July 8, 1952 L. E. BARTON 2,602,851

REMOTE-CONTROL SYSTEM FOR RADIO APPARATUS

Filed Sept. 9, 1949 3 Sheets-Sheet 1

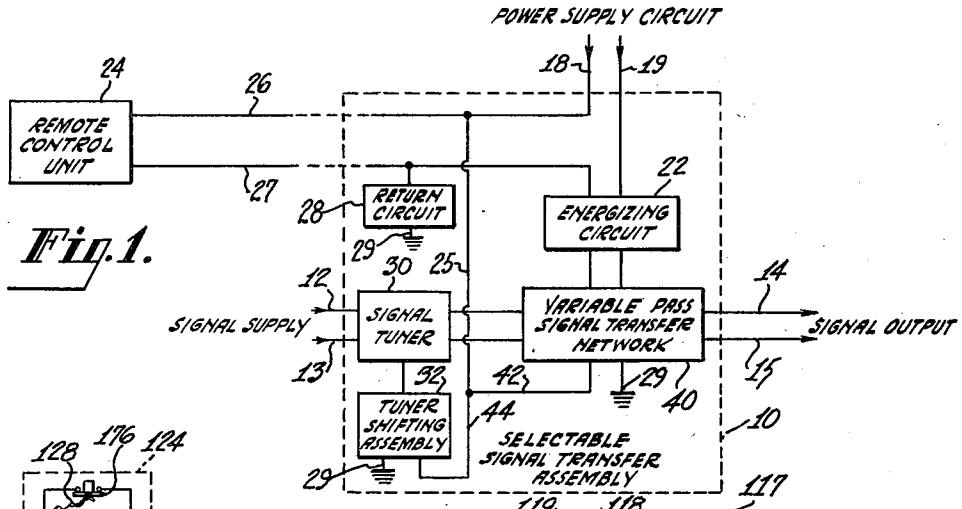


Fig. 1.

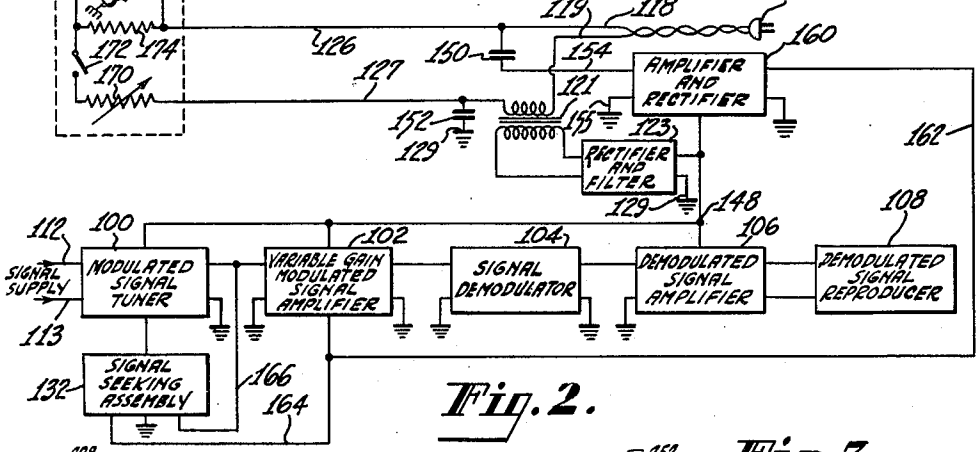


Fig. 2.

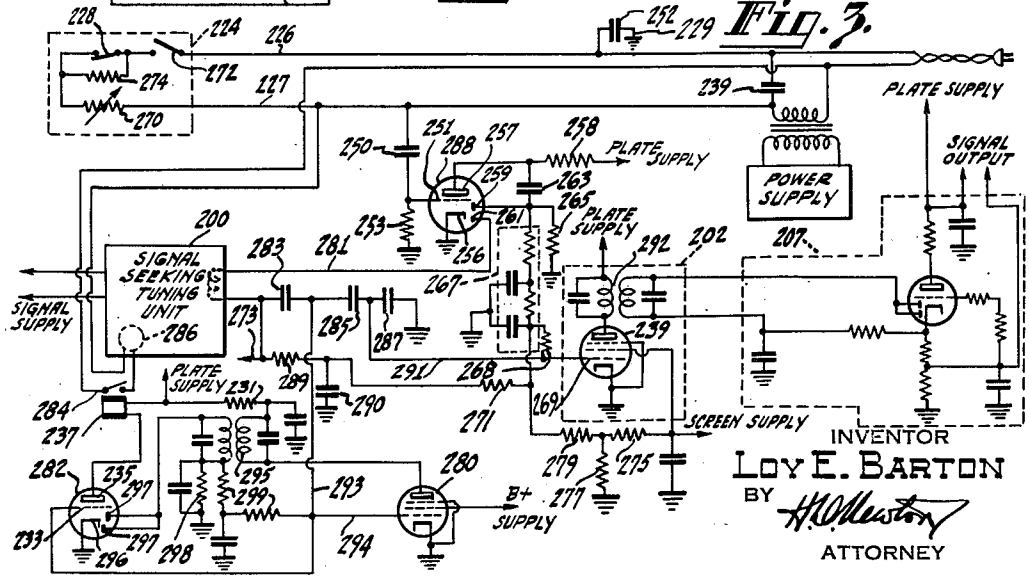


Fig. 3.

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REMOTE-CONTROL SYSTEM FOR RADIO APPARATUS

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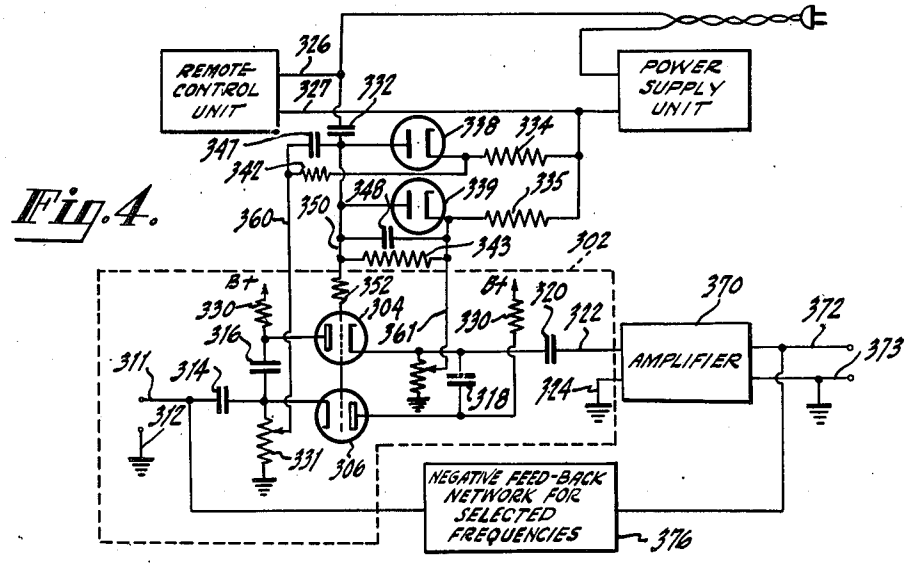


Fig. 4.

