bridge circuit may consist of a piezo-electric device and, in this case, a condenser is provided in the opposite arm in order to balance the capacity of the piezo-electric device either completely or to a greater or lesser extent.

One application of the invention is to receivers for modulated carrier wave signals. In this case the selective means of the retroactive apparatus, as aforesaid is arranged to have its resonant frequency in tune with the carrier-frequency of the incoming signals or frequency conversions of such signals, so that negative reaction is applied for frequencies on each side of the carrier-frequency. In this manner, there is obtained a reduction in the amplitude of frequencies adjacent the carrier-frequency for instance, frequencies removed from the carrier-frequency by, say, 50 to 5,000 cycles and, in consequence, there is provided an increase in effective selectivity apart from that due to any increase in the amplitude of the carrier-frequency which may occur due to the retroaction. Thus, a greater selectivity with stability can be obtained.

Specific circuit arrangements of receivers embodying the invention are shown by way of examples in the accompanying drawings, in which:

Figure 1 shows a circuit arrangement of a superheterodyne receiver, for modulated carrier-wave signals,

Figures 2 and 3 show curves representing the operation of the retroactive means of the receiver shown in Figure 1,

Figures 4 and 5 show modifications of the arrangement shown in Figure 1, while

Figure 6 shows a curve representing the operation of the retroactive means in Figure 5.

In the application of the invention to wireless receivers of the superheterodyne type the retroactive coupling is made over the frequency-changer back to the input thereto in order to increase the effective selectivity at the input of the frequency-changer, which normally comprises selective circuits tuned to the applied signals, the necessary conversion of the frequency back to the original frequency of the applied signals being obtained by means of the frequency-changer or by an additional frequency-changer, for instance as described in my British specification No. 466,415.

Referring to Figure 1, the receiver comprises a pre-selector circuit or circuits, indicated at 30, a local oscillator 31 associated with a detector or mixer 32, an intermediate frequency-amplifier 33 and a second detector 34. A portion of the intermediate frequency signals taken, for example, from the output of the mixer 32 is applied through a feed-back circuit as hereinafter described to another mixing device 36 and combined with a portion of the output of

the local oscillator 31 to reproduce the incoming frequency signals. These reproduced signal frequencies are applied to the selector circuit 30 of the receiver with such phase relationship as to provide negative retroaction for at least the major part of the frequency band passed by the circuit 30.

The feed back circuit comprises an electrical bridge having a piezo-electric device 25 in one arm and a condenser 26 and resistance 27 in parallel in the opposite arm, the remaining arms of the bridge being constituted by a tapped inductance 28 which is tuned by a condenser 29. An output from the mixer 32 is applied to the inductance 28 through the coil 35 coupled thereto and the output of the bridge taken from the junction of the piezo-electric device 25 and resistance 27 and a tapping on the inductance 28 is applied to the mixer 36.

The tuned circuit constituted by the inductance 28 and the condenser 29 is broadly tuned to the intermediate frequency of the applied modulated carrier-wave signals and the piezo-electric device, which has a sharper characteristic, has the same resonant frequency. The piezo-electric device provides an output having a sharp peaked resonant characteristic, while the output from the resistance is of comparatively uniform amplitude for the applied band of frequencies and opposes the output from the piezo-electric device.

It will be understood, therefore, that by varying the value of the resistance 27 the resultant input to the mixer 36 may have different frequency-amplitude characteristics, so that there may be obtained a good control of the final amplitude of the carrier-frequency as compared with the amplitude of associated frequencies, as aforesaid. For example, the output from the resistance, as represented by the line 18 in Figure 2, may be larger than the maximum response of the piezo-electric device of which the frequency-amplitude curve is indicated at 19. The resultant response which is applied to the mixer 36 is represented by the curve 20 which thus has a minimum response at the resonant frequency indicated at f and a substantial response for frequencies at either side of the resonant frequency. After undergoing a frequency change at the mixer 36 this response is applied to the circuit 30 and although the carrier-frequency of the signals in this circuit is not appreciably affected due to the low amplitude of the retroaction at this frequency, the frequencies at either side of the carrier-frequency are reduced as regards amplitude due to the negative retroaction. There is thus obtained at the circuit 30 incoming signals which are modified by the negative retroaction to produce a corresponding effective selectivity, although without amplification.

