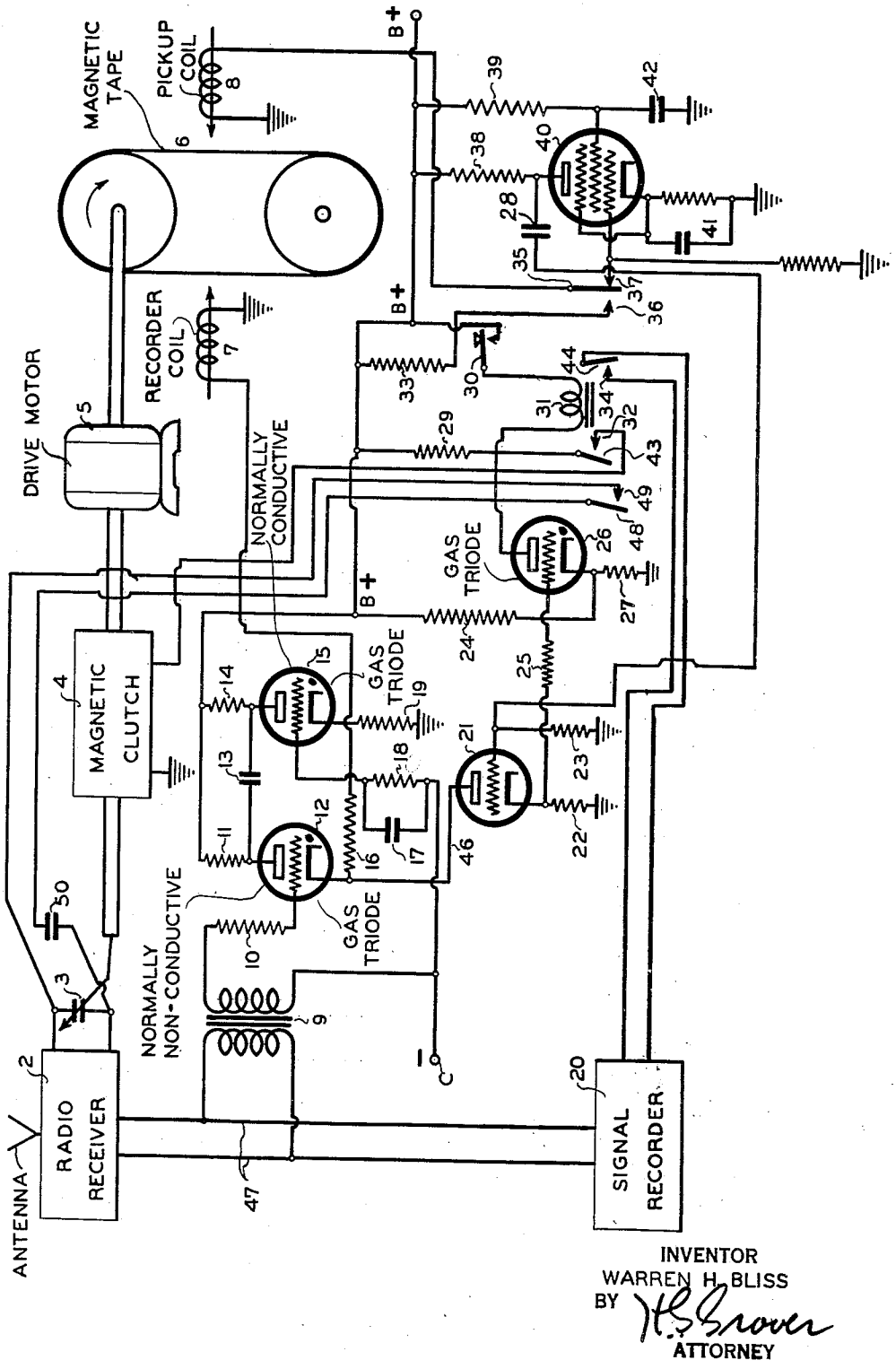
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RADIO RECEIVER

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RADIO RECEIVER

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This disclosure relates broadly to apparatus for scanning a given frequency band of the radio spectrum, locating any new signal which appears therein and controlling a device for making a record of such a signal.