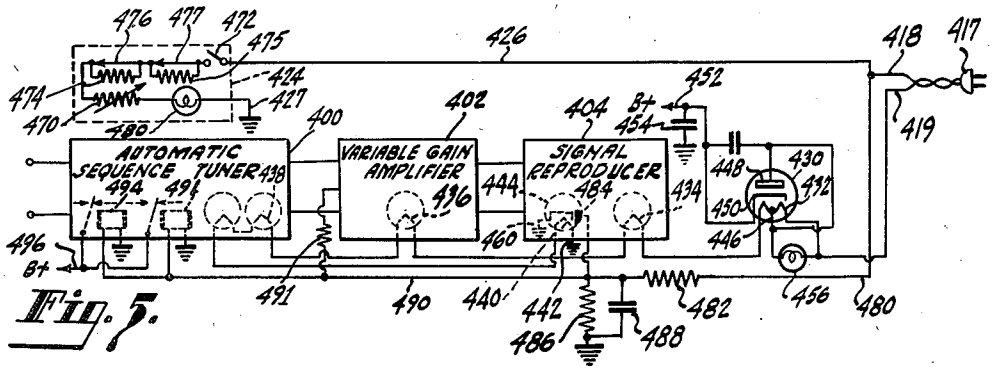


Fig. 5.

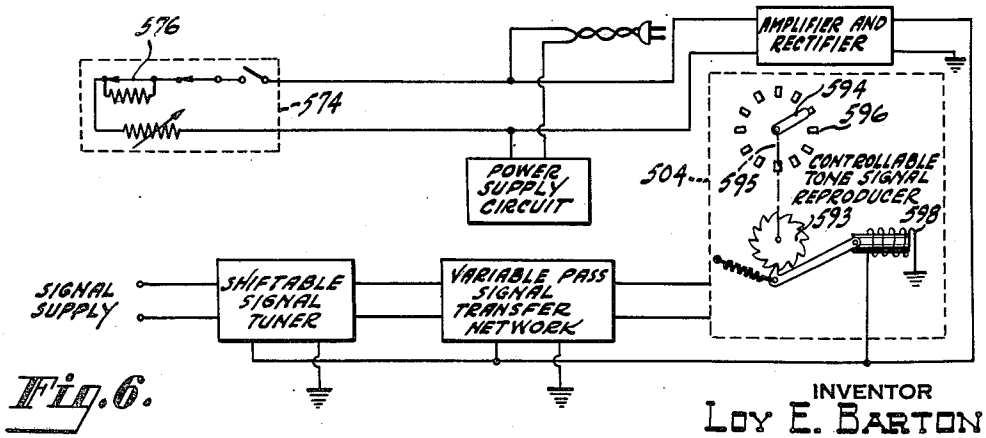


Fig. 6.

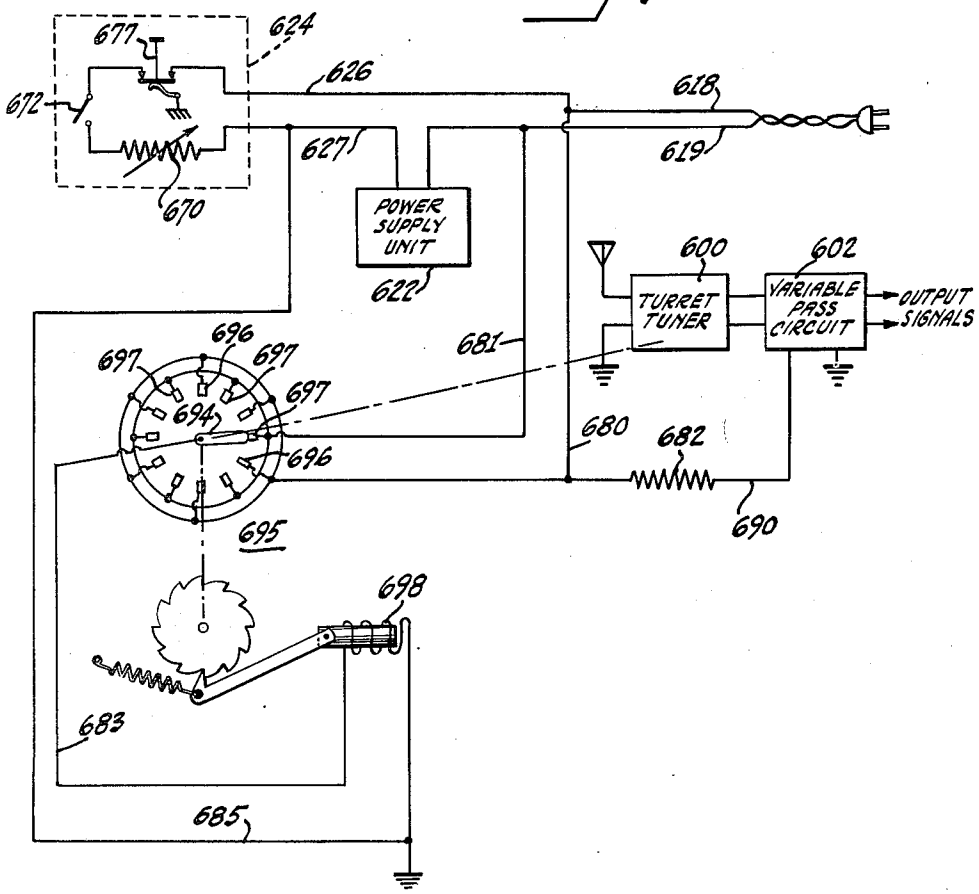
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REMOTE-CONTROL SYSTEM FOR RADIO APPARATUS

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Fig. 7.



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REMOTE-CONTROL SYSTEM FOR RADIO APPARATUS

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Application September 9, 1949, Serial No. 114,812

12 Claims. (Cl. 177—353)

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This invention relates to remote control systems, and more particularly to systems of this character for remotely controlling a plurality of the functions of signal transfer circuits, such as radio receivers and the like.

An illustrative embodiment of signal transfer apparatus to which the present invention pertains is a radio receiver of the type designed for home use. In order to suitable control such a radio receiver it is necessary not only to selectively tune it to any one of a plurality of signalling channels but also, among other things, to regulate the intensity of the reproduced sounds and to turn it on and off. Most radio receivers of the type commonly used in homes have the station selecting, signal amplifying and sound reproducing apparatus mounted in a single cabinet which also is provided with the necessary manually operable knobs for controlling the receiver functions.

It is generally recognized that the best performance of a radio receiver of the character described is obtained when the listeners, including the operator, are somewhat removed from the sound reproducing apparatus, such as a loudspeaker. Moreover, where the loudspeaker apparatus is of a high fidelity type, it is desirable that the listeners be located substantially directly in front of the loudspeaker because of the fact that the reproduced sounds of the higher frequencies do not have wide spreading characteristics. Accordingly, if the operator is close enough to the receiver to manipulate its control knobs, he is not in the best position to enjoy the sound reproduction and, in the case of a high fidelity system, he would probably be in such a position as to lessen the enjoyment of other listeners. Furthermore, an operator positioned adjacent to the receiver tends to adjust the volume controlling facilities so that the intensity of the loudspeaker output is low enough to be comfortable for himself, in which case the intensity would be too low for maximum enjoyment by more remotely positioned listeners.

Listening to a loudspeaker from a distance also has the advantage of introducing pleasing reverberation effects, as a result of the reflection of sounds from the walls of the room in which the loudspeaker is located. This makes the sounds more realistic inasmuch as such reverberation normally accompanies concerts or speeches which people are accustomed to hear in auditoriums or the like.

Remote control facilities are particularly helpful with signal transfer apparatus in the form of television receivers. Television pictures on viewing screens about 8 inches wide or more are not pleasing to watch except from distances of several yards or more. In addition, for a group of people to properly view a picture on a screen of a television receiver of the type usually installed in a home, they would all have to be positioned at some distance from, but approximately directly in front of, the screen so that they subtend a suitably small angle of view.

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Other important remote control considerations are those practical problems faced in military or commercial installations where the signal transfer apparatus may be so bulky or inaccessible as to make provision for direct control quite awkward. Additionally a single operator may be required to control or monitor a multiplicity of different apparatuses yet the direct grouping of all the apparatuses within the reach of one person may be practically impossible without a remote control system.

