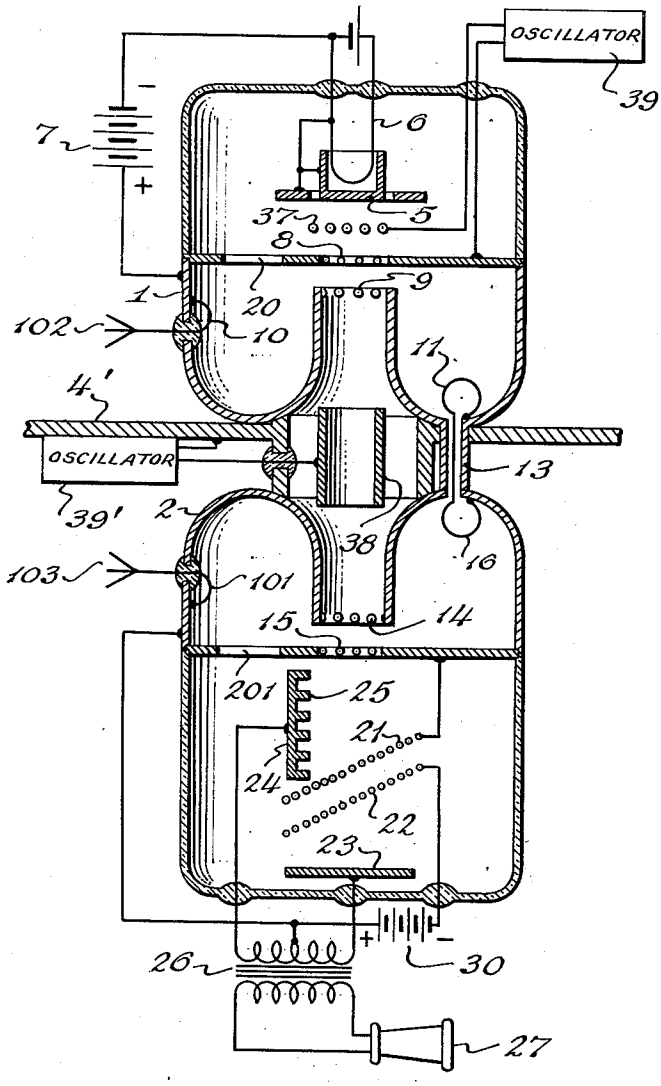
May 20, 1952 W. W. HANSEN ET AL 2,596,996

HIGH-FREQUENCY SUPERREGENERATIVE APPARATUS

Original Filed July 2, 1946 2 SHEETS—SHEET 1

Fig. 1.



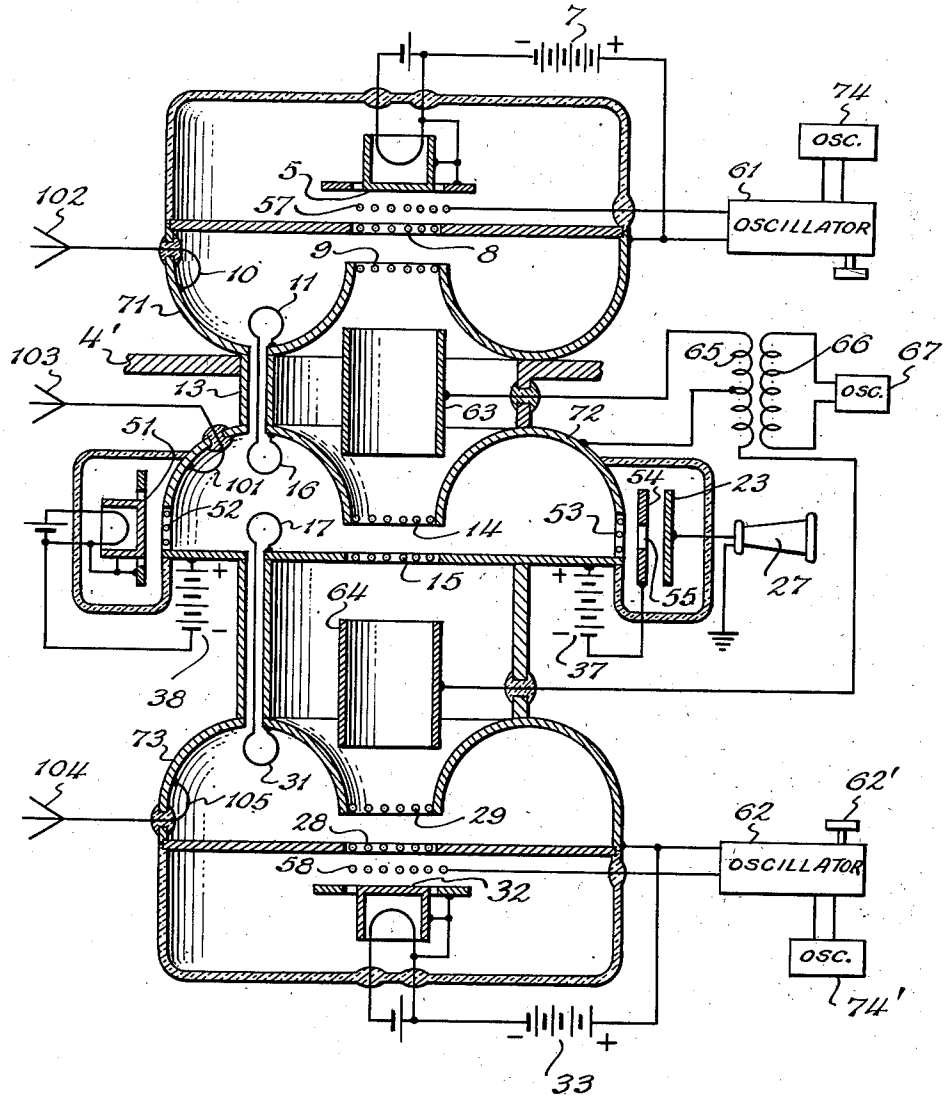
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Fig. 2.



