PUBLISHED

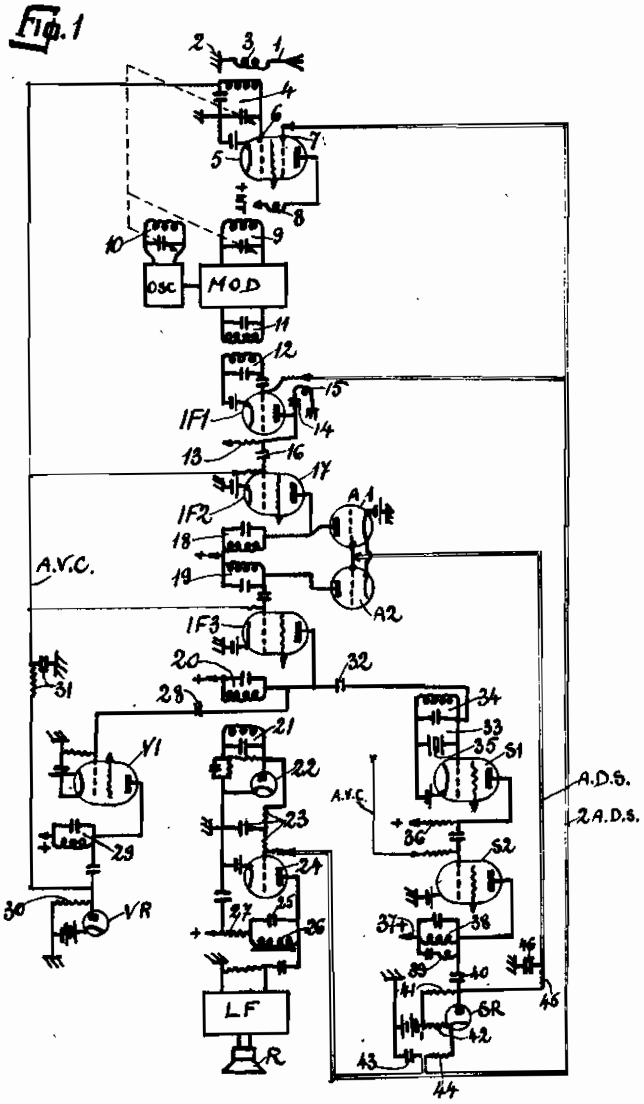
MAY 25, 1943.

BY A. P. C.

E. N. MULLER
AUTOMATIC SELECTIVITY CONTROL
FOR RADIO RECEIVERS
Filed June 13, 1936

Serial No.
85,166

4 Sheets-Sheet 1



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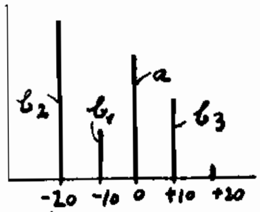

Fig. 2a

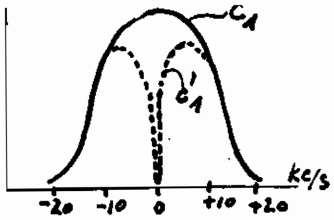

Fig. 3a

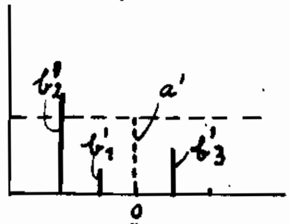

Fig. 2b

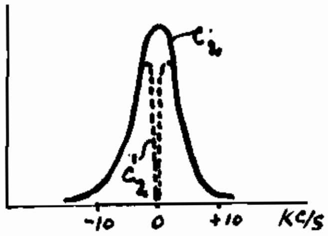

Fig. 3b

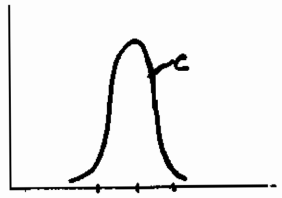

Fig. 2c

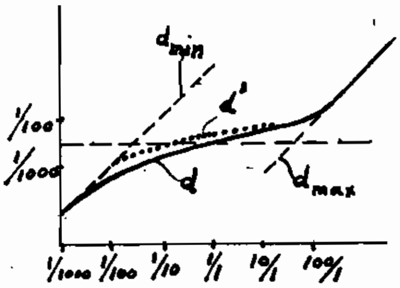

Fig. 4

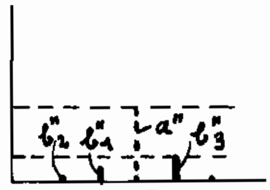

Fig. 2d

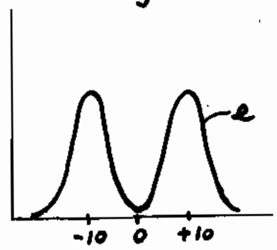

Fig. 6

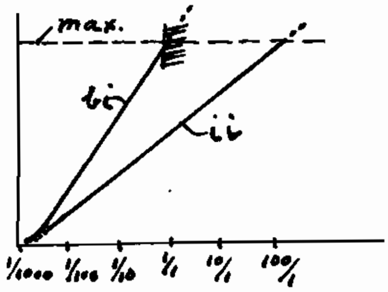

Fig. 5

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Fig. 7

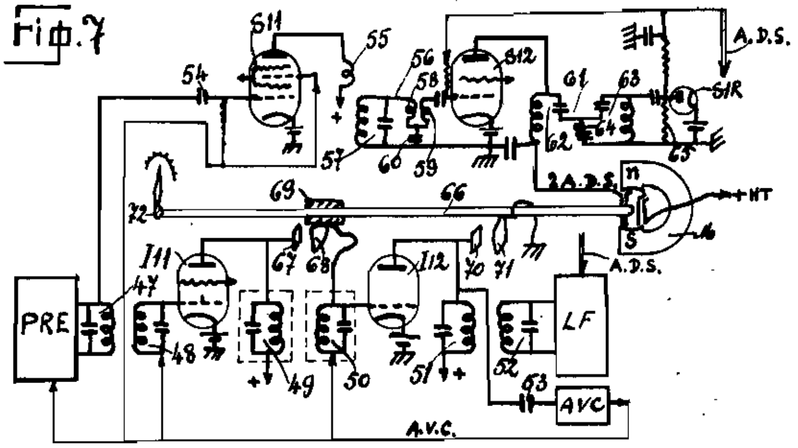


Fig. 8

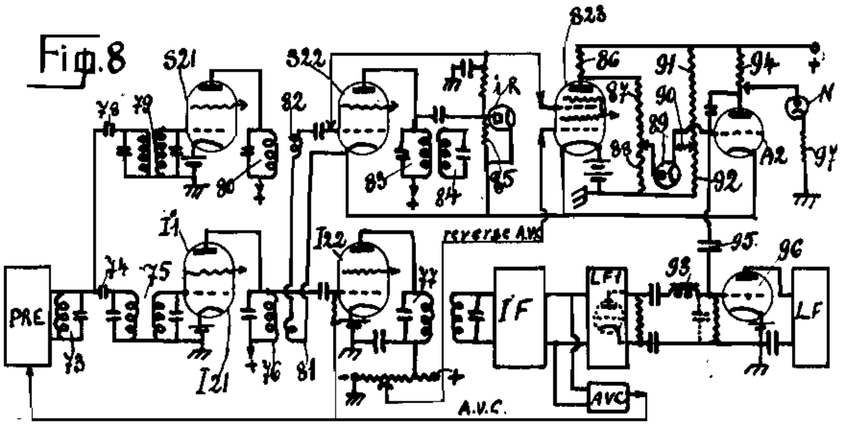
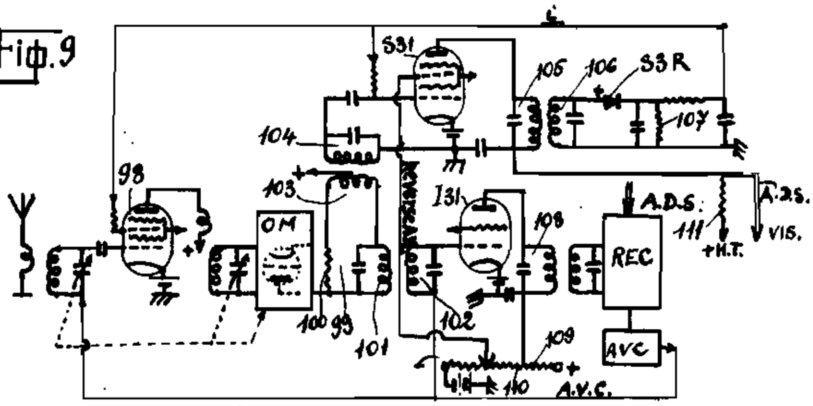