Attempts have been made in the past to solve remote control problems such as those referred to. These attempts have generally taken the form of elaborate arrangements. One such arrangement usually designated as the "wireless" type includes a special auxiliary radio transmitter and receiver for delivering a control signal from a remote control unit to the apparatus being controlled. This type of remote control system is quite expensive and introduces further problems such as rapidly and accurately controlling the signal output intensity over a continuous range, providing a power supply for the remote control transmitter, and arranging the remotely controlled receiver so that it can stand by for receiving transmitted control signals at any time without consuming excessive stand-by energy.

The output intensity control for the wireless type of remote control systems is particularly troublesome inasmuch as it generally requires a continuously variable structure to provide all gradations of intensity. The remote control systems of prior art generally resorted to reversible electric motors for this purpose, connecting such a motor to operate a conventional volume-control potentiometer in either direction. This type of arrangement introduces the added awkwardness of requiring anticipation of motor overrun as well as delays in circuit manipulation by reason of the operator's having to shift from one remote motor control element to another before the volume-control motor can be placed in operation and stopped at the desired intensity setting.

Another prior attempt at solving the remote

control problem was to construct the signal transfer circuit in separate units, the loudspeaker being a unit separate from the circuit portion which included the conventional tuning, on-off, and volume-control elements. By placing the latter unit at the remote control location, the desired remote control is obtainable. This adds considerably to the cost of the apparatus however and also introduces other complications such as the provision of interconnecting lines between the spaced units and between the units and one or more power supplies, the relatively large bulk of the control assembly as well as its fragile nature by reason of the presence of vacuum tubes, delicate tuning structure, etc.

It is accordingly an object of the present invention to provide improved remote control systems that are simple yet conveniently provide a plurality of different control operations.

Among the further objects of the invention are the provision of improved remote control systems for signal transfer circuits such as in radio receivers, and which effect rapid and smooth volume-control adjustments as well as on-off control and other operations, yet are of simple construction.

An additional object of the present invention is the provision of a remote control system for connection in series in the power supply line that energizes a signal transfer circuit such as a radio receiver and which provides a plurality of independent control operations with not more than two remote control conductors.

The above as well as other objects of the invention will be more readily understood from the following description of exemplifications thereof, reference being made to the accompanying drawings wherein:

Figure 1 is a block diagram of the essential elements of a remote control system according to the invention;

Figure 2 is a block diagram of a remotely-controlled radio receiver embodiment of the invention, showing more of the circuit details;

Figure 3 is a circuit diagram of a practical form of the embodiment of Figure 2;

Figure 4 is a detail view of a further modification of remote control system exemplifying the invention;

Figures 5, 6 and 7 are block diagrams, with parts in detail, of still further types of remote control systems embodying the invention.

According to the present invention a remote control system for a signal transfer apparatus having a pair of power supply leads, includes a control assembly having impedance-inserting elements connected through remote control connectors in series in one of the power supply leads. The impedance-inserting elements are adjustable to insert a controllable impedance in the power supply circuit for developing a controllable voltage across these elements. Circuit elements are connected at the signal transfer apparatus for applying the controllable voltage to control the operation of the apparatus. The impedance-inserting elements may include on-off switch structure as well as a plurality of impedance elements for developing voltages of different magnitudes that are distinguishable from each other for effecting different types of control.

The developed voltages are utilized to control the signal output intensity, vary the tuning through a band of signal frequencies, change the signal frequency band to which the apparatus responds, or alter the tonal emphasis of portions of the frequency spectrum covered by the signal output. These controls can be effected individually or in any desired combination.

The invention may be used with signal transfer circuits energized from an alternating current (A. C.) power supply, or with circuits energized by a direct current (D. C.) power supply, or with the so-called A. C.-D. C. type circuits that can be energized by either type of power supply.

The controllable voltages can be applied for circuit control purposes with or without amplification. In some examples of the invention whether or not such amplification is used, the voltage drop produced in the power supply voltage by the controllable voltage is too small in magnitude to be of any significance with respect to the energization of the circuits. In other words the circuit-energization by the power supply continues without noticeable change in spite of the power supply voltage variations caused by remote control manipulation. In other examples of the invention control voltages of relatively large magnitude may be used and the circuit energization may be appreciably lessened or completely interrupted momentarily by certain of the remote control manipulations. In such cases, interference with the operation of the circuit may be reduced as by limiting the relatively large control voltages to effecting control functions, such as the changing of the station selection, that do not involve continuous listening. Any drop in the signal output caused by the appreciable decrease or interruption of energizing voltage, will thereby be masked by the functional change in the circuit operation which takes place at the same time.

The invention makes possible a continuous remote control of signal output intensity together with one or more additional control functions using not more than two remote control connectors. Moreover without the use of additional connectors some modifications of the invention provide automatic coordination of different controls, such as the automatic changing of the signal output tone emphasis to compensate for output intensity variations.

Referring to Figure 1, the invention is here shown in block diagram form. A selectable signal transfer assembly **10** is connected for passing signals of specific frequencies from signal supply leads **12**, **13** and delivering the selected signals to signal output leads **14**, **15** at a controllable intensity. The assembly **10** is energized from a power supply circuit by means of power supply leads **18**, **19** which are connected for delivering current through an energizing circuit **22** which converts the current to a form suitable for operation of the assembly, if this is necessary. Thus for example where the conventional alternating current power is supplied by leads **18**, **19**, and the signal transfer assembly is operated by direct current, the energizing circuit **22** will include a rectifier and may also include a filter network for smoothing out the rectified current. Where the power supplied to leads **18**, **19** is direct current, the energizing circuit **22** need be nothing more than suitable leads far applying the direct current without appreciable modification to the assembly components such as the transfer network **40**.

One of the power supply leads **19** runs directly to the energizing circuit **22**, the other lead **18** having connected in series with it, a remote con-

trol unit 24. Remote control conductors 26, 27 establish the series connection.

In Figure 1, the selectable signal transfer assembly includes a signal tuner 30 for selecting the desired signals from those supplied, and a variable pass signal transfer network 40 for adjusting the intensity of the signals delivered to output leads 14, 15. A tuner shifting assembly 32 is connected to the tuner 30 for selectably shifting the tuning so as to pass the desired signals and to change the selection at will. For such shifting it is preferred to have automatic tuning devices which provide accurate signal selection in response to simple electrical pulses. Suitable forms of tuner shifting assemblies, as well a signal tuners are shown by way of example in the automatic tuners of U. S. Patent No. 2,453,187, granted November 9, 1948 to Blain, U. S. Patent No. 2,411,754, granted November 26, 1946 to Pifer et al. and U. S. Patent No. 2,304,871, granted December 15, 1942 to E. F. Andrews. The tuner 30 may include one or more stages of amplification, but if desired it may be merely a positioning arrangement for changing the position of a frequency response control structure connected to selective circuits that do not include amplification stages.

The variable pass signal transfer network 40 may be any convenient arrangement for controlling the signal output intensity in response to a variable control voltage. Suitable forms of such network include the conventional biased amplifiers where the amplification depends upon the bias voltage, or variable impedance devices such as described in U. S. Patent No. 2,247,468, granted July 1, 1941.

The construction of Figure 1 includes a return circuit 28 which connects the remote control conductor 27 to a common conductor represented by the symbol 29. Although the return circuit 28 is shown separately it may be combined with the energizing circuit 22 in many cases. An additional lead 25 connects the other remote control conductor 26 to the various apparatus or devices to be remotely controlled. For this purpose the lead 25 includes branches 42, 44 connected respectively to the variable pass signal transfer network 40 and to the tuner shifting assembly 32 which devices are also returned to the common conductor 29, as shown.

