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SIGNAL SEEKING RECEIVER

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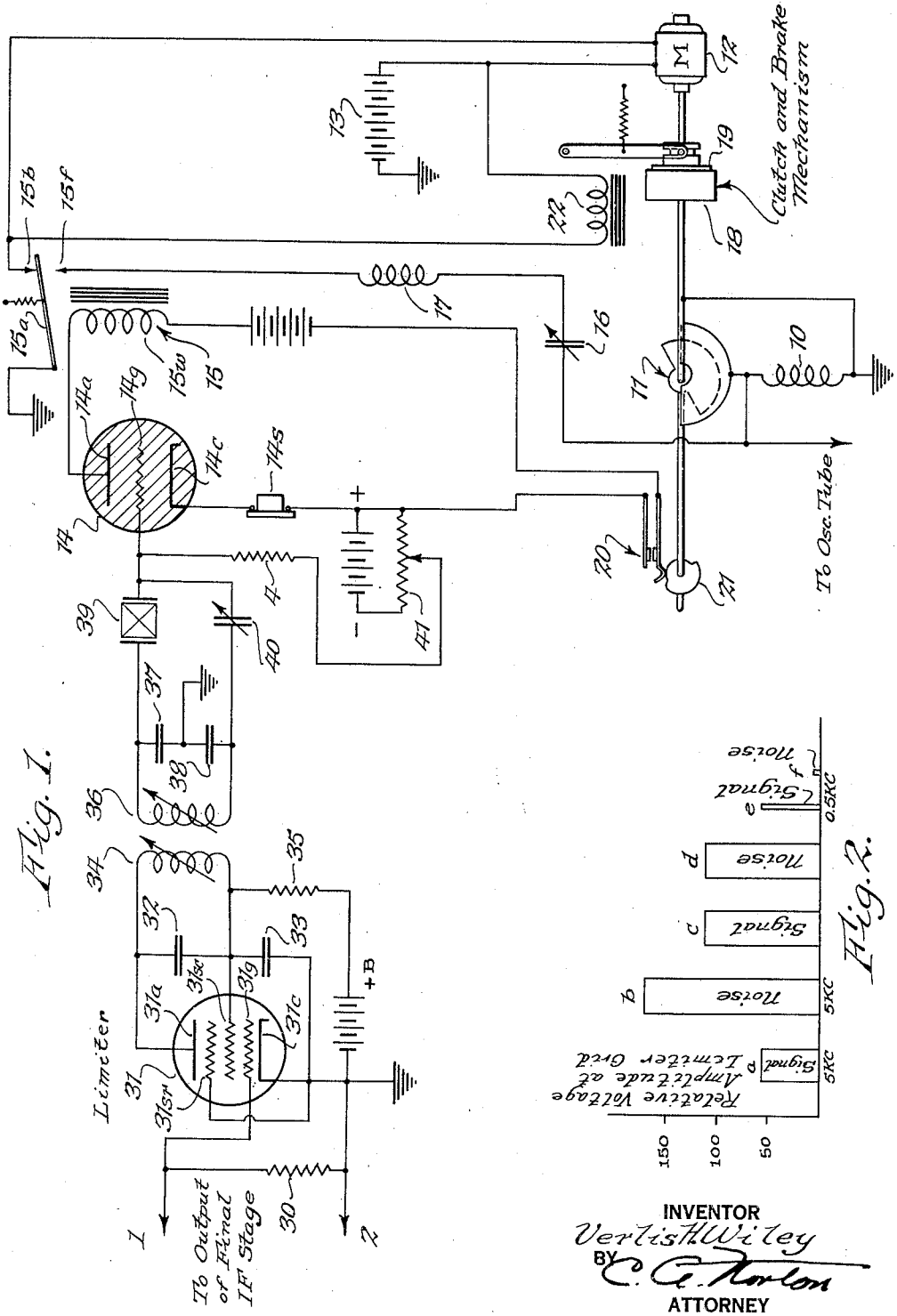


Fig. 1.

Fig. 2.

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SIGNAL SEEKING RECEIVER

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9 Claims. (Cl. 250—20)

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This invention relates to improvements in automatic tuning apparatus of the type in which a tuning instrumentality such as a variable condenser or inductance is operated by a motor and the tuning variation is stopped automatically as soon as the circuit or circuits desired to be tuned have reached resonance.