Fig. 9



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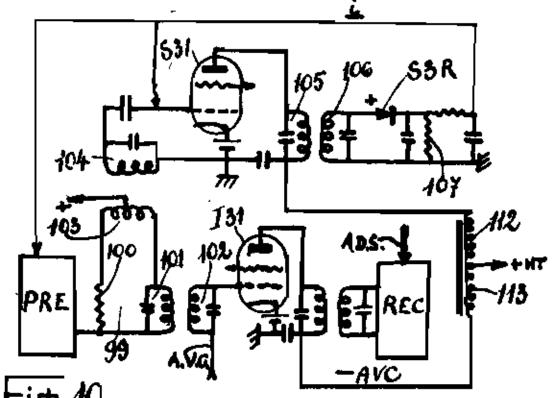

Fig. 10

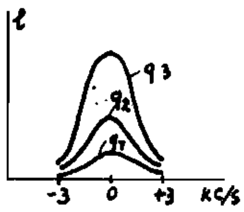

Fig. 12

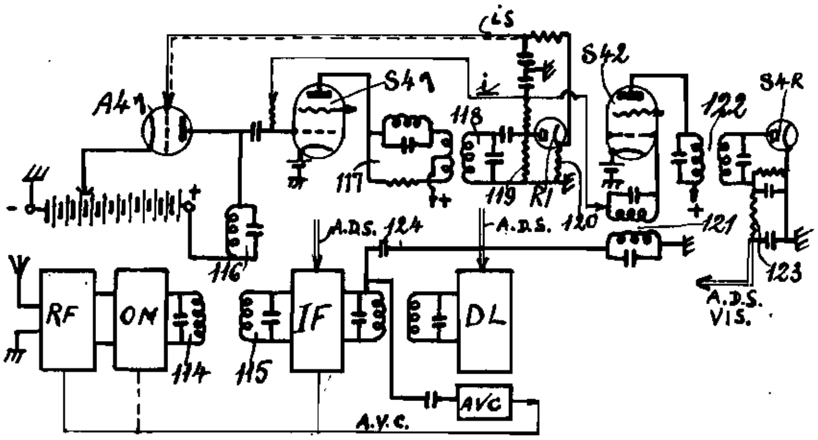

Fig. 11

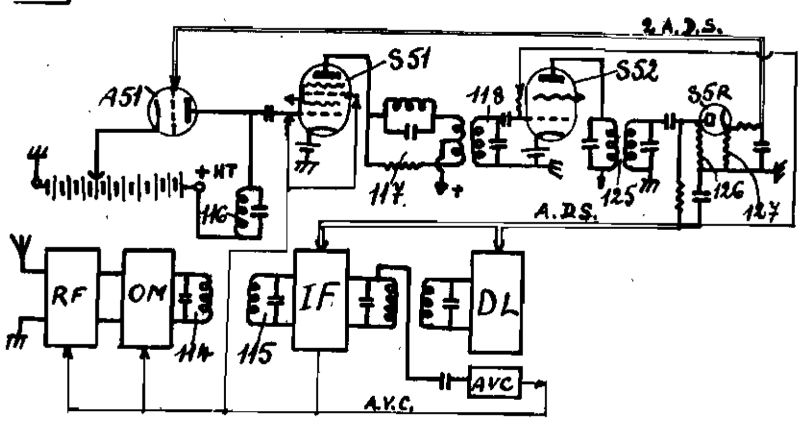

Fig. 13

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ALIEN PROPERTY CUSTODIAN

AUTOMATIC SELECTIVITY CONTROL FOR RADIO RECEIVERS

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Application filed June 13, 1936

The present invention applies to radio and like modulated carrier wave receivers and relates more particularly to arrangements for automatically controlling the response of such receivers to the modulation frequencies in view of giving 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 such a 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 would be exaggerated. Another form of interferences, the so-called "static" caused by man-made interferences, or atmospherics, also gives frequently an unpleasant background when receiving comparatively weak stations. All these interferences 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 section of the receiver by increasing the degree of selectivity, and in addition thereto in many instances also in the audio portion of the receiver 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 that condition of the receiver which is opposite to the sharply selective state, whether this condition be 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 so adjusting the means for increasing the fidelity as to give the best possible compromise between fidelity and absence of interferences is leaved to the operator.

Since the required degree of adjustment varies from one station to another this places a considerable hardship on the user of the receiver and it also requires an appreciable degree of experience and furthermore the degree which has been adjusted does not remain correct due to causes such as fading both of the desired station and of the interferences.

It is known to provide a radio receiver with automatically actuated fidelity regulation means 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 takes not into account the value of the interference level, so that in many instances serious interferences are experienced especially when a rather strong transmitter is neighboured by a stronger one. For this reason a manual control in addition to the automatic one, is practically indispensible with the said device.

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

The 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.

My invention applies more particularly to those interfering waves which are set up by stations having a small frequency spacing from the desired transmitter since these are usually the most unpleasant. It will however be shown that it is also very suitable for minimising the noises caused by so-called static and when hereinafter reference will be made to an interfering wave or carrier it will be understood that this latter kind of interfering wave is not excluded.

If in a receiver in accordance with my invention the strength of the carrier which it is desired to receive grows stronger whilst the interference level remains the same the degree of fidelity will increase. It will decrease however and the degree of selectivity will increase concomitantly when the strength of the wanted carrier increases and the interference level is increased in a larger proportion. Although it would theoretically be best to control the degree of fidelity exactly in accordance with the ratio of the wanted to the interfering field strengths, it is obvious that such a high degree of precision is by no means required in actual practice, it being all the same easy to obtain even better results than when the receiver fidelity would be adjusted continuously by a skilled operator. Since it is also possible to express the ratio just mentioned by the difference in decibels between the level of the interferences and of the wanted carrier intensity respectively 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.

An important feature of my invention is to provide in a tunable radio receiver an auxiliary control channel which responds efficiently to the interfering waves, more particularly to the interfering carriers, and which responds to a comparatively small degree to the desired carrier, and this channel embodying a rectifier associated with suitable amplifier means, the D. C. output serving to control an essential part of the fidelity regulating means of the receiver.

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.

In a preferred form of carrying out the invention, a single set of tensions derived from the said control channel, or a plurality of sets of tensions which are closely related, serve to control the predominant part, or the whole, of the fidelity control means of the receiver.

These tensions preferably represent the ratios of the wanted to the interfering fieldstrengths on an efficiently compressed scale, since the range of these ratios at the input of the receiver is extremely large and would otherwise be likely to cause overload of the control channel or of the regulated means. My invention provides different manners for carrying out this compression, the main forms profiting by the reduction of the efficiency with which the interfering waves are transmitted by 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.

My invention also provides different classes of filter circuits for giving the required response to the interfering waves, with the substantial exclusion of the wanted carrier. One of these classes uses selective circuits which are common up to an important degree to the receiver channel proper and to the selectivity control channel, there being chiefly added means for substantially attenuating, or removing, the wanted carrier. Another class uses for the auxiliary control channel circuits which are approximately tuned on the frequencies where the interfering carriers are most likely to operate.

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, 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.

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. 2–5 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. 3–11; Fig. 12 is a graph illustrating the operation of a feature shown on Fig. 11, whilst Fig. 13 shows still another arrangement in accordanee with my invention.

