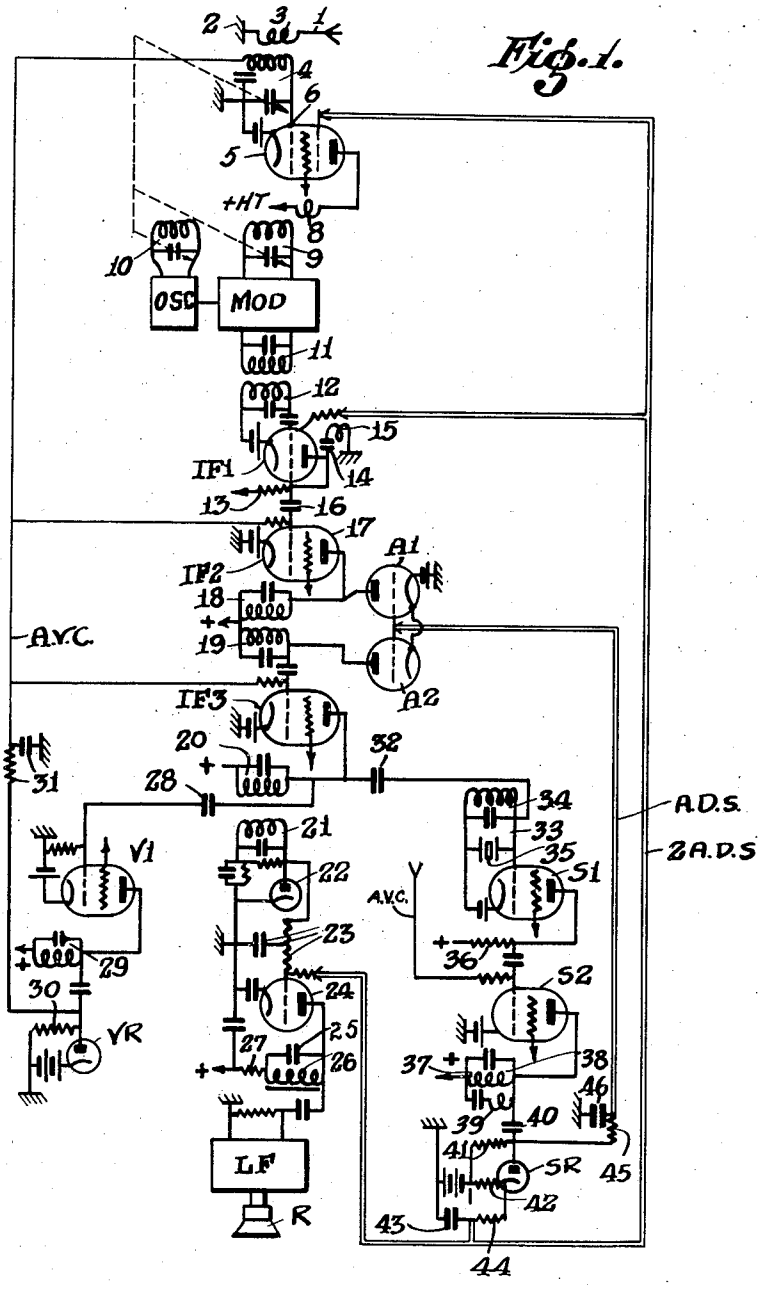
July 11, 1944. E. N. MULLER 2,353,180

AUTOMATIC SELECTIVITY CONTROL FOR RADIO RECEIVERS

Filed June 13, 1936 4 Sheets-Sheet 1

Fig. 1.



Inventor:
EGON NICOLAS MULLER
By Allfolcombe
Attorney.

July 11, 1944. E. N. MULLER 2,353,180

AUTOMATIC SELECTIVITY CONTROL FOR RADIO RECEIVERS

Filed June 13, 1936 4 Sheets-Sheet 2

Fig. 2a.

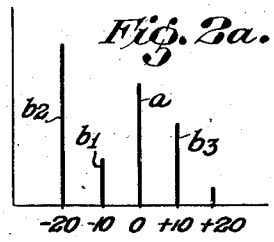


Fig. 2b.

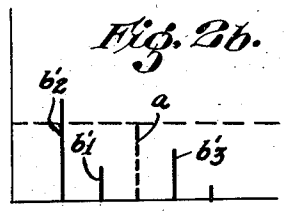


Fig. 2c.

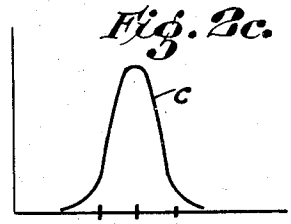


Fig. 2d.

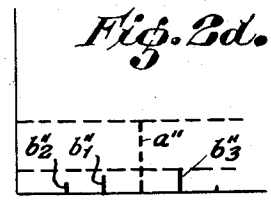


Fig. 6.

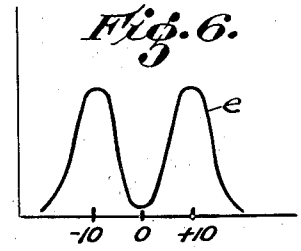


Fig. 3a.

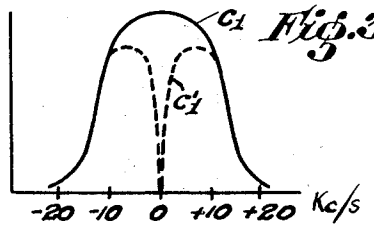


Fig. 3b.

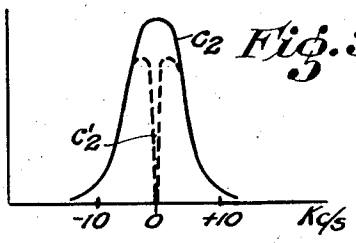


Fig. 4.

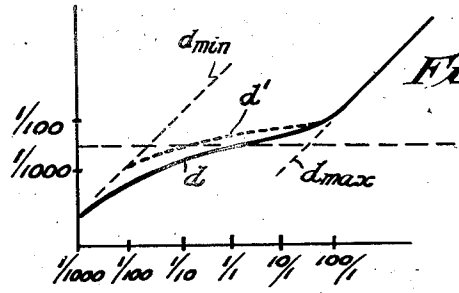
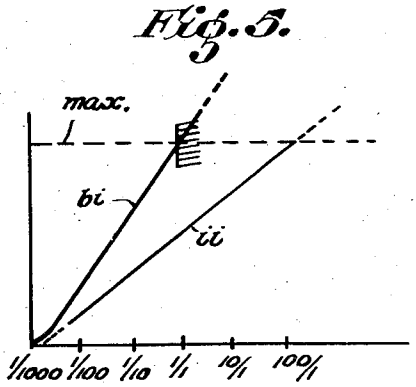


Fig. 5.



Inventor:
EGON NICOLAS MULLER,
By Attorney.

July 11, 1944. E. N. MULLER 2,353,180

AUTOMATIC SELECTIVITY CONTROL FOR RADIO RECEIVERS

Filed June 13, 1936 4 Sheets-Sheet 3

Fig. 7.

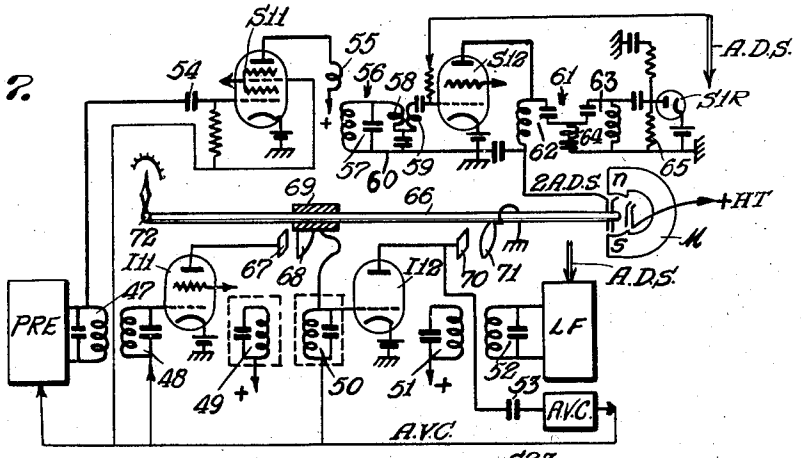


Fig. 8.

