Sept. 14, 1937. L. R. KIRKWOOD 2,092,885

VOLUME CONTROL SYSTEM

Filed Sept. 29, 1934 2 Sheets-Sheet 1

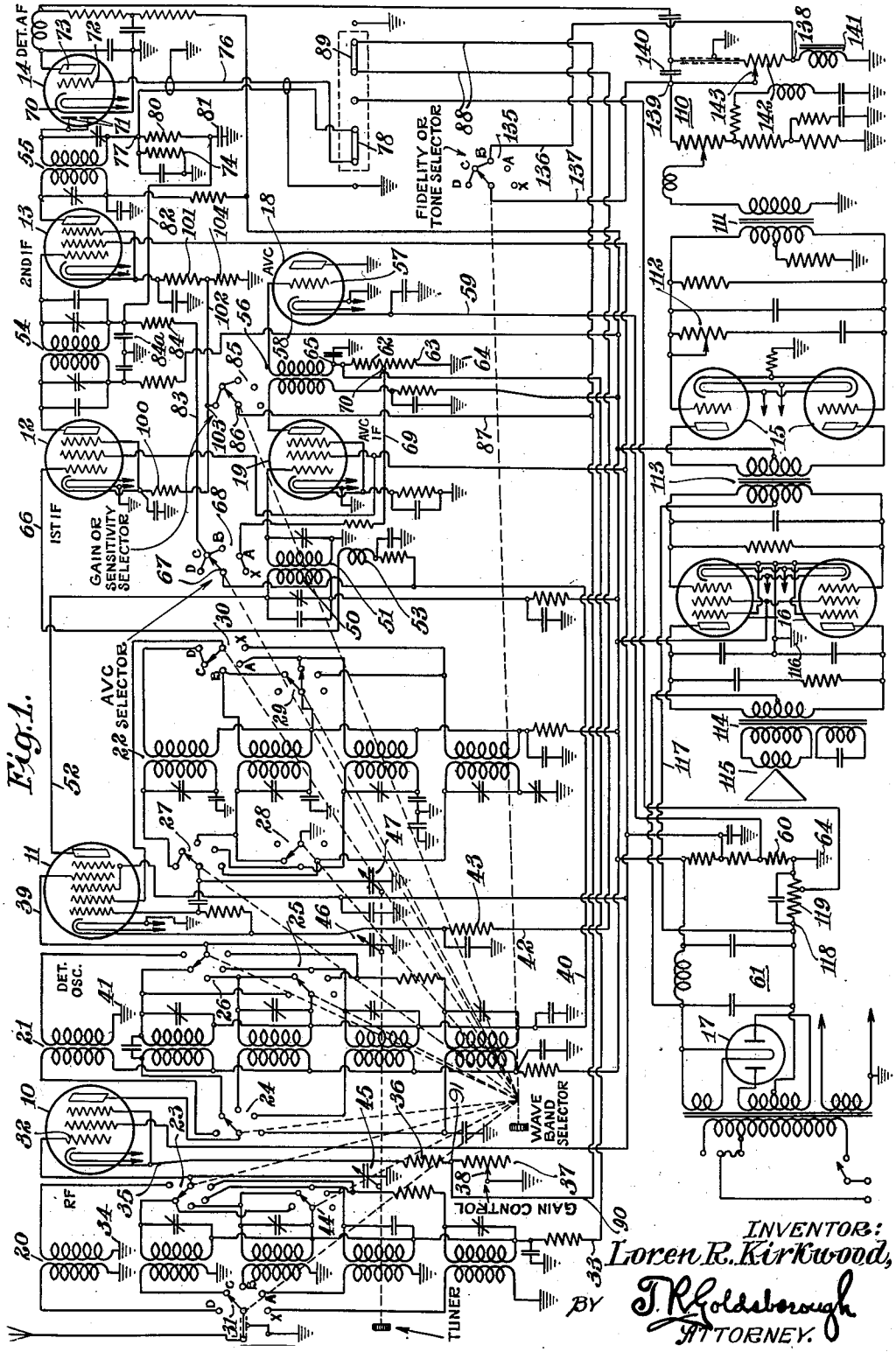

Fig. 1.

INVENTOR:
Loren R. Kirkwood,
BY J. R. Goldsborough
ATTORNEY.

