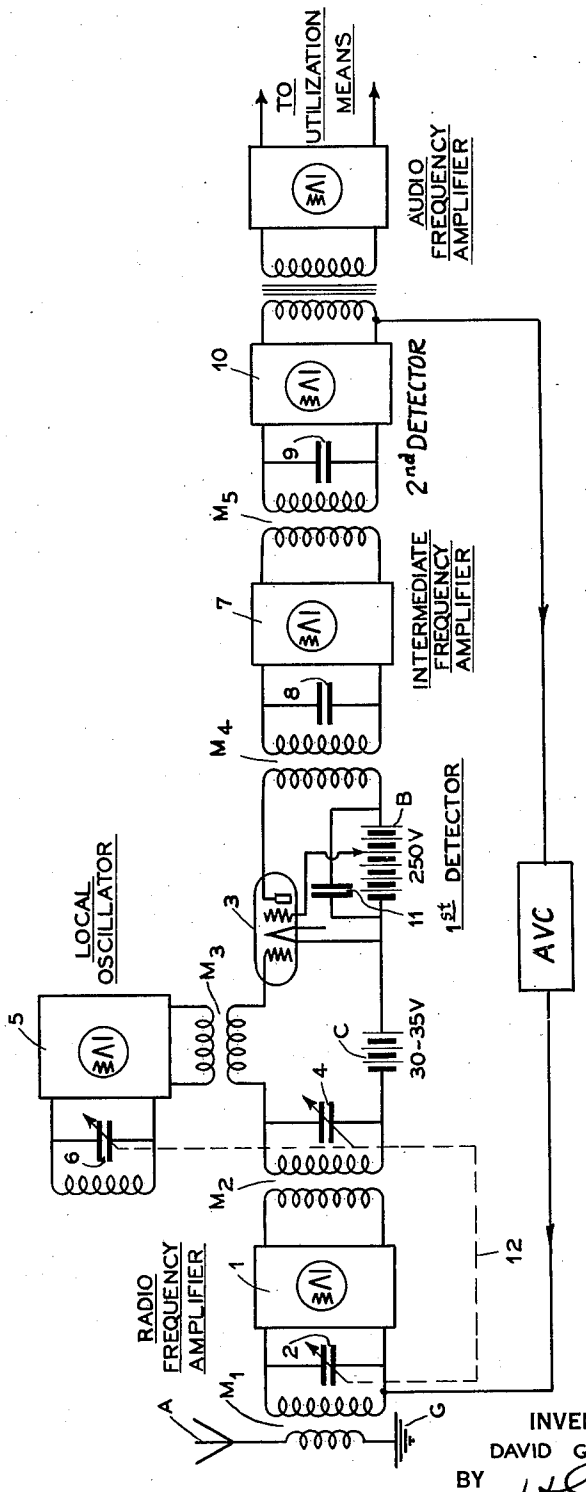
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SUPERHETERODYNE RECEIVER

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SUPERHETERODYNE RECEIVER

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My present invention relates to superheterodyne receiving systems, and more particularly to an improved type of frequency changer, or first detector, circuit for use in a superheterodyne receiver.

It has been well appreciated for some time that power detectors are desirable, if not necessary, where the desired station is of sufficient strength, either by virtue of strong transmission or considerable amplification in the receiving set. Thus, in a tuned radio frequency receiver employing modern radio frequency amplification, such as produced by a multi-stage radio frequency amplifier, a detector must be employed which will not readily overload. This is so since a detector circuit which readily overloads constitutes the weak link in the amplification chain, and will result in premature distortion. Similarly, the same condition pertains in the second detector of a superheterodyne receiver where both the radio frequency and intermediate frequency amplification have created a signal of considerable strength.

