

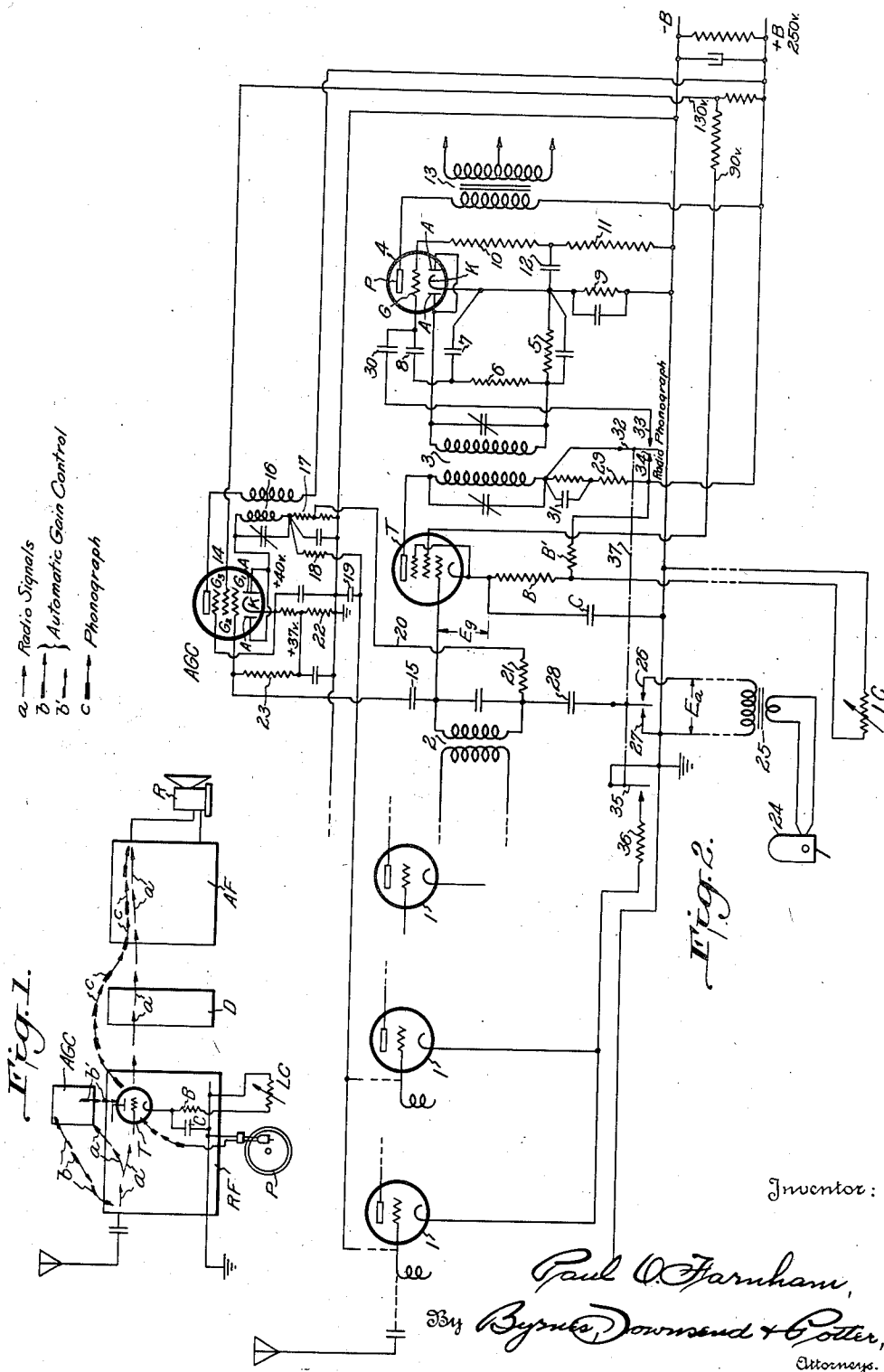
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RADIO RECEIVER

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RADIO RECEIVER

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This invention relates to radio receivers and particularly to the design of circuits that determine the audio output or room level of reproduction of carrier wave signals and/or phonograph records when such level is controlled from a point remote from the audio amplifier system of the receiver.

The invention is also applicable in case the control of output level is not remote from the audio amplifier system.