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UNITED STATES PATENT OFFICE

2,596,996

HIGH-FREQUENCY SUPERREGENERATIVE APPARATUS

William W. Hansen, deceased, late of Stanford University, by Olive D. Ross, executrix, Palo Alto, Russell H. Varian, Stanford, and Sigurd F. Varian, Menlo Park, Calif., assignors to The Board of Trustees of The Leland Stanford Junior University, Stanford University, Calif.

Continuation of abandoned application Serial No. 681,096, July 2, 1946, which is a division of application Serial No. 218,064, July 8, 1938, now Patent No. 2,406,370, dated August 27, 1946. This application July 15, 1950, Serial No. 174,028

18 Claims. (Cl. 250—20)

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This invention relates, generally, to novel electron discharge tube apparatus and circuits adapted for reception and detection of electromagnetic energy and for remote object detection, and operating at frequencies of the order of 10^8 or more cycles per second. The present application is a continuation of our application Serial No. 681,096, filed July 2, 1946, and abandoned July 17, 1950, which is a true division of application Serial No. 218,064, filed July 8, 1938 (Patent No. 2,406,370). Application Serial No. 516,012, filed December 29, 1943 (Patent No. 2,406,371), is also a division of said application Serial No. 218,064.

The principal object of the present invention is to provide a novel electronic apparatus adapted for receiving or detecting high frequency signals.

Another object of the present invention lies in the production of improved superregenerative receivers for high frequencies, and particularly such receivers operating on the velocity-modulation principle.

A still further object of the invention is to produce methods and means for detecting objects at a distance by the alternate transmission and reception of radio waves intercepted by such objects or by the use of superregenerative apparatus.

Other objects and advantages will become apparent from the specification, taken in connection with the accompanying drawings wherein the invention is embodied in concrete form.

In the drawings,

Fig. 1 is a longitudinal cross-sectional view and schematic circuit diagram of a preferred embodiment of the present invention, and

Fig. 2 is a similar view of another form of the invention.

In Fig. 1, there are shown two resonant circuit members or cavity resonators 1 and 2 of the type disclosed in U. S. Patent No. 2,242,249, issued May 20, 1941, on application Serial No. 214,452 which was filed June 18, 1938. Resonators 1 and 2 and their associated apparatus comprise two intercoupled velocity-grouped electronic circuit means, the principles of operation of which are described in U. S. Patent No. 2,242,275, issued May 20, 1941, on application Serial No. 168,355 which was filed October 11, 1937. An electron emitter 5, such as an activated-oxide surface heated by a filament 6, is connected with a battery 7 for accelerating the electrons from emitter 5 into the resonator system. Resonator 1 is provided with a pair of spaced grids 8 and 9 in the path of these electrons. Resonator 2 has a pair of spaced grids 14 and 15 also in the path of the electron stream. Resonator 1 is also shown provided with a coupling loop 10 and a connected antenna 102. An opening 20 in resonator 1 may be used with or in lieu of antenna 102 for receiving energy. A coupling loop 16 in resonator 2 is coupled to a similar loop 11 in resonator 1 by coupling concentric transmission line 13, whereby the resonators 1 and 2 are electromagnetically coupled together. Resonator 2 is provided with a coupling loop 101 coupled to an antenna 103. Antenna 103 or opening 201 in resonator 2 (or both) may be used for radiating electromagnetic energy from resonator 2.