Sept. 14, 1937. L. R. KIRKWOOD 2,092,885

VOLUME CONTROL SYSTEM

Filed Sept. 29, 1934 2 Sheets-Sheet 2

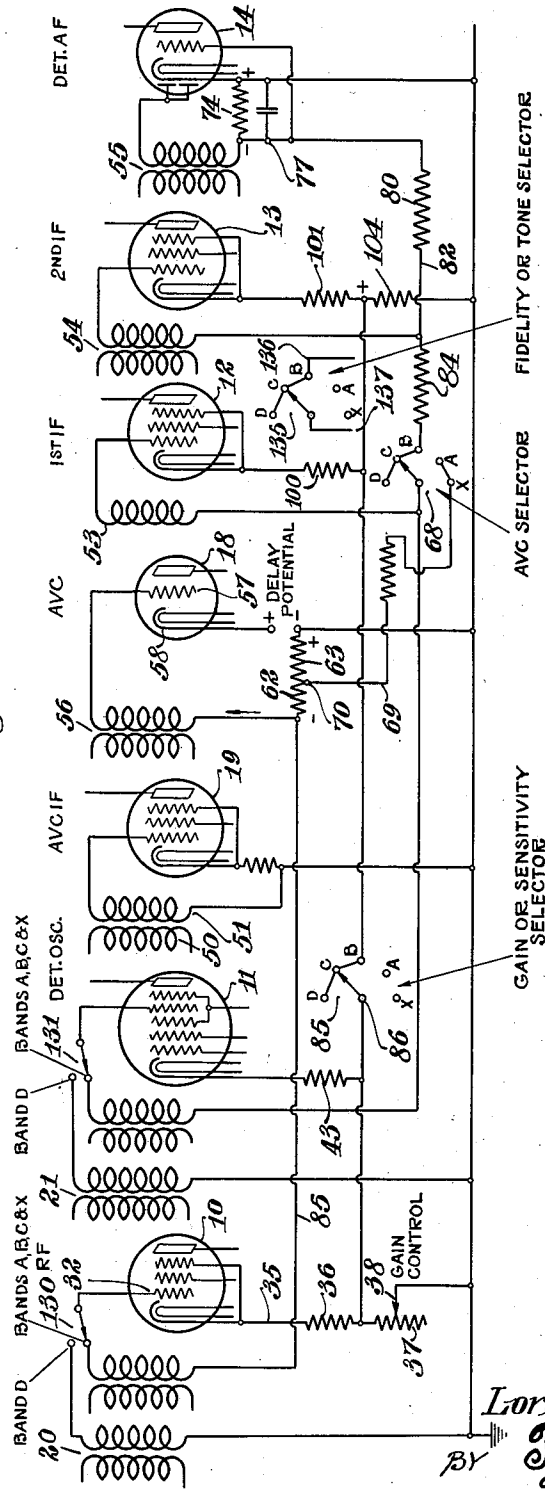

Fig. 2.

INVENTOR:
Loren R. Kirkwood.
BY T. R. Goldsborough
ATTORNEY.

Patented Sept. 14, 1937

2,092,885

UNITED STATES PATENT OFFICE

2,092,885

VOLUME CONTROL SYSTEM

Loren R. Kirkwood, Merchantville, N. J., assignor, by mesne assignments, to Radio Corporation of America, New York, N. Y., a corporation of Delaware

Application September 29, 1934, Serial No. 746,048

25 Claims. (Cl. 250—20)

The present invention relates to volume control systems for radio receiving apparatus, and more particularly it relates to automatic volume and sensitivity control systems for superheterodyne radio receivers of the "all-wave" or multiple band type.

All-wave receivers at present are adapted to receive signals in a plurality of selected wave bands covering a relatively wide frequency range, and in common with usual receiver design, include a plurality of amplifier devices or tubes together with automatic and manual volume control means therefor arranged to supply an amplified signal of substantially constant voltage amplitude to the second detector or audio frequency output system.

The automatic volume control system may include means responsive to variations in signal strength for controlling the biasing potential on one or more of the amplifier tubes, thereby to control the gain and the signal volume. Manual sensitivity control means may be provided in connection with certain of the amplifier tubes, or in cooperation with the automatic volume control means, to adjust the gain of the receiver.

I have found that additional automatic control means must be provided in order to provide substantially constant average signal amplitude on the output system or at the audio detector of a receiver adapted to cover a relatively wide frequency range, such as an "all-wave" or multi-range receiver, the automatic volume control of certain of the amplifier stages, and the sensivity, or gain in the same or other amplifier stages, preferably, being arranged for control by the band selecting means.

It is, therefore, an object of this invention to provide an improved volume control system for a superheterodyne all-wave or multi-range radio receiver, which may be operated in conjunction with the band selecting or wave-changing devices thereof automatically to establish differing predetermined desired conditions of gain or amplification on certain of the amplifier and other circuits of the receiver, whereby the signal output of said receiver may be made substantially more uniform and constant throughout the frequency range.

It is a further object of the present invention to provide an improved automatic volume control system for an all-wave or multi-range superheterodyne receiver.

It is a further object of the present invention to provide an improved volume control system for an all-wave or multi-range superheterodyne receiver comprising automatic volume control means, and means for adjusting said means and the sensitivity of the receiver in accordance with the changes in the wave bands over which the receiver is adapted to operate.

It is a further object of the present invention to provide, in a superheterodyne radio receiver having automatic volume control means, a second automatic volume control means, in cascade relation thereto along the signal channel, and means for selecting one of said automatic volume control means for certain wave bands and the other of said automatic volume control means for certain other wave bands to control differing portions of the signal amplifying circuits of the receiver.

It is a still further object of the present invention to provide a volume control system for an all-wave superheterodyne radio receiver which includes two automatic volume control means having differing control characteristics, and selector means adapted to be operated in conjunction with the wave-changing means for the receiver, for rendering each of said means effective to control various portions of the receiver.

It is also an object of the invention to provide an improved automatic volume control system for a superheterodyne receiver having wave-changing means whereby it is adapted to operate over a plurality of wave bands, and having a diode type second detector, wherein automatic volume control potentials are derived selectively from the diode circuit automatically in response to adjustment of said wave-changing means for certain wave bands.

It is a still further object of the invention to provide selector means in a radio receiver, adapted for conjoint operation with wave band changing means to adjust said receiver for differing conditions of sensitivity, automatic volume control and fidelity simultaneously with wave band change.

