

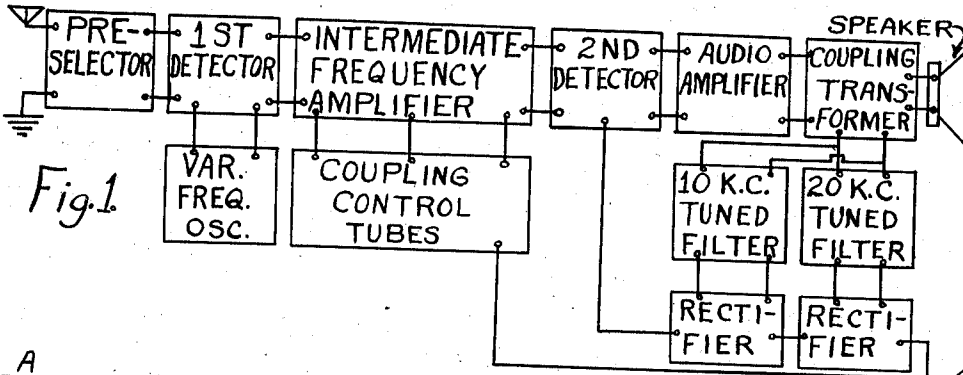
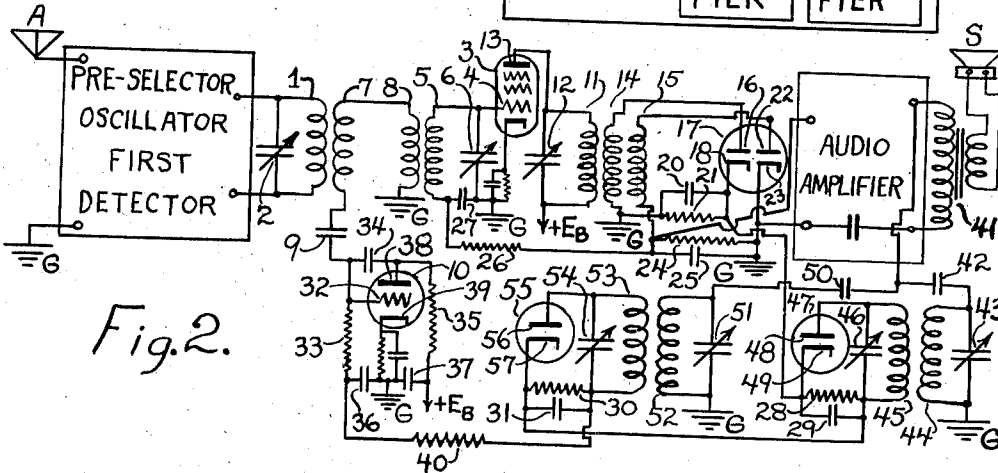
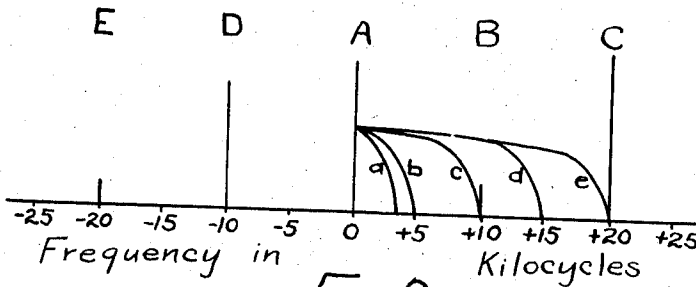
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AUTOMATIC FIDELITY CONTROL

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AUTOMATIC FIDELITY CONTROL

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7 Claims. (Cl. 250—20)

This present invention of mine concerns improvements in radio receivers. It particularly relates to methods of, and means for, the automatic control of radio receiver fidelity as a function of the strength of desired and undesired signals.