Circuits of this nature are shown and described in the co-pending application of William S. Winfield, Serial No. 463,775, filed October 29, 1942, in which the fundamental principles of such apparatus are discussed. The invention herein is applicable to "signal-seeking receivers," one form of which is described in my earlier application, Serial No. 534,389, filed May 6, 1944.

In signal-seeking receivers, also sometimes called "stop-on-carrier receivers" or "signal-tuned receivers," the tuning instrumentality is driven by a motor and scans the entire spectrum within the range of the receiver. When an incoming signal is tuned in, the voltage produced by the signal operates a control tube, which in turn, operates a relay opening the motor circuit so that the receiver remains tuned to the incoming signal. Receivers of this type are particularly advantageous for use in automobiles because the receiver may be operated as a pushbutton receiver without the necessity of resetting the pushbuttons whenever the vehicle travels to a different area.

It is necessary that such a receiver shall stop only on an incoming signal of predetermined strength; i. e., one which is strong enough to give good reception, but the receiver must be free from false stoppage caused by noise or static impulses. In accordance with my invention I have been able to produce a receiver which is for all practical purposes entirely immune to such false stoppages.

With such a receiver installed in an automobile, I have been able to follow trolley cars where the noise level was so high that it completely masked any but the very strongest local signals, and under such circumstances have been able to operate the receiver throughout the entire spectrum, the receiver selecting and stopping on not only local signals but also on weak distant signals without any false stoppage due to noise or static.

From the foregoing it will be understood that it is an object of this invention to provide a signal-seeking receiver which will unfailingly stop at an incoming signal even under extreme conditions of noise and static, and which is free from false stoppages resulting from noise or static.

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It is still a further object of this invention to provide such a receiver in which this result is obtained without the sacrifice of sensitivity.

Still other objects and advantages of my invention will be apparent from the specification.

The features of novelty which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its fundamental principles and as to its particular embodiments, will best be understood by reference to the specification and accompanying drawing, in which

Fig. 1 is a circuit diagram of so much of a radio receiver as is necessary to an understanding of my invention, and

Fig. 2 is a series of curves illustrating the operation of my invention.

Referring now more particularly to the drawing, 1 and 2 represent input terminals to be supplied with signal voltage, which may be derived from the final I. F. stage of a superheterodyne receiver of the usual type, or from the final R. F. stage of a tuned radio-frequency receiver.

It will be understood that terminals 1 and 2 are supplied with only a portion of the voltage output from the receiver, the remainder of the output being supplied to a detector, the output of which may be amplified and operate a loud speaker in the usual manner.

Connected between terminals 1 and 2 there may be provided a resistance 30, which may be in the input circuit of amplifier tube 31. This may be a pentode tube having cathode 31*c*, control electrode 31*g*, screen 31*sc*, suppressor 31*sr*, and anode 31*a*.

Cathode 31*c* may be connected to ground and to one terminal of resistance 30. Control electrode 31*g* may be connected to the other terminal of resistance 30. Suppressor 31*sr* may be connected to cathode 31*c* and screen 31*sc* through resistance 35 to +B and thence to cathode and ground. The output of tube 31 may be passed through a transformer comprising primary 34 and secondary 36, and primary 34 may be connected at one end to anode 31*a* and at the other end through resistance 35 to +B.

Condenser 32 may be provided, shunting primary 34, and condenser 33, shunting resistance 35 and the +B source. The secondary of the transformer may be shunted by condensers 37 and 38 in series, the common point of which may be grounded and one terminal of secondary 36 may be connected to one electrode of piezoelectric crystal 39, the other terminal of which may be

connected through condenser 40 to the opposite terminal of secondary 36.

The common point of crystal 39 and condenser 40 may be connected to control electrode 14g of control tube 14, which may be a triode having cathode 14c, control electrode 14g, and anode 14a. This tube will preferably be of the thyratron type. Control electrode 14g may be connected through resistance 4 to a variable point on resistance 41, which may be in shunt with a suitable biasing battery. Connected between cathode 14c and the + terminal of the biasing source, I may provide switch 14s in the form of a normally closed pushbutton switch, which the operator opens for a moment when it is desired to start the tuning operation. This interrupts the plate circuit of tube 14, deionizing the tube, and starts the tuning motor, as will be described. Included in the anode circuit of tube 14 there may be provided relay 15 in series with the source of plate current, and this relay 15 may comprise an actuating winding 15w, armature 15a, and front and back contacts 15f and 15b respectively.