Prior known systems for the remote control of the room level of reproduction have been comparatively expensive and complicated or have lowered the tone quality. When the receiver includes connections to a phonograph pick-up it has been the practice to provide a separate room level control for the phonograph attachment. The present practice of operating the audio detector of radio receivers at high carrier levels has further complicated the design of radio-phonograph combinations since the audio amplification provided for the reproduction of radio programs is usually insufficient for satisfactory phonograph reproduction.

A distortionless control of the audio output level may be obtained by varying a direct current bias on a radio frequency amplifier tube in a manual control stage which follows a radio amplifier of the automatic gain control type.

An object of the invention is to provide a radio receiver including circuit arrangements for the reproduction of locally produced audio frequency signals, such as delivered by a microphone or a phonograph pick-up, and in which higher audio amplification is provided for locally produced audio signals than is employed for radio reception. An object is to provide, in a radio receiving system adapted to reproduce local phonograph records, a simple and efficient control of room level output associated with a stage which amplifies modulated carrier waves during radio reception and amplifies audio frequencies during phonograph reproduction. A further object is to provide a control of the type just stated which may be located at the receiver itself but which is particularly adapted for use with remote controlled receivers. More specifically, an object is to provide a radio-phonograph combination including a radio amplifier in which the gain is automatically controlled before demodulation of the radio signal and an amplifier or control stage at which the radio voltage level is held approximately constant by the radio amplifier, the control stage being operated as a radio amplifier

for radio reception and as an audio amplifier for phonograph operation.

These and other objects and advantages of the invention will be apparent from the following specification, when taken with the accompanying drawing in which:

Fig. 1 is a schematic view of an embodiment of the invention which graphically illustrates the method of operation contemplated by the invention;

Fig. 2 is a fragmentary circuit diagram of an embodiment of the invention.

In the schematic view, the reference character RF identifies the radio frequency amplifier of a radio receiver, the amplifier including stages of carrier wave amplification and, in the case of a superheterodyne, one or more stages of intermediate frequency amplification. The last tube T of the amplifier RF works into the detector D, and the resulting audio frequency voltages are amplified in the audio amplifier AF and reproduced by an appropriate device R.

The path taken by a received radio signal is indicated by the unfeathered arrows *a* in Fig. 1, and it will be noted that the amplified radio frequency voltages are impressed in parallel upon the last amplifier tube T and upon an automatic gain control unit AGC. The direct current bias voltage developed by the gain control unit is returned to the preceding amplifier tubes (not shown) as a gain control bias to maintain an approximately constant radio voltage level at the input to the tube T. The radio voltage level at the detector D may be held substantially constant, so far as concerns the operation of the automatic gain control, by impressing a fraction of the available gain control voltage upon the control grid of the amplifier T. The path of the bias voltage applied to the first amplifier tube or tubes is indicated by the longer single-feathered arrows *b*, and the bias voltage applied to the tube T is shown by the similar but shorter arrows *b'*.

The room level of reproduction is not controlled by a regulation in the audio frequency system but by a regulation of the radio frequency or audio frequency gain in a stage subsequent to that point in the amplifier system which feeds the automatic gain control. As shown, the cathode circuit of the tube T includes a fixed bias resistor B and a resistance LC which may be manually adjusted to regulate the room level of reproduction. The resistance LC may be located within the receiver for local operation or may be connected between resistor B and ground by a cable extend-

ing to any convenient point. It is particularly to be noted that the cable leads are filtered for alternating currents by the bypass condenser C, and that only a direct current voltage is impressed across the cable leads. This system of manual control has decided advantages over the customary manual control by a regulation in the audio frequency system. A bias control in the high level audio stages will result in substantial distortion and a remote control including a voltage divider located between the detector and first audio amplifier will be comparatively expensive if good quality reproduction is to be obtained.

When a phonograph attachment is included in the receiver, the audio frequency voltage developed by a suitable pick-up is not impressed upon the first stage of the audio amplifier AF, but upon the radio frequency amplifier tube T, and the amplified voltage is then transferred to the audio amplifier, as indicated by the double-feathered arrows c. A circuit of this type has the double advantage of providing high amplification for phonographic reproduction, and of employing the radio room level control LC for regulating the room level for phonographic reproduction.