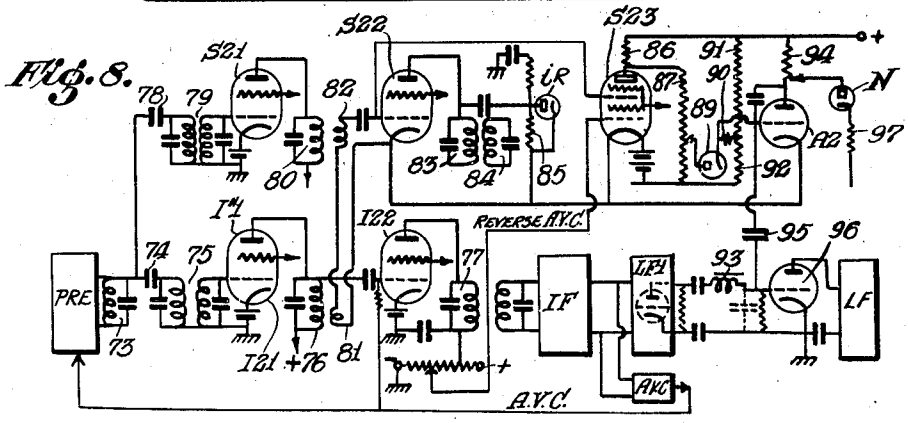
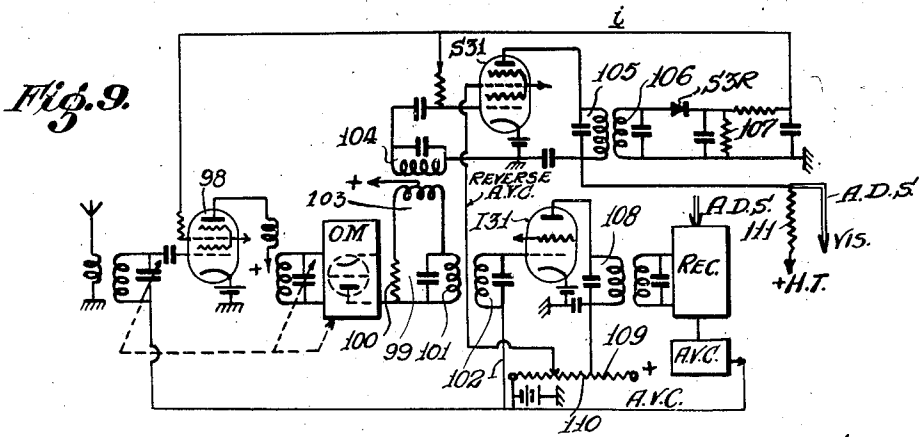


Fig. 9.



Inventor:
EGON NICOLAS MULLER,

By Allotcombe
Attorney.

July 11, 1944. E. N. MULLER 2,353,180

AUTOMATIC SELECTIVITY CONTROL FOR RADIO RECEIVERS

Filed June 13, 1936 4 Sheets-Sheet 4

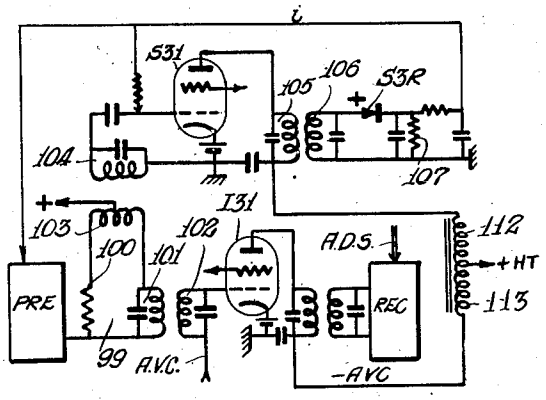


Fig. 12.

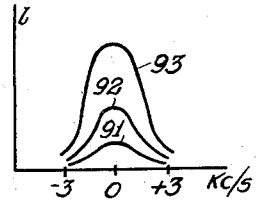


Fig. 10.

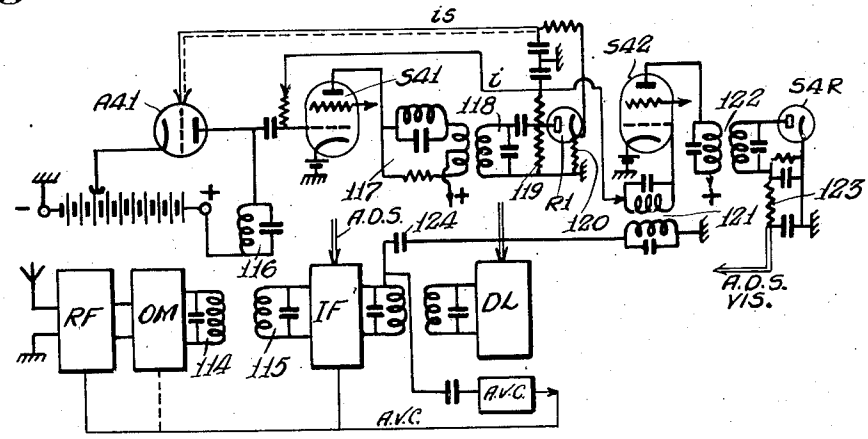


Fig. 11

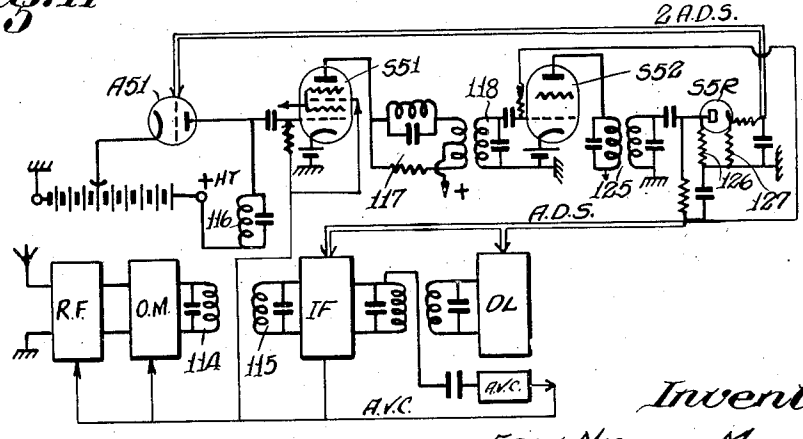


Fig. 13.

Inventor:
EGON NICOLAS MULLER
By Cruttenden
Attorney.

Patented July 11, 1944 2,353,180

UNITED STATES PATENT OFFICE

2,353,180

AUTOMATIC SELECTIVITY CONTROL FOR RADIO RECEIVERS

Egon Nicolas Muller, Esch-sur-Alzette, Luxemburg; vested in the Alien Property Custodian

Application June 13, 1936, Serial No. 85,166
In Luxemburg June 15, 1935

10 Claims. (Cl. 250—20)

The present invention applies to radio and like modulated carrier wave receivers and relates more particularly to arrangements for automatically controlling the frequency response thereof, to permit under the particular local reception conditions the best possible degree of fidelity compatible with a sufficient freedom of background noises.

It is highly desirable that a radio receiver should be substantially free from so-called "amplitude" or "linear" distortions. It is also well known that most stations cannot be received with a perfectly faithful reproduction since the interferences caused by the modulation of one or more stations operating on adjacent frequencies or due to the so-called "static" caused by man-made interferences, or atmospherics, would give an unpleasant background of noise. All these interferencies are reduced to a reasonable degree when the width of the modulation band correctly transmitted by the receiver is restricted. This restriction is usually carried out in the carrier frequency amplifier section of the receiver by increasing the degree of selectivity thereof, and if desired in the audio amplifier. Since this restriction of the band width impairs the quality of reproduction it is important that it shall be carried out to the strictly necessary degree only and a judicious compromise is therefor necessary in this matter. The terms fidelity, or quality will be used hereinafter to indicate a condition of the receiver obtained by broadening the carrier frequency response of the receiver only, or by conjointly extending the audio response of the audio frequency portion of the receiver towards the treble. With most receivers the care of adjusting the fidelity control means to vary the compromise between fidelity and absence of interferences is left to the operator.

However such an adjustment, since varying from one station to another, requires much care and experience, and is furthermore liable of becoming incorrect when the desired station or the interfering one is subject to fading.

It is known to provide in a radio receiver arrangements for automatically regulating fidelity operating in dependence on the strength of the desired carrier wave. The disadvantage of this system is that in most cases the degree of selectivity is not set correctly since the device is not capable of taking into account the value of the interference level, so that in many instances serious interferences are experienced especially when it is desired to receive a rather strong transmitter having small frequency spacing from a stronger one. For this reason a manual control in addition to the automatic one, is practically indispensable with the said device.

My invention is clearly distinguished from these prior devices and it overcomes the disadvantages just mentioned.

Accordingly a broad object of my invention is to avoid the inconvenience of these well-known methods of automatic fidelity control.

An object of this invention is to provide a new or improved receiver wherein the automatic fidelity and selectivity control takes into account the intensity of the interference waves.

Whilst my invention is more particularly concerned with the interfering carrier waves of adjacent channel frequencies, it may be performed in such a manner as to be also very useful in lowering the back-ground noise due to so-called "static"; it should accordingly be understood that the terms "interfering carrier amplitude" or "interference waves" or the like appearing hereinafter should not be interpreted in a narrow sense.