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Beyond resonator 2 there is shown a detector arrangement having two spaced parallel grids 21 and 22 placed near the exit grid 15 of resonator 2, but at an angle with respect to grid 15. This structure is claimed in the above-mentioned application Serial No. 516,012, Patent No. 2,406,371. A plate 23 is placed near the grid 22 on the side opposite grid 15. A second plate 24 is placed as indicated about at right angles to the surface of grid 15. The surface of plate 24 is provided with fins 25 or other means for preventing secondary-electron emission from plate 24. Plates 23 and 24 are connected to a push-pull transformer 26 which delivers its output to a telephone or other receiver 27.

Between the emitter 5 and the grid 8 there is located a control grid 37 connected to an oscillator 39 of comparatively low frequency. Between resonators 1 and 2 there is a tubular electrode 38 connected to a second low frequency oscillator 39'.

In the operation of this system, the electrons of the beam in passing through the grids 8 and 9 of resonant circuit member 1 are alternately accelerated and decelerated, as explained in Patent No. 2,242,275. As a result of the changes in velocities of the electrons of the beam and of their subsequent passage through the field-free drift space between grids 9 and 14, they arrive at the grid 14 of resonator 2 in groups or bunches distributed in time at the frequency of oscillation of the resonator system. Resonator 1 may therefore be termed an "electron-grouping circuit." Energy is transferred from the electrons to the electromagnetic field within resonator 2, and this resonator 2 is thereby excited to a state of oscillation and may be termed an "electron-beam-excited circuit." Some of the energy of the oscillation frequency is transmitted from resonator 2 to resonator 1 through feed-back coupling loop 16, transmission line 13 and coupling loop 11. Thus, the resonator 1 is maintained in a state of

oscillation, and the electron beam is accordingly continuously acted upon and bunched.

Assuming that a modulated carrier frequency is received by resonator 1 through either hole 20 or antenna 102, or both, the electrons of the beam are velocity-modulated and grouped in the manner discussed above. These electrons then travel through grids 14 and 15 and encounter grids 21 and 22. The electrons emerging from grid 15 have varying velocities, depending upon the amplitude of oscillation in the resonators 1 and 2. Some of the electrons pass through grids 21 and 22 and hit plate 23. Other electrons (that is, the slower ones) are reflected from grids 21 and 22 to plate 24, in a manner which will now be described more fully. The two grids 21 and 22 are parallel and close together. A potential difference is established between grids 21 and 22 by the battery 30, maintaining grid 22 negative with respect to grid 21. The resultant field between grids 21 and 22 acts like a flat mirror so far as the slower electrons leaving grid 15 are concerned. These slower electrons, on entering the field between grids 21 and 22, have their motion opposed by this field and are deflected toward plate 24. The faster electrons are deflected or refracted somewhat, but nevertheless penetrate the field between grids 21 and 22 and hit plate 23. The slower electrons are not able to penetrate this field, but bounce to the left, as in ordinary optical reflection, to be received by plate 24.

In the structure comprising resonators 1 and 2, all the electrons leaving the grid 15 have substantially the same velocity when the system is not oscillating. As the amplitude of oscillation increases, the electrons vary in velocity. For larger amplitudes of oscillation, the extremes of electron velocity are more widely separated. Thus the number of electrons flowing to plates 23 or 24 corresponds to the amplitude of oscillation of the resonators. The potential difference between grids 21 and 22 is adjusted either so that most of the electrons are reflected toward plate 24 or so that most of them are permitted to pass to the plate 23. The precise difference of potential between grids 21 and 22 giving the most sensitive or the most efficient detector action, as may be preferred, can be found by experimental adjustment of battery 30. The detector characteristic of this system is analogous to that found in ordinary vacuum tube circuits.

Since practically all the electrons emerging from grid 15 eventually strike either plate 23 or plate 24, any increase in current reaching one of these plates is accompanied by a decrease in current reaching the other plate. Hence, the current produced by electrons reaching plate 23 is one hundred eighty electrical degrees out of phase with the current produced by electrons reaching plate 24. Accordingly, the currents from plates 23 and 24 are appropriate to the operation of any push-pull apparatus usually used with push-pull detectors, such as transformer 26 and receiver or other utilization device 27.

