Feb. 6, 1940.  R. A. BRADEN  2,189,308

CONSTANT SELECTIVITY RECEIVER

Original Filed Jan. 6, 1931

Fig. 1

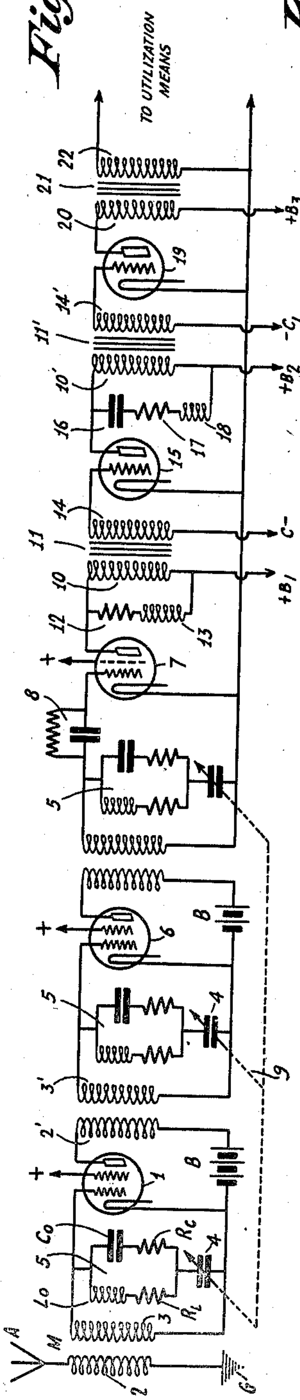
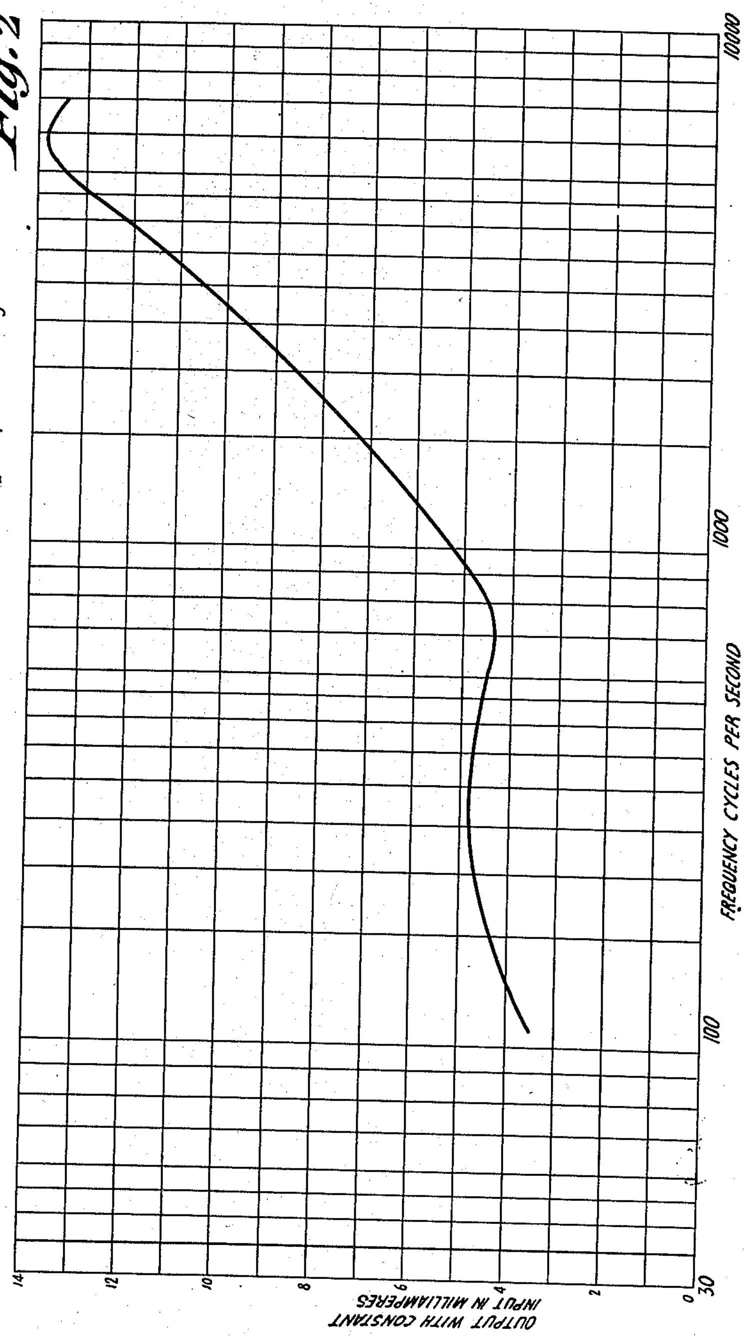



Fig. 2

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# UNITED STATES PATENT OFFICE

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## CONSTANT SELECTIVITY RECEIVER

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Application January 6, 1931, Serial No. 506,877
Renewed February 1, 1933

5 Claims. (Cl. 250—20)

My present invention relates to radio receivers, and more particularly to a radio receiver employing a compensated audio frequency amplifier.

