

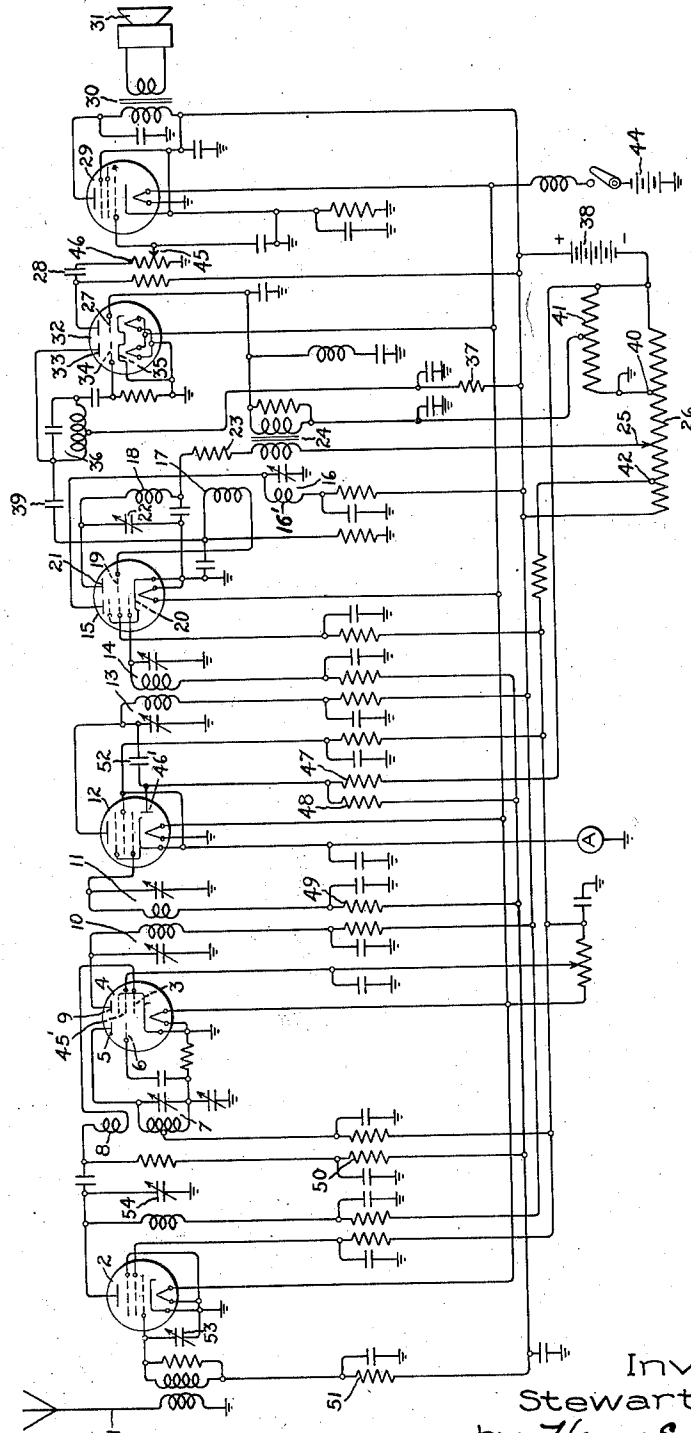
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HIGH FREQUENCY RECEIVING SYSTEM

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HIGH FREQUENCY RECEIVING SYSTEM

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My invention relates to high frequency receiving systems and more particularly to radio receivers such as are employed on automotive vehicles by municipal police.

One of the objects of my invention is to provide such a high frequency receiver which has high selectivity and which when operated in the short wave band produces substantially uniform response during rapid movement through city areas, for example.

A number of problems are presented in the construction of radio receivers which meet the demands of municipal police operation. The frequency bands assigned for such use are in the high frequency portion of the spectrum one of them extending, for example, from thirty to forty-two megacycles. If it be desired to operate a number of transmitters at different frequencies in this band, it is necessary to design the receivers with high selectivity. Since the transmitters are of low power and since, by reason of the characteristics of these short waves, the radiated energy is distributed non-uniformly over the area in which reception is desired, it is necessary that the receiver be highly sensitive, and that automatic volume control means be provided. The conventional automatic volume control means, however, while useful, is inadequate for use in such equipment on moving vehicles.