In monitoring the radio spectrum for enemy and illegal stations, a transmitter which suddenly goes into action sends a short message at high speed and then shuts down quickly is very hard to detect. A primary object of the present invention is to provide a method of and apparatus for detecting the signals from such unknown stations.

An important feature of the present invention lies in an arrangement which enables the receiver to scan or hunt continuously over a given band of frequencies, and when a new signal is found that was not there previously the receiver stops hunting and remains on the frequency of the new signal so that it may be recorded. In order to accomplish this result, a panoramic representation of all signals in the band is set up, registered or stored for reference or comparison purposes. This registration may employ any suitable recording system such as a magnetic tape. The incoming signals are then continuously compared with those registered on the tape. The sudden appearance of any new signal is quickly detected, which action causes it to be recorded in another apparatus as a continuous record available for study.

A more detailed description of the invention follows in conjunction with a drawing whose single figure illustrates a specific embodiment of this invention.

Referring to the drawing, unit 2 is any conventional radio receiver with a motor driven vernier tuning condenser 3 which is connected in parallel with the main tuning condenser of the receiver. The motor which drives the condenser 3 is labeled 5. It is preferred that the receiver sweep over a desired portion of the radio spectrum, and that it follow a standard saw-tooth variation in which the forward sweep is very slow compared to the return sweep. The main tuning condenser across which the vernier 3 is connected may be the frequency determining element of a local oscillator in a superheterodyne receiver, or where a multi-stage tuned radio frequency receiver is employed, it is preferred that all tuning condensers of the different stages vary simultaneously by a unicontrol means.

A magnetic clutch 4 is so arranged that the motion of condenser 3 may be suddenly stopped at any position in response to energizing current in the coil of the actuating magnet of the clutch. The motor 5 also drives a loop 6 of magnetic tape.

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The relative speeds of rotation of the condenser 3 and tape 6 must be such that the loop of tape 6 makes one complete circuit while the condenser 3 sweeps through a complete cycle of operation twice. During each cycle of operation of condenser 3, the receiver 2 will sweep through the desired portion of the radio spectrum to be studied and will be ready for the next sweep.

The detected output from the receiver 2 is fed through leads 47 and audio transformer 9 into a pulse reshaper consisting of gas triodes 12 and 15, sometimes known as "Thyratrons." This pulse reshaper 12, 15 is sometimes referred to as a trigger circuit which requires an initiating pulse to change the condition of equilibrium for a duration depending in part upon the constants of the circuit elements and in part upon the electrode voltages.

The term "reshaper" has here been employed because the circuit 12, 15 converts the shape of an initiating pulse into a substantially rectangular pulse for use by the recorder coil in a manner described later.

These triodes 12 and 15 have plate resistors 11 and 14 and cathode resistors 16 and 19. A magnetic recording coil 7 is connected in series with the cathode resistor 16 of triode 12. Normally, that is, in the absence of an initiating pulse, tube 12 is non-conducting and tube 15 is conducting. An initiating pulse reverses these conditions of current conduction of these two tubes. The grid of gas triode 12 receives the incoming pulses from transformer 9 over resistor 10. The grid of triode 15 is connected to a supply of negative bias C— through a large resistor 18 which is shunted by a small condenser 17. A condenser 13 is connected between the plates of the two gas triodes, and its value determines the duration of the reshaped pulse.

A magnetic pick-up coil 8 is located half way around the tape from the recording coil 7 and is connected to an armature 35 of relay 31 having oppositely disposed contacts 36 and 37, by means of which the coil 8 can be connected either to the grid of vacuum tube pentode amplifier 40 or to the B+ plate supply through resistor 33. Pentode 40 has the usual resistors and condensers for class "A" operation. Its plate is coupled via condenser 28 to the grid of a vacuum tube triode 21. This triode 21 has its plate connected through connection 46 to the cathode of gas triode 12, and the cathode of tube 21 is coupled directly to the control grid of gas triode or "Thyratron" 26. Resistors 23 and 22 are also used for the grid and cathode, respectively, of vacuum tube 21.