It is well known in the prior art that a radio frequency amplifier employing tuned circuits tends to attenuate the side band frequencies more or less seriously, according to the sharpness of tuning, the number of stages of amplification, the wave length and other well known factors. Thus, a 1,000 cycle side band will be attenuated to a certain percentage of the carrier amplitude, a 2,000 cycle side band will be cut to a smaller percentage, while a 5,000 cycle side band will be attenuated to a still smaller percentage of the carrier amplitude, and so on.

Again, those skilled in the receiver art, well known that in any commercial tuned radio frequency amplifier the amount of attenuation of the side band of frequencies depends on the wave length, becoming more serious as the wave length increase. In other words, in broadcast receivers employing a single tuned circuit in each stage, it is a common characteristic of such receivers to tune too sharply at low carrier frequencies, and too broadly at high carrier frequencies.

A careful analysis of the problem has shown that there are two important phases to be considered. In the first place, it is essential to design the radio frequency amplifier in such a manner that the attenuation of the side band frequencies transmitted through the amplifier will be the same at all wave lengths. In the second place, it is equally important to design the audio frequency amplifier in such a manner that its amplification increases with frequency up to substantially 5,000 cycles.

The first phase of the problem, as disclosed in my copending application Serial No. 396,956, filed on October 3, 1929, and granted December 15, 1936, as Patent No. 2,064,146 relating to "Constant resistance amplifier circuit," may be solved, for example, by providing a multi-stage radio frequency amplifier which includes at least one tuned circuit in each pair of coupled input and output circuits, the tuned circuit possessing a constant resistance over a predetermined range of frequencies whereby the sharpness of tuning is substantially the same at all frequencies within a predetermined range, such as the broadcast range. In this way, a tuned radio frequency amplifier is provided which does not tune too sharply at low carrier frequencies, and too broadly at high carrier frequencies, but rather has a constant selectivity characteristic throughout the desired radio frequency range.

Now, I have discovered a novel method of, and devised means for, solving the second phase of the aforementioned problem, the method utilizing the principles disclosed in my aforementioned copending application and an audio frequency amplifier having a characteristic which essentially permits increase of amplification with increase of frequency up to the greatest value of audio frequency desired to be amplified, as for example 5,000 cycles, whereby the audio frequency amplification of the receiver will be apparently the same at all carrier frequencies.

Accordingly, it is one of the main objects of my present invention to provide a radio receiver comprising a constant selectivity tuned radio frequency amplifier combined with an audio frequency amplified whose fidelity curve is modified so that the over-all curve of the receiver is practically flat up to 5,000 cycles whereby a receiver of good fidelity is obtained.

Another important object of the present invention is to provide a method of, and means for, operating a radio receiver consisting in maintaining the radio frequency resonance curve a constant shape at all wave lengths, and simultaneously employing an audio frequency amplifier whose frequency characteristic is the inverse of the radio frequency resonance curve.

Another object of the invention is to provide a radio broadcast receiver arrangement utilizing a compensating audio frequency amplifier with a constant selectivity radio frequency amplifier for bringing up the high notes to the same amplitude as the low notes whereby improved quality of reception is secured throughout the broadcast range without impairing the selectivity of reception in any way.

Other objects of the invention are to improve generally the simplicity and efficiency of radio receivers, and to particularly provide a receiver utilizing a constant selectivity radio frequency amplification in combination with a compensating audio frequency amplifier which is reliable in operation, possesses a flat over-all characteristic up to 5,000 cycles, and is, in addition, economical to construct.

The novel features which I believe to be characteristic of my 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 I have indicated diagrammatically one circuit organization whereby my invention may be carried into effect.

In the drawing:

Fig. 1 diagrammatically shows a receiver embodying the invention,

Fig. 2 is a graphic representation of the operation of the compensating audio frequency amplifier.

Referring to the accompanying drawing, there is shown in Fig. 1, in a diagrammatic manner, a radio receiver comprising the usual signal energy collecting means consisting of an antenna A, grounded as at G. The grounded antenna circuit is coupled, as at M, to the input electrodes of the screen grid tube 1 in the first stage of radio frequency amplification. The coupling means M comprises a primary coil 2 connected in the antenna circuit and a secondary coil 3 connected between the control electrode and cathode of the tube 1, the latter although being shown of the screen grid type being adapted for substitution by any other type of space discharge device, such as a triode.