Referring to Fig. 1 a radio receiving system comprises a signal collecting means 1 and ground 2, the energy set up therebetween being transferred through the coupling coil 3 to the circuit 4 which is tuned upon the frequency of the wanted signals and shunted across the input electrodes of the amplifier tube 5. This tube is preferably of the screened pentode type comprising in addition to the main control grid 6 a suppressor grid 7 brought out to a separate terminal; by a suitable dimensioning of the electrodes of this tube it is possible to vary its internal resistance by controlling the negative bias of the suppressor grid, without there being too pronounced a degree of variation of the mutual conductance of the tube, the resistance thereof increasing when the negative bias is increased. The connections of the screen grid of the tube and of the heater element thereof (it being preferably of the equipotential-cathode type) have not been represented, nor have they for the other tubes of the receiver system, in view of simplifying the drawings. The valve 7 includes in its anode circuit a transformer comprising a primary aperiodic coil 8 connected to the sources of high tension supply +HT and very tightly coupled to the tuned secondary 9 which is tuned upon the wanted signals and connected to a suitable frequency changing device of any well known kind and which has been represented as comprising a modulator MOD cooperating with a local oscillator OSC tunable by means of the circuit LO, this circuit bearing a constant frequency difference equal to the intermediate frequency with respect with 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 disponible across 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 amplification given by the tube IF1, by means of a control of its negative grid bias, it is thus possible to lower the decrement of its grid circuit to variable degree. 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; undesired interactions between the circuits 11, 12 and 18, 19 are avoided by the interposition of the tube IF1 which therefor acts also as a so-called buffer valve. The degree of damping of the circuits 18 and 19 may be varied by including them in the anode circuits of the auxiliary tubes A1 and A2, of the triode type. The grid bias of these tubes is variable and their anode-cathode paths act therefor as variable resistances in shunt across the associated circuits and damping them 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 triode type and has a characteristic of the variable mutual conductance 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 transfered 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 V1 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 which includes a coupling network indicated by the general reference 37 and comprising a parallel resonant circuit 38 shunted by a series resonant circuit 39 both these circuits tuned upon the nominal intermediate frequency. This network gives a substantial response at frequencies spaced by some 10 kc. from the operating intermediate frequency where the interfering carries are most likely to operate (the circuit 38 being preferably rather damped, for this purpose); for the desired carrier frequency on the other hand the impedance of the network is less high, its response curve being double-humped with a marked depression between the two peaks.

The high frequency energy set up across the network 37 is applied to the rectifier SR which is of the diode type, the top of the network being connected through the condenser 40 to the anode of the diode, the current flowing by reason of the unilateral conductivity through the rectifier resistances 41 and 42 and setting up tensions there across, the resistance 41 being connected to the anode and the other 42 to the cathode of the diode SR, the two other ends being connected together and to a source of negative potential with respect to the ground. Thus when no appreciable high frequency voltage is applied, both its anode and cathode assume substantially with respect to ground the potential of this negative source of current whereas if high frequency signals are impressed to the diode, the potential of the diode anode further falls with respect to ground whilst that of the cathode rises and tends to attain, and even to depass the ground potential. The DC tensions led of at the diode anode are cleared from their high frequency and low frequency components by means of the resistance-capacity filter 45, 46 and they are applied through the line A. D. S. to the grids of the auxiliary tubes A1 and A2. The time constant of the filter may vary between fairly large limits and be equal to, say ⅕ 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. The cathode of the tubes A1, A2 is normally at a negative potential with respect to ground, of such value that in the absence of signals applied to the rectifier SR their cathode is at a small relative positive potential of say 3 volts with respect to the line A. D. S. Under these conditions the internal resistance of the tubes A1, A2 is rather small in comparison to the impedance of the associated tuned circuits 18, 19 which then are efficiently damped. However, when the potential of the line A. D. S. falls, due to the high frequency signals applied to the rectifier SR, the increasing negative bias of the tubes A1, A2 towards their cut off point causes their internal resistance to be increased, so that the damping of the associated circuits is progressively reduced.

The DC tensions at the cathode of the diode SR are similarly filtered by means of the resistance 44 and capacity 43, and are then applied through the line marked 2 A. D. S. to the suppressor grid of the radio frequency amplifier tube 5, to the control grid of the intermediate frequency amplifier tube IF1 and to the control grid of the low frequency amplifier tube 24. The cathode potential of these tubes is slightly positive with respect to ground, so that in the absence of signals applied to the rectifier SR these various controlled grids assume fairly large negative potentials with respect to their cathodes. Under these conditions, the internal resistance of the tube 7 is rather low, the tuned anode circuit 8 (through the transformer winding 8) being thus rather damped and passing a wide band of frequencies; the tube IF1 secures by small amplification, so that no appreciable feedback occurs to the tuned circuit 12 which normally due to a rather high decrement passes also a large frequency band. Under the same conditions the tube 24 of the variable mu type as was already mentioned has a high internal anode-cathode resistance, and the associated tuned circuit in its anode path shows marked selective properties and offers a considerable impedance to the upper band of the modulation frequencies which thus are emphasized with respect to the medium and low modulation frequencies, thus offsetting the loss which they encountered in some of the more selective circuits of the intermediate frequency amplifier. These various actions are therefor cumulative and place the receiver in a condition of greatest fidelity. If large frequency tensions are however applied to the rectifier SR, the diode cathode potential rises and also the potential of the line **2** A. D. S. thus reducing the negative bias of the associated valve grids. The internal resistance of the tube **5** is thereby increased and the original selectivity restored to the tuned circuit **9**; the resonance curve of the filter **11—12** is sharpened as the feed back increases due to the increasing amplification of the tube IF**1**; the internal resistance of the tube **24** decreases and the resonance properties of the circuit **25—26** are no longer very marked, so that the various modulation frequencies are amplified to comparable degree due mainly to the resistance **27**. 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 LF**1** from reaching positive potentials, or the grids 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.

The effect of the regulation of the frequency response of the receiver section following the branch off point **20** will not be considered at first, when I shall now proceed to the explanation of the operation of the device, nor will be made reference to the interferences caused by a regular background noise.

It will be seen that I have provided a receiver system comprising a first amplifier section which extends up to the branch off point **20** and includes the major part of the fidelity and selectively control means of the receiver, this section passing a band of frequencies including the wanted carrier frequency (i. e. the nominal intermediate frequency), the modulation side bands of this carrier, and also up to an appreciable degree the interfering carriers and their modulation. In cascade with this first section is another "receiver" section feeding an utilisation device which reproduces the wanted modulation and also up to a certain extent the interfering modulation. In cascade with the first receiver section and in parallel with the receiver section just mentioned is another amplifier channel which roughly passes the same frequency band as this latter section, with the exception however of a narrow band of frequencies including the "wanted" carrier, the frequency response for the interfering carriers being approximately the same as in the second receiver section. The rectifier of this channel therefor provides DC tensions which depend on the strength of the interfering carriers.

A good reproduction requires that the interfering modulation shall not disturb too strongly the wanted modulation, and since the interfering modulation is accompanied by correspondingly strong interfering carriers (the variations of the modulation depths being usually comparatively small and therefor susceptible of being neglected), the strength of the interfering carriers across the rectifier of the auxiliary amplifier section may serve to measure the degree of noise caused by the interfering modulation.

It is of course not the absolute strength of the interference on which depends the noise caused thereby, but its value relative to the strength of the wanted station, and this result is attained since the degree of transmission of the receiver section up to the point **20** was subject to an efficient overall gain control operating inversely in accordance with the field strength of the wanted carrier.

The tensions rectified by the auxiliary channel rectifier so actuate the selectivity control means of the first receiver section that the degree of transmission of the interferences in this first section remains sufficiently low, primary across the auxiliary rectifier, and as a consequence also across the reproducer, there being realized what may be termed a true control cycle.