The remote control unit 24 includes adjustable impedance elements (some forms of which are shown in detail in other figures to be described) which can be connected between conductors 26 and 27 for insertion in series in the power supply circuit. A controllable voltage can accordingly be developed between conductors 26 and 27, by means of the voltage drop developed by the power supply current in traversing these impedance elements. This voltage is applied by means of return circuit 28, 29 and leads 25, 42, (or 44) to the apparatus to be controlled. Also, by increasing the inserted impedance to relatively large values as by opening the circuit with an infinite impedance, the power supply can be effectively cut off, thereby deenergizing the apparatus. This provides on-off control.

A feature of the invention is that, by incorporating in the remote control unit a continuously variable impedance element, a continuously variable control voltage may be readily provided to enable desirably smooth operation of such devices as the variable pass signal transfer network 40. This type of remote control operation is accordingly made possible with only two remote

control leads. Furthermore by providing the remote unit 24 with two different impedance elements arranged for selectable insertion in the power supply circuit, two different control voltages can be provided. By arranging for one control voltage to always be higher than the other, and by having the control structures voltage-responsive, the controls can be readily distinguished from each other. Three or more individually distinguishable control voltages may be similarly provided, for effecting a corresponding multiplicity of control functions. In fact, substantially the entire available power supply voltage may be arranged to be developed across the conductors 26, 27 and applied for control purposes, as by using a remote control impedance which is relatively high in magnitude with respect to the impedance offered by the remainder of the apparatus connected to the power supply circuit. In some cases this high control voltage may be used to directly operate control structures such as tuning solenoids.

Figure 2 shows a remotely controlled radio signal receiving apparatus as one illustrative embodiment of the invention. The various signal transfer stages shown include a modulated signal tuner 100 which may be of the heterodyne type for example, a variable gain modulated signal amplifier 102, a demodulator 104, a demodulated signal amplifier 106 and a demodulated signal reproducer 108. These stages are cascaded together for receiving modulated signals from signal supply leads 112, 113 and may be of any suitable types such as those conventionally used in home type radio receivers. Examples of such circuits are given in the RCA Receiving Tube Manual, Technical Series RC 15, copyrighted 1947, by Radio Corporation of America, pages 213, 214, 216, 217, 220, as well as in the Perpetual Trouble-Shooter's Manuals, published periodically by John F. Rider, Publisher, Incorporated, 404 Fourth Avenue, New York, N. Y.

The energizing power for operating the receiver is obtained by means of a plug 117 which can be inserted in a receptacle connected to a commercial alternating current power supply line. Leads 118, 119 from the plug 117 connect through a remote control unit 124 to a power supply transformer 121 the output of which supplies a rectifier and filter assembly 123. Here the alternating current is converted to suitable direct current which is applied between a B+ bus 148 and a common return conductor 129 and delivered to the various stages.

One of the remote control conductors 126 is connected by capacitor 150 to one input lead 154 of a combined amplifier and rectifier 160. A capacitor 152 connects the other remote control conductor 127 to the other input lead 155 of the amplifier and rectifier 160, by way of the common return conductor 129. Alternating current voltages delivered to the amplifier and rectifier 160 are converted to direct current control voltages which bias the variable gain amplification stage 102 through the lead 162 and the common return conductor. By branch conductor 164 these control voltages are also impressed on a signal seeking assembly 132 which may be of the type described in the above-identified patent to Andrews. For completing the signal-seeking circuit, a connector 166 supplies received signals from one of the signal stages of the receiver.

In the form of the invention shown in Figure 2, the remote control unit is an assembly of an adjustable resistor or potentiometer 170, an on-

off switch 172, and another resistor 174 all connected in series. The resistor 174 is shunted by a switch 176 held in normally closed position as by a spring bias 128. As illustrated, the on-off switch 172 is in its "off" position, the power supply circuit to transformer 121 is effectively open, and the receiver is not operating.

By closing switch 172, the power supply circuit is completed and the receiver is placed in operation. At the same time the alternating current voltage developed by the passage of the energizing current through the adjustable resistor 170 is applied to the input circuit of amplifier and rectifier 160 through capacitors 150, 152 and leads 154, 155 together with the common return conductor 129. The rectified output of the amplifier and rectifier 160 biases the amplifier stage 102 and determines the output level of the signals delivered by this stage. It is preferred that any automatic gain control facility that the receiver may include be ineffective to control the amplifier 102, inasmuch as such automatic gain control may interfere with the output intensity control of the invention.

If the output intensity is to be increased it is only necessary to change the impedance of resistor 170 in the direction which suitably alters the bias to stage 102. Conversely, by adjusting the resistor 170 in the opposite direction, the output intensity is decreased. The total range of voltage supplied to the input circuit of amplifier and rectifier 160 for changing the signal output intensity from maximum to minimum need not be more than about 1 or 2 volts or even less, depending upon the amplification provided in apparatus 160.

For changing the signal selection of stage 100, switch 176 is momentarily opened. This temporarily inserts the resistance of resistor 174 in the power supply circuit, thereby increasing the voltage drop between leads 126, 127 and boosting the voltage applied to the assembly 160 as well as that delivered by leads 162, 164 to the signal seeking assembly 132. Resistor 174 has a resistance high enough to raise the voltage at lead 164 to a value higher than any voltage developed by resistor 170 alone. Furthermore the signal seeking assembly 132 is arranged to respond only to voltages of the higher magnitude, as by including in it a suitable control relay that is only actuated when the control voltage becomes higher than the highest voltage available across resistor 170.

When triggered off by the momentary high voltage pulse, the signal seeking assembly begins to tune the receiver across any predetermined frequency band, and when a suitable different signal is tuned in and applied to the assembly as by lead 166, the tuning is automatically stopped. The above-mentioned Andrews patent is referred to for a further explanation of a typical signal seeking operation.

The higher tuning control voltages are also applied to the amplier stage 102 but will have no untoward effects. In fact by arranging the intensity control so that the intensity is decreased at higher control voltages, the receiver will be automatically muted when the tuning is triggered off, thereby preventing the reproduction by stage 108 of undesired triggering clicks and noises. If desired the muting may be prolonged as by arranging for the signal seeking assembly 132 to supply to lead 164 a suitable intensity-diminishing voltage whenever it is in signal seeking operation.

The opening of on-off switch 172 after the receiver has been in operation will cause the power supply voltage drop between remote control conductors 126, 127 to increase to a relatively large value. This relatively high voltage will be applied to the input circuit of amplifier and rectifier 160 so that adequate precautions should be taken to insure against damage to the equipment. The higher the input impedance of the amplifier and rectifier 160, between leads 154, 155, the higher will be the voltage developed between these leads, limited only by the power supply voltage between leads 118, 119. By keeping this input impedance of the order of 1 megohm, and providing capacitors 150 and 152 of sufficiently high impedance, a large part of the power supply voltage will be effectively dissipated across these capacitors and the voltage across leads 154, 155 will be reduced to harmless proportions. The high voltage at the input of the remote control amplifier may cause the signal seeking assembly to be triggered when the remote unit is switched to off position, but the power supply being simultaneously interrupted, no appreciable tuning will take place.

If the input impedance between leads 154, 155 is sufficiently reduced in value, an appreciable power supply current will flow between supply leads 118, 119 through the circuit 150, 154, 155, 129, 152, and the primary winding of power transformer 121, even with switch 172 in "off" position. This residual current can be used to deliver heat to any indirectly heated vacuum tube cathodes that are included in the receiver. Such cathodes are normally heated by a separate secondary winding (not shown) of the power transformer and when cold require several seconds to reach operating temperature after the closing of switch 172. This delay is essentially the thermal lag in the heating of these cathodes, and is considerably diminished by the small amount of residual heating.