In carrying out my invention I provide a receiver equipped with a control or pilot channel including a rectifier for directly or indirectly producing a regulator potential, and associated with a selective network or a plurality of appropriate filters or selective devices adapted to impress in the main interfering carrier energy on the said rectifier; conveniently this channel is fed from a desired point in the main amplifier for reception of the desired signals, the common amplifier section being referred to hereinafter as "preliminary amplifier" or "preamplifier."

While the interference responsive control channel may be provided with selective circuits tuned to the carrier frequencies near the desired signal frequency, an arrangement of this general character in practice presents a number of inconveniences, one of which is the low effectiveness, whereby a plurality of like circuits should in general be used, especially so if the device must be able of taking into account comparatively weak interference waves, so that the receiver may with reliability be set to the high-fidelity position when the prevailing reception conditions permit so; other inconveniences are indicated hereinafter.

Whilst in some instances circuits of the character just referred to may be made use of in combination with the typical features of this invention. However it is preferred in general to omit any circuits specifically tuned to the interference frequency or frequencies, and to provide

as an essential selective constituent in the control channel or in association therewith, and in some instances as the sole constituent therein, a resonant circuit or other selective device e. g. a piezo-electric crystal, adapted to reject or attenuate in a substantial proportion the desired carrier energy. It is frequently possible to associate this circuit or device with the output circuit of the "preamplifier" so that this element may simultaneously serve as a coupling circuit for the input of the specific reproducer section, of the receiver. However with a scheme of the character defined it is essential or desirable to provide additional selective circuits or devices for substantially attenuating the interference carrier waves the frequency of which is spaced in a substantial proportion e. g. by 20 kilocycles or more, from the desired carrier frequency. In accordance with the invention, all of these circuits or an essential portion thereof may be included in the common preliminary amplifier, and will thereby efficiently aid in providing an adequate resultant response curve characteristic well adapted for transfer of the desired signal frequency range.

A main object of my invention is to provide a receiver wherein the degree of fidelity is controlled directly in dependence on the strength on the desired carrier wave and inversely in proportion to the strength of the interfering waves.

If in a receiver in accordance with my invention intensity of the desired carrier wave becomes stronger whilst the interference level remains at a predetermined intensity the degree of fidelity will increase. The fidelity will decrease however when the strength of the wanted carrier increases but in a lower proportion than the strength of the interference level. Although it would theoretically be best to control the degree of fidelity exactly in accordance with the ratio of the respective intensities of the desired and interfering carrier amplitudes, it is obvious that such a high degree of precision is by no means required in actual practice, it being easy to obtain even better results than when the receiver fidelity would be adjusted continuously by a skilled operator. Since the above ratio may be defined by the difference in decibels between the respective intensities I have termed my invention automatic "differential" selectivity control, and I have for the purpose of simplifying the description thereof used the abbreviation "A. D. S." particularly when designating control tensions produced in accordance therewith.

It is highly desirable that the receiver shall take into account the relative intensities of the desired and interfering signals over a wide range of level intensities of the incoming signals. However by applying such a wide range of intensity variations on the interference waves, as present across the signal source, to the control channel and to the fidelity control means in association therewith, it is very likely that these channels and means would be quite considerably overloaded, and that the control action could not possibly operate correctly. It is accordingly an object of this invention to provide means for preventing such risk of overload, as by operating "compression" of the control potentials and/or of the potentials responsive to the intensity of the interference waves.

The two above important objects of the invention I prefer to carry out by suitably varying the transfer characteristics of the carrier frequency amplifier path associated with the control device, in response to the intensity of the incoming signals.

According to a preferred form in which to carry out the invention, the fidelity control means are regulated in response to the output of a single control rectifier of which the feed path is suitably controlled in accordance with the amplitude of the oncoming signals; or the regulating potentials may be derived from the combined effects of signal responsive and interference responsive rectifiers.

According to another feature of the invention the transmission efficiency of the said auxiliary control amplifier and/or of an amplifier section of the receiver which feeds the said channel is modified inversely in accordance with the strength of the desired carrier, these means being preferably the same as or associated closely with, the overall gain control device which is usually incorporated in the receiver.

My invention provides different manners for carrying out this compression, the main forms making use of a decrease in transfer efficiency of the interfering waves in a selectivity-controlled receiver section which is common to the receiver proper and to the control channel, or alternatively, or conjointly, modifying the gain of the control channel inversely in dependence on the strength of the tensions across the rectifier of the said channel.

A subsidiary object of my invention is to provide means for rendering visual the operation of the selectivity control device so as to allow an appreciation of the quality with which a station may be received and to show off the prevailing reception conditions, this device being fed by the same tensions as the selectivity control or by means closely associated therewith. A modified form of this feature gives at the same time indications on the degree with which the receiver is in tune with the carrier.

Various types of fidelity control means adapted to be operated in response to a control potential, are known in the art, those indicated hereinafter being purely exemplary.

For a more complete understanding of my invention, reference should be had to the accompanying drawings of which:

Fig. 1 is an electrical diagram of one arrangement in accordance with the invention; Figs. 2*a*–5 are graphs illustrating the operation of the arrangement shown in Fig. 1; Fig. 6 is a graph illustrating the operation of some other forms of the invention, these forms being further illustrated by Figs. 7–11; Fig. 12 is a graph illustrating the operation of a feature shown on Fig. 11, whilst Fig. 13 shows still another arrangement in accordance with my invention.

Referring to Fig. 1, a typical form of the invention is embodied in a radio receiver of the superheterodyne type including a signal collecting means **1** and ground **2**, a radio frequency amplifier **5**, frequency changer device OSC—MOD, and three intermediate frequency amplifier valves IF**1**, IF**2**, IF**3**. The radio-frequency energy set up between antenna and ground is applied to the amplifier tube **5** by the intermediate of the coupling coil **3** and of the resonant circuit **4** which is tuned to the frequency of the wanted signal. This tube may be an indirectly heated pentode with a so-called suppressor grid **7** connected to a separate outlet. The anode circuit thereof is associated with a transformer comprising an aperiodic primary **8** connected to the high-tension supply+HT, and a very tightly coupled resonant

secondary 9 tuned to the desired signal frequency, and connected to a suitable frequency changer device of any well-known kind. As shown, the same comprises a modulator MOD co-operating with a local oscillator OSC tunable by means of the circuit 10, there being a constant frequency difference equal to the intermediate frequency between the oscillator frequency and the signal frequency. As is common use in modern receivers, the tunable circuits 4, 9 and 10 are ganged and operable by a common tuning control. The output of the frequency changing device includes a circuit 11 tuned to the operating intermediate frequency and coupled, as by mutual inductance to the circuit 12 which is also tuned to this frequency and connected to the input electrodes of the tube IF1. This tube is of the triode type and has a low internal resistance and a so-called variable mutual conductance characteristic. The anode circuit of this tube includes a resistance 13 connected to the source of positive potential, the energy at intermediate frequency set up across this resistance being applied through the condenser 16 to the amplifier tube IF2 which is thus connected in cascade with IF1, and part of the energy from the resistance 13 being also fed back to the circuit 12 through the condenser 14 and the coil 15, this latter coupled with the circuit 12. By varying the negative grid bias and hence amplification at IF1, it is thus possible to lower the decrement of its grid circuit in a desired proportion. The tube IF2 is preferably of the screen-grid type and its anode circuit comprises a band pass filter consisting of the two tuned circuits 18 and 19 coupled as by mutual inductance; a main function of the tube IF1 is to act as a so-called buffer valve, to prevent undesired inter-action of the circuits 11, 12 and 18, 19. The circuits 18 and 19 are in effect shunted by the auxiliary tubes A1 and A2, of the triode type. The grid bias of these tubes is variable and their anode-cathode paths act therefore as variable resistances for damping the associated circuits to a variable degree. The circuit 19 is connected to the input electrodes of the tube IF3 the anode circuit of which includes a resonant circuit 20 having one side connected to the high tension supply, the said circuit being tuned to the intermediate frequency.

The circuit 20 is coupled as by mutual inductance to a similar tuned circuit 21 which is connected to the input electrodes of the demodulating rectifier 22, of the diode type. The modulation frequencies thus obtained are fed to the first low frequency amplifier tube 24 through a condenser, and a filtering device 23 for removing the high frequency components. The tube 24 is of the variable-mu triode type and its anode circuit includes a resonant circuit tuned to a frequency near the top of the modulation band which it is desired that the receiver shall reproduce correctly, say 7000–8000 c./s., the said resonant circuit comprising a coil 26 and a condenser 25 and being connected in series with a resistance 27 of low value, say 5000 ohms.

One side of this resistance is also connected to the high tension supply. The voltage set up across the network 25—26—27 is transferred to a further low frequency amplifier section LF and actuates a reproducer R.