The provision for a slight negative retraction at the carrier-frequency has the advantage that it ensures stability of operation but the resistance 27 may have such value that a zero resultant response is obtained at the carrier-frequency. Furthermore, the resistance may have such a value that the output obtained therefrom is somewhat less than the output through the piezo-electric device, as shown by the response curves in Figure 3. In this case the resultant response applied to the mixer 36 has an appreciable value, as indicated at 21, for frequencies approximating to the resonant frequency, there being minimum values at two frequencies f^1 and f^2 at either side of the resonant frequency. A

larger response is further obtained for other frequencies of the band as indicated by the parts 22 of the response curve. It will be understood in this case that, by applying negative retroaction as regards the frequencies of the band included in the parts 22 of the response curve shown in Figure 3, there will be obtained positive retroaction for frequencies at and adjacent the carrier-frequency. Thus, in this manner the carrier-frequency may be augmented by retroaction in addition to the amplitudes at other frequencies being reduced as hereinbefore described for obtaining selectivity.

It will be understood, therefore, that by varying the value of the resistance 27 the amplitude of the carrier-frequency may remain unaltered or may be raised or lowered as required and, if desired, this resistance may be varied automatically under the control of the signals in order to provide an automatic volume control for the receiver.

The condenser 26 is preferably of such value as to balance the capacity of the piezo-electric device 25 in order to obtain a substantial symmetrical response characteristic for the bridge circuit. In some circumstances it is desirable to unbalance the bridge circuit as regards capacity or inductance so as to modify the change of phase at the carrier-frequency with respect to other adjacent frequencies. This unbalancing of the bridge circuit may be controlled automatically according to the strength of the signals in order to provide an automatic volume control. Furthermore, instead of employing the complete bridge circuit in the intermediate stage of the receiver it may be partly in the intermediate frequency stage and partly in another stage separated therefrom by a frequency-changer.

One example of an arrangement of this nature is shown in Figure 4. The receiver comprises a pre-selector 30, local oscillator 31, mixer 32, an intermediate frequency amplifier 33 and a second detector and output stage 34. One feed back circuit comprises inductance 35, the tuned circuit 28, 29 and the piezo-electric crystal 25 and balancing condenser 26 which are connected with a second mixer 36 where the energy fed back is reconverted to the original signal frequency by means of the local oscillator 31. The second feed back circuit comprises an absorber 37 coupled with the output of the pre-selector 30 and feeding an amplifier 38 the output of which is connected with the pre-selector 30. In operation the piezo-electric crystal is tuned to the intermediate frequency of the receiver and the feed back in this part of the circuit is arranged to be positive. The absorption circuit 37 is arranged to eliminate the wanted carrier-frequency and the feed back here is in the negative direction. By adjusting the magnitude of the feed back in the two circuits effects similar to that described with reference to Figure 1 may be obtained.

Instead of employing a piezo-electric device as selective means, for the retroactive apparatus, other selective means can be employed such as, for example a series tuned circuit. It will be also understood that the bridge circuit aforesaid provides a response which is characteristic of an absorption circuit and, in carrying out the invention, other forms of absorption circuit may be employed. For example as illustrated in Figure 5 two piezo-electric devices 39, 40 with different resonant frequencies may be employed, one in each of two opposite arms of the bridge, and unbalanced by means of a condenser 41 so as

to provide a minimum response at an intermediate frequency.

As described in my co-pending application for U. S. Letters Patent Serial No. 232,194, the input to the two piezo-electric devices is applied in opposed phase by means of the centre tapped inductance 28 and, since the change in phase occurring in a signal when tuned through the resonant frequency of such a device is very sudden, the outputs from the two devices may be regarded as being in phase for energy of frequencies between their resonant frequencies, while energy passing below the resonant frequency of the lower frequency device and above the resonant frequency of the higher frequency device will also be in phase but of opposite sign. Since a piezo-electric device will have an inductive reactance for signals of a frequency above the resonant frequency and a capacitive reactance for signals of a frequency below the resonant frequency, the addition of a condenser in shunt therewith will increase the energy transfer below the resonant frequency and decrease the energy transfer above the resonant frequency. If, therefore, the condenser is connected in shunt with the device of lower resonant frequency, a characteristic of the form shown in Figure 6 may be obtained wherein the peaks at f_1 and f_2 are at the resonant frequencies of the devices 39 and 40 respectively. Adjustment of the size of the condenser determines the relative response of the circuit to signals of a frequency between f_1 and f_2 and above and below these frequencies, and, if desired, a relatively complete suppression of energy between f_1 and f_2 may be obtained, and owing to the difference in phase of energy passing the circuit between and outside of the peaks at f_1 and f_2 , the feed back may be arranged to be negative for all frequencies except within the range f_1 — f_2 . The feed back within this range will be positive but by a suitable design of the circuit the energy transfer in this range may be reduced to a very low value.