Resistors 24 and 27 form a potential divider

between the B+ lead and ground to maintain a high negative grid bias on gas triode 26 by elevating the cathode potential above ground. The plate circuit of this tube contains in series the actuating coil of relay 31 and a switch 30. In the absence of energizing current through the winding of relay 31, contact pairs 32—43, 36, 35, and 34, 44 will be normally open, while contacts 35—37 will be closed. Contact 32 is connected to the magnetizing coil of clutch 4 and serves to complete the circuit of this coil with the B+ lead through a resistor 29. The closure of contacts 34—44 causes the signal recorder 20 to commence recording. Recorder 20 is connected to the receiver 2 by means of leads 47 and records the signals from the receiver. This recorder may be any conventional type of device for permanently recording radio signals and operates to record only when contacts 34—44 are closed by the action of relay 31.

The operation of the system of the invention will now be described in greater detail: Switch 30, whose function is described later, is normally open (as shown). The radio receiver 2 is made to swing its tuning over a given frequency band of the radio spectrum by means of the small motor driven condenser 3 which operates in conjunction with the main tuning device of the receiver in such a way as to cause it to scan over the given band of the radio frequency spectrum in an approximately linear manner. At the end of each sweep, the tuning of the receiver very quickly reverts to its original position in preparation for another sweep, or putting it in other words, the tuning jumps back and starts over again. For purposes of explanation, a sweep cycle of one second duration may be assumed. As the receiver sweeps over a portion of the radio spectrum, each radio signal encountered will appear as a pulse of voltage in the output leads 47.

These pulses are recorded on the loop of magnetic tape 6 which is exactly two sweep cycles in length. Due to the fact that pulses from the receiver 2 vary widely in both shape and magnitude, a reshaper or trigger circuit consisting of gas triodes 12 and 15 is provided. Normally, tube 12 is non-conducting and tube 15 is conducting. When a pulse from the receiver appears in leads 47, it passes through transformer 9 and is applied to the grid of tube 12, thus firing or initiating conduction in tube 12, as a result of which current is set up through the recording coil 7. When tube 12 starts conducting, it changes the condition of charge on condenser 13, thus reducing the voltage on the plate of tube 12 below the arc sustaining value, as a result of which tube 15 ceases conduction momentarily. The tubes 12 and 15 regain their original status after a time interval depending upon the value of condensers 13 and 17. In this manner a comparatively square pulse of current is obtained from the cathode of tube 12 for energizing the recorder coil 7 for each received pulse, irrespective of its character. Thus, all pulses received on the receiver 2 irrespective of their shape and magnitude, are recorded on the tape alike.

Since the magnetic tape 6 is synchronized with the frequency sweep of the receiver, a panorama of the radio signals in the chosen band of the radio frequency spectrum is set up or registered on the tape as soon as the tape has made a few revolutions. In the case of keyed continuous wave signals, several sweep cycles may be necessary to set up the complete panorama because the signals of a given station will not be present during every sweep. Because each station has a given frequency, the signals from each station will always appear at the same position on the panorama. As the receiver continues to hunt over the spectrum, each station will have a representative magnetic pulse on the tape and no new pulses will be recorded, since each incoming pulse will be applied at a point where it was previously registered. At this time, switch 30 should be closed. Now, if new signals, of a different frequency than those previously registered, suddenly appear in the spectrum being scanned, these will form new recorded spots, as will be explained later.