Figure 3 shows the circuit details of a practical embodiment of the invention. The circuit follows generally along the lines of the apparatus of Figure 2, including a signal seeking tuning unit 200, a variable bias control amplifier 202 for amplifying modulated signals selected by the tuning unit 200, and a combined demodulator and demodulated signal amplifier 207. A tuning control network including an amplifying tube 280, and a combined rectifier and amplifier tube 282 is connected to operate a relay 284 for energizing a signal seeking tuning motor 286. Another combined rectifier and amplifier tube is provided at 288 for supplying the rectified control voltage.

The remote control leads are here shown at 226, 227, lead 226 being returned by way of capacitor 252 to ground (common chassis return conductor 229), and lead 227 being connected through capacitor 250 to the input grid 251 of control tube 288. A grid resistor 253 returned to the cathode 256 of tube 288 through the common ground connection completes the input circuit for the control amplifier. The remote control amplifier is energized by connecting the anode 257 of tube 288 through a plate load resistor 258 to the plate supply line which is not shown but is the positive terminal of a direct current source having its negative terminal grounded, as described above in connection with Figure 2.

Tube 288 includes two rectifier anodes 259, 261 each of which cooperates with the cathode 256

to provide a separate diode rectifier. Amplified remote control voltages are developed across the load resistor 258 and impressed through a coupling capacitor 263 between rectifier anode 259 and the grounded cathode 256. Rectified or direct current voltages corresponding to the remote control voltages are accordingly developed across a rectifier load resistor 265 connected between the rectifier electrodes.

A cascaded series resistance and shunt capacitance filter 267 smoothes the rectified remote control voltage and delivers the smoothed voltage through resistor 268 to bias the signal input grid 269 of amplification stage 202, with respect to ground. Another resistor 271 applies the smoothed voltage to an automatic gain control bus 273, and a standard bias obtained from the junction of two resistors 275, 277 connected across a direct current source such as the screen supply line (not shown), is applied through resistor 279 to the smoothed rectified voltage.

The incoming modulated signal waves selected by tuning unit 200 are impressed between anode 261 and cathode 256 by means of lead 281 and the chain of capacitances 283, 285, 287. The automatic gain control bus 273 is connected across the entire chain and is returned to ground through the load provided by resistances 277, 279, 271. An additional filter stage including series resistor 289 and shunt capacitor 290 assures that only rectified and smoothed voltage free of signal variations appear at the input to stage 202.

The automatic gain control bus 273 is supplied by rectifier anode 261 with a negative voltage corresponding to the level of the carrier on which the signal modulations are supplied. The positive swings of the incoming signals can be considered as by-passed by the rectifier which is conductive only for these swings. The load provided by resistors 271, 279, 277 on the automatic gain control voltage is such that only an insignificant fraction of this automatic negative voltage appears across the resistors 279, 277 at the input of stage 202.

The rectified and smoothed remote control voltage is also negative, and by having the resistance of resistor 265 in the order of magnitude of the combination of resistances 279, 277, this control voltage is not unduly loaded by the network including the automatic gain control circuit itself. The automatic gain control voltage will accordingly have substantially no effect on the operation of stage 202 whereas the remote control voltage will be transmitted to the automatic gain control bus.

The standard bias voltage from bleeder chain 275, 277 is of positive sign and merely establishes a reference bias which provides a maximum of signal transfer by stage 202 when the remote control voltage, which is of negative sign, is a minimum. Increasing the remote control voltage causes the bias to become more negative thereby decreasing the intensity of the signals transferred by the controlled stage.

Modulated signals are supplied to the controlled stage 202 by the lead 291 from the input grid 269 to the junction between capacitors 285 and 287. A conventional coupling transformer 292 forms the output circuit of stage 202 and is tuned to the proper frequency channel for coupling the modulated signals to the next stage 207.

Signal seeking by unit 200 is controlled by a lead 293 which delivers the tuned input signals from the junction of capacitor 283, 285 to the input grid connection 294 of a triggering amplifier tube 280 of the type described in U. S. Patent No. 2,010,253, granted August 6, 1935. The tube 280 amplifies these signals and a coupling transformer 295 impresses the amplified signals between the cathode 296 and the rectifier anodes 297 of tube 282. Negative voltages corresponding to the intensity of the signals are thereby developed across a rectifier load resistor 298 and applied, through a filter network including resistors 299, to the input connection 294 of triggering amplifier tube 280. These resistors 298 and 299 provide a grid return circuit for tube 280. A relatively high resistance 231 is inserted in the plate circuit of tube 280, as explained in Patent No. 2,010,253, and as the signal intensity at input connection 294 increases, the rectified voltage at this connection becomes more negative.

Tube 282 includes a grid 233 for controlling the passage of current between the cathode 296 and an anode 235, and this grid is directly connected to the input lead 294. The windings 237 of relay 234 are inserted in the anode or plate circuit of tube 282, so that negative voltages at lead 294 cut off the anode current of this tube and deenergize the relay windings. Normally open relay contacts are closed when the relay windings are energized in response to the absence of signals at lead 293, and effect the operation of tuning motor 286. When the tuning motor 286 is in operation and the tuning reaches a frequency at which signals are received, a negative voltage will develop at lead 294 and grid 233, cutting off the current through windings 237, deenergizing the relay and causing the tuning motor to stop. To assure accuracy in tuning, the transformer 295 may be provided with a sharp or narrow coupling bandwidth as compared to the conventional pass band of the signal circuits including coupling transformer 292. The tuning will thereby be automatically stopped only in the narrow range which can be accurately fixed with respect to the broader signal pass band. To compensate for any overshooting of the tuning motor 286, the narrow coupling band may be shifted somewhat so that the motor energizing circuit is opened somewhat before the tuning motor reaches the exactly tuned position.

Figure 3 shows a remote control unit 224 including an on-off switch 272, a volume control resistor 270, and a tuning switch 278 and tuning resistor 274. Manipulation of the resistor 270 to change the resistance in the power supply circuit will adjust the intensity of the signals delivered at the signal output circuit which may include one or more further amplification stages and a loudspeaker. This is effected by a corresponding change in remote control voltage that is thereby made at the automatic gain control bus 273 as explained above. When it is desired to change stations, it is only necessary to momentarily open remote switch 278 thereby applying a relatively high negative bias to the controlled stage 202 effectively muting the apparatus. This high bias is also applied to the automatic gain control bus 273 which biases previous signal transfer stages. The intensity of signals delivered to lead 281 is thereby diminished and the trigger network is arranged to respond to such loss of signal by energizing the relay 237 and starting a signal seeking operation.

An additional capacitor 239 is shown connected across the remote control conductors 226, 227 at their radio receiver end. This reduces the introduction of undesired radio signals into the signal circuits by way of the remote control con-

ductors which sometimes make an efficient signal receiving antenna.

Without in any way limiting the invention and to assist persons skilled in the art in making and using it, there are given below the circuit constants for a practical embodiment of the construction of Figure 3:

Voltages	Resistors (ohms)	Capacitors (micromicrofarads)	Tubes
plate supply 250 screen supply 50 B+ supply 100	231- 250,000 253-1,000,000 258- 22,000 265- 470,000 268-1,000,000 270- 0.6 271-1,000,000 274- 10 275- 570,000 277- 83,000 279- 170,000 289- 270,000 298- 470,000	239-100,000 250- 10,000 252-100,000 263-100,000 283- 5,000 285- 250 287- 1,500 290- 10,000	239-6BA6 280-6SJ7 282-6SR7 288-6SR7

With the above constants, the apparatus of Figure 3 is highly suited for home type radio receivers in which the tuning unit **200** includes a stage of radio amplification, a heterodyne type tuning stage and an intermediate or beat frequency amplification stage, two of the stages being of the vacuum tube type having a bias connection to the automatic gain control bus **273**.