The grid 37, the electrode 38 and the oscillators 39 and 39' are used to control the operation of the system for starting and stopping or varying the amplitude of oscillation. As is described in U. S. Patent No. 2,281,935, issued May 5, 1942, on application Serial No. 326,150 which was filed March 27, 1940, an alternating voltage applied to grid 37 or to electrode 38 accomplished amplitude modulation of the amplitude of oscillation of resonators 1 and 2. If this voltage is made sufficiently high, the oscillation of the system

can be stopped during part of every modulating cycle. The frequency of oscillators 39 and 39' may be of any desired value up to about 10^7 cycles per second, or even higher if the frequency of the resonators 1 and 2 is higher than 10^8 or 10^9 cycles per second. Ordinarily, the frequencies of oscillators 39 and 39' will be well within the frequency range of ordinary triode oscillators. Either grid 37 or electrode 38 or both may be used. Ordinarily, only one will be required, although in some instances it will be convenient to use both operating at the same or different frequencies.

The assemblage shown in Fig. 1 will operate alternately as a simple velocity modulation apparatus for transmission of radio waves and for the detection thereof. It will also operate as a superregenerative receiver. For best results the assemblage is placed in a suitable parabolic or other reflector as described in application Serial No. 185,382, filed January 17, 1938, which matured into U. S. Patent 2,415,094 on February 4, 1947. Also, a shield 4' is ordinarily used between the transmitter antenna 103 and the receiver antenna 102.

Either grid 37 or tube 38 is used with its corresponding oscillator 39 or 39' adjusted so that during part of the low frequency oscillation cycle of oscillator 39 or 39' the resonator system will oscillate strongly and during another part of the cycle it will oscillate weakly. It is characteristic of velocity modulation apparatus of the present type, one form of which is called the "klystron," that it is comparatively sensitive to the effects of incoming signals when oscillating weakly but relatively insensitive when oscillating strongly. For effective radiation strong oscillations are desired. The adjustment of voltage on grid 37 or tube 38, whichever is used, is made such as may be required to nearly stop oscillations during part of each low frequency cycle of oscillator 39 or 39'. During other parts of the cycle the system can operate with less restriction and at some parts of the cycle without any restriction.

Thus, the system transmits pulses of high frequency radiation, the pulses being at the frequency of the low frequency oscillators 39 or 39', and in between pulses of radiation the system is prepared to receive radiation. If the transmitted radiation encounters a suitable reflecting body or object some radiation will be returned to the system where it will be received and detected during the reception part of the low frequency cycle. In this mode of operation, the system operates alternately as a detector and as an oscillator.

Furthermore, it may operate as a superregenerative detector if adjusted properly. During superregenerative operation, oscillator 39 or 39' is adjusted so that, during part of its low frequency oscillation cycle, the resonator system will gain oscillatory strength, and during another part of the cycle, the oscillations will be made to die down; that is, will be "quenched." The adjustment of voltage on grid 37 or electrode 38, whichever is used, is such as required to nearly or completely stop oscillations during part of each low frequency cycle. During other parts of the cycle, the system operates in an oscillating condition. The conditions for superregeneration are, in general, fulfilled if the oscillator is allowed repeatedly to build up self-sustained oscillations for a period shorter than the time required for the oscillator to reach full oscillation and then is stopped. The amplitude reached before oscillation is stopped is then sensitive to incoming signals. This amplitude hence corresponds to the modulation enve-

lope of the received signal. The amplitude of oscillation of the resonators is detected by the detector arrangement already described, so that the output signal supplied to receiver 27 will be the modulation envelope of the signal received by antenna 102 or through hole 20.

The above-described use of the application as a superregenerative detector for modulated waves does not require the use of antenna 103 or opening 201 so that these features of Fig. 1 may be omitted when using the apparatus solely for reception of modulated waves.

The present apparatus may be used as an object-detecting system in another manner. For such a system, antenna 103 or opening 201 (or both) are also used. As described above, the combination of the two resonators 1 and 2, and their feedback coupling 13 serves as an oscillator, and the oscillations thereby produced may be radiated by the antenna 103 or the opening 201 or both toward a distant object whose presence and (as will be seen) velocity are to be determined.