The anode of the tube 1 is connected to the positive terminal of a source of uni-directional current B through the primary coil 2′, the negative terminal of the source B being connected to the cathode in the well known manner. The input circuit of the tube 1 is tuned by a variable condenser 4, the latter being connected in series with a circuit generally denoted by the reference numeral 5. The circuit 5 comprises an inductance $L_O$ in series with a resistance $R_L$, the latter two elements being in shunt with the series connection between the capacity $C_O$ and resistance $R_c$.

The primary coil 2′ is coupled to the secondary coil 3′, both coils constituting the coupling means between the output circuit of tube 1 and the input circuit of screen grid tube 6. In a manner similar to that shown in connection with the input circuit of the tube 1, the input circuit of tube 6 is tuned by a variable condenser 4 connected in series with an impedance circuit 5, the latter comprising the same elements as explained in connection with the impedance circuit in the input circuit of tube 1. The anode of tube 6 is energized from a source B, the latter, if desired, being a source common with the source B connected with the anode of tube 1.

The output circuit of the tube 6 is coupled, by the same type of coupling used in connection with the first two tubes, to the input circuit of the screen grid tube 7, the control electrode circuit of this tube being arranged for detection. This is accomplished by the well known series capacity and shunt grid leak connection, generally denoted by the reference numeral 8, in the control electrode circuit. Here, again, a variable condenser 4, connected in series with the impedance circuit 5, is employed for tuning the input circuit of the tube 7. In order to simultaneously and similarly vary the tuning of the two radio frequency amplifier stages and the detector stage, the rotors of the condensers 4 are mechanically connected, as conventionally shown by the dotted lines 9, for common mechanical movement, this being accomplished actually by any method and means well known to those skilled in this art.

As clearly disclosed, and explained, in my copending application Serial No. 396,956, already referred to, the utilization of the impedance circuit 5 in series with the tuning condenser 4 in each tuned radio frequency stage results in a substantially constant degree of sharpness of tuning throughout a predetermined range of frequencies, such as the broadcast range. Briefly, it being understood that details of design are clearly disclosed in my aforementioned copending application, the tuned radio frequency amplifier is rendered constantly selective by suitable selection of the values of the constants of the elements $L_O$, $R_L$, $C_O$ and $R_c$, it being clearly understood that the present disclosure of the means for imparting a constant resistance characteristic to the tuned radio frequency circuits is not to be interpreted as limiting in any manner the mode of securing a constant selectivity characteristic. In fact, my aforementioned copending application discloses other modes and principles of securing the same result, the essential feature for the design of the tuned radio frequency stages being the production of amplifying tuned circuits possessing a constant effective resistance throughout a given frequency range.

Assuming, then, that the detector stage impresses across the primary coil 10 of the first audio transformer coupling 11, a band of audio frequencies having a width of substantially 10 kilocycles, that is to say each side band is 5,000 cycles wide, the remaining problem, solved by me in the present application, is to transmit this selected band of audio frequencies through the subsequent audio frequency amplifier in such a manner that the audio frequency output will be apparently the same at all audio frequencies within selected 10 kilocycle bands. The solution of this phase of the problem is now to be described in detail. Across the primary coil 10 is connected a series connection of a resistor 12 and an inductance 13, it being understood that the anode of the detector tube 7 is maintained at the proper positive potential by a source $B_1$. The secondary coil 14 of the transformer 11 is connected between the control electrode and cathode of the tube 15, the latter while being shown as of the triode type being adapted to be substituted for by any other desired type of space discharge device. The control electrode is preferably maintained at a proper negative biasing potential by connecting the low potential terminal of coil 14 to the negative terminal of a biasing source C, the positive terminal of the source C being connected to the cathode, in a manner well known to those skilled in the art, but not shown herein in order to preserve simplicity of description.

The tube 15 has its anode positively biased from a source $B_2$, it being obvious that this source may be the same source as the source $B_1$, the anode being connected to the positive terminal of source $B_2$ through the primary coil 10′ of the second audio transformer 11′. A series impedance path, composed of a capacity 16, a resistance 17, and an inductance 18, all in series, is connected across the primary coil 10′. The secondary coil 14′ of transformer 11′ is connected between the input electrodes of tube 19, the latter preferably being an audio power tube of any desired type.