This state of matters is further explained in connection with Figs. 2*a* to 2*d* of the drawings. Fig. 2*a* shows the distribution of the carriers at the reception point, the field-strength intensities being indicated vertically and the frequencies of the different carriers which are to be taken into consideration being indicated horizontally, the frequency of the "wanted" transmitter *a* being taken as a point of reference and marked zero (this being the nominal intermediate frequency) whilst the frequency of the interfering carriers b, b_1, b_2, . . . b_3 which extend on both sides of the wanted one are marked −10, −20 . . ., +10, +20 . . . (kc/s).

On Fig. 2*a* which bears indications similar to those of Fig. 1*a*, it is assumed that the action of the automatic gain control device of the receiver has been "complete" i. e. that the over all transmission efficiency of the receiver amplifier up to the point **20** has been adjusted exactly inversely in accordance with the field strength of the wanted carrier, and when it is supposed an instant that the wanted carrier has not been removed from the tensions reaching the rectifier SR (this being of course a mere speculation) the wanted carrier would be applied to this rectifier with a predeterminated amplitude a' whichever may be its actual field strength; all the other carriers set up tensions in accordance with the ratio a'/a this applying of course only if the selection power of the receiver is not taken into consideration.

In fact the amplifier has such a selectivity characteristic as to attenuate the interfering carriers to a degree dependent on their frequency spacing from the wanted carrier, this response at a particular instant being represented by Fig. 2*c*, where the frequencies are indicated horizontally, as previously, whilst the relative (percentual) gain of the receiver is indicated vertically. As was indicated previously it may be assumed for the purpose of simplifying the explanation that the relative response is the same as in the second "receiver" section and in the auxiliary amplifier section, except for the frequencies in the immediate neighbourhood of the wanted carrier, this being of no importance as far as the interfering carriers are concerned.

It may be assumed that the wanted signals will not be too strongly interfered if the condition of a ratio

$$\frac{\text{interfering carrier strength}}{\text{wanted carrier strength}}$$

of not more than some 1:320 is fulfilled in the receiver and the control channels. This ratio is completely determinated if that carrier which interfers most has a predeterminated value, this carrier being b''3, in the example shown and is represented on Fig. 2d; it corresponds to the carrier b3, Fig. 2a and is usually one of the transmitters distanced by some 10 kc from the desired one. The strength of this carrier as applied to the rectifier SR varies in direct proportion to the field strength of the interfering carrier and to the relative (percentual) gain of the receiver so that when this latter is suitably regulated any relative or absolute interfering field strength value may be compensated so as to let it substantially assume the predeterminated value b''3, or remain inferior thereto.

It will be at first supposed that the receiver is tuned to a strong carrier, and that the interfering carriers are very weak or absent. The action of the A. V. C. consists in placing the receiver under reduced sensitivity conditions, the interferences reaching the rectifier SR being thus very reduced too, so that there is no appreciable A. D. S. tension capable of displacing the receiver out of its position of minimum selectivity, this being its normal position. This condition is represented by curve c_1 of Fig. 3a where the frequencies are indicated horizontally and the relative gain vertically.

It will now be supposed that, whilst the wanted carrier (and thus the receiver sensibility) remains at its primitive value, an interfering carrier increases considerably its intensity. The A. D. S. tension (proportionate to b''3, Fig. 2d) tends to increase in the same proportion and is applied through the lines A. D. S. and 2 A. D. S. to the selectivity regulation means which cause a sharpening of the receiver resonance curve. This increase of selectivity opposes itself to an increase of the tension applied to and rectified by SR and if the device is sensible, the increase may remain very weak, having the tendency to remain naught, but in reality it must keep a given value, whatever small it be, to be capable of exercising the necessary action.

Now suppose that, whilst the interfering carrier continues to set up a comparatively high field strength, the field produced by the wanted station falls to a much lower value. The A. V. C. device increases considerably the sensibility of the receiver and thereby the tension applied to the rectifier SR increases considerably. This has for effect an appreciable increase of the A. D. S. tensions which tend therefor to increase considerably the degree of selectivity and this again tends to prevent the increase of the tensions across the rectifier SR, there being soon attained a position of equilibrium corresponding to a moderate increase of tension across SR, the degree of selectivity being represented by curve c_2 of Fig. 3b which bears indications similar to those of Fig. 3a.

The whole of this control action may be represented graphically by the curve d of Fig. 4 in which the abscissae represent the ratios of the interfering carrier field strength to the wanted carrier field strength such as they are present at the input of the receiver and the ordinates represent the same ratios across the rectifier SR which are thus proportional to the A. D. S. tensions.

It is supposed that the device is adjusted so that the desired ratio 1:320 (this ratio being in fact imaginary) across SR is realized exactly for an input ratio of 1:1; an ideally efficient action of the selectivity control device would be expressed by a 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.

A better efficiency is often attained if the premature action of the rectifier for small interference levels is prevented, e. g. by biasing the rectifier SR negatively. The action of regulation would then and for a given degree of bias be represented by curve d'. The difference between the two curves resides, from a principal viewpoint, in the fact that the second arrangement has the tendency to keep the output ratios at a value corresponding to the delay tension of the rectifier SR, from a practical view-point the advantage consists in that a given absolute variation of the A. D. S. tension capable of producing a given effect corresponds to a much smaller percentual variation of the H. F. tensions applied to the rectifier.

A comparison of the two curves d and d' shows furthermore that curve d' has a higher average level corresponding thus to a smaller average selectivity; on the other hand an increase of the sensitivity of the device has the tendency to produce an opposite variation. This phenomena is without any importance, as it may easily be corrected in the receiver section which follows the branch-off point 20. Means may also if desired be incorporated to allow a manual setting of the average selectivity degree, apart from the automatic control whose object is to maintain this setting constant under varying conditions; these means may modify the response curve of the second receiver section, or they may alternatively comprise a variable delay tension for the rectifier SR.

Some of the suppositions previously made are not always fulfilled exactly, or some small additional means are necessary to this end.

It was assumed that the efficiency of the gain control device operated by the wanted carrier was complete at the point 20. With the devices usually used, it often occurs however that there remain appreciable differences, the high frequency tensions varying for instance in the ratio of 1:2 when tuning successively upon a weak, and upon a strong transmitter. With an efficient selectivity control action it might thus happen that the degree of selectivity is too large for strong "desired" transmitters, since the efficiency of the channel providing the A. D. S. tensions was not sufficiently reduced. This inconvenient may be eliminated in many different ways, and in the example represented by Fig. 1 the grid of the high frequency amplifier tube S2 in the selectivity control channel is also regulated by tensions varying inversely in dependence on the wanted carrier strength, by connecting it to the A. V. C. control line.

Also it might sometimes prove difficult for the A. V. C. channel to respond with sufficient sharpness upon the carrier which it is desired to tune in, particularly when the receiver was in a position of minimum selectivity and is rapidly tuned upon a weak transmitter. Additional selective circuits tuned upon the intermediate frequency and following the branch-off point 20 may to this end be included in this channel in addition to the circuit 29, and these circuits may provide a rather flat-topped or any other response curve in the proximity of the nominal intermediate frequency whilst they help in providing a sharp cut off for the frequencies appreciably spaced therefrom.

It is possible for the same purpose to provide the receiver with an accessory device for placing it in a condition of predetermined e. g. average selectivity when the tuning cntrol is operated, as by placing the selectivity control device out of circuit, or by reducing its efficiency towards high fidelity degrees; such a device may comprise e. g. a tuning knob so disposed that its operation requires a small axial shift of 1–2 millimeters, a small axial spring restoring it to normal, and a switch being operated thereby; such devices have been proposed for other purposes and are sufficiently well known as to require no further description.

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. It will be easily understood that since this control does not exerce any repercussion upon the tensions reaching the rectifier SR, any desired degree of fidelity may be easily adjusted by this means.

This regulation could theoretically operate with such a high efficiency as to render unnecessary a control of the circuits preceding the branch off point, these circuits being constantly adjusted to a high degree of selectivity so as to render unprobable the interference even by a relatively strong transmitter. There are however several reasons which render it disadvantageous of using this method alone.