It has been found, for example, that the signal reproduced by a receiver operating in the wave band referred to, is subject to violent and extremely rapid fading with movement of the vehicle. This may be attributed to dead spots such as occur under structural steel underpasses, for example, or behind hills, or due to passage of the vehicle through a nodal point of a standing wave in space, or by reason of multiple reflections from different reflecting surfaces. That is, due to reflections of a ten meter wave, for example, from the different reflecting surfaces which exist in city districts standing waves frequently occur having nodal points along the streets where the signal intensity is very slight. Further waves from a common source arriving at the same point over different paths, or after reflection from different surfaces, may tend to neutralize each other and thus produce a point of low signal intensity by reason of the multiple reflection. An automobile receiver passing through such areas at ordinary automobile speeds therefor is subject to extremely wide and extremely rapid signal intensity variations.

The conventional automatic volume control means wherein the bias on the grids of radio

frequency amplifiers is varied by rectifying a portion of the received signal and supplying the resulting unidirectional electromotive force to these grids have been found to be wholly inadequate to compensate for this type of fading. This is by reason of the fact that in order that the signal may not be impaired by action of the automatic volume control means the circuits thereof are designed with a time constant such that they do not respond to signal variations of the received carrier. This delayed action, however, is too slow to permit of compensation for the type of fading referred to.

Thus, one of the objects of my invention is to provide a radio receiver having the required selectivity and sufficient sensitivity to respond to the low signal levels which occur due, for example, to reflections of the wave to be received and which at the same time is capable of producing a substantially uniform signal output.

A further problem is presented in that a radio receiver having the required sensitivity, and especially when designed for operation in high frequency channels such as are assigned to police use, also respond to automobile ignition noises and the like. Accordingly, a further object of my invention is to provide a receiver of the type referred to having the required selectivity, sensitivity and automatic volume control action, and which at the same time is substantially unresponsive to damped oscillations such as are produced by automobile ignition systems.

In accordance with my invention all of these requirements are satisfactorily met through proper use of the principles of superheterodyne and super-regenerative reception in the same receiver. I prefer to employ the super-regenerative principle in the second detector of the superheterodyne radio receiver. Then by proper choice of the intermediate frequency relative to the degree of noise elimination and selectivity required together with other careful adjustments including the quench frequency and its magnitude very satisfactory reception may be had.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which I have shown an embodiment of my invention.

Referring to the drawing, I have shown therein a radio receiver adapted for operation of the type referred to. This receiver comprises an antenna 1 from which received oscillations are supplied to the input of a radio frequency amplifier 2 in which they are amplified and supplied to the grid 3 of a converted stage 4. The envelope of the converter stage encloses a cathode and the elements of both the converter stage and the local oscillator, the elements of the latter comprising the anode 5, grid 6, and the cathode of the converter. The frequency determining circuit 7 of the local oscillator is connected between these latter elements and coupled to an inductance coil 8 in the circuit of grid 3 of the converter. The output from the converter stage is connected between the anode 9 and cathode thereof and comprises tuned circuits 10 and 11 between the converter stage and an intermediate frequency amplifier 12, tuned circuits 13 and 14, between the intermediate frequency amplifier 12, and a second intermediate frequency amplifier 15, and a tuned circuit 16 connected in the output of the intermediate frequency amplifier 15. The inductance 16' of the tuned circuit 16 is loosely coupled to two inductance coils 17 and 18, the former of which is connected between the grid 19 and cathode 20 of the second detector of the receiver, and the latter of which is connected between the anode 21 and cathode 20 of this detector. The inductance 18 is tuned by means of a condenser 22 to the intermediate frequency and is, of course, coupled to the inductance 17 for purposes of regeneration, the degree of this latter coupling being very much closer than that between coil 16 and either of coils 17 and 18.