In the circuit diagram, Fig. 2, the detailed circuit connections of the radio frequency amplifier are not shown as the invention is not dependent upon the exact form or method of operation of this section of the receiver. A plurality of tubes 1 are illustrated and, if desired, one of these tubes may have its circuits so arranged that it constitutes a frequency changer for reducing the incoming carrier wave to an intermediate frequency. The last tube T of the radio amplifier is coupled to the preceding tube by a transformer 2 which is tuned to the frequency of the desired carrier or to an intermediate frequency in the case of a superheterodyne receiver. The plate circuit of tube T includes the primary of a tuned coupling transformer 3 which feeds the detector which preferably takes the form of the diode elements of a tube 4 of the commercial design known as type 55. As shown, the high potential terminal of the secondary of transformer 3 is connected to the joined anodes A and the low potential terminal is connected to the cathode K through the audio load resistance 5. The audio voltage is transferred to the control grid G of tube 4 through a radio frequency filter comprising resistance 6 and condenser 7, the grid connection including a blocking condenser 8. The cathode circuit includes the bias resistance 9 and the direct current bias is impressed on the grid G through the sections 10, 11 of a high resistance, the junction of the sections being connected to the cathode through a bypass condenser 12. The amplified audio voltage developed in the plate circuit is transferred to the succeeding audio amplifier stage or stages, usually a push-pull audio amplifier, through a transformer 13.

The automatic gain control system AGC comprises the combined radio frequency amplifier and detector tube 14 which may take the form of a pentode amplifier and diode rectifier. The control grid G_1 is connected to the secondary of transformer 2 through a condenser 15 and the plate circuit includes the primary of a tuned transformer 16 which impresses the amplified radio voltage upon the anode or anodes A of the diode rectifier. The secondary of the transformer 16 is connected to ground through the resistance 17 across which the rectified direct current voltage

is developed. The negative terminal of resistance 17 is connected to the control grids of one or more of the radio amplifier tubes 1 through the usual resistance-capacity filter 18, 19. A fraction, which may be about one-fifth, of the total gain control voltage is applied to the control grid of tube T by a lead 20 which is tapped into an intermediate point on resistance 17 and which includes a resistance 21. Appropriate bias voltage for the control grid G_1 of tube 14 is provided by connecting the grid G_1 to an intermediate point on the bias resistor 22, through the usual resistance 23, while suppressor grid G_3 is ordinarily tied to the cathode.

The manual control of the room level of reproduction is substantially as shown in Fig. 1. The fixed bias resistor B is of such value that, when the adjustable resistance LC is set at zero, the tube T will operate at its normal or maximum gain. The bias voltage E_g on the tube T is thus made up of a component derived from the automatic gain control tube 14 and of a component which depends upon the adjustment of the manual control resistance LC. The junction of resistances B, LC is connected to a point of positive direct current potential, +B, through a resistance B', providing an available potential drop across the adjustable resistance LC which is not dependent upon the space current flow in tube T.

The usual by-passing condensers are shown in the circuits of the tubes T, 4 and 14, but will not be listed in detail as the necessity for and choice of values for such elements is well known in the art.

The phonograph pickup 24 is connected across the primary of an audio frequency transformer 25 that has its secondary connected between ground and one contact 26 of a single pole double throw switch, the other contact 27 being grounded. The contact arm of the switch is connected through a condenser 28 to the low potential (radio frequency) of the secondary of transformer 2, and the audio voltage E_a is thus impressed on the grid of the radio amplifier tube T. The amplified audio voltage developed by tube T is transferred to the first audio amplifier 4 by a resistance coupling which comprises the resistance 29 and the audio frequency condenser 30, the resistance 29 being connected between the plate coil of transformer 3 and the plate current source indicated as +B.

It is usually desirable to have an audio frequency gain characteristic for phonographic reproduction which is different from the gain characteristic for radio reception. High frequency scratch noises may be eliminated by connecting a condenser 31 across a section of the coupling resistance 29, thus reducing the impedance of resistance 29 for the higher audio frequencies which may be present in output of the pickup device 24. A switch contact 32 is connected to the high potential audio frequency terminal of resistance 29 and is adjustable to a phonographic reproduction position, as indicated by the legend "Phonograph" to engage the contact 33 of the lead to the control grid G of the first amplifier of the audio system, or to engage the contact 34 to short circuit the resistance 29, as indicated by the accompanying legend "Radio."

Interference from radio signals during phonographic reproduction may be avoided by adjusting the switch 35 to open the cathode circuits of the first two radio amplifier tubes 1. The cath-

ode leads from the tubes include a resistance 36 that develops an appropriate bias on the said tubes 1 when the switch 35 is adjusted for radio reception. When the cathode circuit is opened to prepare the apparatus for phonographic reproduction, the transmission of radio signals is blocked in the first tubes of the radio amplifier.

As indicated by the dotted line 37, the several switches of the phonographic reproduction system are preferably connected mechanically for their simultaneous adjustment.