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, so that additional means for this purpose may be dispensed with, (these additional means being described with reference to other drawings and desirable in other instances).

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 fig. having already been mentioned).

Strong interfering carriers on the other hand are not efficiently transmitted by the amplifier section common to the receiver proper and the selectivity control device. Under such conditions a sufficient amplification is very easy attained in the selectivity control channel, curve c'_2, Fig. 3*b* showing the frequency response in this channel under these conditions. It is thus seen that the proposed arrangement does not reduce the outmost degree of sensitivity of the selectivity control amplifier, and that the common amplifier section is efficiently used for the amplification of the selectivity control tensions.

It is not essential however that this section be utilized up to a point which closely precedes the demodulator-rectifier, and energy for the selectivity control channel might also be derived from some other point in the carrier frequency amplifier, this being more advantageous with those types of selective filters in the selectivity control channel which do not allow a sufficiently sharp removal of the carrier.

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 DC amplification was used with the arrangement of Fig. 1 since the degree of high frequency amplification is so high that it is often possible with sensible regulation means to omit one of the stages shown; if required, the DC amplification could easily be designed by those skilled in the art; besides, some examples for so doing, and also for instoring upper and/or under limits of action of the control tensions and so avoiding overload of the regulating means associated thereby will be given with reference to other figures. Also there will be shown visual means for indicating the degree of fidelity, and some further fidelity control means.

No detailed reference was made so far to the type of noise caused by the so-called static. There are two kinds of such noises vz. those caused by lightnings, sparks of electrical machines or the like and occurring as irregular pulses of brief duration and large intensity and with appreciable intervals between; and furthermore those occuring as a rather regular and continuous background. This latter may be approximately assimilated to an interfering carrier station, whilst the former pulses may be integrated by a large time-constant, or have their intensity limited, or be suppressed, by blocking the amplifier channel, the means for so doing being sufficiently well known per se as to require no further description.

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. Whilst for small relative interference degrees the two kinds of interferences require about the same degree of selectivity (or reduction of fidelity), for strong relative interference degrees their influence is distinctly different, up to such a point that an adjacent carrier of intensity equal to that of the wanted carrier requires an average selectivity degree whereas if the "static" causes an equivalent tension across the selectivity control rectifier the audition of the transmitter must be abandoned because even with the maximum selectivity degree the noise is exaggerated.

In Fig. 5 the ordinates represent the optimum selectivity degrees for different ratios of the wanted field-strength to the interfering field-strengths, these latter being indicated on the abscissae; the curve *ii* relates to an interference caused by an adjacent transmitter and the curve *bi* to an interference caused by the "static."

It is advantageous to use a single fidelity control device operated by that one of the two interference kinds which is the strongest, and this is easily possible by the device represented on Fig. 1.

It will be seen from Fig. 5 that the maximum selectivity degree could as well be required for an adjacent carrier about a 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 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*.

In Fig. 7 is shown another arrangement wherein the circuits responsive to the interferences are constantly tuned upon the frequencies where the interfering carriers are likely to operate, i. e. they present their outmost response for frequencies spaced from the intermediate one by some 10 kc/s, the response curve presenting two peaks, one on either side of the intermediate frequency, separated by a very marked depression; the resultant resonance curve is that of Fig. 6 where the frequencies are indicated horizontally, the wanted one being taken as a point of reference and marked zero, whilst the relative gain of the amplifier up to the selectivity control rectifier is indicated vertically.

As shown, the receiver system includes a first section which is common to the receiver proper and to the selectivity control channel, and has been generally represented as the "pre-amplifier" PRE; it embodies preferably a frequency changer device of any well known kind, and also if desired a radio frequency amplifier tuned upon the frequency of the wanted signals. This first amplifier section does not embody means for controlling the degree of selectivity, in the example shown. The output at intermediate frequency which appears in the circuit 47 tuned upon the nominal intermediate frequency, is transferred as by mutual inductance, to the tuned circuit 48 connected across the input terminals of the first intermediate frequency amplifier valve I11 of the receiver; in cascade with this is another receiver valve I12 for amplifying the intermediate frequency, these two valves being coupled by a band pass filter comprising the two tuned sections 49 and 50, both tuned upon the nominal intermediate frequency and preferably individually screened, as by screening cans; they are coupled by means of a small condenser comprising a fixed plate 67 connected to the top of the circuit 49, and a movable vane 68 connected to the top of the circuit 50 and fixed upon a shaft 66 which may be easily rotated; this shaft is grounded, the plate 68 being isolated by means of the part 69. The two circuits 48 and 50 are weakly coupled if the condenser 67—68 is small and the resultant resonance curve presents in this case a sharp peak upon the nominal intermediate frequency, this position being suitable when a high selectivity degree is required. When the condenser 67—68 increases its value the band-pass width is expanded, especially towards frequencies lower than the nominal intermediate frequency. The anode circuit of the amplifier valve I12 includes a tuned circuit 51, this circuit resonating exactly upon the intermediate frequency when a high degree of selectivity is required. When an increased fidelity degree is required, this circuit may be slightly detuned towards higher frequencies; this is rendered possible by connecting one plate 70 of a small condenser to the top of this circuit 51, the other plate of the condenser 71 being connected to ground and thus effectively in shunt with the tuned circuit, and being fixed upon the grounded shaft 66; this detuning gives in conjunction with the asymmetrical expanse of the filter 49—50 a resultant response which is symetrical with respect to the nominal intermediate frequency, the condenser 67—68 may be replaced by a differential condenser arrangement having two small fixed plates connected to the tops of the circuits 49, 50 respectively between which is movably arranged and fixed to the shaft 66 a small grounded screening plate. The circuit 51 transfers by mutual inductance the main of its energy to the tuned circuit 52 which is included in the branch of the receiver LF which includes a demodulator, an audio frequency amplifier and a reproducer. Part of the energy of the circuit 51 is also fed through the condenser 53 to the automatic gain control device A. V. C. which is of a well known kind and exercises its action upon the "preamplifier," upon the intermediate frequency amplifier of the receiver, and also upon a further valve S11. This valve is the first high frequency amplifier valve of the selectivity control channel and is fed by the circuit 47 through the condenser 54. It is of the hexode type and comprises in addition to the main control grid a so-called gain control grid which is also controlled by the A. V. C. line. The anode of the tube S11 is coupled to the second high frequency amplifier tube S12 of the selectivity regulating channel by the intermediate of a network comprising an anode coil 55 coupled to a so-called Campbell sifter 56 this latter including the tuned circuit 57 and the two coupled coils 58, 59 with the condenser 60 of such value as to tune the circuit upon the intermediate frequency. This sifter circuit attenuates therefor considerably the wanted carrier frequency whilst it gives a good energy transfer at frequencies distant by several kilocycles from the intermediate frequency.

The tube S12 feeds the selectivity control rectifier S1R through a band pass filter indicated generally by the reference 61 and comprising an anode circuit tuned upon the nominal intermediate frequency and coupled by means of the series resonant circuit 64 comprising an inductance and a condenser also tuned upon the nominal intermediate frequency, to the second parallel resonant circuit 63, the values being so chosen as to give a good energy transfer at the frequencies of the interfering carriers whilst a small amount of wanted carrier frequency energy is only transmitted, the effect of the circuits 56 and 61 being therefor cumulative. The rectifier S1R is of the diode type and biased negatively so as to prevent rectification to take place below a predeterminated value, (this presenting not however in the present case quite the same interest as with the arrangement of Fig. 1). The rectified output after having been filtered, may be directly used to actuate part of the fidelity control means through the line A. D. S., these means having not however been represented, and it is also applied to the grid of the valve S2. This connection fulfills a triple purpose.