In accordance with the invention, in one embodiment, for the control of an all-wave superheterodyne receiver covering a relatively wide frequency range, the gain of a radio frequency amplifier stage is controlled by automatic volume control means having a separate intermediate frequency amplifier channel in parallel with the signal channel, while the gain of an intermediate frequency amplifier stage is controlled by automatic volume control means provided in conjunction with signal channel and the second detector function, by the use of a diode rectifier as the detector and automatic volume control tube. The first detector and the first intermediate frequency

amplifier are provided with selector means actuatable in conjunction with or controlled by the operation of the wave-band changing means, selectively to connect the said first detector and another intermediate frequency amplifier stage with the first automatic volume control means for certain longer wave bands, and with the second automatic volume control means for certain of the shorter wave bands.

The sensitivity or gain control means for the receiver is provided with selector means for placing under manual control, certain of the receiving tubes, such as the radio frequency amplifier and first detector, for the longer wave (lower frequency) bands, and certain additional tubes, such as the first and second intermediate frequency amplifier tubes, for the shorter wave (higher frequency) bands, automatically in response to operation of the wave-changing means. At the same time, the sensitivity or gain of the intermediate frequency or other amplifier may be adjusted, preferably being increased for the shorter wave bands, and tone or fidelity of the receiver may likewise be adjusted to reduce noise in certain wave bands.

Other suitable tube control arrangements may, however, be provided, in accordance with the amplifier requirements to control the sensitivity and the gain over a predetermined number of differing wave bands. For example, as shown and further described hereinafter, a twelve tube superheterodyne receiver operating over five differing wave bands is provided with a volume control system embodying my invention, as a present preferred embodiment thereof.

In the drawings, Figure 1 is a circuit diagram of an all-wave or multi-range superheterodyne receiver embodying the invention as above referred to, and

Fig. 2 is a simplified circuit diagram showing certain of the circuits of Fig. 1 separated from the remainder of the receiver, whereby the control features may more readily be seen and understood.

Referring to the drawings, the receiving system comprises a radio frequency amplifier tube **10**, a first detector and oscillator tube **11**, first and second intermediate frequency amplifier tubes **12** and **13**, respectively, a combined second detector and audio frequency amplifier tube **14**, a pair of push-pull audio frequency amplifier tubes **15** and a pair of push-pull audio frequency power output tubes **16**, together with a power supply or rectifier tube **17**. In addition, there is provided an automatic volume control tube **18** and an intermediate frequency amplifier tube **19** therefor.

The radio frequency amplifier **10** and the combined detector-oscillator **11** are provided with suitable wave band switching means comprising a series of coupling transformers **20**, **21** and **22** which are selectively connected in circuit for differing wave bands, indicated as "X", "A", "B", "C" and "D", by selective switching means indicated at **23**, **24**, **25**, **26**, **27**, **28**, **29** and **30**. The switches are preferably gang or unicontrollable as indicated by the dotted lines, in connection with a similar antenna selector switch indicated at **31**, for connecting the various wave band coils in circuit. The switching arrangement is such that the usual radio frequency, detector and oscillator circuits are provided for the various wave bands. Since the selective switching arrangement per se does not concern the present invention, and is described only by way of example as one of several possible selective means for wave band changing, further description thereof is believed to be unnecessary.

The volume and gain control circuits of the various tubes, however, such as the grid and cathode circuits, are necessarily connected through the above described switching means and additional switching or selector means hereinafter described. Accordingly, for a further understanding of the invention, it is necessary to refer more in detail to the control grid and cathode circuits of the various tubes.

In the radio frequency amplifier stage, it will be noted that the signal input grid indicated at **32** may be connected through the secondary windings of the various transformers **20** by the switching means **23** to a common grid bias supply lead **33**. It will be noted, however, that the transformer for the band D is grounded as indicated at **34**.

The cathode lead of the radio frequency amplifier stage is indicated at **35** and includes a self-bias resistor **36** and a manually variable sensitivity or gain control means comprising a variable resistor **37** connected in series with the self-bias resistor **36**, the variable contact **38** being connected to ground.

In the detector-oscillator circuit, the signal input grid lead indicated at **39** is connected through the selector switch **26** with the various transformers **21** from which a common grid bias potential supply lead **40** is brought out and connected, as will hereinafter be described. It will be noted that in the band D the transformer **21** is also grounded, as indicated at **41**. The detector-oscillator cathode lead, as indicated at **42**, is provided with a self-bias resistor **43**.

In addition to selecting the desired coil system through operation of the switches **23**, **24**, **26**, **27**, **30**, and **31**, additional groups of contacts provided by switches indicated at **44**, **25**, **28**, and **29**, are arranged for short-circuiting radio-frequency, detector and oscillator coils in an adacent frequency band. This is to prevent "dead" spots due to absorption effects caused by the coils, the natural period of which falls in the next higher frequency band. The variable tuning condenser having radio frequency, detector and oscillator sections **45**, **46** and **47** is connected with the various coils through the switch contacts.

The signal output of the first detector, which is the intermediate frequency signal at 460 k. c. in the present example, is supplied directly through two tuned circuits to the grid of an intermediate frequency amplifier stage which includes the tube **19**. The two tuned circuits include the primary **50** connected with the output circuit **52** of the first detector, and the secondary **51** of an interstage coupling transformer. A coupling coil or additional secondary **53** adjacent to the secondary **51** of the transformer and coupled with the primary **50**, is connected directly to the signal intermediate frequency amplifier stage including the amplifier tube **12**. The signal intermediate frequency amplifier and automatic volume control intermediate frequency amplifier stages are in effect in parallel, being supplied from the common primary winding **50**.