Signal energy at intermediate frequency is also fed to a screen grid tube VI comprising an anode impedance 29 such as a circuit tuned to the intermediate frequency, the voltage set up across this circuit being applied to a rectifier VR, such as a diode. The direct current tensions set up across the rectifier resistance 30 after having been filtered by means of the resistance-capacity filter 31, and which tensions vary in accordance with the field strength of the desired station, are applied to the amplifier tubes 5, IF2 and IF3 through the line marked A. V. C., this automatic sensitivity control arrangement being quite conventional and maintaining approximately constant the output across the rectifier VR and hence also across the demodulator 22 and the tuned circuit 20.

A further part of the energy of intermediate frequency set up across the circuit 20 is fed to a screen grid tube S1 through the condenser 32 of very low value, the input electrodes of this tube S1 being bridged by a network 33 comprising the resonance circuit 34 which is comparatively damped and tuned to the nominal intermediate frequency, and which is shunted by the quartz crystal 35, the natural frequency of which is that of the nominal intermediate frequency. This crystal acts as a series resonance circuit and offers a very low resistance path to the nominal intermediate frequency so that this latter is substantially by-passed, whilst for frequencies slightly spaced from the exact intermediate frequency the impedance of the crystal (and also that of the damped resonant circuit 34) is considerable, so that the resultant resonance curve of the network 33 presents a mediate crevasse typical for the quartz filter. The high frequency energy applied to the tube S1 appears amplified across the anode resistance 36 and is transferred to a further amplifier tube S2.

The anode circuit of the amplifier S1 is coupled to the further amplifier S2 by the intermediate of the anode load resistor 36. The amplifier S2 in turn feeds the control rectifier SR through a network 37 and a coupling condenser 40. The network 37 comprises a flatly resonant circuit 38 shunted by a reject circuit 39, both circuits being separately tuned to the I. F. The response curve of this network presents two response peaks with a marked dip at the I. F., and enhances the effect of the network 35, in ensuring predominant transmission of the interference.

The rectifier SR may be of the diode type, and is provided with a anode load resistor 41 for producing a D. C. potential of negative phase, and a cathode load resistor 42 for producing a potential of positive phase, in response to the amplitude of high-frequency energy impressed upon. The negative potential at 41 is applied through the resistance-capacity filter 45—46 and through the lead A. D. S. to increase the negative bias of the auxiliary tubes A1, A2, whereas the "positive" potential at 42 is filtered at 43—44 and is applied through the further control lead A. D. S. 2 to lower the negative bias of the control grids of the tubes IF1 and 24, as well as of the suppressor grid at 7 of the tube 5. The time constant of the filter may vary between fairly large limits and be equal to, say 1/5 sec.; it may be useful to make it somewhat larger than the time constant of the gain control device which is usually about 1/15 sec. Preferably the negative bias of the valve grids assumes a substantial value when no high-frequency energy is impressed upon the rectifier SR, as by providing a battery or other source of fixed potential between ground and the junction of the resistors 41, 42, while suitably adjusting the cathode potential of the con-

trolled tubes. The negative bias of the tubes A1, A2, on the other hand is normally a minimum.

It will be seen that the apparent resistance of the tubes A1, A2, is normally a minimum, and the consequent damping of the circuits 18, 19, ensures a wide band width and high fidelity of signal transmission. Furthermore, the high negative bias of the suppressor grid at 5 normally causes low internal resistance of this tube and damps the associated resonant circuit 9. Furthermore, reaction at the tube IF1 is normally a minimum, since the negative bias of the tube is comparatively high. Likewise, the resonant audio circuit 25—26 is considerably damped, and the associated tube 24 provides moderate and uniform gain.

However, as the potential of the control line ADS increases in response to comparatively increased interference, wave strength, while the potential of the line 2ADS decreases, all the fidelity control means are caused to sharpen the degree of selectivity. It will be understood that the cutoff of other biases of these various tubes are suitably chosen so as to prevent for instance the grids of the tubes 7 and LF1 from reaching positive potentials, or the grid bias of the tube 24 from varying in so wide limits as to cause an appreciable output variation; part of the rectified tensions only might be applied thereto as well.

Regulation of the fidelity control means past the branch-off point 20 will not be considered at first, when I shall now proceed to the explanation of the control device in Fig. 1.

Briefly it may be stated that this device aims to produce across the rectifier SR a control potential in response to the ratio between the amplitude of the wanted carrier wave and the amplitude of that interfering carrier wave which is the most troublesome; and furthermore to control selectivity in such a way as to preserve in substance a constant and predetermined value of this ratio, by means of what may be termed a "true control cycle."

Experiments have shown that with the forms of most of the conventional selectivity response curves, interference will not be too troublesome and fidelity will be optimum consistent with the local reception conditions, provided the amplitude of the desired carrier wave energy at the second detector is about 320 times stronger than the interfering carrier amplitude, although of course it is the side-bands of the interfering stations, and not the carrier waves proper, which bring about the audible interference, in the reproducer.

It will be observed that the receiving amplifier proper and the control channel are fed in parallel from a preamplifier including efficient fidelity control means, and subjected to very efficient signal-responsive automatic gain control. For the sake of clearness of explanation, it may be supposed that the frequency response curves across the demodulating detector and across the control rectifier are exactly alike, except that transfer of the wanted carrier to the latter rectifier is cleanly prevented. In the absence of such carrier prevention, it would therefore be sufficient to ensure that the above ratio assume the required value at the control rectifier.

Broadly, it will be understood that the potential at the control rectifier is dependent upon the amplitude of the interference at the input of the receiver; this potential furthermore varies inversely with the amplitude of the input signal amplitude, since increased signal strength lowers the gain of the preamplifier, hence the effectiveness of transfer of the interference to the control rectifier, whereas decreased signal strength permits efficient interference transmission and the production of a substantial control potential.

For a more complete explanation, reference should be had to Figs. 2*a* to 2*d*. Fig. 2*a* shows the prevailing reception conditions in a particular instance, the carrier amplitudes of the desired station *a* and of the interfering stations *b*, b_1, b_2 being indicated vertically, while the frequencies of these stations are indicated horizontally, the desired carrier frequency being taken as a reference point.

Fig. 2*a* shows the effect of the automatic gain control which is supposed to be extremely efficient, and being furthermore supposed for a moment that there are no selective means whatever, amplification being truly aperiodic. The frequencies are indicated as in Fig. 2*a*, while the output high-frequency energy at the various carrier frequencies is indicated vertically. It will be seen that the output amplitude of the desired carrier assumes a predetermined value *a'*, whichever may be the input amplitude; whereas the output amplitudes b'_1, b'_2, b'_3, of the interfering carriers are defined by the ratio a'/a.

In actual fact the selectivity response curve at the rectifiers SR and 22 is such as to decrease the output amplitude in response to the frequency spacing of the desired carrier and of the interfering carriers, as shown in Fig. 2*c*.

Accordingly, as shown in Fig. 2*d*, the actual output amplitude of the wanted carrier at the rectifier 22 is that indicated in Fig. 2*b*, whereas the actual output amplitudes b''_1, b''_2, b''_3, of the adjacent carriers are decreased in accordance with the response curve in Fig. 2*c*. It will be understood that, provided the above ratio of the output amplitudes of the wanted carrier and of the interfering carriers is secured, and since furthermore the amplitude of the wanted carrier is maintained constant, the output amplitude b''_3 of that carrier which under the prevailing reception conditions is the most troublesome, should also assume a predetermined value, as indicated in Fig. 2*d*, whichever may be the input amplitude of the said carrier. Since the wanted carrier is rejected at the control rectifier, the rectified potential thereacross will be defined in fact by the output amplitude b''_2, and this potential may thus be considered as being truly responsive to changes in the effective value of the said ratio, at the demodulating detector. The said potential is therefore used in such a way as to tend to bring about substantially increased selectivity, and to narrow the response curve in Fig. 2*c* in such a way that the interfering output amplitude shall never increase substantially above the predetermined value b''_2 in Fig. 2*d*.

Suppose for instance that the receiver is tuned to a strong wanted carrier, interference being very low. Since the sensitivity of the receiver is considerably decreased through the A. V. C. device, the input of the selectivity control channel decreases, and likewise the gain of this channel. Accordingly there will be no appreciable A. D. S. potential for decreasing the fidelity, which is normally a maximum.

If however the interference becomes more intense, the A. D. S. potential at the control rectifier tends to increase in very large proportion,

and the selectivity tends to be sharpened in substantial proportion. Since the level at the intermediate frequency cannot rise by virtue of the action of the A. V. C. device, whichever may be the character of the fidelity control means, increased selectivity will be accompanied by less efficient transfer of the interference energy, to the control rectifier, and the A. D. S. potential produced there-across tends therefore to be decreased, the net effect being a low or comparatively moderate potential, the increase being in far lesser proportion than the interference amplitude rise at the receiver input.