One object of my invention is to provide automatic fidelity control in a radio receiver which operates as a function of the strength of desired and undesired signals. Another object is to provide a band expansion system which expands as a function of the amplitude of the desired signal and contracts as a function of the amplitude of undesired signals. Still another object is to provide fidelity control which expands as a function of the strength of the signal being received and contracts as a function of undesired signals especially those in adjacent channels such as those 10 and 20 kilocycles away when operating in the broadcast band. A further object is to provide circuits employing diode rectifier tubes in which one diode controls the response expansion as a function of the desired signal and the other diode provides a counteracting contraction as a function of the beat note produced by interfering signals.

In general, the stronger a received radio signal, the broader the reception band may be made. Static, for instance, is a continuous spectrum which causes disturbances which are a function of the band width of the receiver response. When the desired signals are weak, static is a serious limitation and the best reception of the desired signal is obtained by narrowing the receiver response. Interfering signals are also to a lesser and more random degree a function of desired signal strength and again narrow band reception for weak signals is a partial solution. It is for these reasons that tone and selectivity control systems have been developed which automatically control the audio frequency response or radio frequency selectivity as a function of received signal strength. These systems are designed to broaden the receiver response when receiving signals of large amplitude. My co-pending applications for Letters Patents bearing Serial Nos. 62,074 and 61,458 filed Feb. 3, 1936 and Jan. 30, 1936 and entitled "Coupled circuits" and "Coupled circuit systems" now Patents Nos. 2,120,998 and 2,136,664 issued June 21, 1938 and November 15, 1938, respectively, respectively show systems whereby the receiver fidelity is automatically expanded as a function of received signal strength. My present system may be used in con-

junction with the circuits shown in these co-pending applications.

I have found that while signal strength is an important criterion for determining usable receiver response, there are conditions of reception which require additional control. The most important case of interference not adequately provided for by the signal strength type of control I have found to be due to adjacent channel stations. In this country in the standard broadcast band the stations are positioned 10,000 cycles apart and adjacent channel interference is characterized by a 10,000 cycle beat note. This beat note is the difference frequency between the carrier of the station being received and the interfering station which may be on either or both side channels. Similarly, stations two channels removed produce 20,000 cycle characteristic beat notes. While the interference from these side-channel stations is due to both their carriers and side-bands the beat notes are an indication of the amount of interference and may be used for band width control purposes. I have found that a control system which increases response width as a function of increased signal strength of the desired station and decreases response width as a function of 10,000 and 20,000 cycle beat notes minimizes interference from static and adjacent channel stations. In carrying out this dual control system I generate a control voltage proportional to the desired signal and a second but opposed control voltage proportional to the 10 and 20 kilocycle beat notes. These control voltages are applied to response adjusting means so that the receiver response is broadened by increased desired signal strengths and is narrowed due to 10 and 20 kilocycle beats. The controls may be variously weighted, delayed controls may be used or other beats may be chosen. The channels for some television transmission are 100 kilocycles apart in which case 100 kilocycle beats are used for control purposes.

The appended claims set forth, in particular, the novel features to be found in this invention. The following description, however, when taken in connection with the drawing, will serve to set forth the theory and mode of operation of my invention.

In the drawing,

Fig. 1 shows a block diagram of one form of my invention.

Fig. 2 shows one form of my invention embodied in a radio receiver.

Fig. 3 shows various response curves which may

be obtained in the presence of various desired and undesired signals.

In Fig. 1 I have shown a block diagram of one form of my invention. I have shown a super-heterodyne radio receiver with coupling control tubes controlled so as to expand the receiver response on strong desired signals and to contract the receiver response in the presence of 10 and 20 kilocycle beats. The receiver consists of a "pre-selector" connected to a suitable antenna and ground, a "1st detector" and associated "variable frequency oscillator," an "intermediate frequency amplifier," "2nd detector," "audio amplifier," "coupling transformer" and "speaker." Associated with the "intermediate frequency amplifier" are "coupling control tubes" which may be electronic fidelity control means as the coupling control tubes as disclosed in my above cited applications. In these applications I showed several systems whereby the fidelity and band-pass characteristics of a pair of coupled circuits or a multi-stage amplifier may be controlled as a function of received signal amplitude. In order to accomplish this a direct current component of rectification from the second detector is applied to the control grids of the coupling control tubes.