The need for a power detector in the first detector stage of the superheterodyne receiver is not so apparent and has not been appreciated. Obviously, the desired signal strength at this point is very weak as the signal has been subjected to little or no amplification. Of course, the entire available grid swing determined by the permanent grid bias on the first detector tube is not available for the incoming signal because of the presence of the induced local oscillator swing. However, the amount of local oscillator peak swing has been maintained at a point sufficiently below the maximum permanent bias on the first detector to allow the incoming signal to be superimposed thereon without causing the instantaneous peak swing in the first detector grid to run into the positive region at any time as this causes distortion.

The aforegoing discussion relates only to the reception of the desired signal. Now, there is a real defect which arises from other broadcast channels than the desired one. It often happens that the strength of the signal from an adjacent undesired channel on the grid of the first detector is greater than the strength of signal from the desired channel. This arises by virtue of the limited amount of tuned radio frequency selectivity preceding the first detector. The presence of this excessive undesired signal is of itself no detriment, and will cause no undesired responses in the receiver by virtue of its mere presence because the frequency differential between the same and the local oscillator is not the frequency of the intermediate tuned circuits.

However, if the effect of this excessive local undesired station on the grid of the first detector is great enough to cause the instantaneous grid swing of the first detector to run into the positive region then a peculiar type of distortion and interference takes place in the form of cross-modulation on adjacent desired channels and multiple responses. The latter occur whether or not a desired channel is being received.

There are three solutions for such defects, and such solutions are as follows:

(1) Increased radio frequency selectivity preceding the first detector may be employed;

(2) The local oscillator induced voltage may be reduced;

(3) A power detector employing ample grid bias or other types of detectors which are not subject to overload, may be utilized in the first detector stage.

The first expedient mentioned above is costly as it necessitates additional tuning condensers with the associated difficulties of ganging these additional condensers. Furthermore, additional tuning stages required extra precautions in shielding to prevent the undesired stations from reaching the first detector other than through the orthodox path. The second expedient involving reduced local oscillator swing greatly reduces the translation efficiency of the first detector.

Accordingly, it may be stated that the third solution referred to above comprises the basis of the present invention, and offers as only real solution to an aggravating problem. Hence, it may be pointed out that it is one of the main objects of the present invention to provide in the first detector circuit of a superheterodyne receiver an electron discharge tube arrangement so designed that its grid circuit can handle the induced local oscillator voltage swing, the desired channel signal swing, and the maximum amount of undesired signal swing possible to encounter in practice without resulting in an instantaneous grid swing sufficiently great to pass into the positive region of the first detector characteristic.

Another important object of the present invention is to provide a superheterodyne receiver employing but a single tuned stage of radio frequency amplification prior to the first detector, and to operate the first detector with such plate and grid voltages that the maximum grid voltage swing does not overload the detector tube.

Another object of the present invention is to minimize cross modulation between a desired sig-

nal and an undesired adjacent channel signal in a superheterodyne receiver by designing the first detector of the superheterodyne receiver in such a manner that the instantaneous grid swing of the latter is never great enough to run into the positive region of the detector characteristic.

And still other objects of the present invention are to improve generally the operating efficiency of superheterodyne receivers, and to especially design the first detector circuit of a superheterodyne receiver as a power detector in such a manner that the first detector circuit is not only reliable in operation, but economically manufactured and installed.

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.

Referring now to the accompanying drawing, in which there is shown a conventional type of superheterodyne receiver, it will be noted that the usual grounded antenna A, G is employed for collecting intelligence modulated carrier frequency energy, within the so-called broadcast range between 550 to 1500 kilocycles. The collected carrier energy is impressed as at M_1, upon the tuned input circuit of a radio frequency amplifier 1, it being noted that the input circuit of the amplifier is adapted to be tuned through the frequency range of the receiver by a variable condenser 2. The amplified radio frequency energy is then impressed upon the input circuit of the first detector, which includes an electronic discharge tube 3 of the screen grid type. The input circuit of the tube 3 includes the variable condenser 4 which is adapted to tune the input circuit of the first detector in a manner similar to the tuning of the amplifier 1.