The circuit to be controlled may be represented by inductance 10 and variable condenser 11, and the latter may be driven by suitable electric motor 12 through an interposed clutch and brake mechanism designated by 18 and 19. Power to operate motor 12 may be derived from any suitable source 13, which also may supply power to the relay winding 22 for operating the clutch and brake mechanism in such a manner that when the armature 15a of control relay 15 is carried to front contact 15f, the clutch is disengaged and the brake applied.

The circuit comprising inductance 10 and condenser 11, as stated, is the circuit to be controlled, and may, in the example given, be in the oscillator circuit of a superheterodyne receiver or it may be one or more of the signal-selecting circuits of a tuned radio frequency receiver. In the superheterodyne construction one side may be grounded and the other side connected to the oscillator tube. Since such circuits are well known to those skilled in the art and form per se no part of my invention, they are not specifically shown nor described.

It will be observed that when relay 15 has its armature in back contact position, a circuit is completed from the ungrounded side of source 13 through motor 12, through contact 15b and armature 15a to ground, and also from the same point through the winding of relay 22 to ground in the same manner. Thus, when the relay is in back contact position, motor 12 will operate and condenser 11 will rotate.

Returning for the moment to tube 31 and crystal 39, it will be understood that the input to tube 31 is preceded by a selector circuit which may be the final output circuit of the I. F. stage or the final R. F. stage (the latter in the case of a T. R. F. receiver), and that these circuits have a band pass characteristic of sufficient width to accommodate the necessary side bands accompanying voice or music modulated signals of usual radio quality, and as a practical matter these circuits will have a band width usually not less than 5 kc.

The transformer 34, 36 and crystal 39 are so arranged as to be considerably sharper than this. Preferably they will have a band width which is only a small fraction of the band width of the preceding circuits. As an example, but not in limitation, I have found that very satisfactory results are obtained when the band width in the crystal circuit is only 0.5 kc., and this degree of sharpness is easily obtained.

In case of a superheterodyne, the crystal circuit is tuned exactly to the intermediate frequency, and does not vary when the receiver is tuned. In the case of a T. R. F. set the circuit must vary in its tuning with the other circuits of the receiver and, therefore, a crystal would not be used, a variably-tuned circuit of great sharpness being substituted.

When the oscillator tuning is such as to bring in a signal of sufficient amplitude to fire tube 14, the signal voltage across the cathode and grid of tube 14 will rise until on some positive peak the tube fires. The strength of signal required to fire tube 14 may be controlled and adjusted by adjustment of the connection to resistance 41.

When this tube fires, the space current sharply increases and the armature of relay 15 is moved to front contact 15c, interrupting the motor circuit. Thereupon the motor stops, the clutch is disengaged, the brake applied to the tuning condenser, and the formerly free end of inductance 17 is connected to ground. This establishes a circuit consisting of condenser 16 and inductance 17 in parallel with inductance 10 and condenser 11. The significance of this will now be explained.

It will be observed that while motor 12 is in operation and condenser 11 is rotating, condenser 16 and inductance 17 have no effect because the circuit is open at contact 15c of relay 15. In my preferred embodiment condenser 11 may be a continuously variable condenser operable over 360° so that continued operation of motor 12 causes condenser 11 to turn repeatedly through its cycle, and reversal of direction of the motor is not necessary.

In certain instances in which the tuning is accomplished by moving iron cores into and out of the inductances this motion may be accomplished by a cam so arranged that a complete rotation of the cam makes a complete tuning cycle, and in this case also it is not necessary to reverse the motor.

Switch 20, operated by cam 21 driven in synchronism with the tuning condenser, may be provided in the plate circuit of tube 14 so that during 180° of its 360° rotation (the return half of the condenser cycle; for example, when the capacity is going from minimum to maximum) tube 14 cannot fire. Thus, only one-half of the condenser cycle (for example, when the frequency of the resonant circuit is increasing) is effectively utilized to stop the tuning. When so arranged any overrun of condenser 11 would be in the direction to increase the frequency of the tuned circuit, and this may be compensated for by connecting an additional condenser 16 and inductance 17 into the circuit after the motor stops.

The value of condenser 16 and inductance 17 will naturally depend on the specific installation and the amount of overrun which is encountered, and it is a relatively simple matter to determine by measurement and calculation just how much the frequency has increased due to overrun at any point.