In order to compare the panoramic radio record with the constantly incoming signals, a pick-up coil 8 and a comparator device are used. Since the tape is two sweep cycles in length and recorder coil 7 and pick-up 8 are spaced one cycle apart, the pulses picked up by coil 8 will be at the same phase as those coming from the receiver through the reshaper or trigger circuit 12, 15. Triode 21 compares these incoming pulses with those already recorded on the magnetic tape 6, since the incoming reshaped pulses from the cathode of gas triode 12 are applied to the plate of this triode 21, while the recorded pulses (as picked up by coil 8 and amplified by pentode 40) are applied to the grid of triode 21. The pulse from the receiver applied to the plate of tube 21 must be of opposite polarity to the pulse simultaneously applied to the grid of tube 21 by the pick-up coil 8 through pentode 40. This condition can be assured by properly poling the terminal connections of the pick-up coil 8. Since the pulse applied to the plate of tube 21 is always positive, the pulse applied to the grid of tube 21 should always be negative and of a value sufficient to prevent space current flow through tube 21. When a new signal suddenly appears in the observed band, the plate of triode 21 will receive a reshaped pulse for this new signal but since it has not been registered previously on the magnetic tape the grid of this comparator tube 21 will receive no matching or counterbalancing negative pulse on its grid. Since the plate and grid pulses of stations already recognized are of opposite polarity and cancel each other, the application of a pulse to the plate only of tube 21 caused by the appearance of a new signal will produce a pulse of plate current which flows through cathode resistor 22.

This pulse of current in tube 21, which occurs only for a new signal, will be passed on as a voltage swing to trip or fire gas triode 26. The firing of triode 26 energizes the coil of relay 31 which quickly closes contacts 32—43 and 34—44. The closure of the former contacts causes magnetic clutch 4 to arrest the motion of auxiliary tuning condenser 3, thus leaving receiver 2 tuned to the frequency of the station which has just been found. The operation of relay 31 by virtue of the closure of contacts 34, 44 also causes recorder 20 to go into operation and start registering the newly found signal.

The operation of relay 31 also opens contacts 37—35 and closes contacts 36—35 to apply direct current to pick-up coil 8 for magnetic erasing. While the registered signals on tape 6 are being erased, the signal recorder 20 is receiving the newly found signals. The relay 31 remains energized until switch 30 is opened manually at the will of the operator after the new signals have been recorded for a desired interval of time. The panorama of signals may then be set up again

on the magnetic tape after which switch 30 can be reclosed to put the system in readiness for hunting another new signal.

It should be noted that application of pulses to the grid of tube 21 in the absence of voltage applied to the plate of this same tube will have no effect on the signal recorder 20. Also, gas triode 26 is normally biased well below the firing point (i. e., the critical point at which conduction starts), but when this tube 26 is triggered by the pulse from a new signal through the intermediary of vacuum tube 21, it maintains a state of conduction until it is reset to its normal condition of non-conduction by opening switch 30. Relay 31 and magnetic clutch 4 must be high speed devices so that the hunting or scanning action of the receiver can be stopped instantly; otherwise the receiver tuning would pass on to a different frequency than that of the newly found station. This stopping action is preferably assured by suitable circuits for compensating or correcting for undesirable overshooting of the receiver tuning because of mechanical factors. In order to compensate for the possibility that magnetic clutch 4 may not be able to arrest the motion of condenser 3 quickly enough, when a new signal is found, so that the tuning of the receiver will not be swept beyond the frequency where the new signal is found an additional fixed condenser 50 of suitable value is arranged to be switched in parallel with the vernier scanning condenser 3 at the same instant that the magnetic clutch 4 is energized. The rotation and design of condenser 3 must be such that its capacitance varies linearly from its maximum to its minimum value during the sweep cycle and then snaps back quickly to its maximum value at the end of the sweep cycle. The value of condenser 50 can be set to exactly equal the amount of capacitance overshoot of condenser 3. The use of an additional pair of normally open contacts 48—49 on relay 31 will switch in the compensating condenser 50 at the proper instant. Another way of obtaining this compensation is to employ known types of automatic frequency control to pull the receiver into exact tuning with the newly found station when stopped in the vicinity of the carrier of the unknown station.

A disadvantage of this last method of compensation resides in the fact that if the newly found station has a frequency close to a strong known station, the receiver might be pulled into tuning the known station rather than the newly found station.

What is claimed is:

1. In a radio receiving system, means including a motor for continually and repeatedly changing the receiver response band over a predetermined portion of the radio frequency spectrum, means responsive to the detected output of said receiver including a trigger circuit and a magnetic tape recorder coupled to said trigger circuit for producing recordings representative of the signals received within said spectrum, a permanent recorder, and an electron discharge device circuit operative solely by a signal received within said spectrum but which does not register with the recordings on said tape for operatively connecting said last recorder to the output of said receiver.