Now suppose that the interfering carrier remains intense, while the amplitude of the desired carrier becomes very low. The resultant sensitivity increase of the receiver tends to bring about a very considerably increased A. D. S. potential. However, just so as in the foregoing instance, a moderate rise of this potential and of the selectivity can only take place, so that the decreased interference transfer opposes itself to further sharpening of the selectivity response curve.

It will be observed that when the A. V. C. device is insufficiently efficient, the A. D. S. potential will be too high, and likewise selectivity will be higher than required in accordance with the reception conditions, in those instances where the wanted carrier is comparatively intense. In the arrangement shown, adequate A. V. C. action is therefore secured, even though the A. V. C. action upon the "pre-amplifier" may be insufficient, by applying the A. V. C. line to control the gain of the amplifier S2 in the control channel. Other arrangements for providing very efficient A. V. C. action will suggest themselves to those skilled in the art.

The control action of the device in Fig. 1 will be more fully understood in connection with the graph shown in Fig. 4, wherein the ratios between the amplitude of the interfering carrier and that of the wanted signal at the input of the receiver are indicated horizontally on a logarithmic scale, while the ratios between the amplitude of the interference and that of the desired signal at the control rectifier and more exactly at the demodulating detector are likewise indicated on a logarithmic scale, on the vertical scale.

The adjustment is preferably such that when the desired and interfering carriers at the input have about the same intensity, the output ratio may be about 1:320. It will be understood that if the device is very efficient, the curve shown would be a straight horizontal line; the efficiency of the device is the more pronounced the more curve *d* is inclined towards the horizontal. The minimum or normal selectivity position of the receiver is represented by the straight line *d* min.; that of the maximum selectivity by the line *d* max. These limits are usually attained because of the enormous range of variations at the input. The control action grows more pronounced if the amplification of the auxiliary control channel is increased and it depends closely on the characteristics of the fidelity regulation tubes or other regulation means, but with the proposed arrangement the steepness of the control curve *d* does never grow zero or negative. An advantage thereof is that no critical initial adjustments are required.

The further curve *d'* illustrates the operation of the control device on the assumption that the control rectifier SR is associated with a threshold bias or like means to prevent the selectivity control until the energy impressed upon the rectifier exceeds a predetermined amplitude. This modification frequently may permit a better constancy of the output ratio, since the interference tends to be kept just appreciable enough to maintain the substantially predetermined output ratio.

Of course, it is easy to adjust the desired absolute value of the output ratio, as by providing manually controllable means past the branch-off point of the control channel, or by providing a variable bias of the control rectifier.

No detailed reference has till now been made to the fact that the fidelity degree of the receiver is also controlled after the branch off point **20**, in the example shown by connecting the line **2** A. D. S. to the control grid of the tube **24** and thus controlling the means associated with the anode circuit of this tube. Since the amplitude of the potential across the control rectifier SR is left unchanged by the control of these fidelity regulating means, these control potentials may be used very efficiently to adjust any desired degree of fidelity.

Despite the fact that this control is very efficient, it is however undesirable for several reasons, with an arrangement of the general character shown in Fig. 1, to utilize solely fidelity control means arranged in this fashion.

One of these reasons is that the extremely wide range of the variations to which is submitted the ratio of the wanted to the interfering field strengths makes it very difficult if not impossible to design the amplifier, rectifier and selectivity regulating means of the selectivity control device so that they will properly handle tensions truly corresponding to these ratios. It is most desirable to provide means for compressing the said range, i. e. to let it be represented by tensions which vary between moderate limits only. The arrangement represented by Fig. 1 operating according to the so-called true control cycle principle is very efficient for this purpose.

With the arrangement of Fig. 1, as was already explained, the interfering carriers are efficiently transmitted by the common receiver section, when they are weak, that is, when an efficient amplification is most desirable; in this case the relative gain of the receiver corresponds to curve c_1 of Fig. 3*a* (this figure having already been mentioned).

Whereas in the arrangement shown the "control" channel is fed from a point which precedes rather closely the second detector, whereat accordingly the selectivity may be high, it is important to note that the sensitivity of the control device is not reduced on this account. In fact, as explained hereinbefore, the interfering carrier waves are efficiently transferred by the pre-amplifier feeding both the receiver proper and the control channel, in those instances where interference is weak, and the utmost sensitivity of this control device is governed by this condition, since a high sensitivity of course requires that an appreciable control potential be produced in response to comparatively low interference. The frequency response at the control rectifier in this event may be as shown in Fig. 3*a*, wherein it is seen that in actual fact the selectivity is comparatively broad. On the other hand when the interfering carriers are intense, interference energy is not efficiently transferred by the pre-amplifier, and this is highly desirable since a control potential of substantial amplitude may easily be secured. The selectivity response at the control rectifier may then be as shown in Fig. 3*b*.

However, the control channel may if desired be fed from a point near the frequency changer device whereat both the A. V. C. control and the selectivity-providing means have little effect, such a design being frequently preferable with many of the further control arrangements described hereinafter.

The types of filters represented by Fig. 1 and more particularly the quartz filter are not the sole ones allowing to attain the result in question. Apart from the similarly operating mechanical resonators such as tuning forks and magnetostrictive devices the properties of which are well known, it is possible to use, and a sufficient degree of carrier frequency attenuation is secured, by many other circuits known per se and operating e. g. on the bridge principle, some suitable examples being given with reference to other figures. It is also possible to include a frequency changer stage in the selectivity control channel, for changing the nominal intermediate frequency to a lower value, this facilitating the design of sufficiently selective circuits whilst at the same time a good deal of amplification is secured.

No detailed reference was made so far to the type of interfering back-ground of noise caused by the so-called static, which when of the rather uniform variety, may to some extent be comparable to a interfering carrier wave of a transmitter.

It is to be noted that the degree of interference, and the required degree of fidelity reduction, are not always the same with an interfering carrier wave and a static wave, for an equivalent tension set up across the fidelity control rectifier.

It should be noted however that when the static is comparatively reduced, it interferes in about the same way as a weak transmitter station, whereas when the intensity of static is about the same as that of the wanted signal, the latter can no longer be listened even when the selectivity is a maximum.

Accordingly, the control device must not be responsive in the same way to static and to the interfering carriers in those instances where static is comparatively intense, and this result is efficiently secured by the device in Fig. 1.

It will be seen from Fig. 5 that the maximum selectivity degree could as well be required for an adjacent carrier about hundred times stronger than the wanted one as by a background of static nearly equal in strength to the wanted transmitter; under these conditions the two interference kinds should give the same output across the rectifier SR. It will be seen that a curve similar to *c'2* in Fig. 3*b*, is able of giving this result, the response for frequencies spaced by about ±10 kc. being but a small fraction of the response at the two peak frequencies, these responding to the background.

When a small selectivity degree is required, the two kinds of interferences on the other hand exert approximately the same influence since the peaks of maximum response are in this case situated near the frequencies ±10 kc./s. where the interfering carriers are likely to operate, this being shown by the curve *c'1* of Fig. 3*a*.

Fig. 7 shows an alternative form of the invention whereby to produce across a "control rectifier" SIR a "compressed" potential responsive to the ratio of the amplitudes of the interferences and of the wanted signal, by controlling the transmission effectiveness of the amplifier path between the source of signals and the control rectifier in response to both the amplitudes of the wanted signal and of the interferences.

As shown, the receiving system includes a preamplifier PRE which preferably embodies a frequency changer device, and which feeds the receiving amplifier proper and the control channel. Selectivity control means coupled to the output of the control rectifier, need not be therein included in the present instance.

The receiver proper includes two intermediate frequency amplifier tubes I11 and I12, of which the first is coupled to the preamplifier through a band pass filter with resonant primary **47** and resonant secondary **48**. The amplifier tube I12 is coupled to that I11 through a band pass filter comprising two separately shielded resonant circuits **49**, **50**, of which the coupling and hence the band width, may be regulated electromechanically, as by a motor-galvanometer M provided with a grounded rotatable spindle **66** associated with the armatures **67**, **68** of a small variable condenser, for providing "top" coupling of the circuits **49**, **50**, insulation being provided at **69** upon the control spindle where necessary. The output of the amplifier I12 is coupled to the second detector and low-frequency amplifier LF through a further band pass filter including a resonant primary **51** and a resonant secondary **52**. The effective resonance frequency of the circuit **51** may be varied by the intermediate of the spindle **66** and of the further small variable condenser **70—71**, which in effect is arranged to shunt the circut **51**, the purpose of this control being to compensate the shift of the center-frequency of the resonance characteristic, which tends to take place through the control at **49—50**, so that the resultant band width may be symmetrically expanded.

The circuit **51** is also coupled to the amplifier-rectifier AVC of an automatic gain control network for maintaining in substance uniform signal strength at the output of the receiver proper, the ABC-line being applied to control the gain of the I. F. amplifier tubes I11 and I12, and if desired the gain of the pre-amplifier, it being understood that such latter control is not essential.