Radiation leaving the apparatus by way of antenna 103 and opening 201 will be returned by reflection from the distant object and will be received by antenna 102 and opening 201. The returned radiation will produce an electromagnetic field in resonator 1 whose phase relation relative to the normal bunching field therein is determined by the distance to the distant object. This received signal will combine with the steady oscillation of the system and will add to or subtract from the amplitude of the steady oscillation depending upon the phase of the received signal relative to the oscillation of the system.

Since variation in distance to the distant object will cause a corresponding variation in the phase of the received signal, the observed result of the action of the system will be to produce an undulating intensity of amplitude of oscillation in the resonator 1 as the distance of the apparatus to the distant object varies. By the action of the detector described above, the signal produced in receiver 27 will also be of corresponding undulating intensity, and will have a frequency corresponding to the velocity of approach or recession of the distant object from the apparatus.

In operating in this manner, the system operates as a transmitter during the unquenched portions of the quenching cycle. The resultant amplitude of oscillation of the resonator system depends upon the distance to the distant object, and this amplitude will be periodically varied as the distance to the distant object correspondingly varies. The frequency of the signal heard in receiver 27 will, of course, be proportional to the velocity of recession or approach of the object detected. In this way the system operates to detect the presence of moving objects and also indicates the velocity of the distant object toward or away from the apparatus.

Fig. 2 shows another form of the present invention. In Fig. 2, three resonant circuit members or resonators 71, 72 and 73 are shown mutually spaced and centered on the same axis. A beam of electrons is projected from emitter 5 through resonators 71 and 72 in succession, and a second beam of electron is projected from a second emitter 32 through the resonators 73 and 72 in succession. Between the emitter 5 and its adjacent resonator 71 is a control grid 57 connected to an oscillator 61. A similar grid 58 is located between emitter 32 and resonator 73, and is connected to an oscillator 62. A pair of conducting tubular electrodes 63 and 64 are located respectively between resonators 71 and 72 and between resonators 72 and 73. Electrodes 63 and 64 are connected to the respective ends of a center-tapped secondary coil 65 of a transformer whose primary winding 66 is connected to an oscillator 67.

In Fig. 2, the physical arrangement is such that it is not convenient to use the detector shown in Fig. 1. In place thereof, a third beam of electrons is produced by a third electron emitter 51 and is projected through resonator 72 transversely to the axis of the system, by way of grids 52 and 53 in the walls thereof. This beam passes between the faces of resonator 72 containing grids 14 and 15 and leaves resonator 72 through grid 53. Thereafter, the beam is intercepted by a plate 54 having an opening 55, and the portion of the beam passing through opening 55 impinges upon a plate 23 to which is connected to receiver 27.

The operation of this transverse-beam detector is described in U. S. Patent No. 2,272,165, wherein it is disclosed that the electron beam is deflected vertically with respect to horizontal grids 14 and 15 by the alternating electric field therebetween. The deflection of the electron beam is a function of the amplitude of oscillation in resonator 72, and the detected signal received from plate 23 by the receiver 27 is also a function of the same amplitude. The plate 54 can be arranged with respect to the transverse electron beam so that, with no oscillation in resonator 72, substantially the entire cross-section of the electron beam will pass through opening 55, or so that practically none of the beam goes through under this condition. In either case, oscillations developed in resonator 72 will cause a variation in the number of electrons passing through opening 55, such variation being a function of the amplitude of oscillation.

The arrangement of Fig. 2 may be operated as a system which periodically produces strong oscillations for the purpose of transmitting a strong signal and thereafter has its oscillations damped so that it will act as a sensitive receiver for reflected waves or other modulated received signals. Under this condition of operation, the two electron beams from emitters 5 and 32 are adjusted to have substantially equal effect upon resonator 72. A modulating voltage of any practical frequency is supplied to transformer 66 from oscillator 67 and is thereby impressed in opposite phase upon electrodes 63 and 64, so that electrode 63 will increase in potential when electrode 64 decreases in potential, and vice versa.

The effect of a variation in the potential of electrode 63 is to change the time of flight of electrons in their course from resonator 71 to resonator 72, and also to cause the frequency of oscillation of resonator 72 to vary slightly, an effect which may be undesired. A corresponding and opposite effect occurs as a result of the opposite variation of the potential of electrode 64. The effects of frequency change due to change of time of flight of electrons passing through electrodes 63 and 64 is neutralized by the opposite directions of change of potential of the two electrodes. That is, if the electrode 63 is swung positive with a resultant tendency to increase frequency, the electrode 64 will be simultaneously swung negative and its tendency will be to reduce frequency. The net effect will be that the amplitude of oscillation in resonator 72 will be

varied without any change in frequency. This feature is claimed in our parent application Serial No. 218,064.