Condenser 16 and inductor 17 may then be chosen of the correct value to decrease the frequency by just the desired amount. If tuning condenser 11 is a straight line capacity condenser, then inductance 17 is frequently not necessary and may be omitted, and satisfactory compensation may be achieved by the use of condenser 16 alone.

However, when condenser 11 is of the type customarily used, in which the change of capac-

ity per degree of rotation is not uniform over the range, though the amount of angular overrun is constant, the change in frequency introduced by this overrun will be different at different settings of the condenser, and in such case it is preferable to employ inductance 17 in addition to condenser 16.

The connection of condenser 16, and inductance 17, if the latter is used, decreases the resonant frequency of the circuit, and if the correct values are used, the compensation may be made substantially complete over the entire range, and the circuit acts, in effect, as if there were no overrun present.

In the arrangement above described it has been stated that the circuit tuning on which stopping occurs is from minimum to maximum frequency, and the stopping means is rendered ineffective during the cycle from maximum to minimum frequency, but the apparatus may also be arranged to work in the reverse fashion; that is to say, to stop while the frequency is decreasing, and to be ineffective when the frequency is increasing.

If this is done, then the direction of overrun will be to reduce the frequency below what it should be, and instead of connecting condenser 16 and inductance 17 (in case the latter is used) after the tuning has stopped, these elements will preferably be connected in while the tuning is proceeding, and will be disconnected after the tuning has stopped. This may readily be accomplished by providing an additional set of contacts on relay 15.

It will also be understood that by altering the values of condenser 16 and inductance 17 compensation in either direction; i. e., increase in frequency or decrease in frequency, can be obtained with any of the arrangements described. This is of advantage in affording the designer a considerable latitude in choosing the specific form of circuit and the specific values of the reactances employed to fit to the optimum degree any particular conditions or any particular circuit design encountered.

The amount of compensation required in any particular instance will depend upon a number of factors, among which may be mentioned the speed of the tuning motor, the speed of the tuning instrumentality, the inertia of the moving parts, the nature of the mechanical connection between the motor and the tuning instrumentality, the sensitivity of the control tube, and the frequency range covered.

Three possible conditions may be encountered in the operation of the receiver. First, the signal may be received without noise. Second, noise may be received without signal. Third, both may be received simultaneously. It is desired that the receiver stop scanning the spectrum only on the first and third of these conditions; namely, when a signal is received with or without noise. What is to be avoided is stoppage when noise only is being received.

In the operation of the receiver, suppose the motor to be operating and the receiver to be hunting for an incoming signal which may have the amplitude indicated by *a* in Fig. 2. The signal-selecting circuits, as previously stated, pass a band which may be 5 kc. in width, and this means that they will also pass a noise spectrum of the same width. This may be as indicated in *b*, wherein the noise amplitude may be considerably greater than the signal amplitude. In Fig. 2 the noise amplitude *b* is indicated as approximately three times the signal amplitude.

Amplifier tube 31 is operated as a limiter and is adjusted so that it limits at the maximum voltage developed at the limiter grid by the minimum or weakest usable signal in the absence of noise. When this adjustment is properly made, it will be found that the receiver will stop scanning the spectrum when any signal of the minimum usable strength is tuned in either with or without noise but will not stop scanning when noise alone is received, regardless of the amplitude of the noise. After passing through tube 31 the signal may be amplified to value *c*, which may be approximately twice that of value *a*, but noise will now be limited to the value *d*. No change in band width has occurred, and both signal and noise may occupy a spectrum or band 5 kc. wide.

After passing through crystal 39 a significant change has occurred. There may be a loss of approximately 50% in amplitude of the signal, as indicated at value *e*, and at the same time the band width has been reduced to the band width passed by the crystal.

In this instance, the band width is reduced from 5 kc. to 0.5 kc. The band width of the noise is reduced correspondingly; that is, from 5 kc. to 0.5 kc., but the amplitude of the noise is reduced in the ratio of the band width of the previous circuits to the band width of the crystal circuit; i. e., in the ratio of 5 to 0.5; that is, to $\frac{1}{10}$ of the value of *d*. The theoretical explanation of this phenomenon may be somewhat obscure, but there is no question of the fact, as it can be clearly demonstrated.

Since we have now changed the condition shown by curves *a* and *b* where the noise exceeded the signal by approximately 3 to 1 to the condition shown in curves *e* and *f* where the signal now exceeds the noise by several times, it now becomes possible to adjust the connection to resistance 41 so that the bias voltage applied to tube 14 lies at some value between the top of curve *f* and the top of curve *e*, whereby the noise voltage is insufficient to overcome the bias and thereby fire the tube and stop the tuning, whereas the signal voltage, being greater than this value, will overcome the bias and fire tube 14.