My present invention consists in applying a counteracting control to the coupling control tubes which is a function of interfering signals. Since the most serious interference will be due to stations in the next channel on either side of the desired carrier, I select the accompanying 10 kilocycle beat note with a tuned filter and rectifying the resulting voltages. This rectified voltage is then subtracted from the desired signal generated control voltage producing a net control voltage which depends on the amplitudes of desired and undesired signals. Similarly the interference from the next removed channels may be taken into account by means of a 20 kilocycle tuned filter and associated rectifier the output of which is also subtracted from the normal amplitude generated control voltage. Additional control may be derived from 30 kilocycle beats or higher or other separations may be chosen as for instance 100 kilocycles which is the channel separation for some television transmissions. The 10 kilocycle filter is shown as "10 k. c. tuned filter" receiving an input from the "audio amplifier" output. The filter output is rectified by the "rectifier." Similarly the 20 kilocycle filter is connected to the "audio amplifier" output and feeds a second "rectifier." The output of these two rectifiers is subtracted from the amplitude generated control voltage from the "2nd detector" by reversing the polarity of the outputs from the beat note rectifiers with respect to the amplitude operated rectifier. Thus strong desired signals which are normally above the static level expand the receiver response but stations 10 or 20 kilocycles removed contract the response.

In Fig. 2 I have shown a schematic diagram of the essential circuits of a system similar to that of Fig. 1. In order to show the method of connection and operation of the system without undue complication, a single amplifier inter-stage coupling transformer is shown with automatic coupling control derived from a combination of signal amplitude and two beat frequency interference components as for instance 10 and 20 kilocycles. The remainder of the receiving system is represented by block diagrams. This is not intended to in any way limit the system

to a single stage as several stages may be controlled and many combinations of control are possible.

The system in Fig. 2 shows a "pre-selector," "oscillator" and "first detector" in block connected to an antenna A and a ground G. This unit may also include one or more controlled coupling transformers and amplifier stages. The output of the unit feeds a primary coil 1 tuned by a condenser 2. An intermediate frequency amplifier tube 3 receives on its grid 4 the voltage across a secondary coil 5 tuned by condenser 6. The coupling between primary 1 and secondary 5 is accomplished by the link coils 7 and 8 in series, in which coil 7 is coupled to primary 1 and coil 8 is coupled to secondary 5. This coupling link circuit is completed between ground G back to ground G again thru the blocking condenser 9 and the input capacity of the vacuum tube 10 as set forth in my copending application for Letters Patent entitled "Coupled circuits" filed on Feb. 3, 1936 and bearing Serial No. 62,074. The object of this invention is to provide an improved control system in connection with this coupling link or other types of expansion control.

The output system associated with amplifier tube 3 comprises a primary coil 11 tuned by condenser 12 and connected between a source of plate voltage $+E_b$ and plate 13 of tube 3. Coupled to primary 11 are two secondary coils 14 and 15. While tuning is not shown, these secondaries 14 and 15 may be tuned in conventional ways. Secondary 14 is connected between ground G and anode 16 of the double diode tube 17. The cathode 18 corresponding to anode 16 and forming a diode rectifier therewith is connected to ground G thru the load resistor 21 by-passed by condenser 20. When a signal traverses the system, a rectified voltage drop appears across resistor 21 having an amplitude proportional to the signal. Secondary 15 is connected at one end to anode 22 of the second diode unit of rectifier 17 and at the other end to ground G thru a load resistor 24 by-passed by condenser 25. The time constant of condenser 25 and resistor 24 is small and suitable for generating an audio frequency demodulation drop when a modulated signal is passed thru the system. The input to the "audio amplifier" consists of the drop across resistor 24 as shown. The drop across resistor 24 may also be used for automatic volume control by filtering out the audio frequency components by means of series resistor 26 and by-pass condenser 27. The filtered voltage drop across resistor 24 is applied to the grid 4 of amplifier tube 3 thru secondary 5. The polarity is such that the coil end of resistor 24 is negative with respect to ground which gives the desired negative voltage for automatic volume control on an amplifier tube grid.