The preferred mode of operation of Fig. 2 is similar to that of operation of Fig. 1, in that the system acts alternately as a transmitter and as a receiver of radio signals. As explained before, the ordinary "klystron" is a sensitive detector when its amplitude of oscillation is small, but is less sensitive when the amplitude is large. Accordingly, it can operate either as a detector or as a transmitter satisfactorily by periodically shifting the amplitude from one magnitude to another. This is accomplished in Fig. 2 by the action of either one of oscillators 61 or 62. Either one or the other alone is sufficient, so if one is used the other may be omitted. Assuming the use of oscillator 62, for example, the electron beam from emitter 5 and the coupling of loops 11 and 16 between resonators 71 and 72 are adjusted so that, without the assistance of the electron beam from emitter 32, the system oscillates weakly and acts as a sensitive detector. With the electron beam from emitter 32 added at every positive half cycle of oscillator 62, the system is adjusted so that it oscillates vigorously. Then, the oscillator 62 is arranged so that its frequency can be varied as desired by adjusting knob 62', and so that it impresses a potential on grid 58 sufficient to substantially stop the electron beam from emitter 32 during alternate half cycles of the output of oscillator 62.

In using the device of Fig. 2 as shown trouble may be caused under some circumstances by the electrons that pass clear through the "catcher" 72, and enter the "buncher" 71 or 73 opposite their point of origin. In many cases these electrons will have a more or less random distribution in time, and should therefore cause little trouble, but in case they do make trouble, these electrons can be completely removed by setting the two beams from the two "bunchers" 71 and 73, at a slight angle with respect to each other, or by the use of magnetic or electrostatic deflecting fields in the spaces between the resonators, so that the electrons from one beam do not pass to the opposite "buncher" but are caught by the walls of the device.

The operation of the system then develops as follows: Energy is radiated by means of coupling loop 101 and the antenna 103 connected thereto. The radiated energy goes away from the oscillator and if a reflecting surface such as a remote object, for example an aircraft, is present at a practical distance from the system, some of the radiated energy is reflected back to the system. This reflected and returned energy enters resonator 71 through antenna 102 and is detected by the transverse electron beam from emitter 51, in the receiver 27. In the use of this system the operation is substantially as described in application Serial No. 185,382, except that there, separate detectors and transmitting oscillators are used. In the use of oscillators and detectors intermittently started and stopped at constant frequency there are, as mentioned in application Serial No. 185,382, alternate regions in the radiation field from which reflected signals vary from zero to maximum. To avoid "dead spaces" in the observed space the interrupting frequency is frequency modulated at a lower frequency by additional oscillators 74 and 74' connected to frequency-modulate oscillators 61 and 62, respectively. Arrangements for accomplishing this are shown in application Serial No. 185,382.

Another way of operating the system shown in Fig. 2 is to use it as a superregenerative detector. The modulating voltage impressed on electrodes 63 and 64 is made great enough to stop oscillation in resonator 72 during part of the cycle of the modulating signal. As is well known, a superregenerative receiver is very sensitive to incoming waves during the time when an oscillating state is building up in the system, and, at the same time, the average amplitude of oscillation for radiating purposes may be moderately large. The system thus operates in a manner similar to that of Fig. 1, both as an object detector for moving objects and as a receiver for modulated waves, the energy being radiated by antenna 103 coupled to resonator 72 by coupling loop 101 and being received by both antennas 102 and 104 coupled respectively to resonators 71 and 73 by respective coupling loops 10 and 105. In this mode of operation, grids 57 and 58 and oscillators 61 and 62 need not be used.

Operation of the system of Fig. 2 as a superregenerative detector may be accomplished in another manner, by using one of the beams for quenching the oscillations normally produced by the other beam. In this mode of operation, electrodes 57, 63 and 64 and their coupled oscillators 61 and 67 may be omitted. For example, the beam from emitter 5 may be adjusted so that, with the beam from emitter 32 cut off, oscillations in resonator 72 build up rapidly but with the beam from emitter 32 added, the oscillations are abruptly stopped.

This is accomplished by adjusting the accelerating voltage supplied by battery 33 for the beam from emitter 32 so that the electron current from emitter 32 enters resonator 72 with its radio-frequency component in phase opposition to the radio-frequency component of the electron current from emitter 5. Oscillator 62 is then adjusted to cut off the beam from emitter 32 each half cycle. This starts and stops oscillations in resonator 72 each quenching cycle, as required for superregenerative operation.