2. In a radio receiving system, means including a motor for continually and repeatedly changing the receiver response band over a predetermined portion of the radio frequency spectrum, a magnetic clutch between said motor and said receiver

and adapted to open the link between said motor and said receiver, means responsive to the detected output of said receiver including a trigger circuit and a magnetic tape recorder coupled to said trigger circuit for producing recordings representative of the signals received within said spectrum, a permanent recorder, an electron discharge device circuit operative solely by a signal received within said spectrum but which does not register with the recordings on said tape for operatively connecting said last recorder to the output of said receiver, a relay coupled to said electron discharge device circuit and operative solely upon the flow of space current through said device, a pair of contacts for said relay one of which is connected to the energizing coil of said magnetic clutch and the other of which is connected to a source of potential, whereby operation of said electron discharge device circuit operates said relay and causes the energization of said clutch with a resultant fixation of the receiver response band.

3. In a radio receiving system, means for continually and repeatedly changing the receiver response band over a predetermined portion of the radio frequency spectrum, means responsive to the detected output of said receiver for producing indications representative of the signals received within said spectrum, and means operative solely in response to a new signal received within said spectrum which does not register with the frequency positions corresponding to said first indications for producing an indication of another kind and for stopping movement of the receiver response band.

4. In a radio receiving system, a tuning element controlling the receiver response band, a motor having a drive shaft linked to said element for continually and repeatedly changing the receiver response band over a predetermined portion of the radio frequency spectrum, a magnetic clutch between said shaft and said receiver, an output circuit for said receiver, a trigger circuit coupled to said output circuit for converting the shape of a voltage pulse appearing therein to substantially rectangular wave form, a magnetic tape having a recorder coil in circuit with said trigger circuit for operation from said rectangular wave form pulse, said magnetic tape having such length and being driven at such speed that it travels one complete revolution for an integral number of cycles of travel of the tuning element, a pick-up coil for said magnetic tape positioned at a predetermined location on said tape, a normally inoperative signal recorder also coupled to the output circuit of said receiver, and a comparator device in circuit both with said trigger circuit and said pick-up and responsive to signal pulses from said trigger circuit which do not register with previous recordings for rendering said signal recorder operative and for energizing said magnetic clutch to disengage said motor drive shaft from said tuning element.

5. A receiving system in accordance with claim 4, including a circuit operative in dependence upon the operation of comparator device for correcting the tuning of said receiver to assure the stopping of said receiver on the frequency within said spectrum which corresponds to that of the signal causing the operation of said comparator device.

6. In a radio receiving system, means for causing the receiver to repeatedly scan a predetermined portion of the radio frequency spectrum, means for producing indications representative of

the signals within said spectrum, and means for automatically recording solely those signals within said spectrum which were not present during the previous scanning operation.

7. In a radio receiving system, an antenna therefor, means for causing the receiver to repeatedly scan a predetermined portion of the radio frequency spectrum, means for producing indications representative of the signals within said spectrum, a recorder, and circuit means responsive solely to new signals within said spectrum which do not register with the frequency positions corresponding to said indications for operatively connecting said recorder to the output of said receiver and for simultaneously stopping the scanning of said receiver approximately at the frequency position of the new signals.

8. The method of operating a radio receiving system having a circuit for detecting the signals impressed thereon which includes the steps of automatically and cyclically varying the tuning of the receiver over a predetermined range of frequencies, and utilizing any newly detected signal received by said receiver in said range which was not present during an immediately preceding cycle of variation for automatically stopping said cyclical variation at the point at which the new signal is detected.

9. The method of operating a radio receiving system which includes the steps of automatically cyclically varying the tuning of the receiver over a predetermined frequency range, comparing the time phase of signals appearing in successive cycles of variation, detecting any new signal received by said receiver in said range which was not present during an immediately preceding cycle of variation, utilizing the detected new signal to stop the variation in tuning, and automatically recording solely the intelligence conveyed by said new signal.

10. The method of operating a radio receiving system which includes the steps of automatically and cyclically varying the tuning of the receiver over a predetermined frequency range, and utilizing any new signal received by said receiver in said range which was not present during an immediately preceding cycle of variation for automatically causing the recording of the new signal and simultaneously stopping the variation of the receiver at substantially the point at which the new signal is detected.