When the several switches are adjusted for radio reception, the control grid of the radio amplifier tube T is grounded for audio frequencies through condenser 28 and contact 27, and the coupling resistance 29 is shorted by the engagement of contacts 32, 34. At the same time, the switch 35 is closed and the apparatus functions as a radio receiver. The total bias on the tube T is determined by the adjustment of resistance LC, the direct current drop across this resistance being added to the biasing components due to resistance B and to the automatic gain control unit AGC. The maximum value of LC and the direct current voltage applied through resistance B' to its high potential terminal are so related that a desired low level of audio reproduction, or a complete suppression of all audio output, may be obtained by adjusting resistances LC towards higher values. This type of output level control will function without distortion of the received wave form since the radio voltage on the tube T is approximately constant and the range of adjustment of the bias voltage E_g , for full audio output control, is never excessive. As the control voltage is a pure direct current voltage, no difficulties are encountered when the control resistance is arranged at a distance from the receiver.

When the switches are adjusted for phonographic reproduction, an additional stage of resistance coupled audio amplification is provided by the tube T. Furthermore, the same control unit LC regulates the audio output level and the control unit and phonograph may be located at any desired distance from the radio receiver. As the transmission of radio signals is blocked by switch 35, the rectified output of the automatic gain control unit AGC is zero and therefore the bias applied to tube T is controlled only by the automatic bias resistor B and the manual control LC. With resistance LC set at zero, the voltage drop across resistor B biases the tube for maximum amplification. By increasing the effective value of the resistance LC, the cathode of tube T is made more positive by the current flow through resistance LC from the source of direct current, +B.

While the full advantages of the invention are obtained when the apparatus takes the form of a combined phonograph-radio receiver of the remote control type, it will be apparent that the phonograph reproduction system may be applied to receivers including other forms of output level control and not necessarily including an automatic gain control.

The invention is not restricted to the particular circuit arrangement herein illustrated and described, as various changes may be made in the circuit elements, and their relative locations in the reproducer system without departure from the spirit of my invention as set forth in the following claims.

I claim:

1. The method of increasing the audio amplification of a combined radio receiver-electrical sound reproducer system including a radio amplifier associated with an automatic gain control device arranged so as to maintain the amplifier output substantially constant, a detector and an audio amplifier which comprises converting a radio amplifier stage to an audio amplifier stage and at the same time rendering the automatic gain control inoperative when the system is to be employed for the electrical reproduction of sound, and transferring the amplified audio output of said converted stage directly to the audio amplifier.

2. The method as claimed in claim 1, in combination with the step of preventing amplification of high frequency energy as produced, for instance, by scratching in phonograph reproduction by said audio amplifier when the said radio amplifier stage is converted to an audio amplifier stage.

3. An electrical system for the reproduction of sound from modulated radio frequency waves and from audio frequency waves, said system comprising a radio frequency amplifier, a detector for converting the amplified radio output of said amplifier to electrical currents of audio frequency, an audio amplifier for amplifying said audio frequency currents, an automatic gain control operating on the radio frequency amplifier and arranged so as to maintain the output therefrom substantially constant, means adjustable to modify the characteristics of the radio frequency amplifier to adapt it to operate alternatively at audio frequencies and at the same time rendering the automatic gain control inoperative, and means operable simultaneously with such adjustment of said first means to render said detector inoperative and to transfer the output of the modified radio frequency amplifier to the said audio frequency amplifier.

4. The combination with a radio amplifier, a detector and an audio amplifier, a convertible stage provided with a manually operable volume control device adapted to amplify at radio frequency and alternatively at audio frequency, an automatic gain control operating on the convertible stage to maintain the output therefrom substantially constant at any setting of the manually operable volume control device, switch means operable to alternate positions to impress the radio output of said stage upon said detector when modulated radio signals are to be received and for impressing the audio output of said stage directly upon said audio amplifier when sound waves are to be reproduced from said source, circuit connections controlled by said switch means for impressing electrical waves from said source upon said stage and means controlled by said switch means for rendering the automatic gain control inoperative and for suppressing the reproduction of modulated radio signals when said switch means is positioned for the reproduction of sound from said source.

5. In a radio receiver, the combination with a detector and audio amplifier, of an amplifier stage having input and output circuits each including a radio frequency and an audio frequency impedance, switch means operable to exclude said audio frequency impedances from the respective circuits, means for impressing an audio voltage across the audio impedance of the input circuit, means coupling the detector to the radio frequency impedance of the output circuit, and means operable to couple the audio impedance of

the output circuit to the audio amplifier when the switch means is positioned to include said audio impedances in the respective circuits.