A local oscillator 5 is shown in conventional form, and is adapted to be tuned by a variable condenser 6 through a frequency range which differs from the frequency range through which the condensers 2 and 4 are operative by a desired intermediate frequency. The locally produced energy is impressed, as at M_3, upon the grid circuit of the first detector tube 3. Those skilled in the art are well acquainted with the phenomenon occurring in the first detector, or frequency changer circuit, and it may be briefly stated that the energy impressed upon the input circuit of the tube 3 through the coupling M_2, and the locally produced energy impressed upon the grid circuit of tube 3 through the coupling M_3, heterodyne to produce in the output circuit of the first detector the desired intermediate frequency. The intermediate frequency energy is transmitted through a coupling M_4 to the input circuit of the intermediate frequency amplifier 7, the input circuit of the latter being maintained fixedly tuned by a condenser 8 to the desired intermediate frequency. While the amplifier 7 has been conventionally represented, it will be understood that the amplifier may consist of one or more stages of intermediate frequency amplification, and the design thereof is so well known to those skilled in the art that it need not be described in any further detail in the present application.

The amplified intermediate frequency energy is then transmitted through the coupling M_5 and impressed upon the second detector input which is fixedly tuned, as by a condenser 9, to the intermediate frequency energy, and the detected intermediate frequency energy is subjected to audio frequency amplification in the well known and usual manner. The amplified audio frequency energy is then utilized in any well known fashion, as by head phones, loud speaker or any other type of reproducer.

As pointed out heretofore it has been well appreciated for some time that power detectors are desirable, and in fact necessary, where the desired signal energy is of sufficient strength due to considerable amplification in the receiving set. Thus, a detector must be employed which will not readily overload, as such a condition will constitute the weak link in the amplification chain and will result in premature distortion. Accordingly, the second detector 10 may be a power detector since both the radio frequency and intermediate frequency amplification have created a signal of considerable strength.

It is not believed necessary to describe in any further detail the characteristics of the design of the second detector as a power detector since this is clearly disclosed by W. L. Carlson in United States Patent 1,770,838 of July 15, 1930. It is to be noted that if the detector 10 is a power detector a single stage of audio frequency amplification is sufficient to operate a loud speaker.

Considering, now, the subject matter of the present invention it is again pointed out that the need for a power detector in the first detector stage of the superheterodyne receiver has not been appreciated. Obviously, the desired signal strength at the first detector point is very weak since it has been subjected to but one stage of radio frequency amplification. It often happens that the strength of signal from an adjacent undesired channel on the grid of the first detector tube 3 is greater than the strength of signal from the desired channel. This arises from the limited amount of tuned radio frequency selectivity ahead of the first detector.

If the effect of this excessive local undesired station, combined with the local oscillator swing and the desired station, on the grid of the first detector is great enough to cause the instantaneous grid swing of the tube 3 to run into the positive region, then it can be readily demonstrated that a peculiar type of distortion and interference takes place in the form of cross-modulation on adjacent desired channels and multiple responses. The latter may occur whether or not a desired channel is being received.

It will be appreciated that such cross-modulation, or cross talk, is particularly annoying in the case of a superheterodyne receiver. The latter is considered one of the most selective types of radio receivers, and hence the existence of cross-talk and multiple responses would obviously cause the operator of the superheterodyne receiver considerable disappointment in the selective qualities of the receiver. As explained above, the present invention offers the only real solution to this aggravating problem.

By employing a power detector in the first detector circuit which is operated on high plate voltages such as 250 volts with an associated increased negative grid bias of approximately thirty to thirty-five volts, the grid circuit can handle the induced oscillator voltage swing, the desired channel signal swing, and the maximum amount of undesired signal swing possible to encounter in practice without resulting in an instantaneous

grid swing sufficiently great to pass into the positive region. The source B conventionally designates the 250 volt source, the latter being shunted by a radio frequency by-pass condenser 11, and the source C conventionally designates the grid bias source capable of applying approximately −30 to −35 volts to the grid of the tube 3.