11. In a radio receiving system, an antenna therefor, means for causing the receiver to repeatedly scan a predetermined portion of the radio frequency spectrum, means for producing indications representative of the signals within said spectrum, a recorder, circuit means responsive solely to new signals within said spectrum which do not register with the frequency positions corresponding to said indications for operatively connecting said recorder to the output of said receiver and for simultaneously stopping the scanning of said receiver approximately at the frequency position of the new signals, and means for assuring that the tuning of the receiver does not sweep beyond the frequency position of the new signals.

12. A system in accordance with claim 4, including means for assuring the stopping of the receiver tuning at the position corresponding to the frequency of the newly found signals.

13. In a radio receiving system having a tuning element, an antenna therefor, means including a motor and a magnetic clutch between said motor and a tuning element of said receiving system for causing the receiver to repeatedly scan a predetermined portion of the radio frequency spectrum, means for producing indications representative of the signals within said spectrum, means for comparing the indications with the indications produced in previous scanning operations, a recorder, a relay for controlling the operativeness of said recorder and for controlling said clutch, an electronic circuit for controlling said relay, said electronic circuit being responsive solely to new signals within said spectrum which have not caused indications during the preceding scanning operations for operating said relay to thereby operatively connect said recorder to the output of said receiver and to thereby simultaneously energize said clutch to stop the scanning of said receiver approximately at the frequency position of the new signals.

14. In a radio receiving system having a tuning element, an antenna therefor, means including a motor and a magnetic clutch between said motor and a tuning element of said receiving system for causing the receiver to repeatedly scan a predetermined portion of the radio frequency spectrum, means for producing indications representative of the signals within said spectrum, means for comparing the indications with the indications produced in previous scanning operations, a recorder, a relay for controlling the operativeness of said recorder and for controlling said clutch, an electronic circuit for controlling said relay, said electronic circuit being responsive solely to new signals within said spectrum which have not caused indications during the preceding scanning operations for operating said relay to thereby operatively connect said recorder to the output of said receiver and to thereby simultaneously energize said clutch to stop the scanning of said receiver approximately at the frequency position of the new signals, and reactance means also under control of said relay for assuring that the tuning of the receiver does not sweep beyond the frequency position of the new signals.

15. The method of operating a radio receiving system which includes the steps of repeatedly scanning a predetermined portion of the radio frequency spectrum, causing signals emanating from identifiable transmitting stations in said portion of the spectrum to produce one type of indication in said receiving system, and causing a new signal in said portion of the spectrum which emanates from a newly found transmitting station suddenly appearing during the scanning of said spectrum to produce another type of indication, and automatically recording solely the new signal to the exclusion of the other signals emanating from the identifiable transmitting stations and occurring simultaneously with the new signal.

16. The method of operating a radio receiving system which includes the steps of uniformly, automatically and repeatedly scanning a predetermined portion of the radio frequency spectrum, producing indications representative of the signals within said spectrum, utilizing a new signal appearing in said portion of the spectrum which was not present during the previous scanning operation and for which there is no corresponding indication to automatically stop the scanning of the receiving system at that position which substantially leaves the receiving system tuned to the new signal, and automatically recording solely said new signal.

17. The method of operating a radio receiving system which includes the steps of automatically and repeatedly scanning a predetermined portion of the radio frequency spectrum, detecting the sig-

nals appearing in said portion of the spectrum, and utilizing a new signal appearing in the spectrum which was not present during the previous scanning operation to automatically stop the scanning of the receiving system at that position which leaves the receiving system substantially tuned to the new signal.

18. The method of operating a radio receiving system which includes the steps of automatically and repeatedly scanning a predetermined portion of the radio frequency spectrum, producing indications representative of the signals within said portion of the spectrum, automatically comparing the positions of said indications appearing in succeeding scanning operations, and automatically recording solely a new signal in the spectrum which was not present during the previous scanning operation.