The rectified drop across resistor 21 will yield a voltage which is a function of the strength of the received signal. The current will flow in such a direction as to make the cathode end of resistor 21 positive with respect to ground G. This positive voltage is applied thru resistor 28 by-passed by condenser 29, resistor 30 by-passed by condenser 31, resistor 40 by-passed to ground by condenser 36 and resistor 33 to grid 32 of coupling control tube 10. The input or grid to cathode capacity of tube 10 is a function of the externally added plate to grid capacity 34, the plate load impedance 35 which may be

a simple resistor or a complex impedance, the net effective grid voltage and the characteristics of the tube. Plate 38 is energized by a steady voltage $+E_B$ and cathode 39 is initially biased by a by-passed cathode resistor or by other well known means. The input capacity of tube 10 will increase as the net negative bias on grid 32 is reduced as occurs when increasing signals are received and rectified by diode 17. An increase in input capacity of tube 10 decreases the series impedance of the coupling link circuit between coils 1 and 5 as long as the impedance of condenser 9 in series with the input capacity of tube 10 is greater than the effective impedance of coils 7 and 8 in series. Hence, the system as thus far described operates to increase the coupling between coils 1 and 5 as the received signal increases. If the coupling link is set up to give critical coupling in the absence of a received signal, the coupling will be more than critical for appreciable values of received signal and the interstage transformer (coils 1 and 5 and associated circuits) will show a band-pass characteristic of a width which increases as the strength of the received signal increases.

My present invention particularly concerns auxiliary control means which modify the expansion of the prior system, in accordance with inter-carrier beat interference. The output of the "audio amplifier" feeds an output transformer 41 which in turn is coupled to a speaker S. The high side of the primary 41 is coupled by means of condenser 42 to a tuned circuit consisting of coil 44 paralleled by condenser 43. Since radio transmitters in the broadcast band are spaced 10 kilocycles apart, an interfering station in the next channel on either side of a desired station will produce a 10 kilocycle intercarrier beat. This 10 kilocycle beat will have an amplitude which is a function of the amount of interference caused. This 10 kilocycle beat is selected by tuning coil 44 to 10 kilocycles by means of condenser 43. This selected beat is fed to diode rectifier 47 by means of a second 10 kilocycle tuned circuit consisting of coil 45 tuned by condenser 46 and coupled to coil 44. The voltage across coil 45 is applied to diode 47 by connecting one end of coil 45 to anode 48 directly and the other end to cathode 49 thru direct current load resistor 28 by-passed by condenser 29. When a 10 kilocycle beat appears in the "audio amplifier" output, it is thus selected and rectified and a direct current flows in resistor 28 in such a direction as to make the coil end of resistor 28 negative with respect to the cathode end. Thus starting at ground G cathode 18 of tube 17 becomes positive due to a received signal and the drop across resistor 28 makes the voltage at the coil end of resistor 28 less positive by an amount dependent on the amount of adjacent channel interference.

In a similar manner the interference due to interfering stations in the second channel removed on either side of the desired signal may be taken into account by means of a 20 kilocycle selective and rectifying system. A coil 52 is tuned to 20 kilocycles by condenser 51 and is coupled to the "audio amplifier" output by means of condenser 50. A second coil 53 tuned to 20 kilocycles by condenser 54 is coupled to coil 52 and feeds diode 55. Plate 56 of diode 55 is connected to one end of coil 53 and cathode 57 is connected to the other end of coil 53 thru the direct current load resistor 30 by-passed by con-

denser 31. As in the case of the 10 kilocycle circuit, the direct current voltage drop due to the 20 kilocycle interference is opposed to the expansion control voltage developed in resistor 21. Thus the net effective voltage on grid 32 which controls the band-pass characteristics of the interstage transformer equals an initial bias minus the drop across resistor 21 plus the drop across resistors 28 and 30. In cases of bad interference the combined drops across resistors 28 and 30 may equal the drop across resistor 21 in which case the coupling is reduced to its initial or maximum selectivity value.