The anode circuit of the second detector, which preferably is a tube of the low mu type; extends through the inductance 18, resistance 23, primary winding of transformer 24 to a variable tap 25 on a bleeder resistance 26 from which anode potential for operation of the second detector is obtained. Audio frequency oscillations produced in this circuit by the second detector are supplied through the transformer 24 to the grid 27 of an audio amplifier. The output circuit of this amplifier is coupled by means of a condenser 28 to a second audio amplifier 29, the anode oscillations of which are supplied through a transformer 30 to a suitable reproducing device 31.

The envelope 32, which encloses the electrodes of the first audio amplifier, also encloses the electrodes 33, 34, and 35 of an oscillation generator whereby the quench frequency of the super-regenerative second detector 19, 20, and 21 is produced. This oscillator comprises the tuned circuit 36 connected between the anode 33 and grid 34 in the conventional manner, the intermediate point on the tuned circuit being connected through resistance 37 to the source of anode potential 38. Oscillations from the anode of this oscillator 33, 34, 35 are supplied through a coupling condenser 39 and coil 17 to the grid of said second detector.

All of the anode potentials for operation of the discharge devices of the system are derived from a source of potential 38 through circuits which are obvious from the drawing. The bleeder resistance 26 is connected directly across the source 38 and an intermediate point 40 thereon is connected to ground. The portion of this resistor which is negative with respect to ground is shunted by a second resistor 41 from which bias potential for the grid 27 of the first audio amplifier is obtained. The portion of the resistance which

is positive with respect to the point 40 is provided with a number of taps 25 and 42 connected to those electrodes of the different discharge devices requiring potentials less than the maximum positive potential available from the source 38, such, for example, as the screen grids of the two intermediate frequency amplifiers, the screen grid of radio frequency amplifier 2, and the anode 5 of the converter. Potential for energization of the heating elements of all of the discharge devices is obtained from source 44, one terminal of which is grounded and the other terminal of which is connected to one side of all the different filaments, the opposite side of the different heating elements being connected to ground.

Manual volume control is obtained by variation of the contact 45' on potentiometer 46 in the output of the first audio stage.

The coupling between the coils 17 and 18 should be adjusted for operation of the detector in what is known as the "L" region of super-regeneration. This requires very close coupling. When so adjusted the output from the detector is relatively constant with respect to variations in the input thereto and the detector has very slight response to damped oscillations. The coil 16 should be very loosely coupled to coils 17 and 18 to prevent the circuit of this coil from undesirably loading the detector and altering the amount of regeneration obtained.

The inductance to capacitance ratio of circuit 18, 22 should be very high to prevent the occurrence of squeals or whistling sounds (birdies) in the output of the receiver when the frequency received upon the detector varies from normal by amounts equal to the quench frequency, or a whole multiple thereof, or when the detector is detuned from the received frequency by such amounts. For the same reason the amplitude of oscillations of the quench frequency should be greater than a predetermined value, although, of course, this amplitude should not be too great.

The super-regenerative detector of my system is carefully adjusted for desired elimination of noise such as is produced by damped oscillations generated in the ignition systems of automobiles. To effect this adjustment it is essential that the intermediate frequency to which the second detector responds be very high. If this intermediate frequency be chosen too high, however, difficulty is encountered in obtaining desired selectivity of the system. For example, if the receiver be adapted for operation in the band extending from 30 to 42 megacycles, it is desired that it be capable of satisfactory selection of any desired signal in the band spaced approximately 2 or 3 megacycles from the frequency of other signals in the band. Condensers 53 and 54 are provided for varying the tuning of the radio frequency circuits to select the desired frequency. Such selectivity, however, is difficult of attainment at high frequencies, and accordingly, from the standpoint of selectivity it is desirable that the intermediate frequency be fairly low. It has been found, however, that an intermediate frequency may be chosen at which the desired selectivity may be attained, and at which the second detector has the desired noise eliminating property. In a receiver adapted for response to oscillations in the 30 to 42 megacycle band, an intermediate frequency of 9 megacycles may be employed. This is far higher than is desired were the system designed purely from the standpoint of selectivity but lower than is desired for optimum noise elimination. By use of the circuits shown involving the tuned circuits 10, 11, 75