6. A radio receiver as claimed in claim 5, in combination with means adjustable manually to control the gain of said amplifier stage.

7. A radio receiver as claimed in claim 5, in combination with a radio frequency amplifier for impressing modulated radio signals across the radio frequency impedance of the said input circuit, and means automatically controlling the gain of said radio frequency amplifier to maintain the radio amplifier output approximately independent of variations in the strength of a received modulated carrier wave.

8. In a radio receiver adapted to reproduce phonograph records, the combination with a multi-stage radio amplifier working into a detector, an audio amplifier and a reproducer, of audio impedances and switch means for alternatively including said impedances in and excluding the same from the input and output circuits of the last stage of said radio amplifier, and means operable to couple the audio amplifier to the audio impedance in the output circuit of said last stage when said switch means is positioned to include said impedances in the respective circuits.

9. A radio receiver as claimed in claim 8, in combination with means manually adjustable to control the gain of said last amplifier stage.

10. A radio receiver comprising, in combination with a radio frequency amplifier, means automatically controlling the gain of said amplifier to maintain an approximately constant output level, a detector, an audio amplifier, and means for locally producing an audio frequency voltage, of an amplifier stage adapted alternatively to couple said radio amplifier to said detector or to couple said voltage producing means to said audio amplifier, said stage including a tube having an input circuit including a radio frequency circuit coupled to said radio amplifier and an audio impedance coupled to said voltage producing means, an output circuit for said tube including a radio frequency impedance coupled to said detector and an audio impedance, and switch means operable to one position to exclude said audio impedance from the respective circuits of said tube and to a second position to include said audio impedances in the respective circuits and to couple the second audio impedance to said audio amplifier.

11. In a radio receiver, the combination with a radio frequency amplifier comprising a plurality of cascaded tubes, a detector, and an audio frequency amplifier working out of said detector, of audio frequency impedances, switch means for alternatively including said impedances in or removing the same from the respective input and output circuits of the last tube of said radio frequency amplifier, means for impressing an audio frequency voltage across the first of said impedances, an audio frequency coupling between said second impedance and said audio frequency amplifier, and means for preventing the transmission of radio signals through said radio frequency amplifier when said switch means is

adjusted to include said impedances in the circuits of said last tube.

12. A radio receiver as claimed in claim 11, in combination with manually adjustable means for controlling the gain of said last tube of the radio frequency amplifier.

13. In a radio receiver, the combination with a radio frequency amplifier comprising a plurality of cascaded tubes, radio frequency input and output circuits for one of said cascaded tubes a detector coupled to the said output circuit, and an audio amplifier working out of said detector, of input and output audio frequency impedances, switch means for returning the said input and output circuits to the tube cathode alternatively through or to the exclusion of the respective impedances, and a coupling between the said audio amplifier and the said output impedance.

14. A radio receiver as claimed in claim 13, wherein said output impedance comprises a resistance and a condenser shunting a portion of the impedance, whereby the impedance presented by said resistance to audio frequency currents varies as a function of frequency.

15. A radio receiver as claimed in claim 13, wherein said detector and audio amplifier include a single vacuum tube housing the electronic elements of a detector and of a first stage of audio amplification.

16. In a radio receiver, the combination with a radio frequency amplifier comprising a plurality of cascaded tubes, a last amplifier tube and an automatic gain control tube having radio frequency input circuits fed in parallel from said cascaded tubes, means for returning the rectified output of said gain control tube to said cascaded tubes to bias the same, an audio frequency impedance and switch means for returning the input circuit of said last tube to ground alternatively through or to the exclusion of said impedance, means for impressing an audio frequency voltage across said impedance, a radio frequency output circuit for said last tube, a resistance connected between said output circuit and a source of direct current potential, a detector coupled to said output circuit, an audio amplifier including a control grid and cathode, a switch contact arm connected to the junction of said output circuit and resistance, a pair of switch contacts alternatively engaged by said contact arm and connected respectively to the other terminal of said resistance and to the control grid through an audio frequency condenser, and means for suppressing transmission of radio signals by said radio frequency amplifier.

17. A radio receiver as claimed in claim 16, wherein said last means includes a switch for opening the cathode circuit of at least one of the cascaded tubes of said radio frequency amplifier.

18. A radio receiver as claimed in claim 16, in combination with means adjustable to control the gain of said last amplifier tube, whereby the room level of reproduction of radio signals and of audio frequency voltages impressed across said impedance may be regulated by said adjustable means.

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