By means of the arrangement described the problem of eliminating the cross modulation distortion is simply and effectively solved. This invention is particularly necessary in superheterodyne receiver circuits employing automatic volume control because the radio frequency gain preceding the first detector is automatically increased in proportion as the desired signal is weak. This increase in radio frequency amplification thus tends to bring in the undesired adjacent channel to an excessive degree sufficient to run the instantaneous grid swing of the first detector into the positive region. Hence, when utilizing an automatic gain control circuit, as of the type disclosed by H. T. Friis in United States Patent 1,675,848 of July 3, 1928, it is extremely beneficial to design the first detector circuit to operate as a power detector. It is not believed necessary to go into the details of construction of an automatic volume control circuit since the latter patent clearly discloses the design in operation of such a circuit in a superheterodyne receiver, and additionally since those skilled in the art are acquainted with the manner of embodying an automatic gain control circuit in a radio receiver of the superheterodyne type. There has been shown in the drawing for this reason a conventional representation designated "AVC". This is to be understood as representing an automatic amplification control circuit of the type shown in the Friis patent.

The operation of the present invention is believed to be clear from the aforegoing description. It is, of course, understood that the tuning condensers 2, 4 and 6 are mechanically coupled as shown by the dotted lines 12, for uni-control tuning. In order to maintain the desired intermediate frequency difference between the local oscillator circuit and the radio frequency amplifier and first detector circuits a constant quantity throughout the operating frequency range, an arrangement is employed which is disclosed by W. L. Carlson in U. S. Patent 1,740,331 of December 17, 1929. Such a constant intermediate frequency difference arrangement is too well known to those skilled in the art to require any additional description in the present application.

While the first detector circuit has been shown to embody a power detector tube 3 employing sufficient grid bias to prevent overload at maximum instantaneous grid swing, it is to be clearly understood that the present invention is not limited to a power detector operating by this manner in virtue of increased grid bias and plate voltage. Any other type of detector which is not subject to overload may be employed in the first detector circuit, since the essential principle underlying the present invention involves utilization of a first detector circuit which is designed in such a manner that maximum instantaneous grid swing never passes into the positive region of the detector tube characteristic.

Additionally, it is pointed out that a type of electron discharge tube known as the "variable mu" tube may be employed for the tube 3 in the first detector circuit. Such a tube and its characteristics has been described in the Proceedings of the Institute of Radio Enkineers in volume 18, 1930, the paper being entitled "Reduction of Distortion", attention being particularly directed to pages 2122 and 2123 of this article. The variable mu tube employs high plate voltages and increased grid bias referred to herein, and provides a tube design which lends itself readily to the purposes sought to be attained in the present invention.

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. A superheterodyne receiving circuit comprising a single stage of tuned radio frequency amplification, a grid biased tube detector operating as a first detector, an intermediate frequency amplifier, and a second detector all arranged in cascade, the selectivity of the receiving circuit network preceding the said first detector being sufficiently low to permit the impression upon the first detector grid of an undesired adjacent channel signal of substantial intensity, means to impress a high negative biasing voltage on the grid of the first detector tube, a source of high positive plate voltage therefor, the grid and plate voltages being sufficiently high to give a detector characteristic such that the grid circuit of the first detector can handle a desired channel signal swing and the maximum amount of undesired signal swing possible to encounter in practice without resulting in an instantaneous grid swing sufficiently great to pass into the positive region of the said detector characteristic.

2. A superheterodyne receiver comprising a single stage of tuned radio frequency amplification, a local oscillator, a first detector tube circuit, an intermediate frequency amplifier, and a second detector circuit, means to impress a negative biasing voltage on the grid of the first detector tube of the order of at least 30 to 35 volts, the selectivity of said single stage preceding the said first detector being insufficient to reduce the strength of signal from an adjacent undesired channel on the grid of the first detector with respect to the strength of signal from the desired channel, and a source of commensurately high positive plate voltage for the first detector tube, whereby the grid circuit of the first detector can handle the induced oscillator voltage swing, the desired channel swing, and the maximum amount of undesired signal swing possible without resulting in an instantaneous grid swing sufficiently great to pass into the positive region of the first detector characteristic.