13, 14, 16 and 18, 22, all of which are tuned to the fixed intermediate frequency, common to all received signals, it has been found that the desired selectivity in this band may be obtained. At the same time by careful adjustment of the second detector, the magnitude of the quench frequency produced in circuit 36, and the coupling between coils 17 and 18, it has been found that desired noise elimination may be effected at this intermediate frequency. It is desired that the quench frequency be as widely different from the intermediate frequency as possible although it should be inaudible. A frequency of approximately 20,000 cycles has been found satisfactory for this purpose.

Were the intermediate frequency employed chosen purely from the standpoint of selectivity a frequency would be employed at which the desired selectivity could be obtained with fewer circuits tuned to the intermediate frequency. The most natural design would be one involving not more than a single intermediate frequency stage. In accordance with my invention, however, considerations affecting the design of the circuits for selectivity yield to a design also effecting noise elimination. The result is a higher intermediate frequency of a value dictated by the minimum requirements with respect to noise elimination and added tuned circuits or other expedients necessary to effect the desired selectivity. It has been found that with a system such as that described both desired noise elimination and selectivity of the high order referred to are obtainable in practice.

This choice of intermediate frequency, in addition, avoids the necessity for two intermediate frequencies in successive respective portions of the receiver, the first being chosen from considerations of selectivity, and hence relatively low, and the latter being chosen from considerations of noise elimination by a super-regenerative detector, and hence relatively high, a suitable converter, of course, being employed to produce the latter from the former. While such an arrangement may be highly desirable, for my present application, I prefer the use of a single intermediate frequency as already described.

The super-regenerative detector adjusted to be unresponsive to damped oscillations inherently produces substantially uniform audio output, notwithstanding variations of received signal intensity, and irrespective of the rate of such variations. That is, as the input signal intensity is increased from zero, the output likewise increases at a gradually diminishing rate relative to the increase in input until a substantially constant value of output is obtained beyond which the input may be increased without substantial increase in the output. If the input be too greatly increased, however, overloading is produced in the output of the super-regenerative detector. Accordingly, it will be observed that so long as the input to the detector be maintained within the range at which the detector produces constant output, instantaneously responsive automatic volume control is obtained through the inherent action of this detector. Thus the amplification of the portion of the receiver prior to the second detector should be sufficiently great to amplify the weakest signals to be received to an intensity within the range over which the second detector produces constant output. This amplification, however, should not be so great that strong signals produce overloading of the second detector. Accordingly, notwithstanding the inherent automatic volume control characteristic of the super-

regenerative detector, a conventional automatic volume control means of the slow acting type above-referred to is provided.

This means comprises an anode 46' in the envelope of the amplifier 12, which is connected through intermediate frequency coupling condenser 52 to the anode of amplifier 12, and which cooperates with the cathode of this amplifier to form a diode rectifier operating into a load resistance 47, which is connected between the anode 46' and the negative terminal of the resistances 40 and 41. The cathode of the amplifier 12 is connected to ground through a suitable current indicating device indicated at A on the drawing, the latter of which may be employed for tuning purposes. Thus the potential of resistance 41 is supplied between the cathode and anode of the automatic volume control diode, thereby to bias the anode 46' sufficiently negative to prevent current from flowing in the resistance 47 when the received signal is of less than a predetermined intensity. When current flows in this resistance 47 the potential thereon is supplied through resistance 48 and filter resistances 49, 50, and 51 to the control grids of amplifier 12, converter stage 4, and amplifier 2 respectively thereby to reduce the amplification of these discharge devices upon reception of signals greater than the predetermined intensity.