The "control" channel is coupled to the output circuit **47** of the pre-amplifier through condenser **54**, and includes the amplifier tubes S11, S12, and the control rectifier SIR. The coupling between the tubes S11, S12 is through an aperiodic coupling coil **55** and a so-called "Campbell sifter" circuit **56** including a resonant circuit **57** tuned to the I. F., and two coupled coils **58**, **59**, associated with a condenser **60** for tuning the resultant combination to the intermediate frequency. The latter frequency may therefore in substance be rejected while adjacent frequencies may be efficiently transferred. Coupling between the output of the tube S12 and the rectifier SIR is through another network **61** for rejecting the I. F. and enhancing the action of that **56**, comprising a resonant primary **62**, a resonant secondary **63** and a series-tuned coupling circuit **64**, all the circuits being separately tuned to the I. F.

The rectifier SIR may be a diode and may be biased negatively to prevent rectification of the high-frequency energy impressed upon, until the same exceeds a predetermined amplitude. Fidelity control means (not shown in detail) may be regulated directly by the potential at SIR, through the leads A. D. S.

The effective frequency response curve at the rectifier SIR may be as shown in Fig. 6, which-

ever may be the reception conditions. This response curve presents two peaks at about the operating frequencies of the adjacent carrier waves, at +10 and −10 kilocycles, with a dip or crevasse at the operating tuning frequency of the desired signal, such an arrangement being suitable with the present frequency allocation of the broadcasting stations.

The potentials of the AVC-line are arranged efficiently to control the gain of the control channel, in response to the amplitude of the wanted signal, as by providing at S11 a hexode or like amplifier tube with two control grids, which may both be connected to the AVC lead. In the supposed absence of the "compressing" control detailed hereinafter, AVC or like signal-responsive control upon the amplifier path between the source of signals and the "control" rectifier S1R, in the arrangement shown just so as in the foregoing instance, should tend to take place exactly in inverse proportion to the amplitude of the wanted carrier wave. Accordingly, in the present instance again, the output of the "control" rectifier S1R tends to vary exactly as the ratio of the amplitudes of the interferences and of the desired signal.

The high-frequency amplification of the control channel is also controlled in response to the output of the "control" rectifier, as by applying the rectified potential with "negative" phase to the control grid of the amplifier S12, which is of the variable-mu type, in view of effecting "compression" of the control potentials, to avoid overload of the control system and the various other inconvenience pointed out hereinbefore. The gain of this tube is normally a maximum, and does not decrease until the output at S1R tends to exceed a given value, when interference is appreciable as compared with the desired carrier amplitude. The compressing control as shown is similar to an automatic gain control network, constant output at the rectifier S1R being of course not aimed at. The utmost sensitivity of the control device is not thereby decreased as explained in connection with Fig. 1.

The H. F. amplifier tube S12 in the arrangement shown also serves as a D. C. amplifier, the anode current being arranged to flow through the moving coil of the motor-galvanometer M, high-frequency energy at the output line 2 A. D. S. being by-passed in well-known fashion. Since the anode current varies in response to the output of the rectifier S1R, the position of the motor spindle 66 will be a function of the ratio of the amplitudes of the interferences and of the desired signal. It will be understood that by suitably shaping the condenser armatures at 67—68, any desired fidelity response curve may be had in response to the said ratio.

By virtue of the variable-mu characteristic of the D. C. amplifier S12, the anode current decrease is particularly pronounced when interference is relatively low, so that the D. C. amplifier may be highly sensitive. Furthermore, a sensitive instrument may be used at M since overload thereof is avoided, particularly so as the anode current variation may be very low when the signal is weak and interference is high. The compressing effect pointed out in the above is therefore efficiently enhanced.

Upon the shaft 66 is also fixed a pointer 72 moving before a graduated scale or intercepting a beam of light to a variable extent and giving therefor indications on the prevailing reception conditions and degree of fidelity with which the station may be received. This or some similar device is very suitable for rapidly determining whether a station is worth while receiving, when the tuning control is operated and no program is radiated in the particular moment by the carrier, or when the manual volume control knob is turned towards zero or when the operator has not a sufficiently skilled musical ear.

Other forms of indicators known per se may be used as well and may be operated by tensions derived from the A. D. S. channel.

It will be observed that by virtue of the "compressor" connection A. D. S. in Fig. 7 (and of the compressing control in Fig. 1 as well), the output increase at the control rectifier S1R is rather discrete, even though the interfering amplitude may increase very considerably. Also, the gain or efficiency of transmission of the amplifier path concerned with the interferences, decreases discretely with increased signal amplitude despite the A. V. C. or like signal-responsive control tending to bring about a very considerable change, since most of this control is compensated by the compressor system and cannot become effective.

Fig. 8 shows another form of the invention. Fidelity is therein controlled in response to the combined effects of a rectifier *i*R responsive mainly to the interfering amplitude, and of another rectifier A. V. C. responsive predominantly to the wanted signal frequency, the potentials relative to each of the two rectifiers being in substance separately "compressed" before they are combined.

The receiving system includes a preamplifier PRE which may be as in the foregoing arrangement, and the output circuit 73 of which through condenser 74 and band pass filter 75 is coupled to the amplifier I21 of the receiver, and through the further condenser 78 and band pass filter 79 is coupled to a preliminary amplifier S21 of the control channel. The circuits at 79 may be overcoupled, whereas the coupling at 75 may be less than optimum. The output of the tube I21 through the sharply resonant circuit 76 is coupled to the further intermediate frequency amplifier stages I21 and IF connected in cascade. The output of the tube S21 is associated with a broadly resonating circuit 80.

The further amplifier tube S22 of the control channel is coupled to both of the resonant circuits 76, 80, through the series-connected coils 81, 82, the coupling being such that the high-frequency voltages of exact intermediate frequency induced in the two coils have equal amplitude and oppose each other, whereby energy due to the wanted carrier is in substance balanced out, while the frequencies of the interfering carriers may be transferred with appreciable efficiency, the resultant response curve being similar to that shown in Fig. 6. It will be seen that the circuits 75 and 76 ensure efficient transmission of the wanted carrier to the receiver proper, whereas they prevent in substance such transmission to the control channel.

The output of the amplifier 6 is coupled to the compressing rectifier *i*R through a flatly resonant circuit 83, which is associated with a sharply resonant absorption circuit 84 tuned to the I. F., this arrangement ensuring efficient transmission at the interfering frequencies, and decreased transfer at the wanted carrier frequency.

The output of the selective amplifier IF is coupled to the second detector and audio-frequency amplifier LF1, and to an automatic gain

control network AVC which as shown is applied to vary the gain of the amplifier I22, and of the preamplifier PRE; the latter control may be in discrete proportion, and in effect varies the effectiveness of transmission of interfering carrier energy in response to the wanted signal amplitude. A negative potential is produced across the load resistor 85 of the rectifier *i*R, and is applied to decrease the gain of the amplifier S22 in response to increased output at this rectifier, thereby efficiently compressing the range of any amplitude variations to which may be subject the interfering energy, whether at the source of signals or in the feed path up to this rectifier. Accordingly the compressed potentials at S1R depend mainly on the amplitude variations of the interfering energy at the signal source, and they depend to a moderate or low extent on the amplitude variations of the wanted signal. In order that the fidelity control potentials may depend in the required proportion from the amplitude of the wanted signal, they are derived in accordance with the anode current changes of an auxiliary D. C. amplifier tube 86 which operates as a "mixer tube," and which is provided with two control grids, control being predominantly in response to the potentials at *i*R, and in moderate or comparatively low proportion in response to the signal-responsive potentials. It will be understood that these latter potentials should be "compressed" in analogous fashion, and in comparable proportion, and that the effects of the two sets of potentials upon the flow of anode current should oppose each other.

To this end, the potentials from *i*R are applied with "negative" phase to the so-called gain control grid of the hexode S23, while the signal-responsive potentials are applied with "positive" phase, and are derived by the intermediate of the AVC network. Since as shown the potential of the AVC lead is "negative," a suitable potential is tapped off from a potentiometer associated with the anode circuit of a tube I22 controlled through the AVC line. The thus resulting phase-reversed potentials are applied to the main control grid of the tube S23 over the lead "reverse AVC," to lower the negative bias thereof which may normally be rather considerable negative.

The potentials across the anode load resistor 86 of the tube S23, by proper arrangement of the circuit elements, may represent with fidelity, on a compressed scale, the input ratios of the desired and interfering carrier amplitudes. The extent of control of the two control grids of this tube on the other hand need be only moderate or rather low.