The second intermediate frequency amplifier tube **13** is connected with the first intermediate frequency amplifier tube **12** through a suitable tuned interstage transformer **54** and the second detector is in turn coupled to the second intermediate frequency amplifier tube **13** through a second intermediate frequency amplifier trans-

former 55. Both circuits of each transformer are accurately tuned to the intermediate frequency signal which is 460 k. c.

The intermediate frequency signal, amplified by the tube 19, is applied to the automatic volume control tube 18 through an untuned intermediate frequency amplifier coupling transformer 56. The automatic volume control stage which includes the tube 18 is preferably operated as a rectifier, the rectifying elements including the electrode or grid 57 and the cathode 58. The rectifier circuit is completed through a cathode lead 59, a grid bias potential supply section 60 in the power supply unit 61 and two high resistance elements 62 and 63 connected between ground 64—64 and the low potential side 65 of the secondary or input circuit for the tube 18.

The source of potential, 60, represents any suitable low voltage source for applying a biasing potential to the rectifier 18 whereby rectification of the signal does not occur until the signal level exceeds the biasing voltage. Such voltage is usually referred to as a delay potential in conjunction with diode rectifier devices.

When the delay potential, usually in the order of five volts, is overcome, rectified signal current flows in the circuit including the grid 57, the lead 59, potential source 60 and the resistors 62 and 63. A portion of the rectified signal produces a voltage drop across the said resistors which are of such resistance value that the potential developed across both of them is sufficient to constitute the automatic bias voltage for the radio frequency amplifier stage and the tube 10. For this reason, it will be noted that the lead 33 is connected to include both of said resistors in the bias circuit of the tube 10.

The potential drop across the resistor section 63 alone supplies the automatic bias potential for the first detector and the first intermediate amplifier stages when receiving signals in the bands X and A. For this purpose the control grid lead 66 of the first intermediate frequency amplifier tube is connected through the coupling coil 53 with the lead 40 from the first detector and both leads are then connected to the movable arm 67 of a selector switch 68, corresponding in number of contacts and positions of operation with the wave-changing switches hereinbefore described.

The contacts for the bands X and A are connected together, as indicated, and through a bias potential supply lead, indicated at 69, are connected at a point 70 between the resistors 62 and 63 whereby the resistor section 63 is included in the grid bias supply circuit for said first intermediate frequency amplifier stage when receiving signals in the bands X and A. The remaining contacts of the switch 68 and the circuit connected therewith will hereinafter be described.

Referring now to the second detector 14, it will be noted that it is provided with a cathode 70, two diode plates 71, a control grid 72 and an output anode 73. The diode electrodes together, and the cathode, providing the detector or rectifier, are connected with the signal input circuit provided by the coupling transformer 55, while the grid and plate in conjunction with the cathode provide audio frequency amplification of the rectified signal. The rectified signals are supplied to the control grid 72 from a resistor 74 in the diode circuit. The latter circuit is grounded between the resistor 74 and the cathode 70, as indicated. The control grid connection indicated at 76 is made with the high potential end 77 of the resistor 74 through a terminal board connection 78.

The rectified signal also provides a direct current voltage drop across the resistor 74, whereby the detector and its circuit are utilized as part of a second automatic volume control system for the receiver. More particularly, the second automatic volume control means or second detector, of the diode type, provides both rectified signals for application to the self-contained first stage audio frequency amplifier, and direct current potentials resulting from signal rectification, for automatic volume control purposes.

In the present example, the signal controlled voltage available across the resistor 74 is applied to the second intermediate frequency amplifier for bias and automatic volume control purposes, in all-wave bands, through a suitable potential supply connection comprising a filter resistor 80, a filter by-pass condenser 81 therefor and a potential supply lead 82 connected to the grid circuit of the second intermediate frequency amplifier tube 13 through the secondary of the coupling transformer 54.

The automatic volume control potential derived from the second detector as a signal rectifier may also be applied to other amplifier and detector tubes in the receiver and, in the present example, is applied to the first intermediate frequency amplifier tube 12 and to the first detector signal input grid through a supply lead 83 which is connected through a filter comprising a resistor 84 and a condenser 84a, between the supply lead 82 and the contacts B, C and D of the switch 68. The first intermediate frequency amplifier tube and the first detector tube are therefore placed under control of the second detector along with the second intermediate frequency amplifier when the receiver is adjusted to receive signals in the higher frequency bands B, C, and D.

It has been found that the dual automatic volume control system above described provides for more uniform signal output level under receiving conditions encountered in different bands covering a wide frequency range. For example, in the broadcast and long-wave bands X and A signal levels are relatively high with respect to the higher frequency or shorter wave bands and with compensated volume control means, a constant input to the second detector must be maintained under different receiving conditions in all bands. The double channel intermediate frequency automatic volume control means serves to maintain substantially a constant input to the second detector and yet does not function on an extremely weak signal.

In the short-wave bands, however, receiving conditions are different in that the signal strength is usually comparatively low and fluctuates widely. For this reason it is important to have automatic volume control action below the level at which the double channel system works. This is provided by the diode automatic volume control action of the second detector, which functions on the first detector and two intermediate frequency amplifier stages on the shorter wave bands. It should be noted that this action is present on the second I. F. stage on all bands. This further flattens the action of the double-channel system in bands X and A.