This automatic volume control means operates to maintain the received signal intensities supplied from the first portion of the receiver to the second portion, that is, from the portion of the receiver prior to the second detector, to the second detector, below that value at which overloading of the second detector occurs. Thus while this conventional automatic volume control means may, if desired, be adjusted in the same manner in which it is adjusted for conventional automatic volume control operation, i. e. for minimum practical variation of signal intensity supplied to the second detector, when employed in connection with the super-regenerative detector described it is only essential that it reduce the strong signals sufficiently to avoid overloading since the principal automatic volume control action is obtained through the inherent operation of the second detector.

Thus with the equipment shown not only the high selectivity required, but substantial freedom from automobile interference and desired elimination of the rapid fading described, is satisfactorily accomplished.

While I have shown a particular embodiment of my invention, it will, of course, be understood that I do not wish to be limited thereto since many modifications both in the circuit arrangement and in the instrumentalities employed may be made. I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The combination, in a high frequency receiver for undamped oscillations, of a super-regenerative detector, said detector being adjusted for operation at a predetermined high frequency, said frequency being so high that said detector has substantially no response to damped oscillations, and means to convert the received oscillations to oscillations of said predetermined high frequency and to supply said oscillations to said detector, whereby damped oscillations undesirably received by said means and supplied to

said super-regenerative detector are substantially eliminated from the output of said detector.

2. The combination, in a high frequency receiver adapted for substantially uniform reception of short wave oscillations, of signal intensities varying over a wide range, of a super-regenerative detector adapted for substantially uniform desired response to oscillations of intensities within a predetermined range narrower than said wide range irrespective of the rate of variation in intensity of said oscillations, means to amplify the received oscillations and to supply the received oscillations to said super-regenerative detector, said last means having sufficient amplification to amplify the signal of lowest intensity to be received to an intensity within said narrower range, and means to reduce the amplification of said last means upon reception of strong oscillations having intensities in the upper portion of said wide range so that said strong oscillations are amplified only to an intensity within said narrower range, whereby sensitive response in the output of said detector to the weakest signals to be received is produced and undesired operation of said detector in response to strong signals is prevented, while at the same time substantially uniform output from said detector is produced during variation of the intensity of oscillations supplied thereto over the entire narrower range.

3. The combination, in a superheterodyne radio receiver, of an input circuit responsive to signals having any frequency within a desired range, means including a converter stage for converting all received frequencies to a common intermediate frequency, a super-regenerative detector responsive to said intermediate frequency, said intermediate frequency being so chosen that damped oscillations undesirably received in said input circuit and supplied to said detector produce substantially no response in the output of said detector.

4. The combination, in a superheterodyne radio receiver, of an input circuit responsive to signals having any frequency within a desired range, means including a converter stage for converting all received frequencies to a common intermediate frequency, a super-regenerative detector responsive to said intermediate frequency, said intermediate frequency being so chosen that damped oscillations undesirably received in said input circuit and supplied to said detector produce substantially no response in the output of said detector, said intermediate frequency being higher than would be desired to produce desired selection of the different frequencies to be received, were elimination of response to damped oscillations not required, and circuits having the desired selectivity to said intermediate frequency interposed between said converter stage and said super-regenerative detector.

5. The combination, in a radio receiver adapted for use on automobiles and for response to signals of short wavelength, of means to eliminate from the output of said receiver disturbing currents caused by the ignition systems of automobiles, said means comprising a super-regenerative detector adjusted for operation at a predetermined frequency at which said detector is unresponsive to currents caused by said ignition systems, means to convert the received signals to currents of said predetermined frequency and to supply said currents to said super-regenerative detector, said last means comprising a number of tuned circuits for rendering said receiver sufficiently selective to desired signals, said predetermined frequency being

determined by considerations of minimum tolerable elimination of disturbing currents by said super-regenerative detector and minimum selectivity of said receiver.

6. The combination, in a radio receiver, adapted for use in a field of undesired damped oscillations, a super-regenerative detector adapted to detect currents having a high frequency at which it is substantially unresponsive to said damped oscillations, said frequency being too high for practical amplification with desired selectivity, means to convert received signals to a frequency sufficiently low for practical amplification with desired selectivity, a frequency selective amplifier for amplifying currents of said last mentioned low frequency, means to convert said low frequency oscillations to oscillations having said high frequency which said detector is adapted to detect while unresponsive to damped oscillations, and means to supply said high frequency oscillations to said detector.