19. The method of operating a radio receiving system which includes the step of automatically scanning a predetermined portion of the radio frequency spectrum at a constant and relatively slow rate, automatically restoring the tuning of the receiver to its starting condition at a fast rate immediately after the scanning operation in order to commence rescanning of the same range of frequencies, automatically repeating said scanning operations, detecting a new signal in the spectrum which was not present during the previous scanning operation, and utilizing said new signal to automatically stop the scanning of the system at the frequency position of the new signal, and continuously recording the intelligence conveyed by the new signal.

20. In a radio receiving system having a circuit for detecting the signals impressed thereon, means for continually and repeatedly changing the receiver response band over a predetermined portion of the radio frequency spectrum, means responsive to the detected output of said receiver for producing indications representative of the signals received within said spectrum, a signal recorder, and means responsive to a new signal received within said spectrum which has not caused an indication during the preceding scanning operations for operatively connecting said recorder to the output of said receiver.

21. The method of operating a radio receiving system which includes the steps of repeatedly scanning a predetermined portion of the radio frequency spectrum, causing signals emanating from identifiable transmitting stations in said portion of the spectrum to produce one type of indication in said receiving system, causing a new signal in said portion of the spectrum which emanates from a newly found transmitting station suddenly appearing during the scanning of said spectrum to produce another type of indication, and utilizing said new signal to stop the scanning of the system at approximately the frequency position of the new signal.

22. In a radio receiving system having a circuit for detecting the signals impressed thereon, means for continually and repeatedly changing the receiver response band over a predetermined portion of the radio frequency spectrum, means responsive to the detected output of said receiver for producing indications representative of the signals received within said spectrum, a signal recorder, and means responsive to a new signal received within said spectrum which has not caused indications during the preceding scanning operations for operatively connecting said recorder to the output of said receiver, said last means including a trigger circuit, an electron discharge device coupled to the output of said trigger circuit, and an electromagnetic relay under control of said electron discharge device circuit, said relay having contacts connected to said signal recorder.

23. In a radio receiving system, a tuning element for said receiving system, a magnetic clutch, a motor linked to said tuning element through said magnetic clutch for continually and repeatedly changing the receiver response band over a predetermined portion of the radio frequency spectrum, means responsive to the detected output of said receiver for producing indications representative of the signals received within said spectrum and for comparing said indications with the indications representative of signals received during previous scanning operations, and means operative solely in response to a new signal received within said spectrum which has not caused an indication during the preceding scanning operation for energizing said magnetic clutch to thereby stop movement of said tuning element.

24. In a radio receiving system, a receiver having a tuning element, an antenna coupled to the input of said receiver, means including a motor and a magnetic clutch linked to the shaft of the motor for moving said tuning element and causing the receiver to repeatedly scan a predetermined portion of the radio frequency spectrum, means for producing indications representative of the frequency positions of the signals within said spectrum, a recorder coupled to the output of said receiver, a relay for controlling the effectiveness of said recorder and for controlling the energization of said clutch, and electronic circuit means responsive solely to a new signal within said spectrum which has not caused an indication during the preceding scanning operation for operating said relay to thereby operatively connect said recorder to the output of said receiver and to thereby energize said clutch for simultaneously stopping the movement of said tuning element approximately at the frequency position of the new signal.

25. A frequency spectrum monitoring system comprising a radio receiver having a tuning element for tuning said receiver over a band of frequencies, means including a motor having a shaft linked to said tuning element for periodically and automatically causing said receiver to scan said band from one end to the other at a rate of the order of once per second, signal storage means for producing indications representative of the signals within the band being scanned, an electronic circuit responsive to a new signal received by said receiver and which does not correspond in time position to any of said indications for automatically stopping said motor approximately at the frequency position in said spectrum at which said signal appears, and means for monitoring the output of said receiver.

26. The method of operating a radio receiving system which includes the steps of automatically and cyclically varying the tuning of the receiver over a predetermined frequency range, establishing successive patterns representative of the signals received during successive cycles of variation, automatically comparing the time phase of the signals of a pattern with the time of occurrence of signals received during a preceding pattern, and detecting solely a new signal received by said receiver in said range which does not correspond in time phase with a signal of said pattern.

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