Figure 4 shows another form of the invention. Here a variable pass network **302** includes a pair of electron discharge tubes **304, 306** connected in parallel but with opposite polarities, in a signal transfer line. Signal input connections are shown at **311, 312**, one lead **311** being coupled to the cathode of tube **306** through capacitor **314**, and to the anode of tube **304** through additional capacitor **316**. The anode of tube **306** and the cathode of tube **304** are connected together through capacitor **318**, and to an output conductor **322** by means of capacitor **320**. Another output conductor **324** is connected to input lead **312** by the ground connections shown. The control grids of the tubes **304, 306** are connected together and to a source of variable remotely-controlled bias, such as that of the construction of Figure 3.

The tubes are operated by an electron flow energized from a direct current power source the positive terminal of which is indicated at B+, and the negative terminal of which is grounded. The energizing circuits are completed through anode resistors **330**, and cathode resistors **331**, which prevent the direct shunting of the signal-carrying conductors by the power supply.

Dual remote control bias sources are shown. The variable alternating current voltage developed across remote control leads **326, 327** is transmitted through capacitor **332** and the resistors **334, 335** to the electrodes of the respective rectifiers **338, 339**. Across the electrodes of each rectifier a load resistor **342, 343** and a by-pass capacitor **346, 347** are connected. The anode ends of the load resistors are joined to provide a common negative bias lead **350**, connected through resistor **352** to the grids of tubes **304, 306**. The other ends of the load resistors are separately returned through leads **360, 361** to the respective cathodes of tubes **304, 306** to complete their grid circuits.

By controlling the bias voltage of the tubes **304, 306** the impedance they offer to the passage of signals is effectively varied as desired. One tube, **304**, passes only the positive portions of signal waves from its anode to cathode, but cannot pass the negative portions. The other tube, **306**, passes the negative signal wave portions from its cathode to anode and cannot pass the positive portions. By the arrangement shown substantially symmetrical transfer of both positive and negative portions of the signal will take place at all control settings.

To assure low distortion, one or both of tubes **304, 306** may have its grid provided with a bias compensating adjustment so as to vary the effect of the remote control bias, in order to more closely match the individual tube responses to each other. For this purpose the cathode return resistors **331** may have adjustable taps to which the bias return leads are connected. By varying the tap position, a selectable amount of direct current voltage developed by the passage of anode current through the tube and the resistor **331** will be applied to bias its grid. Variations in tube manufacturing tolerances are compensated for in this manner.

If desired the stage **302** may also be used to effect demodulation of amplitude-modulated incoming signals, by merely omitting one of the tubes **304, 306** together with its associated circuit elements. A carrier by-pass capacitor may also be connected across the output leads **322, 324** to help filter out high frequency ripple introduced into the signals by the demodulation.

Figure 4 also includes an amplifier **370** connected for receiving the signals passed by the network **302** and delivering amplified output signal to output leads **372, 373**. In the above construction although amplification for the remote control voltages could be used, it is not shown, and the remote circuit elements are arranged to directly provide voltages of a magnitude suitable for effecting the desired control.

The remote control system of the present invention not only provides a simple construction for effecting continuous adjustment of the signal output intensity but can also be arranged to automatically compensate the frequency response of the output signals for different intensity levels. Thus it is well known that even though a uniform frequency response is desirable across the entire audio output spectrum to assure maximum fidelity, it is nevertheless preferred, due to the characteristics of the human ear, to emphasize certain portions of the spectrum when the signal output is at an intensity lower than the original signals which they reproduce. Reference is made to U. S. Patent No. 1,938,256, granted December 5, 1933, for examples of such compensation.

According to the present invention a negative feedback network **376**, which selectively passes those portions of the signal spectrum to be automatically emphasized, is connected between the output and input leads of a variable-pass amplifying circuit. This network feeds back a portion of the amplified signals in such a manner that the fed back portions are oppositely phased with respect to the incoming signals and effectively cancel out a corresponding part of these incoming signals thereby diminishing their intensity. By arranging the feedback so that, at the maximum output intensity, it provides the desired fidelity of reproduction, it is clear that as the signal passing ability under the control of the remote unit is decreased the selective feedback will be automatically diminished along with the output intensity while the signal input level does not change. This will have the effect of permitting the selective feedback portions of the spectrum to be automatically boosted in intensity relative to the remainder of the spectrum, exact-

ly as desired, and without complicating the remote control unit.

The above type of automatic compensation by selective feedback can also be effected in the same manner with other variable-pass control stages such as a variable-gain amplifier stage 202 of the construction of Figure 3, whether or not this stage is used as a modulated or demodulated signal transfer stage. When the control stage is used for transferring modulated signals, the signals fed back are preferably taken from the demodulated signal circuit. The feedback of modulated signals is more difficult to confine in selected frequency ranges inasmuch as at the relatively high frequency at which the modulated signals are carried, different portions of the modulating signal spectrum are separated by only a very small fraction of the carrier frequency. Positive feedback can also be used for automatic compensation purposes in place of negative feedback by merely arranging for the positive feedback to be of those portions of the spectrum which are to be de-emphasized at reduced output intensity levels.

Figure 5 shows another form of the invention in which a radio receiver having a transformerless power supply circuit is arranged for remote control. Here power supply leads 418, 419 are connected from a power supply plug 417, through a remote control unit 424 to the transformerless energizing circuit including a rectifier tube 430. Lead 419 goes to one end of the filament 432 of this rectifier tube, from the other end of which additional filaments, including those shown by dash lines at 434, 436, 438, 440, for electron-discharge tubes forming part of amplification or other stages, are connected in series ending in the ground or common return conductor 442. The energizing circuit is completed by connecting power supply lead 418 to ground through remote control lead 426, the remote unit 424 and a remote ground connection 427.

The stages are identified as including automatic sequence tuner 400, variable gain amplifier 402, and signal reproducer 404. By using amplification tubes in which the filaments are used as indirect heaters for separate cathodes, as shown at tube 444, the various stages can be operated by either alternating or direct electric power supplies. To provide the direct current for the electron discharge electrodes of the tubes, a tap 446 from the filament 432 is led to the rectifier anode 448, and its cathode 450 is connected to a B+ bus 452. A suitable filter circuit part of which is shown by the shunt filter capacitor 454 is provided for reducing rectified ripple when alternating current power supplies are used. The electron discharge circuit is completed by ground connections as shown at 460 for stage 404. An indicator or pilot lamp 456 is shown as connected in parallel with the tapped portion of filament 432, so that it is lit whenever the receiver is suitably energized.

The remote control unit 424 in this modification of the invention includes an on-off switch 472, a continuously variable resistance 470 and two additional switches 476, 477, each separately shunted by resistors 474, 475 respectively. A series connected indicator lamp 480 is also provided to show when the remote unit is set for operation.

The receiver actuating circuits include a control lead 489 connecting the remote control conductor 426 through resistor 482 to rectifier anode 484 incorporated along with cathode 444 in a tube of stage 404. A rectifier load resistor 486 and filter capacitor 488 complete the rectifier circuit. Rectified output voltage is supplied by lead 490 to bias the amplifier 402 through resistor 491 and thereby control the volume or output intensity of the signals supplied by reproducer 404, as described above in connection with the construction of Figure 3. Lead 490 is also connected to a pair of sequence tuning relays 492, 494. Relay 492 is arranged to automatically shift the signal selection in sequence through a predetermined group of incoming signal channels, in any band of frequencies, as by means of the tuning arrangement shown in the above-identified Blain or Pifer et al. patents. Relay 494 is correspondingly arranged to switch the frequency band sequentially through a predetermined group of different bands, such as the standard broadcast amplitude modulation and frequency modulation transmission bands.