As shown, these potentials serve to decrease the audio frequency transfer toward the treble in response to increased relative interference, by varying the cutoff frequency of a low-pass filter at the input of the receiving amplifier 96 which is arranged between the further audio sections LF1 and LF. This filter comprises an inductance 93, and a variable condenser consisting of the apparent or dynamic grid to cathode capacity of an auxiliary tube A2 and exhibiting the so-called "Miller" effect, control of the slope of the tube being by a control grid connected to the resistor 86, the sense of the control potentials being such that increased relative interference raises the anode potential at S23, hence decreases the negative bias of the tube A2 and increases the gain of this tube across the anode load resistor 94 thereof, whereby the input capacity of the tube will increase and the cutoff frequency will be lowered. The operation of the arrangement will be readily understood by those skilled in the art. The control potentials may conveniently be led off from a tap on a potentiometer 91—92 connected between the anode of the tube S23 and a desired low potential.

It is undesirable that the cutoff frequency should ever exceed some 9000 cycles, and there is to this end provided a limiting arrangement in the grid circuit of the tube A2, including a diode 89 in series with a fixed resistor 90, the combination being connected between the tap 87—88 and a point of fixed potential tapped off from a potentiometer 91—92 connected across the high-tension supply. The operation will be obvious to those skilled in the art, and the diode 89 while normally conductive, may be rendered non-conductive when the wanted signal is comparatively very intense considerably lowering the anode potential of the tube 86.

The potential variations across the anode load resistor 94 of the tube A2, which decrease in response to increased amplitude of the wanted signal, while they increase in response to increased interference, in the instance shown are applied to vary the effective voltage across a neon lamp N associated with a limiting resistor 97, to show off the prevailing reception conditions, the brilliancy of illumination increasing with increased freedom from interference.

The arrangement shown in Fig. 9 in general is similar to that in Fig. 8, in that two sets of "compressed" potentials are again produced in response respectively to the amplitudes of the wanted signal and of interferences, the potentials being combined in a D. C. amplifier tube S31, which performs in substance the functions of the two tubes S22 and S23 in Fig. 8, and a further function pointed out in detail hereinafter. The pre-amplifier in the present instance includes a radio frequency amplifier 98, of the hexode or like type, and a frequency changer device OM arranged to feed signal energy to the resonant input circuit 102 of the receiving amplifier channel proper, through the sharply resonant circuit 101. The flatly resonant input circuit 104 on the other hand is coupled through the split coil 103 both to the circuit 101 and to a further broadly aperiodic impedance 99 in the output of the frequency changer, the arrangement being similar to that shown in the foregoing and being balanced at the wanted carrier frequency.

The signal receiving amplifier includes an intermediate frequency amplifier tube I31 with an output circuit 108 associated with further amplifier stages indicated at REC, and with an automatic signal responsive gain control network AVC which may inter alia control the gain of the amplifier tube I31 and of the radio-frequency amplifier tube 98.

The control amplifier S31 is coupled to the interference-responsive rectifier S3R through a considerably overcoupled band pass filter 105—106. A dry rectifier may be used at S3R, and the negative potential across the associated load resistor 107 is applied through the lead *i* to control the gain of the high-frequency amplifier S31 in the control channel, and of the radio-frequency amplifier 98, as by controlling the so-called gain control grid of the latter tube. The first-named control serves to provide compression of the interference-responsive potential at S3R in substantially the way indicated in the foregoing. An adequate proportion of compression may be at-

tained more easily and at less expense by the further interference-responsive control of the preamplifier tube, as shown, since this amplifier is in the feed path of the interference responsive control channel. The amplifier tube S31 in the control channel is of the hexode type and the gain control grid thereof is controlled by signal-responsive potentials of positive phase, which may be tapped off from a potentiometer 110 associated with the anode load resistor 109 of the AVC-controlled tube I31, the arrangement being similar to that shown in the foregoing instance. A D. C. load resistor is provided at 111 in the anode circuit of the tube S31, and is by-passed from the high-frequency point of view; the potentials across this resistor may be applied through the lead ADS—VIS to control the desired fidelity control means and visual indicator means. To facilitate the explanation, no notice will for the moment be taken of the high-frequency amplifier function of the tube S31.

It will be seen that just so as in the following instance, a D. C. potential representing on a compressed scale the ratios of the amplitudes of the signal and of the interference, is produced at 111, the amplitude of the signal-responsive potential required to this end being again comparatively very moderate or low, and being a function of the overall proportion of "compression." It should be noted that since the "reverse AVC" control at the tube S31 opposes the signal responsive gain control of the preamplifier 98, the potential at the rectifier S3R (operating through the lead *i*) may be rather exactly responsive to the sole amplitude of the interference wave, this being useful from the "compressor" point of view.

The gain control along line *i* of the radio frequency valve also fulfils the purpose of substantially preventing the so-called crosstalk which frequency occurs with radio receivers having an efficient signal collecting means, and/or an appreciable radio frequency amplification preceding the frequency changer stage. This risk of crosstalk with its well known disadvantages such as apparent selectivity decrease and distortion is most likely to occur in the radio frequency, and frequency changing stages. It exists especially if the wanted transmitter is neighboured by a strong adjacent transmitter, and since in such cases considerable tensions are set up across the rectifier S3R which responds to such a transmitter, these tensions may be used to avoid the said risk. In the example shown, this result has been attained in as far as the radio frequency amplifier tube is concerned by reason of the increased "admission" of the control grid due to the increased negative bias of the "gain control" grid which flattens the characteristic of the tube as is well known, and inasmuch as the frequency changer stage is concerned by reason of the decreased gain due to the same control. The output of the receiver on the other hand is practically not concerned thereby as there is sufficient gain control through the AVC line upon the various tubes to make good for this voluntary reduction of sensitivity.

The result just mentioned could be obtained by many different ways, e. g. by decreasing the input voltage of the radio frequency tube by means of an auxiliary tube placed in shunt across the tuned input circuit so as to lower its impedance, and the arrangement may again be such that a decrease of the voltage applied to the input of a radio frequency, or the frequency changer stage, is accompanied by an increase in selectivity, or by using in at least one of the intervalve couplings in the early amplifier stages a band pass filter with sharply resonant primary the secondary of which is shunted by an auxiliary tube serving as a variable resistance, this giving at the same time a decrease of sensitivity and an increase in selectivity. Other circuits known per se may also be used for the present purpose. Modifications of the arrangement shown may include the provision of a second rectifier fed in parallel with the rectifier S3R, and responsive to tensions exceeding a given amplitude, as by providing a threshold bias for that rectifier, whereby a control potential may be derived in response substantially to the reception of comparatively intense interfering carrier waves only, whereas the sensitivity of the controlled receiver portion may be high, with a consequent reduced valve hiss, when receiving a weak carrier wave not substantially subject to the risk of cross-talk caused by the carriers adjacent to the desired one.

The further arrangement shown in Fig. 10 is analogous to that in Figs. 8 and 9, in that a "compressed" potential, in substance responsive to the amplitude of the interference wave, is derived from a rectifier S3R, a similar potential being derived from the AVC network or a like signal-responsive rectifier. In the present instance, these potentials are combined by algebraic super-imposition, more particularly as shown by means of a motor of the galvanometer type having two windings connected in series. The coil 112 thereof is traversed by the interference responsive rectifier S3R as by arranging the same in the anode circuit of the tube S31, which is controlled by this rectifier to provide compression. The second coil 113 is traversed in the appropriate sense by the signal-responsive current of an amplifier tube I31 controlled through the AVC network.

This differential action is only strictly correct for a suitable (logarithmic) compression law of the channels producing the tensions dependent on the wanted and on the interfering carriers respectively.

In other words, the signal and interference responsive potential or current amplitudes as expressed in volts should vary in accordance with the field strengths of these waves as expressed in decibels.

In actual practice the requirements are however not very critical and may be sufficiently well performed by providing at S31 and I31 tubes of the variable mu kind having approximately the required characteristic; the requirements are still further lowered when a substantial proportion of signal-responsive control is carried out ahead of the rectifier S3R; the "preamplifier," this action being in the present case not offset or lowered since the tube S31 need only have one control grid and need not be controlled by reverse AVC tensions.

A like differential superimposition might in an alternative construction comprise leading off the selectivity control tensions from a resistance traversed simultaneously by the anode current of a first valve controlled by the rectifier of the channel tuned upon the signals and by another valve controlled by reverse AVC tensions. It may sometimes be preferable to use, instead of a galvanometer with two differentially connected windings, a galvanometer of the wattmeter kind comprising a moving coil traversed by the current of one of the valves, and a further fixed winding for modifying the magnetic field in which

operates the first winding the arrangement being analogous to that shown in Figs. 8 and 9.