In this mode of operation, the system of Fig. 2 also operates either as a superregenerative detector for modulated waves or as an object-detector and velocity for moving objects, as in Fig. 1.

In Figs. 1 and 2, if desired, only a single radiating means supplied from either the electron grouping circuit or the electron absorbing circuit may be used both as transmitter and receiver.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. High frequency superregenerative receiving apparatus, comprising means for producing an electron stream, a cavity resonator coupled to said stream and excited by a received wave, a second cavity resonator coupled to said stream, means for intercoupling said cavity resonators to produce self-sustained regenerative oscillations in said second resonator, means for detecting changes in the amplitude of oscillations of said second resonator, and means for periodically varying the current of said stream at a periodicity less than the time required for said second cavity resonator to build up oscillations therein.

2. High frequency superregenerative receiving apparatus comprising means for producing a stream of free electrons, receiving circuit means including a cavity resonator connected to receive and responsive to a received wave for varying the velocity of the electrons of said stream, means in the path of said stream for detecting variations in the velocities of the electrons of said stream, an utilization device controlled from said detecting means and electrode means between said stream-producing means and said detecting means for periodically controlling said electron stream at a periodicity smaller than the time required for said receiving circuit means to build up oscillations therein.

3. High frequency superregenerative receiving apparatus, comprising means for producing an electron stream, means excited by a received wave for velocity-modulating said stream, means for extracting high frequency energy from said stream, means intercoupling said extracting means and said modulating means to produce self-sustained regenerative oscillations, means for detecting changes in the amplitude of said oscillations, and means including an electrode interposed between said velocity-modulating means and said extracting means for periodically controlling said stream to prevent said oscillations at a periodicity less than the time required for said oscillations to build up to full amplitude.

4. High frequency superregenerative receiving apparatus comprising cavity resonator means responsive to a received wave, means for producing oscillations in said resonator means comprising a source of electrons and means for projecting said electrons in energy-exchanging relation to said resonator means, output means responsive to the amplitude of oscillation of said resonator means, and means including an electrode interposed between said cavity resonator means and said output means for periodically quenching said oscillations at a periodicity smaller than the build-up time of said oscillations in said resonator means, said quenching means comprising a source of quench oscillations connected to said electrode for varying the magnitude of the current of said stream.

5. Superregenerative receiver apparatus comprising a velocity-modulation oscillation tube including a cathode, an accelerating electrode, a velocity-modulator circuit, an energy-extracting circuit separated from said modulator circuit by a drift space, and a detector electrode system positioned beyond said extracting circuit, means for maintaining an accelerating voltage between said cathode and said accelerating electrode, and an auxiliary oscillator coupled to said tube to vary the electron beam current intensity periodically to interrupt the oscillations of said tube.

6. Superregenerative receiver apparatus comprising means for producing an electron stream, a cavity resonator means positioned to receive and interact with said stream to produce high frequency oscillations, detecting means positioned in the path of said stream and responsive to the amplitude of said oscillations, and means for periodically quenching said oscillations.

7. High frequency object detecting apparatus comprising an electromagnetic oscillator, detector means for indicating the oscillating condition of said oscillator, means coupled to said oscillator for transmitting radiation therefrom toward a distant object and for receiving radiation reflected by said distant object, means for alternately and regularly changing the condition of said oscillator from a sensitive detecting condition to an efficient oscillating condition, and an alternating-current circuit coupled to said detector means whereby the frequency of excitation of said circuit indicates the velocity of approach or recession of said object toward or away from said apparatus.

8. High frequency object detecting apparatus, comprising means for producing an electron stream, means for varying the velocity of the electrons of said stream, receiving means coupled to said velocity-varying means, means for extracting high frequency energy from said velocity-varied electron stream, transmitting means coupled to said extracting means, means interconnecting said extracting and varying means whereby self-excited oscillations are produced in said transmitting means, and means for causing said extracting circuit to oscillate alternately with strong and weak oscillations, whereby said apparatus is adapted to alternately serve as a sensitive detector of waves radiated by said transmitting means and reflected from a distant object and as an efficient oscillator to transmit said radiations.

9. High frequency apparatus comprising means for producing an electron stream, means responsive to received energy for periodically varying the current of said electron stream, means for extracting high frequency energy from said varied stream, means interconnecting said extracting and varying means whereby self-excited oscillations are produced in said extracting means, means for radiating a portion of said extracted energy, and means for causing said extracting circuit to oscillate alternately with strong and weak oscillations, whereby said apparatus is adapted to serve alternately as an efficient oscillator to transmit radiations and as a sensitive oscillating detector of radiations reflected from a distant object.