Firstly this valve serves as a DC amplifier for the A. D. S. tensions such as rectified by the diode S1R, the DC tensions which are applied thereto modifying its anode current, whilst the tube continues to operate at the same time as a high frequency amplifier. This current traverses a small motor M of the galvanometer type, of a well known kind, for instance of the moving coil type, and causes rotation of the shaft 66 against spring action and hence adjustment of the condensers 67—68 and 70—71 in dependence on the current variations of the tube and thus on the applied A. D. S. tensions. To avoid undesired interactions, one side of the motor is connected to the high tension supply, and the other side to the "cold" terminal of the tuned circuit 62, through the line 2 A. D. S., this terminal being also grounded for the high frequency energy through a by-pass condenser. Obviously any suitable regulation curve may be obtained by suitably shaping the plates of the variable condensers 67—68 and 70—71, since there is no repercussion of the fidelity control upon the control channel.

The valve S12 has a variable mutual conductance and acts also very efficiently to compress the range of variations of the interfering high frequency tensions reaching the rectifier S1R since an increase in the strength of the interfering carriers causes an increased negative A. D. S. tension which decreases the transmission efficiency of the control channel. The output of the rectifier does not therefor reach such high values under strongly interfered conditions, whilst under weakly interfered conditions the transmission efficiency is optimum, since the biased rectifier does not respond to such small carriers. The considerable practical importance of some such compression was already shown, and is the more valuable as there are no controlled fidelity means in the "preamplifier" which would give the same effect.

This compression takes furthermore place for the DC tensions rectified by S1R, since for large DC tensions as applied to the tube S12 the current variations in the galvanometer motor are small, whilst they are comparatively large for small DC tensions applied to the tube which has then a large mutual conductance.

The current variations of the tube S12 might as well be used to give other fidelity control effects such as varying the inductance of tuned circuits in the carrier amplifier channel, as by causing them to flow through an auxiliary winding associated with an iron core in the field of which is a small winding upon an iron dust core and which forms the inductance of such a tuned circuit. Other selectivity control means will not be further enumerated since they are sufficiently well known per se.

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 degree of fidelity with which the station may be received. This or some similar device is very suitable for rapidly determinating whether a station is worth while listening, 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 seen that with the arrangement of Fig. 7 the transmission efficiency of the selectivity control channel up to the rectifier S1R (including the "preamplifier") was varied inversely in accordance with the field strength of the desired station so that the initial range of the variations of the field strength of the interfering carrier was considerably expanded and in fact doubled (when the level variations are expressed in decibels). The action of the compression device (provided it was efficient) consisted therefor necessarily in the re-compensation of an essential part of the transmission efficiency variations according to the wanted carrier strength which were introduced by the A. V. C. device.

Fig. 8 shows a modified arrangement wherein the said variations are introduced mainly at a point in the auxiliary channel which follows the "compressing" rectifier, and it also serves to illustrate a means whereby a suitable frequency response of the fidelity control channel with an efficient attenuation of the "wanted" carrier has been attained through the cooperation of selective circuits in the "receiver" channel and in the auxiliary control channel.

This arrangement comprises a "preamplifier" including a frequency changer device with the intermediate frequency energy appearing across the tuned circuit 73, from where the "receiver" channel is fed through the condenser 74, this channel comprising an input band pass filter 75, a first intermediate frequency amplifier tube I21, coupled through the circuit 76 which is sharply tuned upon the intermediate frequency, to the second amplifier valve I22. In cascade therewith is a further amplifier section tuned upon the carrier frequency and generally represented by the reference IF. This preferably includes means for varying its degree of selectivity and is followed by a demodulator and audio frequency amplifier means. The selectivity control channel is fed from the "preamplifier" through the condenser 78 of low value and comprises an input band pass filter 79, a first high frequency amplifier valve S21, in the anode circuit of which there is a resonant circuit 80 tuned upon the nominal intermediate frequency and which preferably is rather damped. The coupling of the two circuits of the band pass filter 79 is rather tight so as to give a broad resultant resonance curve, whilst that of the similar band pass filter 75 in the "receiver" channel is rather loose so as to give a sharply peaked resonance curve. It is seen that the constitution of the first sections of the "receiver" amplifier and of the selectivity control amplifier, up to the tuned circuits 70 and 80 is quite similar, apart from the differences of their band pass width. The second selectivity control amplifier valve S22 is coupled to both these channels by means of the two coils 81 and 82 coupled to the circuits 60 and 78 respectively, these coils being connected in series, and connected in shunt across the input electrodes of the tube S22; these coils pick up equal amounts of energy at nominal intermediate frequency, but of opposite phase relationship, so that the desired carrier is substantially cancelled out whilst frequencies removed from the nominal intermediate frequency, and more particularly the frequencies of the interfering carriers, are not too much attenuated.

It is necessary in order that the balance of this circuit shall not be offset to exerce no gain control action upon the tubes S21 and I21, or to exerce such an action in equal proportions upon the two tubes. The anode of the tube S22 is coupled to the rectifier iR through a network presenting a marked double humped response ensuring a good transmission efficiency to the interfering carriers and a less good transmission to the wanted carrier, this network comprising connected between the anode of the tube and between the high tension supply a rather flatly tuned circuit 83 to which is coupled an absorption circuit 84. The rectifier iR is of the diode type and has its cathode connected to the cathode of the tube S22, and also to the cathode of a further amplifier tube S23 in the selectivity control channel. The control grid of the tube S22 and the gain control grid of the tube S23, which tube is of the hexode or like type, are controlled by the negative DC tensions set up across the load resistance 05 of the rectifier IR by the interfering signals.

These tensions represent on a compressed scale the variations of the input strengths of the interfering carriers and also up to some extent the variations of the wanted carrier since in the arrangement shown the common preamplifier was subject to gain control derived through the line A. V. C. In order that these latter variations shall be of sufficient amplitude relative to the variations of the interfering carrier values it is necessary to exerce thereupon some supplementary action inversely in dependence on the wanted field value. The degree of this supplementary action depends on the degree of compression to which were subject the high frequency tensions reaching the rectifier iR and this action is carried out in the DC amplifier tube S23, which comprises two control grids giving a multiplicative effect. Since the tensions derived from the rectifier iR are of "normal" phase, that is, the control line growing more negative for increasing values of the interfering carriers, it is necessary that the tensions dependent on the strength of the wanted carrier and which are applied to the main control grid, of this tube, shall be of reversed phase. They are derived from the anode circuit of a tube controlled by the normal gain control tensions, in the example shown of the tube I22 which tube includes a resistance connected between the source of high tension supply and the bottom of the tuned anode circuit 77, part of the DC current variations set up there across being lead of through the line Reverse A. V. C. by means of a potentiometer connected between the resistance and ground; the cathode of the tube S23 and also the cathodes of the associated tubes are at such a potential relative to ground that for maximum gain control tensions the negative bias of the tube S23 is slightly negative. In the anode circuit of this tube is included a resistance 86 across which are therefor set up DC tensions which depend directly on the strength of the interfering carriers and inversely on the strength of the wanted carrier, and it is easy to find out the degree of reverse A. V. C. action for which these tensions are truly representative for the ratios of the interfering field strength to the wanted field strength at the input of the receiver.

They may be used directly for actuating the fidelity regulation means in the intermediate frequency and/or audio frequency sections of the receiver. On Fig. 8 has also been shown by way of example one manner for reducing the range of the transmitted audio frequencies towards the treble by means of a low pass filter connected between a first section of the audio frequency amplifier LF1 and between a further amplifier tube 96 to which is coupled the final low frequency amplifier. This low pass filter comprises a variable condenser connected between the input terminals of the amplifier tube 96 and associated with the fixed inductance 93, the variable condenser being constituted by the apparent input impedance of an auxiliary thermionic tube A2 of the triode type the grid of which is connected to the grid of the tube 96 through the condenser 95, and which exhibits the so-called "Miller effect" that is, the apparent variation of its capacitative impedance when its amplification is varied, due to a variation of its negative grid bias; for this purpose the tube A2 comprises a resistance 94 in its anode circuit and has its grid to anode internal capacity increased by means of a small external condenser. Its grid bias is controlled by part of the fidelity control tensions derived from the anode circuit of the tube S23 through a potentiometer 87—88 connected between ground and anode in a manner which will be detailed hereinafter.