The arrangement may thus be used to give the pre-selector circuits 30, in effect, a band pass characteristic of a very satisfactory shape irrespective of the frequency to which these circuits are tuned. Furthermore, the retroactive circuit may comprise one or more parallel tuned circuits, for example, a plurality of such circuits, arranged in series, with or without the bridge circuit hereinbefore described.

It will be appreciated that the invention is applicable to the selective treatment of a band of frequencies, for instance, constituted by a carrier-wave and one or both side-bands, in transmitting, repeating or receiving apparatus. The apparatus according to the invention may also be used to suppress the carrier-frequency of a modulated carrier-wave transmission by connecting a piezo-electric crystal tuned to the frequency of the carrier-wave in parallel with the condenser 29 of Figures 1, 4 and 5. The apparatus in accordance with this invention may also be used to change the phase of the carrier-frequency with respect to associated frequencies.

I claim:

1. A retroactive valve apparatus for an applied band of frequencies comprising a frequency changer having a valve oscillator and a mixing device, to which mixing device said band of frequencies and the local oscillations are applied, and retroactive means for feeding a portion of the beat frequency signal output from the frequency changer to the oscillator to provide at the

input of the frequency changer a substantial negative retroaction for a major part of the band of frequencies and a less negative retroaction for a narrow intermediate part of said band of frequencies.

2. A retroactive valve amplifier comprising a frequency changer having a local oscillator and mixing device to which device local oscillations and signal frequencies are applied to form a beat frequency, retroactive means comprising a bridge circuit having a selective device in one arm and a resistance in the opposite arm, means for feeding a portion of said beat frequency to said bridge circuit and means for combining the output of said bridge circuit with local oscillations and for feeding the resultant signal frequency to said frequency changer to provide at the input circuit of said frequency changer a substantial negative retroaction at all signal frequencies except the frequency band of the wanted signal frequency.

3. A retroactive valve amplifier comprising a frequency changer having a local oscillator and mixing device to which device local oscillations and signal frequencies are applied to form a beat frequency, retroactive means comprising a bridge circuit having a piezo-electric crystal in one arm and a resistance shunted by a condenser in the opposite arm, means for feeding a portion of said beat frequency to the input of said bridge circuit, a second mixing device to which is applied the output of said bridge circuit and oscillations from said local oscillator and means for feeding the output of said second mixer to the input of said frequency changer to provide a substantial negative retroaction at all signal frequencies except the frequency band of the wanted signal.

4. A retroactive valve amplifier comprising a frequency changer having a local oscillator and mixing device to which device local oscillations and signal frequencies are applied to form a beat frequency, an absorption circuit comprising two piezo-electric crystals having different resonant frequencies arranged in opposite arms of a bridge and a condenser connected in parallel with the crystal of the higher frequency, means for feeding a portion of the beat frequency to the input of said absorption circuit, a second mixing device to which is applied the output of said absorption circuit and oscillations from said local oscillator, and means for feeding the output of said second mixer to the input of said frequency changer to provide a substantial negative retroaction at all frequencies except those lying between the resonant frequencies of the crystals in said absorption circuit.

5. A retroactive valve amplifier comprising a frequency changer having a local oscillator and mixing device to which device local oscillations and signal frequencies are applied to form a beat frequency, a selective circuit tuned to said beat frequency, a second mixing device to which beat frequencies from said selective circuit and oscillations from said local oscillator are fed, and means for feeding the output of said second mixer to the input of said frequency changer so as to provide positive retroaction, an absorption circuit tuned to suppress the wanted signal frequency to which signal frequencies are fed, an amplifier the input of which is coupled with the output of said absorption circuit and the output of which is fed to said frequency changer to provide a substantial negative retroaction at all frequencies except the frequency band of the wanted signal.

6. In retroactive valve apparatus for an applied band of signal frequencies, the combination with a valve having input and output circuits, of means to feed back a portion of the signal energy from said output to said input circuit, said means including an absorption circuit receiving signal energy from said output circuit, said absorption circuit comprising a bridge having in opposite arms thereof mechanical resonators of different resonant frequency within the range of signal frequencies of said applied band, capacitative means in parallel with the mechanical

resonator of higher frequency, whereby the energy output of said absorption circuit at frequencies intermediate resonant frequencies of said mechanical resonators is reduced to a relatively low value, and means for feeding the output of said absorption circuit to the input circuit of said valve so as to provide substantial negative retroaction at all signal frequencies except those intermediate the resonant frequencies of said mechanical resonators.

JAMES ROBINSON.