10. In a device of the character described, an oscillator having antennae means for radiating and receiving electromagnetic energy, said oscillator having means for setting up an exciting electron stream for establishing oscillations of limited amplitude therein to operate the device as a sensitive receiver, the amplitude of said oscillations being determined by the amplitude of energy received thereby, additional oscillator means for cyclically varying the electron stream current for increasing the amplitude of oscillation of said oscillator at cyclically regular intervals to operate the device as an efficient transmitter of electromagnetic radiation, whereby a portion of the energy transmitted while the device is an efficient transmitter may be received by reflection from a remote object while the device is operating as an efficient receiver, and a detector responsive to changes in amplitude of oscillation of said oscillator.

11. High frequency apparatus comprising an oscillator having means for radiating and receiving electromagnetic energy, means for causing said oscillator to operate with oscillations of limited amplitude whereby said oscillator is adapted to operate as an efficient receiver of electromagnetic radiation, the amplitude of oscillation as a receiver being determined by the amplitude of energy received thereby, means for periodically increasing the amplitude of oscillation of said oscillator whereby said oscillator is adapted to operate as an efficient transmitter of electromagnetic radiation, and a detector respon-

sive to changes in amplitude of oscillation of said oscillator, whereby a portion of the energy transmitted while the device is an efficient oscillator and received by reflection from a remote object while the device is operating as an efficient receiver will indicate the presence of said object.

12. Ultra high frequency apparatus comprising a resonator, means for producing first and second streams of electrons and directing said electron streams through said resonator, means including said last-named means for producing ultra-high frequency oscillations in said resonator, and means for regularly quenching the oscillations in said resonator, said last-named means comprising means for modulating said second electron stream at the frequency of said oscillations and in phase opposition to said oscillations.

13. Ultra high frequency apparatus comprising first and second aligned resonators, means for directing an electron stream through said first and second resonators, said first resonator including means for imparting velocity modulation to the electrons of said stream, said second resonator including means for deriving oscillatory energy from said stream, said means included in said second resonator being spaced an appreciable distance from said means included in said first resonator whereby said velocity modulation results in arrival of said electrons at said second resonator in bunches, means for providing regenerative feedback from said second resonator to said first resonator for rendering said apparatus self-oscillatory, means for periodically interrupting the oscillations in said first and second resonators at a frequency appreciably lower than the resonant frequency of oscillations in said resonators, means for injecting weak oscillatory signals into one of said resonators, and means responsive to average strength of oscillations in one of said resonators for detecting variations therein according to variations of the injected weak signals.

14. Ultra high frequency apparatus as defined in claim 13, further including means coupled to said second resonator for radiating energy therefrom at predetermined intervals.

15. Radio object detection apparatus comprising a velocity modulation oscillator including a cavity resonator, means for supplying thereto direct current power to produce oscillations in said resonator, means for directionally radiating an appreciable part of the energy produced therein, and for introducing therein high frequency energy reflected back from distant objects, and means for rendering said velocity modulation oscillator alternately oscillatory and quiescent.

16. Radio object detection apparatus as defined in claim 15, including means responsive to variations of strength of oscillations in said velocity modulation oscillator for detecting variations of average strength of the energy reflected back from distant objects.

17. Ultra high frequency apparatus comprising a velocity modulation oscillation generator including a resonator, means for producing an electron stream and directing it through said resonator, means cooperating with said electron stream producing means and said resonator for imparting velocity modulation to said electron stream for providing ultra high frequency energy-yielding bunches therein for energizing said resonator; and means modulating said generator at a frequency appreciably lower than the resonant frequency of said resonator for rendering said generator alternately oscillatory and quiescent, said last-named means including a degenerative feedback quenching circuit acting upon said resonator in response to said modulating means for recurrently dynamically damping out the oscillatory energy in said resonator at a repetition frequency equal to said appreciably lower frequency.

18. Superregenerative receiver apparatus comprising a velocity modulation oscillator including first and second cavity resonators, feedback coupling means between said second resonator and said first resonator, means for producing a stream of electrons and directing said electron stream through said first and second cavity resonators to produce high frequency oscillations therein, means for periodically interrupting the high frequency oscillations therein, means for injecting oscillatory signals into one of said resonators, and means responsive to the average strength of oscillations in said resonators.

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