In the construction of Figure 5 no separate amplifier is used to increase the magnitude of the remote control voltages. These voltages after passing through the rectifier 484, 444, directly control the signal intensity and through relays 492, 494 also control the signal selection. Relay 492 is connected to respond to an impressed voltage higher than any possible intensity control voltage developed across remote control resistor 470, whereas relay 494 responds only to voltages higher than any intended for merely operating relay 492. Switch 476 may be designated as the station selector for operating relay 492, so that its shunting resistor 474 has a resistance sufficient for developing the desired control voltage. Switch 477 can then control the band shifting relay 494 through the insertion of the suitably higher impedance of resistor 475.

For energizing the apparatus, switch 472 is closed, establishing the power supply circuit through the remote control unit 424. It will be noted that the receiver may then be operated with either alternating or direct current power supplies. The filaments 434 to 440 are suitably heated by either type of power. Alternating current is converted to direct current by rectifier stage 430 for the electron-discharge circuits, while direct current will pass through this rectifier stage to also supply direct electron-discharge current. For direct current power supplies, the plug 417 must be connected with the proper polarity so that the rectifier 430 can pass the energizing current.

In this form of the invention the remote control system will operate whether alternating or direct current is supplied to leads 418, 419. The alternating current operation corresponds to that described in connection with the constructions of Figures 2 and 3, and develops a variable negative bias voltage at lead 490 with respect to ground. With direct current energization lead 419, connected to rectifier anode 448, must be positive with respect to lead 418, and ground conductor 427 is accordingly also positive with respect to lead 418. Any voltage appearing at lead 418 will therefore be negative with respect to ground so that the control unit will operate in the same sense as with alternating current power supplies. The remote control rectifier 484, 444 will have no untoward effect on the negative bias at lead 490.

The opening of switch 476 will cause the development of a control voltage sufficient in magnitude to mute the receiver and operate relay 492 to change the station selection. The switch

477 will, when opened, similarly actuate band selecting relay 494. The voltage developed by the opening of switch 477 will be large enough to also operate relay 492.

If desired, resistor 475 may be omitted from the circuit so that the band shifting control voltage is the maximum obtainable from the power supply. The switch 472 may then also be omitted, the band shifting switch 477 being then also used as an on-off control.

When the remote control unit is in the off position, in the construction of Figure 5, the apparatus continues to be energized by way of leads 418, 480, resistor 482, lead 490, relays 492, 494, and resistor 486 in parallel, the ground return of the relays, ground return 442, filaments 440, 438, 436, 434, 432, and lead 419. To reduce this power consumption the relays 492, 494 are connected to switch open the electron discharge or B+ circuit to the electron-discharge stages in units 400, 402, 404, when the relays are energized. B+ lead 496 connecting the lead 452 to the relay armatures effects this operation and also provides the voltage that can be used to initiate automatic tuning. Inasmuch as the heating current passed through the rectifier filament 432 is greatly reduced during such off conditions by reason of the impedance added to the filament circuit, the rectifier cathode 450 is not heated to its designed operating temperature so that the current passed by the rectifier is greatly reduced in amount and constitutes an insignificant power drain. The rectifier load 486 is generally of high impedance with respect to the windings of relays 492, 494, so that its power drain can be ignored by comparison with that of the relay windings. If desired, the resistor 486 may also be omitted permitting the relay windings to act as rectifier loads.

The construction of Figure 5 is especially advantageous in that the omission of a remote control amplifier reduces the number of components and at the same time the remote control voltages required still do not lower the power supply voltage to any significant extent. Not more than about 5 or 10 volts is all that is needed for effecting any desired range of volume control. Lower control voltages are used where the controlled variable-pass circuit is in the form of a variably biased electronic amplifier stage using a sharp cut-off type of amplifier tube, such as that commercially identified as type 6SJ7. The extra rectifier anode 484 in Figure 5 is normally present and not used in amplifiers operated with a tube such as that commercially identified as type 6AV6 having a triode and two rectifier anodes, only one of which is used as a signal detector. In any event, the mere addition of an extra rectifier anode can be readily made by substituting a dual purpose amplifier-rectifier tube such as that known as type 6SF7 for a conventional single-purpose intermediate frequency amplification tube such as type 6SK7. This substitution involves no appreciable increase in cost. In those cases where only direct current power supplies are used, the extra rectifier anode 484 is not needed.

Figure 6 shows another embodiment of the invention in which a stepping switch 595 is connected to be energized by one of the controls of a remote control unit 574 for controlling the tone of signals reproduced by a reproducer 504. The stepping switch may be of conventional construction having solenoid windings 598 actuated by opening remote switch 576, for example, to advance a ratchet wheel 593 and rotate a switch blade 594 from one of a set of contacts 596 to the next. The blade and contacts are connected in any suitable well known tone control circuits. The remainder of the construction may be essentially the same as that shown in Figure 2 for example.

Figure 7 shows a still further construction according to the invention, in which no remote control amplifier is needed and the apparatus is substantially completely de-energized when the remote control unit is set to off position. Here a stepping mechanism 695 generally similar to that of the construction of Figure 6 includes a switch arm 694 which moves at each step to successively engage alternate contacts 696 and 697. Contacts 696 are all connected together and to power supply lead 618 through conductor 680, while contacts 697 are similarly all connected through conductor 681 to the oppositely poled power supply lead 619. The movable arm 694 completes the turret energizing circuit through lead 683, windings 698 of a stepping solenoid, and a return lead 685 connected to remote control conductor 627. The remote control unit 624 connected between remote control conductors 626 and 627, includes an on-off switch 672, a volume control resistance 670 and a tuning switch 677. The tuning switch is shown as normally held closed as by a suitable mechanical biasing spring, and manually operable. The volume control connection to a variable pass circuit 602 is completed by the ground connection shown and a lead 690 including resistance 682 between conductor 680 and the circuit 602. A turret tuner 600 forming a signal selecting portion of a transfer circuit is mechanically connected to be moved along with the switch arm 694, as shown by the dash-dot linkage.

It will be noted that one terminal of the windings of solenoid 698 is permanently connected, through lead 685, to conductor 627. Switch arm 694 alternately shifts the connection of the other terminal of this solenoid between lead 618 and lead 619 of the power supply. Additionally, the voltage between leads 618 and 627 depends upon the impedance that the control unit 624 presents between them, being large when the impedance is high or infinite, and small when the impedance is low.

The voltage between leads 619 and 627 also depends upon the impedance presented by the unit 624. With a low impedance substantially the entire power supply voltage appears between leads 619, 627. However when the energizing current is sharply limited, as by opening switch 677, the voltage across these leads is greatly reduced. This voltage change is opposite to the voltage change between leads 618 and 627.

Considered in another light, the power supply voltage between leads 618, 619 divides itself between two energizing circuit legs, one leg being the circuit from lead 618 to lead 627, and the other leg being from lead 627 to lead 619. The relative values of the divided voltages depends upon the impedance offered by the remote unit 624.

The solenoid 698 is shifted from one leg to the other in successive steps under the control of the remote unit. At one step the circuit is deenergized and substantially no voltage is applied across the solenoid. At the other step the circuit is energized, and a low voltage may be applied across the solenoid. The first step is

the desired "off" condition that entails minimum power drain.

In the condition shown in Figure 7 the apparatus is in this off position, the on-off switch 672 being open-circuited. Some current will flow through resistance 682 and the variable pass circuit 602 by means of leads 618, 680, 696, the ground connections, leads 685, 627, the power supply unit 622 and lead 619, as pointed out in connection with the construction of Figure 5, but such current will be extremely small. It is noted that none of the contacts 696 are connected to the switch arm 694 so that there is no other circuit completed from lead 618 to lead 619.