The automatic volume control system thus includes a source of amplified signals providing delayed control potentials, and a combined detector and rectifier as a source of further

amplified signals, substantially in cascade along the signal channel with respect to the first automatic volume control means, providing control potentials without delayed action. The selecting means is operative with the wave changing means being arranged to apply the latter potential for controlling a major portion of the circuits for the higher frequency bands.

Selective automatic adjustment of the sensitivity or gain and manual control of the major portions of the signal circuit thereby is provided by further selective control means connected with the wave changing means as will now be described.

The sensitivity or gain control of the receiving system is manually adjustable by means of the device **37—38** and is further automatically adjustable by the operation of a switch **85** having the same number of contacts or positions as the wave-changing and automatic volume control switches, and connected therewith for simultaneous operation.

In the present example, the switch arm, indicated at **86**, is connected through a circuit lead **87** with the cathode lead **42** of the first detector, the connection being completed through a pair of leads **88** and a terminal board **89**. The lead **87** is also connected through a circuit lead **90** with a tap point **91** between the sensitivity control resistor **37** and the self-bias resistor **36** in the cathode lead **35** of the tube **10**.

As will be seen from an inspection of the circuit diagram, the above described circuit connections provide for connecting the negative ends of the self-bias resistors **36** and **43** together, and, through the variable resistor **37**, to ground. The anode current for both the tube **10** and **11**, therefore, is caused to flow through the variable resistor **37**, thereby providing manual sensitivity control for a major portion of the circuits of the receiver.

It will further be seen that as the resistance of the device **37** is increased as by moving the contact **38** downwardly, as viewed in the drawings, the bias potential upon the radio frequency amplifier stage and the first detector will be increased and the sensitivity or gain of the receiver will correspondingly be reduced. This is a condition for operation on the longer wave bands, X and A.

In these longer wave bands, however, the gain of the intermediate frequency amplifier is reduced through any suitable means such as increased biasing potential in addition to a normal self-bias potential derived from self-bias resistors indicated at **100** and **101** in the first and second I. F. stages, respectively. For applying the additional potential, the self-bias resistors are connected together at their negative ends through a circuit connection lead **102** and are further connected with the tap points B, C, and D of the switch **85**, as indicated at **103**. The lead **102** is connected to ground through a potential drop producing impedance or resistor **104** providing the additional source of biasing potential for both of the intermediate frequency amplifier tubes.

From an inspection of the switching connections provided by the switch **85**, it will be seen that operation of the switch on the contacts X and A serves to permit the additional biasing potential provided by the resistor **104**, through which the anode current for both intermediate frequency amplifiers flows, to be applied to the intermediate frequency amplifiers to reduce the gain by increasing the negative biasing potential. When the switch arm **86** is moved to the position B, C or D the variable resistor or sensitivity control device **37** is connected in parallel with the resistor **104**. Therefore, when the contact **38** is moved to reduce the resistance **37** to zero, the resistor **104** is likewise short-circuited and reduced to zero. The gain of the radio frequency amplifier and first detector as well as the connection of the first and second intermediate frequency amplifier stages is then at a maximum value. Thus the amplifier and detector stages may simultaneously be controlled in gain or sensitivity by adjustment of the contact **38**, in the higher frequency bands.

Stated in other words, the manual sensitivity or gain control means is automatically adjusted whereby, in bands X and A, it controls the radio frequency amplifier and first detector, while in bands B, C, and D it controls in addition, the two intermediate frequency amplifier stages at a higher gain level in the intermediate frequency amplifier. The reason for this is, that for a given degree of sensitivity in bands X and A the residual bias potential must be considerably higher in the radio frequency and first detector stages than in the bands B, C, and D. This prevents possible overloading of these stages due to the high-signal strengths encountered in bands X and A. Also, in bands B, C, and D, for a given degree of sensitivity the radio frequency amplifier stage operates at a higher gain, which gives an improved signal to noise ratio. In the present example, it will be seen that the gain is increased by the manual gain control resistor **37** being connected, in effect, in parallel with the bias resistor **104** for the high frequency bands, thereby simultaneously reducing the bias potential on the intermediate frequency amplifier stages and increasing the gain therein and placing said amplifier under control of the sensitivity or gain controlling device **37**.

It has been found that as a result of reducing the intermediate frequency amplifier gain while providing manual control of the radio frequency amplifier and detector gain for the stronger higher wave band signals, and selectively switching in the intermediate frequency amplifier for manual control on the lower wave bands (higher frequency) interfering pickup on I. F. leads when the sensitivity of the receiver is reduced by manually operated sensitivity control on bands B, C, and D is much reduced and the signal to noise ratio is improved. The switching control further provides a volume control system which will control signals to the maximum of sensitivity of the receiver on hands B, C, and D, that is, the higher frequency bands.

It will be noted that the wave-changing switches **23** and **26** provide for changing the biasing potential on the radio frequency amplifier stage and the first detector when said switches are moved to the position D for the shortest wave range. This is accomplished through the direct ground connections **34** and **41** which eliminate the automatic volume control potential source provided by the resistors **62** and **63** for the radio frequency stage. It also eliminates the automatic volume control connection for the first detector provided by the second detector from the resistor **74**. In other words, the operation in the band D is similar to the bands B and C except that no automatic volume control bias potential is applied to the radio frequency amplifier and first detector tubes and this is accom-

plished by the simple expedient of grounding the grid coils in the system shown. For the very short wave lengths employed, this is of advantage for the reason that short, direct circuit connections are provided as is desirable for stability of operation and for reducing stray interstage coupling.