With a receiver properly adjusted in accordance with my invention and installed in an automobile, I have repeatedly operated the receiver behind trolley cars where the noise was so great as to mask the signal entirely, and it might be supposed that under such conditions the tuning had been stopped by the noise, but, by driving far enough away from the trolleys to reduce the noise, it was always found that the receiver was tuned to an incoming signal which could then be heard, and this action is so stable and so reliable that once the bias on tube 14 is properly adjusted, the tuning operation may be considered for all practical purposes as entirely immune to false stoppage by noise even under the most extreme conditions, and the receiver will unfailingly operate even where the noise level is so high that the listener would consider it not worth while to operate the receiver.

While I have shown and described certain preferred embodiments of my invention, it will be understood that modifications and changes may be made without departing from the spirit and scope of my invention, as will be clear to those skilled in the art.

In this application I have explained the principles of my invention and the best mode in which

I have contemplated applying those principles, so as to distinguish my invention from other inventions; and I have particularly pointed out and distinctly claimed the part, improvement, or combination which I claim as my invention or discovery.

1. In a signal-seeking receiver of the superheterodyne type having an intermediate-frequency amplifier, in combination, a circuit to be tuned, a variable tuning instrumentality in said circuit, a motor for operating said tuning instrumentality, a motor-energizing circuit, a control tube responsive to incoming signals, means controlled by said tube for opening said motor circuit in response to incoming signals, and means for preventing false opening of said motor circuit by received static or noise impulses, said last means comprising a circuit interposed between the output of the intermediate frequency amplifier of the receiver and said control tube and including in cascade a limiter and a final frequency selector having a much narrower acceptance frequency band width than that of said receiver and tuned substantially to the center of the receiver acceptance frequency band.

2. In a signal-seeking receiver of the superheterodyne type having an intermediate-frequency amplifier, in combination, a circuit to be tuned, a variable tuning instrumentality in said circuit, a motor for operating said tuning instrumentality, a motor-energizing circuit, a control tube responsive to incoming signals, means controlled by said tube for opening said motor circuit in response to incoming signals, and means for preventing false opening of said motor circuit by received static or noise impulses, said last means comprising a circuit interposed between the output of the intermediate frequency amplifier of the receiver and said control tube and including in cascade a limiter and a finel frequency selector having a much narrower acceptance frequency band width than that of said receiver and tuned substantially to the center of the receiver acceptance frequency band, whereby normal signal strength substantially exceeds normal noise level at the output of said final frequency selector, and means for impressing on said control tube a bias greater than the normal noise strength but less than normal signal strength.

3. In a signal-seeking receiver of the superheterodyne type having an intermediate-frequency amplifier, in combination, a circuit to be tuned, a variable tuning instrumentality in said circuit, a motor for operating said tuning instrumentality, a motor-energizing circuit, a control tube responsive to incoming signals, means controlled by said tube for opening said motor circuit in response to incoming signals, and means for preventing false opening of said motor circuit by received static or noise impulses, said last means comprising a circuit interposed between the output of the intermediate frequency amplifier of the receiver and said control tube and including in cascade a limiter and a final frequency selector having a much narrower acceptance frequency band width than that of said receiver and tuned substantially to the center of the receiver acceptance frequency band, whereby normal signal strength substantially exceeds normal noise level at the output of said final frequency selector, and means for impressing on said control tube a bias of such value as to prevent response of said tube to normal noise while permitting response thereof to normal signals.

4. In a signal-seeking receiver of the superheterodyne type having an intermediate-frequency amplifier, in combination, a circuit to be tuned, a variable tuning instrumentality in said circuit, a motor for operating said tuning instrumentality, a motor-energizing circuit, a control tube responsive to incoming signals, means controlled by said tube for opening said motor circuit in response to incoming signals, and means for preventing false opening of said motor circuit by received static or noise impulses, said last means comprising a circuit interposed between the output of the intermediate frequency amplifier of the receiver and said control tube and including in cascade a limiter and a final frequency selector comprising a piezoelectric crystal having a much narrower acceptance frequency band width than that of said receiver and tuned substantially to the center of the receiver acceptance frequency band.