Upon the closing of switch 672, signal transfer energization is effected and at the same time solenoid windings 698 are energized through the circuit 618, 626, unit 624, leads 627 and 625, windings 698, lead 683, arm 694, contact 697, and leads 681 and 619. The solenoid accordingly advances the arm one step shifting it from contact 697 to a contact 696. This breaks the principal solenoid energizing circuit at contact 697 and substitutes for it the energizing circuit contact 696 which is at low voltage by reason of the small voltage drop between leads 626 and 627 when the switch 672 is closed. The solenoid is not actuated by this low voltage.

A feature of the invention is that one of the control functions of the signal transfer circuit is connected for operation by the same mechanism that provides the low drain characteristic. In the construction of Figure 7, the specific control function so connected is the station selection.

For shifting the tuning, switch 677 is momentarily opened, thus greatly increasing the voltage drop between leads 626, 627, and actuating the solenoid to advance the arm 694 by one step from a contact 696 to a contact 697. The solenoid is thereby deenergized exactly as it was with the apparatus in off condition. However, when the remote control circuit is completed after the momentary opening of tuning switch 677, the tuner is again shifted one step carrying the arm 694 to the next contact 696. The turret tuner is arranged so that it tunes to a different signal for each two steps of the stepping mechanism.

By way of example the turret tuner may be any of the turret constructions described in pages 76 to 79 of the September 1948 issue of the periodical "Electronics," or the turret tuning arrangements shown in the above-identified Blain or Pifer et al. patents, where it is only necessary to mount and connect a rotatable selector switch corresponding to arms 694 and contacts 696, 697 upon the rotatable turret.

The signal transfer circuits combined with the invention can also be of the more complicated types such as those in television receivers. In such combinations the number of remote control functions usually required in television tuning for example is adequately provided.

The tuner portion of the television receiver may include an automatic frequency control arrangement to compensate for any drift that may take place in the tuning after it is set by the remote unit. This arrangement will also facilitate the tuning operation itself, in those receivers where turret type tuning is used. Furthermore, since the television picture is more significant than the sound, the continuously variable control of the remote unit can be connected to control the picture brightness or intensity. The sound output level may be left either at a convenient fixed setting as by an automatic device, or it may be arranged for adjustment by one of the auxiliary control members of the remote control unit.

While several exemplifications of the invention have been indicated and described above, it will be apparent to those skilled in the art that other modifications may be made without departing from the scope of the invention as set forth in the appended claims.

What I claim is:

1. In a remote control system for controlling the operation of signal transfer apparatus from a distant location through not more than two conductors; a power supply circuit including a pair of power supply conductors, a control assembly having remote control connectors and impedance-inserting elements connected through said remote control connectors in series in one of the power supply conductors; said impedance-inserting elements including a first adjustable impedance for developing a first continuously adjustable control voltage, and switch means connected for inserting a second impedance having a higher impedance value than the first impedance to develop a second control voltage across said second impedance higher than and distinguishable from the highest adjustable value of the first control voltage; and circuit elements connected for applying the controllable voltages to control the operation of the apparatus.

2. The combination as defined by claim 1 in which said switch means is also connected for inserting a third impedance having a higher impedance value than the total of the first impedance and the highest adjustable value of the first impedance to develop a third control voltage across said third impedance higher than and distinguishable from the first and second control voltages.

3. In a remote control system for controlling the operation of signal transfer apparatus from a distant location through not more than two conductors; a power supply circuit including a pair of power supply conductors, a control assembly having remote control connectors and impedance inserting elements connected through said remote control connectors in series in one of the power supply conductors; said impedance-inserting elements including an on-off switch device, a first adjustable impedance for developing a first continuously adjustable control voltage thereacross, and additional switch structure connected for inserting a second impedance having a higher impedance value than the first impedance to develop thereacross a second control voltage higher than and distinguishable from the highest adjustable value of the first control voltage; and circuit elements connected for applying the controllable voltages to control the operation of the apparatus.

4. In a remote control system for controlling the operation of signal transfer apparatus from a distant location through not more than two conductors; a power supply circuit including a pair of power supply conductors, a control assembly having remote control connectors and impedance inserting elements connected through said remote control connectors in series in one of the power supply conductors; said impedance-inserting elements including a first adjustable impedance for developing a continuously adjustable control voltage thereacross, and a switch means connected for inserting a second impedance having a higher impedance value than the first impedance to develop a second control voltage thereacross higher than and distinguishable from the

highest adjustable value of the first control voltage; said signal receiving network including a voltage controlled variable gain signal amplifier, a shiftable signal selector for selecting one signal from a group of different incoming signals, and voltage actuated selection shifting elements responsive only to said second control voltage; and circuit elements connected for applying the controllable voltages to the variable gain signal amplifier and the selection shifting elements.

5. The combination as defined by claim 4 in which the selection shifting elements are of the stepping relay type.

6. The combination as defined by claim 4 in which the selection shifting elements are of the signal seeking type.

7. The combination as defined by claim 4 in which control leads are connected for simultaneously applying the control voltages to both the variable gain signal amplifier and the selection shifting elements.

8. The combination as defined by claim 4 in which the variable gain amplifier is connected for having its gain diminished by increasing control voltages for automatically muting the system when said second control voltage is applied to shift the signal selection.

9. In a remote control system for controlling the operation of signal transfer apparatus from a distant location through not more than two conductors; a power supply circuit including a pair of power supply conductors, a control assembly having remote control connectors and impedance inserting elements connected through said remote control connectors in series in one of the power supply conductors; said impedance-inserting elements including a first adjustable impedance for developing a first continuously adjustable control voltage thereacross, switch means connected for inserting a second impedance having a higher impedance value than the first impedance to develop a second control voltage thereacross higher than and distinguishable from the highest adjustable value of the first control voltage; said switch structure being also connected for inserting a third impedance having a higher impedance value than the total of the first impedance and the highest adjustable value of the first impedance, to develop a third control voltage thereacross higher than and distinguishable from the first and second control voltages, said signal receiving network including a voltage controlled variable gain signal amplifier, a shiftable signal selector for selecting one signal from a group of different incoming signals in a plurality of frequency bands, voltage actuated selection shifting elements responsive only to said second control voltage for shifting the signal selection in any one band, and responsive only to said third control voltage for shifting from one frequency band to another; and circuit elements connected for applying the controllable voltages to the variable gain signal amplifier and the selection shifting elements.

10. In a remote control system for controlling the operation of signal transfer apparatus from a distant location through not more than two conductors; a power supply circuit including a pair of power supply conductors, a control assembly having remote control connectors and impedance inserting elements connected through said remote control connectors in series in one of the power supply conductors; said impedance-inserting elements being substantially continuously variable to develop a substantially continuously variable control voltage thereacross; said signal receiving network including a voltage controlled variable gain signal amplifier; and circuit elements connected for applying the controllable voltage to control the gain of the variable gain signal amplifier.

11. The combination as defined by claim 10 in which said impedance-inserting elements include off-on switch structure.

12. In a remotely controlled signal transfer system: an amplification unit having an input circuit and an output circuit; a variable transfer network in at least one of said circuits and having remote control leads connected for changing the signal amplification in response to the electrical characteristics of said leads, and a signal-frequency-responsive feedback network connected to return signals from a part of the system on the output circuit side of the variable-transfer network to a part on the input circuit side of the variable-transfer network for automatically changing the frequency response of the system with changes in signal amplification.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,669,112	Winter	May 8, 1928
1,823,739	Horton	Sept. 15, 1931
1,900,095	Brownstein	Mar. 7, 1933
2,100,467	Borden	Nov. 30, 1937

FOREIGN PATENTS

Number	Country	Date
314,112	Great Britain	June 24, 1929