The advantages of the control system provided may be appreciated from a consideration of the various wave bands, covered by the receiving system shown. It will be noted that the frequency of operation in the band D is relatively high. The operating wave bands of a receiver embodying the invention as herein described are as follows:

Band	Kilocycles
Band X	140–410
Band A	540–1720
Band B	1720–5400
Band C	5400–18,000
Band D	18,000–36,000

Referring further more particularly to Fig. 1, the second detector signal output is taken through a suitable volume and tone controlling network indicated at **110** and is applied to the balanced driver stage **112** which includes the tubes **15**, through a push-pull input transformer **111**. The tubes **15** are connected through a push-pull interstage coupling transformer **113** with a balanced power output stage including the tubes **16**. The output tubes **16** are connected through a push-pull output transformer **114** with a suitable sound producing or loud speaker device **115**.

It will be noted that the power output stage utilizes a fixed biasing potential for the tubes **16** which is derived from a ground connection **116** for the cathodes of tubes **16** and a grid supply lead **117** which is connected to the negative end **118** of a potential source **119** in the power supply system **61**, this source being provided in the present example by a resistor having a ground connection **64** as indicated.

Automatic adjustment of the fidelity or tone of the receiver is desirable for various reasons. Under present broadcasting conditions it is necessary to reduce hum noises particularly in the higher frequency bands where percentage modulation is lower and tendency for acoustic feed back to circuit elements causing frequency variation in tuning may result in additional noisy operation. Also, a reduction of the response characteristic of a receiver may be desirable to provide a balance of audio frequency response about a predetermined mean frequency. To this end the higher frequency response may be reduced with selective circuits causing side band reduction, and a corresponding reduction in low frequency response may be required to maintain a uniform tone.

Accordingly, it has been found that tone control means may to advantage be connected with the wave changing means to provide a change in the audio frequency response characteristic of a receiver for differing wave bands.

A switching or selector means adapted for operation as a tone control means is indicated at **135**, and having connection with the audio frequency amplifier through leads **136** and **137** at a suitable point for effecting a change in fidelity or tone.

In the present example, the selector means **135** is a switch having the same number of points or selector positions as the wave changing switches and connected to reduce the low frequency response when wave bands B, C, and D are used. The switch points corresponding to said bands are connected together and to the lead **136** while the switch arm is connected to the lead **137**. The two leads **136** and **137** are connected with differing points **138** and **139** respectively on a tone control network comprising a series condenser **140** in the audio frequency circuit and a shunt choke coil **141** controlled by a potentiometer device **142** as a low frequency tone control means. The switch serves to connect the movable contact **143** of the potentiometer to the end of the resistor section thereof adjacent to the choke coil and at the opposite end from the series condenser **140**. The series condenser **140** serves to attentuate low frequency signals as does the shunt choke coil **141**. Therefore, a reduction in low frequency response results when the bands B, C, or D are in use. For the bands X and A the switch **135** is open and no attenuation of low frequency signals results.

Other suitable tone or fidelity control connections may be provided, however, for the same or differing selector means and attenuation in other audio frequency ranges as may be desired. The tone control system shown has the advantage that it may be operated to a limited degree to increase and decrease the low frequency response below a certain frequency when the bands B, C and D are in use. This is for the reason that the contact **143** is movable from a lower to a higher position as viewed in the drawings, along the resistor **142** to gradually short circuit the series condenser **140** and thereby increase the low frequency response.

With reference to the diagram in Fig. 2 and the bias potential supply circuits of Fig. 1 shown separately therein, it should be noted that in order to simplify the circuit diagram further, two switches **130** and **131** are provided in lieu of the wave-changing switches **23** and **26** of Fig. 1, to indicate the grounding of the input circuits for the radio frequency amplifier and the detector for the band D. The wave band switches have been eliminated to simplify the diagram. The gain control selector switch **85** and the automatic volume control selector switch **68** are shown with all of the contacts as arranged in Fig. 1 for five-band reception. For the sake of further simplifying the drawings, the interstage transformers, whether tuned or untuned, are shown without tuning means.

From the foregoing description it will be seen that in an all-wave superheterodyne radio receiving system it is particularly advantageous to have the automatic volume control and the sensitivity control means automatically or selectively adjustable with changes in the wave bands to be received, and this is particularly desirable in connection with a receiver such as that shown and described, which is adapted to cover a relatively wide frequency range including a plurality of bands, certain of which include the relatively high frequencies. For example, it will be noted that in the present receiver, the band D extends to 36,000 k. c., which is below 10 meters.

The advantages in automatically adjusting or reducing the sensitivity of a radio receiver in succeeding amplifier stages, preferably in the intermediate frequency amplifier, while retaining manual control of the preceding lower signal voltage stages, such as the input or radio frequency and first detector stages, for higher signal intensities offered at present by stations in the lower frequency channels, together with delayed

automatic volume control in the input stages and separate automatic volume control of a succeeding stage such as the intermediate frequency output stage, are the reduction of noise to signal ratio in all wave bands, lack of distortion because of a uniform loading of the second detector and comparatively flat automatic volume control characteristic.

I claim as my invention:

1. In a multi-range radio receiver, the combination with wave band selector means, of means controllable by said selector means for changing the signal amplification in certain portions of said receiver in response to wave band change, automatic volume control means, and selector means for connecting said automatic volume control means with certain predetermined gain controlling circuits of said receiver in response to wave band change.