The control electrode of tube 19 is negatively biased from a source $C_1$, in a manner similar to the control electrode of tube 15, while the anode of tube 19 is positively biased from a source $B_3$ through the primary coil 20 of the output audio transformer 21. It is of course understood that the sources $B_1$, $B_2$ and $B_3$ can be the same source, and if desired, can even be the same source as the sources B in the radio frequency stages; and, in the same manner, the sources C and $C_1$ can be a common source of biasing potential. The secondary coil 22 of output transformer 21 may be connected to any well known type of utilization means, such as head phones, a loud speaker and the like.

In Fig. 2 there is shown, in a graphical manner, a curve which demonstrates the operation of the compensating audio frequency amplifier. It will be noted from the curve that the amplification increases with frequency up to about 5,000 cycles in substantially direct proportion to increase in frequency from a point approximately at 700 cycles. In other words, an audio frequency amplifier is employed in the receiver circuit shown in Fig. 1, whose frequency characteristic is the inverse of the radio frequency resonance curve. This characteristic is imparted to the audio frequency amplifier by the design, as shown in the audio stages in Fig. 1, of the primary coil circuits of the audio transformer 11 and 11'. This may be explained in the following manner:

At low audio frequencies resistance 12 shunts current away from transformer coil 10, thus reducing amplification. At higher audio frequencies, coil 13 becomes effective, and the circuit 12, 13 has high enough impedance so that the amplification is only slightly reduced. The second audio transformer circuit acts in the same way, except that the greatest reduction of amplification occurs at the resonant frequency of 16, 18 (amount of reduction at this frequency being determined by 17).

Thus, Fig. 2 graphically shows the combined effect of both shunting circuits in the audio frequency amplifier. It is pointed out that while compensation in the audio frequency circuit could be applied to any receiver, the best results are secured when the amount of compensation required is the same at all carrier frequencies. This, of course, explains why a radio frequency circuit having constant selectivity is employed.

While I have indicated and described one arrangement for carrying my invention into effect, it will be apparent to one skilled in the art that my 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 my invention as set forth in the appended claims.

What I claim is:

1. In a radio signalling system, a pair of coupled resonant circuits, at least one of said circuits being sharply tunable to a predetermined carrier frequency and its associated side bands due to modulation, said tuned circuit including an impedance element having resistance therein arranged in such a manner that the resonance curve of the coupled resonant circuits is substantially the same at whatever carrier frequencies in a desired carrier frequency range the said one circuit is tuned to, and a compensating audio frequency amplifier comprising at least two coupled stages, the coupling between said stages being designed in such a manner that the amplification of the audio frequency amplifier increases with audio frequency whereby the apparent audio frequency amplification of the side bands of selected carrier frequencies throughout said range is substantially uniform.

2. In combination, in a radio receiver, a radio frequency amplifier, means for tuning said amplifier over a desired range of modulated carrier frequencies, additional means electrically associated with said tuning means and amplifier for producing a uniform selectivity characteristic for said amplifier, means for detecting selected modulated carrier energy, and an audio frequency amplifier having an amplification characteristic which is directly proportional to audio frequencies to be amplified.

3. In combination, in a radio receiver, a selective radio frequency amplifier having relatively low damping, means for adjusting the amplifier to selectively amplify a desired carrier frequency and associated side bands due to modulation, said amplifier including additional means to preserve a constant predetermined amplification ratio between a selected carrier and its side bands throughout a desired carrier frequency range, a detector, and an audio frequency amplifier including means to preserve an audio frequency amplification ratio between the detected selected carrier and side bands which is the inverse of said radio frequency amplification ratio.

4. The method of receiving bands of radio frequencies, corresponding to modulated carrier energy at different carrier frequencies, throughout a desired frequency range, which consists in selecting a desired band of radio frequencies comprising a carrier and its side bands due to modulation, subjecting the selected band to radio frequency amplification, selectively amplifying the amplified band at least another time whereby amplification of a given frequency in the selected band varies inversely according to a predetermined relation with the spacing between the said given frequency and the carrier, detecting the selectively amplified band of frequencies to produce a band of audio frequencies corresponding to the selected band of radio frequencies, amplifying the band of audio frequencies in a manner inverse to that at radio frequency amplification, and maintaining said predetermined radio frequency amplification relation substantially constant for all selected bands of radio frequencies throughout said desired frequency range.

5. An apparatus for receiving a carrier wave modulated by a desired signal including, in combination, selective receiving means, the selectivity of said means being such that the amplitude of the modulation frequencies over a substantial portion of the modulation frequency range will be relatively altered, means for relatively altering the amplitude of the said modulation frequencies in the opposite sense, and additional means, electrically associated with said selective receiving means, for maintaining the said first alteration substantially constant over the tuning range of said receiving means.

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