There is also connected between ground and high tension supply a potentiometer comprising the two resistances 91 and 92; which are of such value that the point of intermediate potential so determined is at a fairly large negative potential with respect to the cathode of the tube A2. Connected to the point of variable potential on the potentiometer 87—88 is the anode of a diode, the cathode of which is indirectly heated (this being not represented) and connected through the resistance 90 of high value to the point of fixed potential on the potentiometer 91—92.

Under strongly interfered conditions the junction point of the resistances 87—88 assumes a potential which is but little negative with respect to the cathode of the tube A2 and at an appreciable position with respect to the junction point of the resistances 91—92; the diode is therefore conducting and has a small internal resistance, so that the grid of the tube A2 may be practically considered as being at the potential of the junction point 87—88. Therefor this tube secured a high amplification and simulates a large condenser, so that the cut off frequency of the associated filter is low. For weak interferences or a strong desired carrier, the opposite condition takes place up to a point of high cutoff frequency when the diode 89 ceases to conduct.

The potential difference between the anode of the tube A2 and ground, which varies inversely to that of the anode of the tube S23 with respect to the ground, has also been used for operating a visual indicator N of the neon type the cathode of which is connected to ground through the resistance **97**, the purpose of which is to limit the flow of current, its anode being connected to the anode of the tube A**2**, or to some suitably chosen point on its anode resistance **94**, so that the tube illuminates either constantly or for degrees of fidelity over a predetermined valve only, the degree of illumination increasing with an increase of fidelity, i. e. under less interfered receiving conditions.

In Fig. 9 there is shown a further arrangement which serves inter alia to illustrate another way for compressing the range of variations of the interfering carriers. The "preamplifier" comprises a radio frequency amplifier valve **98** associated with tunable circuits and a frequency changer device referred to as OM, this latter including in the anode circuit of the first detector a network **99** comprising a circuit **101** tuned upon the nominal intermediate frequency and in series therewith one half of the small coupling coil **103**, and in shunt therewith a resistance **100** in series with the other half of the coupling coil **103**, the common intermediate point on the coil **102** being connected to the high tension supply.

The damping of the tuned circuit **101** is small, and the value of the resistance is equal to the impedance which the tuned circuit offers to the nominal intermediate frequency. The "receiver" amplifier is coupled to the circuit **101** by mutual inductance between this circuit and the tuned input circuit **102** of the first intermediate frequency valve **131**. The A. V. C. device is also fed from some point of the intermediate frequency section of the receiver amplifier REC, the action of the automatic gain control device being conventional and exercising inter alia upon the tubes **131** and **98**, this latter control also modifying the energy transferred to the selectivity control channel. This channel being fed by virtue of the mutual inductance between the coupling coil **103** and a circuit **104** tuned rather broadly upon the nominal intermediate frequency so as to offer a substantial impedance to the interfering carrier. It will be seen that, as the two halves of the coupling coil **103** induce equal voltages at nominal intermediate frequency and of opposite phase, this nominal frequency is substantially cancelled out, whilst for the interfering carriers the amount of voltages induced is substantially different so that a considerable amount of these frequencies is transmitted.

Connected to the anode of the high frequency amplifier tube S**31** there is a tuned circuit **105** the other terminal of which is grounded for the high frequency energy through a large by-pass condenser and connected to the high tension supply through a resistance **111**. The circuit **105** is coupled to the tuned circuit **106**, as by mutual inductance, so tightly that the resultant band pass filter presents a marked double humped characteristic ensuring an efficient transmission to the energy of the interfering carriers. This energy is applied to a dry rectifier S**3**R e. g. of the well known copper oxide type, the negative tensions set up across the rectifier resistance being applied through the line *i* to the main control grid of the tube S**31**, and also to the gain control grid of the radio frequency amplifier valve **98** of the common "preamplifier" channel for a purpose which will be described hereinafter. Since both these valves are in the selectivity control channel, one first effect of this control is that the high frequency variations reaching the rectifier S**3**R are efficiently compressed, this result being very desirable as has been shown. The tube S**31** is of the hexode or a like type and comprises also a "gain control" grid to which are applied reverse A. V. C. tensions derived from the anode circuit of a tube which is controlled by the normal gain control device, in the instance shown the intermediate frequency amplifier tube I**31**; the anode circuit of this tube comprises for this purpose a resistance **109** part of the potential variations set up across this resistance being taken off by means of the potentiometer **110** connected between the top of the resistance and a source of negative potential with respect to ground. The potentials are so chosen that for full A. V. C. voltage applied to the tube L**31** the gain control grid of the tube S**31** assumes approximately ground potential, whilst for smaller A. V. C. voltages it grows increasingly negative with respect to ground. This reverse A. V. C. action counteracts to some extend the action of the gain control device as has been exercised upon the selectivity control channel prior to the rectifier SR**3**, (this action having been exercised in the instance shown upon the common preamplifier tube **98**); for this reason the potential variations led off at the rectifier S**3**R represent approximately the variations of the field strength of the interfering carriers (as distinct from the relative strength of these carriers), on a considerably compressed scale. A small degree of control action in dependence on the strength of the wanted carrier at some point following the rectifier S**3**R, will therefore be sufficient for providing correct A. D. S. tensions, and this action is efficiently carried out in tube S**31** in a fashion similar to that which was described with reference to fig. 8, vz. by the simultaneous application in respectively opposite phases of DC tensions derived from the amplifiers for the wanted and for the interfering carriers respectively. The A. D. S. output appears in the anode resistance **111** of the tube S**31** which thus serves at the same time as a DC and as a high frequency amplifier for the selectivity control tensions. It is easy to find the correct degree of reverse A. V. C. control, since the effect of the "counter action" of this control upon the high frequency amplification of the tube (which counter action is only apparent as was shown) is seriously smaller than its effect action upon the DC amplification.

The gain control along line *i* of the radio frequency valve also fulfils the purpose of minimising the so-called crosstalk which frequently 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 distorsion 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 S**3**R 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 A. V. C. 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 proposed arrangement such as the use of a second rectifier fed in parallel with S3R and responding to tensions above a given value only, as by biasing it negatively, with the purpose of causing the control to operate only for strong interfering transmitters and using the optimum sensitivity for weak transmitters which are not subject to the risk of crosstalk, and also reducing the background noise due to valve hiss and the like, will be obvious to those skilled in the art.

The tensions across the resistance 111 may also actuate a visual indicator of quality through the line Vis. which may e. g. be of the cathode-ray oscillograph type.

Fig. 10 shows a modification of the arrangement just described wherein the correct efficiency of the tensions rectified in the rectifier S3R is attained by means of a motor galvanometer 112—113 for operating the selectivity regulating means, this galvanometer comprising two differentially connected windings, of which the one, viz. 112 is traversed by a current depending on the output of the rectifier S3R by including it in the anode circuit of the tube S31, which is controlled by this rectifier whilst the other winding 113 is traversed by a current dependant on the strength of the wanted carrier, by including it in the anode circuit of the tube 131.

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 actual practice the requirements are however less critical and may be sufficiently well performed by choosing for S31 and I31 tubes of the variable mu kind having approximately the required characteristic; the requirements are still further lowered when a certain amount of control action by the wanted carrier was effectuated prior to the rectifier S3R; this may easily be the case by reason of the usual gain control of 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 A. V. C. tensions.

A like differential effect could also be attained by 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 A. V. C. 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.

Fig. 11 serves inter alia to illustrate the way in which part of the fidelity control means may be directly controlled by tensions depending chiefly on the strength of the interfering carriers, and to a smaller extent on the strength of the "wanted" carrier, and also a way of giving selectivity control tensions of reversed phase.