There are many ways in which the various control voltages may be weighted. Since desired signal amplitude is the most important criterion in expansion control, the entire drop across resistor 21 will usually be used for control although its effect may be delayed by well known means until the signal exceeds a predetermined amplitude. The 10 kilocycle beat will be the most important index of interference from adjacent channels and all or part of the drop in resistor 28 may be used to oppose the expansion control from resistor 21. The 20 kilocycle beat being an index of secondary interference will usually be made less effective by picking off only a part of the drop across resistor 30 for opposed control. If the audio amplifier response is reduced at 20 kilocycles, a proportionally larger percentage of resistor 30 drop may be required for control. Other means may be used for adjusting the proportion of 10 and 20 kilocycle control such as potentiometers across the audio amplifier output, reduced coupling in the beat selective coils or other well known means.

The diodes 47 and 55 may be combined in a single envelope. Circuits selecting 30 or 40 kilocycles may be added to the system or other beat separations may be chosen. In television, for instance, the interfering beat may be 100 kilocycles or more in which case the selective circuits should be tuned to these frequencies. Several stages of an intermediate frequency amplifier may be coupled by means of the controlled transformer set forth above and it may also be applied to radio frequency amplifier stages.

Fig. 3 shows several plots of signal amplitudes and various resulting overall receiver response curves. The desired carrier is shown by A at 0 on the frequency scale. The vertical height of line A represents the strength of this desired carrier. Curve *a* represents the overall fidelity of receiver embodying my present control system in the contracted or no signal condition in which the maximum selectivity of the interstage coupling transformers is effective. However, when receiving a strong signal as A, the response is expanded until the overall fidelity is as shown by curve *c* covering practically the entire audible spectrum up to 20 kilocycles. A weak station 20 kilocycles below the desired carrier at E will cause a slight amount of interference and reduces the receiver fidelity to *d* by the action of the 20 kilocycle beat between E and A on the 20 kilocycle contraction circuit. A strong station at C having a frequency 20 kilocycles greater than A will cause a great deal of interference in the 10 to 20 kilocycle band and will reduce the receiver band-pass to curve *c* in which the response is cut off at 10 kilocycles thru the action of the resulting strong 20 kilocycle beat note. A weak station at B which is 10 kilocycles above A will cause interference and a 10 kilocycle beat which operates the 10 kilocycle

contracting circuit reducing the receiver response to curve *b*. A strong signal at D which is 10 kilocycles below the desired carrier A will further operate the 10 kilocycle contracting circuit and may even reduce the receiver response to curve *a* which is the initial unexpanded condition. This cancellation of expansion will take place if the sum of the interfering signals produce rectified contracting voltages equal to the expansion voltage due to the rectification of the desired signal.

While I have described only one system whereby my invention may be carried into effect, and have pointed out a few possible variations, it will be apparent to one skilled in the art that many modifications are possible without departing from its spirit and scope as set forth in the appended claims.

What I claim is:

1. In a radio receiver including radio and audio frequency amplifiers, the combination of at least one interstage coupling transformer, a controlled capacity thermionic vacuum tube including at least a control grid, a cathode and a plate and at least two rectifiers, said interstage transformer comprising a tuned primary, a tuned secondary and a coupling link between said primary and secondary and in series with the input capacity of said capacity tube, means for applying carrier signal voltages to one of said rectifiers and means for producing an output rectified voltage proportional to said signal, means for selecting and applying to the second of said rectifiers interfering signals traversing the audio amplifier of said receiver and producing an output voltage proportional to said interfering signals, and means for applying said two rectifier output voltages in opposite polarity to the control grid of said controlled capacity thermionic vacuum tube.
2. In a carrier wave receiver comprising a carrier frequency amplifier, signal detector, audio amplifier and loud speaker, the combination of thermionic vacuum amplifier tubes connected in cascade by means of interstage coupling transformers, said transformers comprising tuned primary and secondary coils and means for coupling said primary and secondary comprising coupling link coils, means for varying the current in said coupling coils comprising the input capacity of a thermionic vacuum tube connected in series with said link coils, means for rectifying signals traversing said receiver comprising a thermionic vacuum tube and associated load circuit, a 10 kilocycle selective circuit connected between said audio amplifier and a second rectifier, means associated with said second rectifier for producing a direct current proportional to the 10 kilocycle signals present in said audio amplifier, means for applying to a control element of said link coil series vacuum tube a bias including at least a part of the direct current outputs of said last two rectifier tubes.
3. In a carrier wave receiver including a carrier frequency amplifier, signal detector, and audio amplifier, the combination of, a carrier frequency interstage coupling transformer including a tuned primary, a tuned secondary, and a coupling link coupled to said primary and said secondary for coupling said primary to said secondary, a coupling tube including a control electrode connected to said coupling link for controlling the coupling between said primary and secondary, means for selecting beat note signals in the output of said signal detector in the region of 10 kilocycles, means for rectifying said beat note signals, means for selecting beat note sig-