2. In a multi-range radio receiver, the combination with wave band selector means adapted to adjust said receiver for response in a plurality of differing wave bands, of means responsive to variations in the amplitude of a received carrier wave and in cascade connection along said signal channel providing automatic volume control potentials having differing control characteristics, signal amplifying means having gain control connections, and means conjointly controllable with said wave band selector means for applying said potentials selectively to certain of said gain controlling connections in response to wave band changes.

3. In a radio receiving apparatus, the combination with an electric discharge signal amplifier, of automatic volume control means providing differing automatic volume control characteristics in response to variations in the amplitude of a received carrier wave, wave band selecting means, and means for selectively controlling said amplifier in accordance with one of said automatic volume control characteristics when said wave band selector means is adjusted for reception in one predetermined band, and for controlling said amplifier in accordance with the other of said automatic volume control characteristics when the wave band selecting means is adjusted for reception in another predetermined band.

4. In a radio receiver, the combination with wave band selector means, of means providing two separate signal amplifying channels, means connected with each of said channels providing separate automatic volume control potentials and uni-control means connected with said wave band selector means for simultaneously adjusting gain controlling connections in said receiver and automatic volume control connections selectively with said control potentials in response to operation of said wave band selector means, whereby said receiver is automatically adjusted for differing conditions of reception in differing wave bands to provide substantially constant signal output.

5. The combination with a multi-range radio receiver having wave band selector means, sensitivity control means, and automatic volume control means, of a second automatic volume control means, and means simultaneously controllable with said wave band selector means for connecting differing predetermined gain controlling portions of said receiver selectively with either of said automatic volume means and with said sensitivity control means, whereby differing degrees of control are derived therefrom for differing wave bands.

6. In a multi-range radio receiver, the combination with selective wave band changing means, of gain controlling means, automatic volume control means providing two differing control potentials from differing sources, and means controllable by said wave band changing means in connection therewith for simultaneously changing the automatic volume control from one source to the other and the signal gain through said receiver in predetermined relation to the seclected wave band.

7. In a system for receiving radio signals over a relatively wide frequency range in a plurality of separate frequency bands, the combination with frequency band changing means, of gain control means, automatic volume control means, a second automatic volume control means, and selector means operable in connection with said frequency band changing means by common control for selectively therewith establishing predetermined gain controlling connections with either of said automatic volume control means.

8. In a radio receiver having a signal channel adapted for receiving signals over a relatively wide frequency range in a plurality of separate frequency bands and having frequency band changing means, of a volume control system therefor comprising a gain control circuit connected with said signal channel, an automatic volume control circuit connected with a portion of said signal channel, a second automatic volume control circuit connected with a portion of said signal channel following the first named portion, a fidelity control circuit connected with the signal channel, and selective control means in each of said circuits connected with said frequency band changing means and operable simultaneously therewith to change the response characteristic of the receiver with changes in the frequency bands in predetermined mutual relation.

9. In a radio receiving system, the combination of wave band selecting means for adjusting said system for signal response in a plurality of differing frequency ranges, automatic volume control means connected with and controlling a signal amplifying portion of said system, a second automatic volume control means connected with and controlling a second signal amplifying portion of said system, and selector means, simultaneously operable in connection with said wave band selecting means, for connecting a further signal amplifying portion of said receiving system selectively with either of said automatic volume control means for differing frequency ranges.

10. In a radio receiving system having wave band selector means, the combination of automatic volume control means therefor, amplifier means for supplying a signal wave to said automatic volume control means, a detector of the diode rectifier type, amplifier means separate from the first named amplifier means for supplying a signal wave to said detector, means for deriving automatic volume control potentials from said detector, and selector means for applying said potentials to a portion of said receiver in response to adjustment of said wave band selector means.

11. In a radio receiver, the combination of wave band changing means, sensitivity control means, automatic volume control means, fidelity control means, and means conjointly operable with said wave band changing means for changing a condition of operation of said sensitivity, automatic volume control and fidelity control

means simultaneously with changes in wave band.

12. The combination with a radio receiver adapted to operate over a frequency range including relatively low and relatively high signal frequencies and having band selector means for adjusting the tuning, of means providing automatic volume control potentials and delayed automatic volume control potentials, and selector means operative with the frequency band selector means for applying the delayed control potentials to a plurality of the amplifying circuits of the receiver when said receiver is adjusted for response in the lower frequency ranges.

13. In a radio receiving system, the combination with wave-band-changing means for adapting said system to receive signals in a plurality of wave bands, the combination of means providing a plurality of volume controlling potentials at least two of which are variable in differing degrees in accordance with variations in the strength of a received carrier wave and certain of which are variable manually, a radio frequency amplifier stage having gain control connection with one of said first named potentials, and with said manually variable potential, an output intermediate frequency amplifier stage having gain control connection with another of said first named potentials, whereby the gain of said last named amplifier stage and radio frequency amplifier stage are controlled in differing degrees, an intermediate frequency amplifier stage having gain control connections selectively with said first named potentials, means for changing said last named connections in response to wave band change, and means for changing the gain in at least one of said amplifier stages independently of said volume controlling potentials, in response to wave band change.