As shown the receiver is of conventional type and comprises a radio frequency amplifier RF, a frequency changer device OM, these two also in the path of the selectivity control channel, and comprising no selectivity control means in the arrangement shown; coupled thereto by mutual inductance between the tuned circuits 114, 115 tuned upon the intermediate frequency, is an intermediate frequency amplifier IF feeding the demodulator and low frequency amplifier DL and a gain control device A. V. C. which operates through the line A. V. C. and modifies inter alia to a certain extent the transmission efficiency of the comon "preamplifier." Both the two receiver sections IF and DL may include means for controlling the fidelity and operated in accordance with my invention.

The selectivity control channel comprises an input circuit 116 coupled by mutual inductance to the circuit 115 and connected across the input terminals of the first high frequency amplifier tube S41, and is also in the anode circuit of an auxiliary triode tube A41 which functions as a variable resistance to vary the decrement of the tuned circuit, for the purpose and in a manner described hereinafter. The anode circuit of the tube S41 is coupled to the rectifier Ri through a network 117 comprising a resistance and a tuned circuit sharply tuned upon the nominal intermediate frequency and differentially connected to the rather damped tuned circuit 118 tuned upon the intermediate frequency (a similar filter having already been described previously) this diode-rectifier producing in accordance with the strength of the interfering carriers potential variations negative with respect to ground in a resistance 119 and positive with respect to ground in the rectifier resistance 120; these latter tensions being inter alia applied through the line *i* to the grid of the tube S41 so as to compress the range of the variations of the tensions which are applied to the rectifier Ri. The tensions applied thereto depend mainly on the strength of the interfering carriers, and to a smaller extent on the strength of the wanted carrier. The DC tensions apeparing across the resistance 120 are filtered and applied through the line *is* to the grid of the auxiliary tube A41, the cathode of this tube being at a high potential with respect to ground corresponding to its cut off bias, so that in the absence of interfering carriers as applied to the rectifier Ri the internal resistance of the tube is extremely high and does not cause an appreciable damping of the associated circuit 116; under these conditions the coupling of this circuit with the transformer 114, 115, is rather tight and causes a marked absorption of energy at intermediate frequency, this resulting in a broadening of the resonance curve thereof and in a better degree of fidelity, the loss of sensitivity needing not be considered inasmuch as the receiver channel is concerned. Under the same conditions the response curve effective across the tube S41 is also broadened due to the interaction between the circuit 116, and the band pass filter circuits 114, 115, and the transfer of energy of the interfering carriers is therefore good.

If however due to a strong interfering transmitter the negative bias of the tube A41 is decreased, its internal resistance is lowered up to small values, causing considerable damping of the associated circuit 116, this on the one hand reducing the amount of energy transmitted to the tube S41 and so efficiently contributing to the compression of the variations of tensions applied to the Ri, and on the other hand effectively decoupling this circuit 116 with the associated transformer, so that the response curve of this latter grows more sharply peaked with a concomitantly increasing degree of selectivity in the receiver and also in the selectivity control channel, this latter effect in turn causing a further decreased response of this channel to the interfering carriers and thus a further improved compression. It is to be noted that the loss of sensitivity for this channel is not compensated by the A. V. C. device. A further amplifier section of the selectivity control channel includes a high frequency amplifier tube S42 fed from the intermediate frequency channel of the receiver preferably from a point close to the demodulator through a small condenser 124 and a loosely coupled sharply resonant band pass filter 121; these tensions mainly of nominal intermediate frequency are amplified by the tube S42 to a variable extent in dependance on the strength of the interfering carriers, by connecting the grid of this tube to the rectifier Ri through the tuned grid circuit. Energy at carrier frequency is transferred from the anode of the tube S42 through the sharply resonant band pass filter 122 to the rectifier S4R, of the diode type. The output tensions appearing in the load resistance are negative with respect to ground and their phase is such that a relative increase in strength of the interferences caused a smaller negative tension, since less energy of intermediate frequency is thereby transmitted. These tensions serve to actuate the fidelity control means, through the lines A. D. S., and they depend both on the strength of the interfering carriers, and of the wanted carrier, the tube S42 being preferably controlled to such an extent that with the fidelity control through the lines A. D. S. the action of this latter carrier predominates since with the selectivity control exercised upon the selectivity regulating means 115—116 the action of the interfering carried predominated, so that finally both exercise a correct action.

It is furthermore seen that the A.D.S tensions appearing across the load resistance of the rectifier S4R depend strongly on the degree with which the receiver is in tune with the wanted carrier, a small amount of detuning having the same effect as a considerable decrease in the strength of the carrier and corresponding thus apparently to a degree of small fidelity and of strong interferences. If these tensions are therefore applied to a visual indicator of any suitable type known per se which may be for instance of the oscillograph type, through the line A.D.S/VIS this indicator will exactly indicate the degree of fidelity when the receiver is exactly tuned; and it will at the same time allow the operator to exactly tune in this point which is characterized by the maximum deflection, or the maximum degree of illumination or like indication according to the type of the indicator. Fig. 12 serves to illustrate this operation, the frequencies being indicated horizontally, the wanted one being taken as a point of reference and marked zero and the degrees of illumination or like indications being indicated vertically, the curves q1 q2 q3 relating to stations which may be received under conditions of increasing fidelity. It is seen that no appreciable indication is given for amounts of detuning larger than some 3 kc. The device is particularly suitable in the receivers where the tuning is effectuated partially according to the indications of the ear of the operator, by known arrangements called e. g. aural tuning, such devices being inoperative in the momentary absence of a program and leading to difficulties in the cases where the receiver is audible only in close proximity of the exact tuning position. A visual indicator of tuning only, on the other hand, has not many applications in a receiver of the type mentioned and does not give useful indications on the "quality" of the station.

The arrangement shown by Fig. 13 serves to illustrate the way in which the high frequency tensions reaching the selectivity control rectifier, are caused to represent the variations of the ratio: interfering to wanted field strengths by the simultaneous action of a so-called true control cycle and by a variation of the transmission gain efficiency of the amplifier channel, feeding the said rectifier, the same arrangement also giving some further advantages of the so-called true control cycle which were detailed in connection with Fig. 1.

The receiver comprises a common "preamplifier" with frequency changer means, with intermediate frequency, demodulator and audio frequency sections and a gain control section, all of these similar to those of the arrangement which was just described. The selectivity control channel is fed in a like manner through the controlled tuned circuit 116 and the first high frequency amplifier tube of this channel which is of the hexode type, has both its main control and its "gain control" grids controlled by the A.V.C line to such an extent that the high frequency tensions reaching the selectivity control rectifier S5R have been subject to a "complete" action of the wanted carrier strength i. e. this action varying exactly inversely in proportion to the said field strength. The rectifier S5R which is coupled to the second high frequency valve S52 of this channel through the tightly coupled band pass filter 125 exercises a compression action upon this channel by connecting the control grid of the tube S52 to the line A.D.S; which is at a variable negative potential due to the DC tensions set up by the interfering carriers in the diode load resistance 126 connected between ground and diode anode. The tube A51 is controlled through the line 2 A.D.S in which are set up variable positive potentials derived from the diode load resistance 127, this control exercising a correct influence upon the degree of fidelity of the band pass filter 114–115 which further reduces the range of variations of the tensions as would otherwise be applied to the rectifier S5R and at the same time varies the amount of interfering energy derived through the circuit 116, this giving a cumulative effect like in the preceding arrangement. It is to be understood that with my invention the use of separate fidelity regulation means actuated by tensions dependent on the strength of the wanted carrier is not precluded, these means if used, exercising preferably a small action on the overall fidelity degree only, so as to remediate, to an otherwise unsufficient such control.

Although I have described my invention as embodied in several concrete forms, it should be understood that the various means represented may be modified in many different ways. The rectifying means might for instance be of the push-pull-type, or of the 3 electrode type; in fact, any other means suitable for the purpose and known per se might be used. Also it should be understood that I do not limit my invention to the particular arrangements which were described since various modifications thereof will suggest themselves to those skilled in the art without departing from the spirit of my invention, the scope of which is set forth in the annexed claims.

EGON NICOLAS MULLER.