3. A superheterodyne receiving circuit comprising a radio frequency amplifier, a first detector circuit, a local oscillator circuit, an intermediate frequency amplifier, a second detector circuit, the selectivity of the radio amplifier being sufficiently low to permit the transmission to the first detector of an undesired adjacent channel signal having an intensity comparable to that of the desired signal intensity, means to impress a negative biasing voltage on the grid of the first detector tube of the order of 30 volts, and a source of positive plate voltage for said first detector which is so high that the maximum instantaneous grid swing of the first detector tube is not capable of running into the positive region of the first detector characteristic.

4. In the operation of a superheterodyne radio receiver including an intermediate frequency amplifier, a first detector tube, and a second detector tube, the method which includes reducing the selectivity preceding the first detector to an amount such that the strength of signal from and adjacent undesired channel on the grid of the first detector is comparable with or greater than the strength of signal from the desired channel, obtaining rectification in the first detector tube by negatively biasing the grid thereof, and increasing the negative grid bias and positive anode potentials applied to the first detector tube in order to sufficiently raise the characteristic saturation point thereof so that the maximum instantaneous grid swing of the first detector never runs into the positive region of the first detector characteristic.

5. In the operation of a superheterodyne receiver of the type having sufficiently low selectivity preceding the first detector to permit the impression upon the first detector of an undesired adjacent channel signal comparable in intensity to the desired signal, the method of preventing distortion in the form of cross-modulation on adjacent desired channels and multiple responses caused by overloading of the first detector tube, which includes so adjusting the constants of the first detector that the maximum instantaneous grid swing of the latter never runs into the positive region of the first detector characteristic.

6. A superheterodyne receiver including only a single stage of tuned radio frequency amplification prior to the first detector circuit, the selectivity ahead of the first detector being insufficient to substantially suppress undesired adjacent channel signals, characterized by the feature that the constants of the first detector circuit are so adjusted that the maximum instantaneous grid swing of the first detector is prevented from running into the positive region of the first detector characteristic.

7. In a superheterodyne receiver comprising a radio frequency amplifier adapted to have its amplification automatically varied to maintain the receiver volume at a predetermined level regardless of carrier fluctuations, a local oscillator, a frequency changer tube circuit coupled to said amplifier and oscillator for producing a desired beat frequency, the said amplifier having insufficient selectivity to reduce the undesired adjacent channel signal intensity whereby the undesired signal is substantially amplified when weak desired signals are received, the constants of the frequency changer tube being so adjusted as to prevent the instantaneous grid swing of the frequency changer tube from running into the positive region of its characteristic.

8. In a superheterodyne receiver comprising a radio frequency amplifier adapted to have its amplification automatically varied to maintain the receiver volume at a predetermined level regardless of carrier fluctuations, a local oscillator, a frequency changer tube circuit coupled to said amplifier and oscillator for producing a desired beat frequency, the said amplifier having insufficient selectivity to reduce the undesired adjacent channel signal intensity whereby the undesired signal is substantially amplified when weak desired signals are received, the constants of the frequency changer tube being so adjusted as to prevent the instantaneous grid swing of the frequency changer tube from running into the positive region of its characteristic, means for amplifying said beat frequency, and a detector circuit coupled to said beat frequency amplifying means, said second detector comprising a power detector capable of delivering sufficient power to operate a reproducer with but a single stage of audio frequency amplification.

9. A method of receiving signals with a superheterodyne receiver, of the type including a signal collector, a first frequency changer tube, a second frequency changer tube and a reproducer, which consists in collecting broadcast signals, reducing the selectivity between the collector and first frequency changer tube to a point such that undesired signals are applied to the latter with an intensity comparable to the intensity of desired signals whereby reproduction of demodulated desired signals is accompanied by reproduction of demodulated undesired signals, and maintaining the relative grid and plate potentials of the first frequency changer tube such that overloading of the latter by applied collected signals is constantly prevented and the effect of said reduced selectivity substantially compensated for.

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