nals in the region of 20 kilocycles, means for rectifying the last said beat note signals, means for combining at least a portion of the rectified output of said detector and rectifiers, and means for applying said combined outputs to the control means of said coupling tube for controlling the coupling between said primary and said secondary.

4. In a carrier wave receiver, the combination of at least two rectifiers, a thermionic coupling tube comprising at least a grid, a cathode and a plate, two cascaded thermionic repeater tubes, a transformer connected between said repeater tubes comprising at least a primary and a secondary coil, means for coupling said primary and secondary comprising at least in part the grid to cathode impedance of said coupling tube, an audio amplifier, a double tuned 10 kilocycle transformer connected between said audio amplifier and one of said rectifiers, means for applying carrier wave signals traversing said receiver to the other of said rectifiers, direct current load circuits connected in series with said rectifiers, means for deriving at least a part of the grid bias of said coupling tube from the combined outputs of said two rectifiers.

5. In a carrier wave receiver, the combination of, at least two rectifiers, a thermionic coupling tube including at least a grid, a cathode, and a plate, two thermionic repeater tubes, a transformer connected between said repeater tubes including at least primary and secondary coils, means for coupling said primary and secondary coils including at least in part the impedance of a path across said coupling tube, an audio amplifier, a high frequency beat note selector connected between said audio amplifier and one of said rectifiers, means for applying carrier wave signals traversing said receiver to the other of said rectifiers, direct current load circuits connected to each of said rectifiers, means for combining at least a portion of the rectified signals traversing said load circuits in opposed polarity, and means for applying said combined signals to the grid of said coupling tube for controlling the coupling between said primary and secondary coils.

6. In a carrier wave receiver, the combination of, at least three rectifiers, a thermionic coupling tube including at least a grid, a cathode, and a plate, two thermionic repeater tubes, a transformer connected between said repeater tubes including at least primary and secondary coils, means for coupling said primary and secondary coils including at least in part a path thru said coupling tube, an audio amplifier, a 10 kilocycle beat note selector connected between said audio amplifier and one of said rectifiers, a 20 kilocycle beat note selector connected between said audio amplifier and a second of said rectifiers, means for applying carrier wave signals traversing said receiver to the third rectifier, direct current load circuits connected to each of said rectifiers, means for combining at least a portion of the rectified signals traversing said load circuits, and means for applying said combined signals to the grid of said coupling tube for controlling the coupling between said primary and secondary coils.

7. In a carrier wave receiver, the combination of a four winding intertube transformer, a coupling control tube comprising a grid, a cathode and a plate, a carrier wave double diode detector, an output circuit connected in series with each of said diodes, a double diode interference rectifier, an output circuit connected in series with

each of said diodes, an audio amplifier, a 10 kilocycle selective circuit and a 20 kilocycle selective circuit wherein the interstage transformer comprises a tuned primary, a tuned secondary, a link circuit coil coupled to said primary and a second link circuit coil coupled to said secondary, said link coils being connected in series between ground and the input circuit of said coupling control tube, said 10 kilocycle circuit being connected between said audio amplifier and one

diode of said double diode interference rectifier, said 20 kilocycle circuit being connected between said audio amplifier and the second diode of said double diode interference rectifier, means for deriving at least a part of the bias on said coupling control tube grid from at least a part of the output of one of said carrier voltage diodes and at least a part from the output voltages of said 10 and 20 kilocycle interference rectifiers.

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