14. In a radio receiving system, the combination wtih wave-band-changing means for adapting said system to receive signals in a plurality of wave bands, the combination of means providing a plurality of volume controlling potentials at least two of which are variable in differing degrees in accordance with variations in the strength of a received carrier wave and certain of which are variable manually, a radio frequency amplifier stage having gain control connection with one of said first named potentials, and with said manually variable potential, an output intermediate frequency amplifier stage having gain control connection with another of said first named potentials, whereby said last named amplifier stage and radio frequency amplifier stage are controlled in differing degrees, an intermediate frequency amplifier stage having gain control connections selectively with said first named potentials, means for changing said last named connections in response to wave band change, means for changing the gain in at least one of said amplifier stages independently of said volume controlling potentials, in response to wave band change, and circuit connections through said wave band changing means for breaking said first named gain control connection for the radio frequency amplifier in response to wave band change to a predetermined higher frequency wave-band.

15. In a multi-range selective wave band radio receiving system, the combination of means providing a signal amplifying channel, a detector connected therewith, automatic volume control means connected with a portion of the signal channel and including additional amplifier means, said automatic volume control means and said detector providing controlling potentials responsive to variations in the strength of a received carrier wave, and means for automatically supplying certain portions of the receiving system selectively with either of said potentials for controlling the gain of said receiver in differing degrees automatically in accordance with changes in wave band.

16. In a radio receiving system, the combination of wave band changing means for adapting said system to receive signals in a plurality of differing wave bands, automatic volume control means connected in parallel with and separate from a portion of the signal channel of said system and including amplifier means, providing controlling potentials responsive in differing degrees to variations in the strength of a received carrier wave, means for automatically connecting certain portions of the receiving system selectively with said potential-providing amplifier means to apply said potentials for controlling the gain of said receiver automatically in different degrees for certain of said differing wave bands to be received, and means for independently controlling the sensitivity of said system in accordance with certain changes in wave band selection.

17. In a superheterodyne radio receiving system, having wave band selecting means for adapting said system to receive signals in a plurality of differing wave bands, the combination of automatic volume control means comprising a pair of signal rectifying devices, means for deriving a gain controlling potential from one of said devices and a delayed gain controlling potential from the other of said devices, signal amplifying means, means for selectively connecting said signal amplifying means with said gain controlling potentials in accordance with changes in wave band selection, means for controlling the gain of said system, and means for independently changing the gain of said system in accordance with changes in the wave band selection.

18. In a superheterodyne radio receiving system, the combination of wave band changing means, automatic volume control means including a second detector providing volume controlling potentials which vary in differing degrees in response to changes in the amplitude of a received carrier wave, selector means operable conjointly with said wave band changing means for independently adjusting the sensitivity of at least a portion of said receiving system and for selecting a volume controlling potential from said automatic volume control means in accordance with changes in wave band selection, and means for controlling the gain of said system.

19. In a superheterodyne radio receiving system, the combination of wave band changing means, automatic volume control means including a second detector providing volume controlling potentials which vary in differing degrees in response to changes in the amplitude of a received carrier wave, and selector means operable with said wave band changing means for independently adjusting the sensitivity of at least a portion of said receiving system and for selecting a volume controlling potential from said automatic volume control means in accordance with changes in the wave band.

20. In a superheterodyne receiver, the combination of means for changing the wave bands over which the receiver is operative, and means for changing the sensitivity, automatic volume

control and fidelity of said system in accordance with changes in wave band selection.

21. In a multi-range superheterodyne receiver having a radio frequency amplifier and an intermediate frequency amplifier, the combination of gain control means for said radio frequency amplifier, separate automatic volume controlling means for said radio frequency amplifier and for said intermediate frequency amplifier, wave band changing means, and means simultaneously operable therewith for changing the gain in said intermediate frequency amplifier and for connecting said intermediate frequency amplifier with said gain control means for simultaneous control with said radio frequency amplifier.

22. In a multi-range superheterodyne receiver having a radio frequency amplifier and an intermediate frequency amplifier, the combination of gain control means for said radio frequency amplifier, separate automatic volume controlling means for said radio frequency amplifier and for said intermediate frequency amplifier, wave band changing means, means simultaneously operable therewith for changing the gain of said intermediate frequency amplifier and for connecting said intermediate frequency amplifier with said gain control means for simultaneous control with said radio frequency amplifier, an audio frequency amplifier including a tone controlling network, and means for simultaneously adjusting the response characteristic of said network with adjustment of said wave band changing means.

23. In a radio receiving system, the combination of means for selectively changing the tuning of said system for the reception of signals in differing frequency bands and means selectively operable simultaneously with said first named means for adjusting the sensitivity and tone quality of said system, automatic volume control means, and means for controlling the operation of said automatic volume control means in accordance with changes in tuning of said system.

24. In a superheterodyne receiver adapted to be tuned over a relatively wide frequency range, the combination of a radio frequency amplifier stage, automatic volume control means connected with said stage for controlling the gain of said stage, an intermediate frequency output stage, automatic volume control means including a second detector for controlling the gain of said output stage, and means for connecting certain signal amplifying stages of said receiver selectively with a predetermined one of said automatic volume control means when said tuning range is adjusted.

25. In a multi-range superheterodyne receiver, the combination of wave band changing means therefor, a radio frequency amplifier, an intermediate frequency amplifier, automatic volume controlling means for said radio frequency amplifier, a second automatic volume controlling means for said intermediate frequency amplifier, and means for controlling the application of automatic volume controlling potentials to at least one of said amplifiers from one of said automatic volume controlling means.

LOREN R. KIRKWOOD.