Fig. 11 shows still another control system including a preamplifier with a radio frequency amplifier section RF and a frequency changer device O. M., the latter coupled to the main signal receiving channel portions IF and DL through a band pass filter with a resonant primary 114 and a resonant secondary 115. There is provided an absorption circuit 116 coupled to the circuits 114 and 115, the damping of this circuit 116 being controlled as described hereinafter, the three circuits being tuned to the intermediate frequency. The energy across the circuit 116 is impressed upon the amplifier tube S41 of the control channel, this tube being coupled to a compressing rectifier R*i* through a network 117—118 for transferring in substance interference wave energy only and similar to that 99 in Fig. 9. The rectifier R*i* is provided with a load resistor 119 for producing a compressing potential of negative phase which through the lead *i* is applied to control the gain of the tube S41, and with a load resistor 120 for producing a potential of positive phase which through the line *is* is applied to control the damping of the circuit 116. To this end, an auxiliary tube A41 is connected in shunt across this circuit, the internal resistance of the tube being varied through control of its grid by the line *is*. When interference is high, the negative bias of this tube may be lowered from excess-bias to a low value, and the resultant decrease of internal resistance firstly sharpens the selectivity of the band pass filter 114—115 to decrease the transfer at interference frequencies, and secondly decreases the overall energy level at the input of the tube S41, thereby bringing about efficient compression. The AVC device operates to preserve constant level at the demodulating detector while it does not seriously modify the level conditions at the input of the control channel. The AVC control of the preamplifier may be moderate or low, whereby the potential variations across the rectifier R*i* are predominantly due to changes in interference wave strength, and in a lower proportion to changes of the signal strength; accordingly, to have adequate control effect of the latter changes upon the fidelity control system, some further signal-responsive action is carried out. To this end, further fidelity control means are provided and are controlled through the lead ADS—VIS by means of a potential derived at 123 from a rectifier S4R and responsive in larger proportion to changes in the desired carrier amplitude than to changes in the interference amplitude. This rectifier is coupled to the output circuit 122 of a high-frequency amplifier S42 in the control channel, fed with high-frequency potentials from the signal-responsive channel, through the band pass filter 121, the gain of this tube being varied through a potential of negative phase derived from the load resistor 119, whereby when interference is high a lower potential is effective at S4R. It will be seen that the phase of the potentials at the control rectifier is normally reversed in the present instance, as compared with the phase of the interference-responsive control rectifiers hereinbefore.

A visual indicator may be controlled through the line ADS—VIS, and it will be seen that, providing the circuits 121 and 122 are made sharply selective, the indications of this indicator at exact resonance will faithfully be in dependence upon the prevailing reception conditions, whereas when the receiver is off resonance, a higher interference level is simulated, as shown by the diagrams in Fig. 12, whereby the indicator also operates as a visual aid to exact tuning.

Fig. 13 shows a further arrangement in accordance with the invention, which in the main combines the features of the arrangements in Figs. 1 and 7, many of the circuit elements being arranged in a manner similar to that shown in the foregoing instance.

The control channel includes the amplifiers S51 and S52 fed through interference-responsive coupling networks. The fidelity control potential across the load resistors 126 and 127 is coupled to the output of this channel, the variable fidelity control means being controlled with an appropriate phase through the lead ADS, while the control potential is also applied through the lead 2 ADS to control the gain of the amplifier S52 and both the response level and selectivity response curve of the network 114—115—115 through control of the auxiliary tube A51, whereby to operate very efficient compression. The preamplifier as well as the control amplifier S51 are efficiently controlled through AVC potentials, whereby the compressed potential at S5R may be truly representative of the input ratio variations of the desired and interfering wave amplitudes.

Means for varying the gain of a high frequency amplifier adapted for transmission of the desired signals, and operating in response to the desired signal strength, are known in the art, for the purpose of maintaining constant the desired signal output; accordingly I do not claim the employment of such control means, apart from the combination substantially as set forth, and for the purpose specified hereinbefore.

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

1. In a radio receiver, the combination of a channel responsive to the wanted carrier frequency; selectivity regulating means in said channel; means responsive to the frequency of incoming interference and including a rectifier for producing a potential responsive to the amplitude of interference for operating said selectivity regulating means; amplifier means in the feed path of said interference responsive rectifier, having gain control means; and an operative connection between said gain control means and said interference responsive rectifier for decreasing the gain in response to increased amplitude of incoming interference, whereby said interference-responsive potential may vary thru a limited range of values while corresponding to interference strengths varying thru a wide range of values.

2. In a radio receiver, the combination of a channel responsive to the wanted carrier frequency and provided with selectivity regulating means; means responsive to the frequency of incoming interference and including a rectifier producing a potential responsive to the amplitude of interference energy for operating said selectivity regulating means; amplifier means in the feed path of said interference-responsive rectifier provided with gain control means; means including a rectifier responsive to the reception of the wanted carrier to the substantial exclusion of interference frequencies, and a coupling connection between said last-named rectifier and said gain control means, for decreasing the gain in accordance with increased carrier strength whereby to alter the amplitude of said selectivity

regulating potential responsive to interference strength inversely with wanted carrier strength.

3. In a radio receiver, in combination, a channel responsive to the wanted carrier frequency, provided with selectivity regulating means; means responsive to the frequency of incoming interference and including a rectifier for producing a potential responsive to the amplitude of interference energy; amplifier means in the feed path of said interference responsive rectifier, provided with gain control means; an automatic gain control network responsive to the wanted carrier frequency and including a rectifier responsive to carrier strength; an operative connection between said network and said gain control means, adapted to alter the level of energy at said interference responsive rectifier inversely in accordance with wanted carrier strength; means for altering the effectiveness of interference energy transmission in the feed path of the interference responsive rectifier, and an operative connection between said transmission altering means and the output of the interference responsive rectifier adapted to compress the range of variations of said interference responsive output; and an operative connection between said interference responsive rectifier and the aforesaid selectivity regulating means.

4. A receiver according to claim 3, characterized in that said means for altering the effectiveness of interference energy transmission are gain control means; further characterized in that said gain control means are provided in an interference-responsive amplifier in substance distinct from the wanted carrier responsive receiver circuits; and in that the potential of the automatic gain control network for altering the level of interference response is also applied to control the gain of said distinct amplifier.

5. A receiver according to claim 3, said means for altering the effectiveness of interference transmission being selectivity regulating means operated in response to the output of said interference responsive rectifier to decrease the band width of efficiency transmitted frequencies in response to increased interference strength; said last-named regulating means being provided in a receiver section both feeding the interference responsive means and the carrier responsive channel.

6. In a radio receiver, in combination, a wanted carrier responsive channel comprising selectivity regulating means; a selective amplifier responsive to incoming interference including at least one rectifier for producing a potential responsive to interference strength; gain control means in the feed path of said rectifier and an operative connection from said gain control means to said interference responsive rectifier for decreasing the gain in response to increased interference strength to produce a compressed range of potential variations at said interference responsive rectifier in response to a wide range of incoming interference strength variations; an automatic gain control network responsive to the carrier including a selective amplifier with gain control means, and a carrier-responsive rectifier having an operative connection to said last-named gain control means whereby to produce at the output of said rectifier a potential of which changes represent on a compressed scale changes over a wide range of incoming wanted carrier strength; means for combining in opposed relationship the compressed potentials derived respectively from said interference and carrier responsive rectifiers; and means for applying the combined control effects to operate the aforesaid selectivity regulating means, in a sense such that increased interference causes increased selectivity.

7. In a radio receiver, in combination, a channel responsive to the frequency of the wanted carrier, including selectivity regulating means; a selective amplifier responsive to incoming interference, having gain control means and including a rectifier for producing a potential responsive to interference strength; an operative connection from said rectifier to said selectivity regulating means; an amplifier responsive to the frequency of the wanted carrier including an automatic gain control network, means for deriving from said amplifier a first potential representing incoming carrier strength variations on a compressed scale; and means for applying said first potential to decrease the gain of the interference-responsive amplifier whereby the amplitude of the aforesaid interference-responsive potential is altered inversely with changes in the strength of the wanted carrier; means for deriving a second potential from said carrier-responsive amplifier representing incoming carrier strength variations on a compressed scale; means for combining in opposed relationship said second carrier-responsive potential and the interference-responsive potential to substantially compensate the control influence upon said interference-responsive potential of said first carrier-responsive potential; and means for applying the control effect of said combined two potentials to decrease the gain of the interference-responsive amplifier in accordance with increased incoming interference strength to compress the range of interference responsive potential variations at said interference-responsive rectifier.

8. A receiver according to claim 2, wherein said selectivity regulating means are applied to a visual indicator means for indicating the prevailing reception conditions in response to the relative strengths of wanted carrier and interference.

9. A receiver according to claim 6 provided with a visual indicator means, and means for additionally utilizing the combined control effects to operate said indicator means.

10. In a radio receiver of the variable selectivity type, the method of adjusting the selectivity regulating means which comprises automatically adjusting the selectivity in the sense of lower values directly in accordance with the strength of the incoming carrier wave of desired frequency and inversely in accordance with the strength of a carrier wave which may interfere so that a tenfold increase in interfering carrier strength may produce substantially the same control effect as a tenfold decrease of wanted carrier strength.

EGON NICOLAS MULLER.