7. The combination, in a radio receiver, of a super-regeneration detector, frequency selective means to amplify the signals received in said receiver at a frequency lower than that at which they are received, means to convert the amplified signals to high frequency, and means to supply said high frequency to said super-regenerative detector, practically the entire selectivity of said receiver being produced in said frequency selective means, said lower frequency being chosen from considerations of desired selectivity and said higher frequency being in the range of frequencies where desired operation of said super-regenerative detector is obtained with no objectionable noise response notwithstanding reception in said receiver of undesired undamped oscillations.

8. The method of utilizing a superregenerative detector for reception of radio frequency oscillations in fields of interfering damped oscillations, which comprises the step of operating said super-regenerative detector at a frequency so high that its response to said damped oscillations is practically a minimum, said high frequency being chosen from considerations of minimizing said response, converting the received radio frequency oscillations to oscillations of said high frequency and supplying said high frequency oscillations to said superregenerative detector.

9. The method of utilizing a superregenerative detector for reception of radio frequency oscillations in fields of interfering damped oscillations which comprises the step of operating said super-regenerative detector at a frequency too high for practical amplification with requisite selectivity, and such that the response of said superregenerative detector to said damped oscillations is practically a minimum, said frequency being chosen from considerations of minimizing said response, converting the received radio frequency oscillations to a frequency lower than said high frequency and suitable for desired amplification and selectivity, amplifying said lower frequency with requisite selectivity, converting the amplified lower frequency oscillations to oscillations of said high frequency and supplying said high frequency oscillations to said superregenerative detector.

10. The combination, in a radio receiver for reception of oscillations having frequency between 30 and 42 megacycles, in fields of interfering damped oscillations, of means to convert the received oscillations to oscillations having a frequency in excess of eight megacycles, a super-regenerative detector, means to amplify said oscillations having frequency in excess of eight

megacycles and to supply said amplified oscillations to said detector, the portion of said receiver prior to said detector having selectivity such that substantially no response is produced to currents having frequency different from the received frequency by more than three megacycles, said superregenerative detector having substantially no response to said damped oscillations when operated at said frequency in excess of 8 megacycles.

11. The method of utilizing a super-regenerative detector for reception of voice modulated radio signals in fields of interfering damped oscillations, which comprises the step of operating said super-regenerative detector at a frequency too high for practical amplification of said radio signals with requisite selectivity, and such that response of said super-regenerative detector to said damped oscillations is too low substantially to impair reception of said voice signals, said frequency being chosen from considerations of reducing said response, converting the received radio frequency signals to a frequency lower than said high frequency and suitable for desired amplification and selectivity, amplifying said lower frequency with requisite selectivity, converting the amplified lower frequency oscillations to oscillations of said high frequency and supplying said high frequency oscillations to said super-regenerative detector.

12. The combination, in a radio receiver for re-

ception of short wave voice modulated radio signals in fields of interfering damped oscillations, of a super-regenerative detector adapted for operation at a frequency so high that its response to said damped oscillations produces no substantial impairment of reception of said voice signals, means to convert the received signals to oscillations of said frequency, and means to amplify said converted oscillations with requisite selectivity and to supply the amplified oscillations to said detector, said frequency being higher than is desired from considerations of selectivity and lower than desired from considerations of reducing said response to said undamped oscillations.

13. The combination in a superheterodyne radio receiver having two intermediate frequencies in successive respective portions of said receiver, of frequency selective means in the first portion to select the first intermediate frequency and a super-regenerative detector in the second portion to detect the second intermediate frequency, said intermediate frequencies being widely spaced in the frequency spectrum, the first being sufficiently low for high selectivity to be obtained by said selective means and the last being so high that said super-regenerative detector has practically no response to damped oscillations received in said receiver.

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