5. In a signal-seeking receiver of the superheterodyne type having an intermediate-frequency amplifier, in combination, a circuit to be tuned, a variable tuning instrumentality in said circuit, a motor for operating said tuning instrumentality, a motor-energizing circuit, a control tube responsive to incoming signals, means controlled by said tube for opening said motor circuit in response to incoming signals, and means for preventing false opening of said motor circuit by received static or noise impulses, said last means comprising a circuit interposed between the output of the intermediate frequency amplifier of the receiver and said control tube and including in cascade a limiter and a final frequency selector comprising a piezoelectric crystal having a much narrower acceptance frequency band width than that of said receiver and tuned substantially to the center of the receiver acceptance frequency band, whereby normal signal strength substantially exceeds normal noise level at the output of said final frequency selector, and means for impressing on said control tube a bias greater than the normal noise strength but less than normal signal strength.

6. In a signal-seeking receiver of the superheterodyne type having an intermediate-frequency amplifier, in combination, a circuit to be tuned, a variable tuning instrumentality in said circuit, a motor for operating said tuning instrumentality, a motor-energizing circuit, a control tube responsive to incoming signals, means controlled by said tube for opening said motor circuit in response to incoming signals, and means for preventing false opening of said motor circuit by received static or noise impulses, said last means comprising a circuit interposed between the output of the intermediate frequency amplifier of the receiver and said control tube and including in cascade a limiter and a final frequency selector comprising a piezoelectric crystal having a much narrower acceptance frequency band width than that of said receiver and tuned substantially to the center of the receiver acceptance frequency band, whereby normal signal strength substantially exceeds normal noise level at the output of said final frequency selector, and means for impressing on said control tube a bias of such value as to prevent response of said tube to normal noise while permitting response thereof to normal signals.

7. In a signal-seeking receiver, in combination, a signal-selecting frequency selective circuit to be tuned, having a band characteristic of sufficient width to pass voice and music modulated signals of usual radio quality, a variable tuning

instrumentality in said circuit, a motor for operating said tuning instrumentality, a motor-energizing circuit, a control tube responsive to incoming signals, means controlled by said tube for opening said motor circuit in response to incoming signals, and means interposed between said control tube and said signal-selecting circuit for reducing the amplitude of noise impulses, said last-mentioned means comprising a limiter for limiting noise impulses of the amplitude of desired signals, and a frequency-selective circuit supplied by said limiter, having an acceptance band width substantially narrower than the signal-selecting circuit, and tuned substantially to the center of the receiver acceptance frequency band.

8. In a signal-seeking receiver, in combination, a signal-selecting frequency selective circuit to be tuned, having a band characteristic of sufficient width to pass voice and music modulated signals of usual radio quality, a variable tuning instrumentality in said circuit, a motor for operating said tuning instrumentality, a motor-energizing circuit, a control tube responsive to incoming signals, means controlled by said tube for opening said motor circuit in response to incoming signals, and means interposed between said control tube and said signal-selecting circuit for reducing the amplitude of noise impulses, said last-mentioned means comprising a limiter for limiting noise impulses of the amplitude of desired signals, and a frequency-selective circuit including a piezoelectric crystal supplied by said limiter, having an acceptance band width substantially narrower than the signal-selecting circuit, and tuned substantially to the center of the receiver acceptance frequency band.

9. In a signal-seeking receiver, in combination, a signal-selecting frequency selective circuit to

be tuned, having a band characteristic of sufficient width to pass voice and music modulated signals of usual radio quality, a variable tuning instrumentality in said circuit, a motor for operating said tuning instrumentality, a motor-energizing circuit, a control tube responsive to incoming signals, means controlled by said tube for opening said motor circuit in response to incoming signals, and means interposed between said control tube and said signal-selecting circuit for reducing the amplitude of noise impulses, said last-mentioned means comprising a limiter for limiting noise impulses of the amplitude of desired signals, and a frequency-selective circuit including a tuned transformer and a piezoelectric crystal connected to the secondary thereof supplied by said limiter, having an acceptance frequency band width substantially narrower than the signal-selecting circuit, and tuned substantially to the center of the receiver acceptance frequency band.

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Certificate of Correction

Patent No. 2,491,942 December 20, 1949

VERLIS H. WILEY

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 3, line 66, for "quaity" read *quality*; column 4, lines 20 and 31, for "15c" read *15f*; column 7, line 40, for "finel" read *final*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 20th day of June, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

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