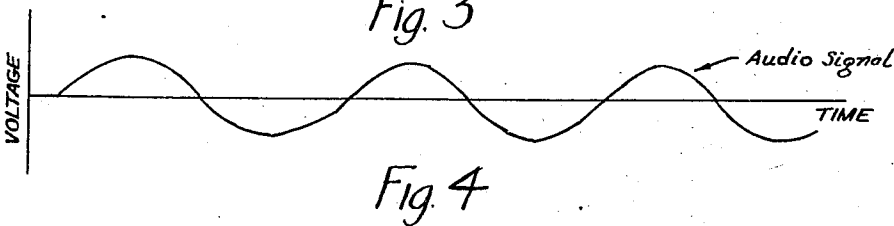
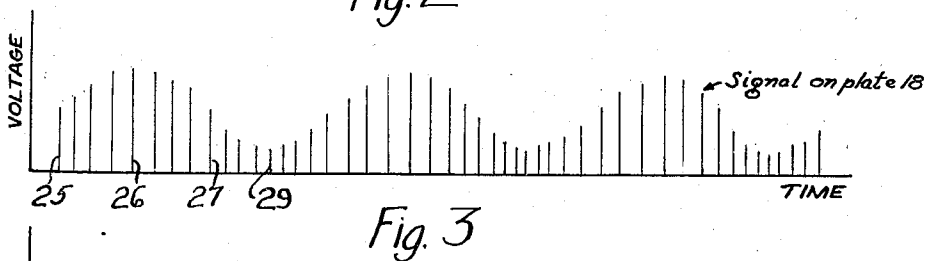
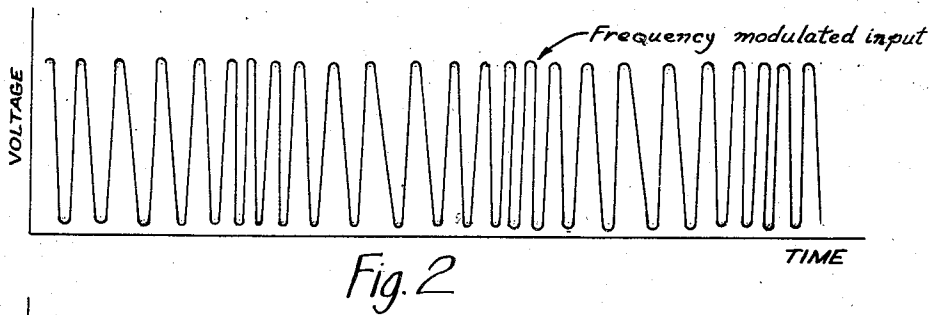
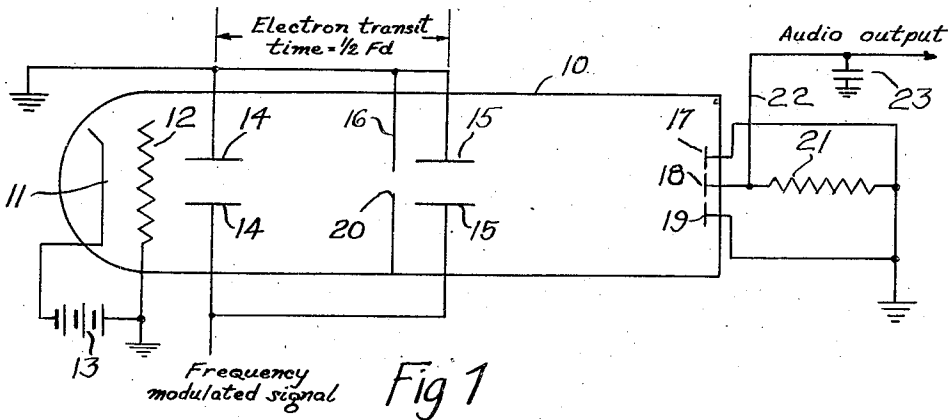


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RADIO RECEIVER FOR FREQUENCY
MODULATED SIGNALS

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The present invention relates to electrical apparatus and particularly to a radio receiver for the reception of frequency modulated signals.

More particularly still the invention relates to a detector of frequency modulated signals comprising an electron gun type tube.

The detector of this invention utilizes an electron gun tube having two pairs of deflecting plates which are separated by an amount such that the transit time of an electron from one pair of plates to the other is exactly a half period of the input signal wave when the input is at one edge of the intermediate frequency band.

As will be hereinafter explained, by utilizing a plurality of collector plates in the tube, "spurts" of electrons are produced and these spurts impinge upon a particular one of the collector plates to an extent dependent upon the instantaneous frequency of the signal input wave, thereby producing in the output circuit a plurality of voltage impulses of varying amplitude which, when integrated, are identical with the original modulation.

It is an object of the invention to provide a detector of frequency modulation which is simple in construction and operation and which comprises an electron gun tube.

It is another object of the invention to provide such a detector which can be utilized with known forms of limiter circuits and which comprises a single tube for converting the incoming radio frequency signal (after reduction to intermediate frequency) to an audio frequency signal identical to the original modulation.

Other objects and features of the invention will be seen when the following specification is considered in connection with the appended drawings, in which:

Figure 1 is a schematic diagram of the electron gun tube and circuits of my invention;

Figure 2 is a curve showing the wave form of a typical frequency modulated input signal;

Figure 3 is a curve showing the resulting output from the collector plate of the electron gun tube prior to its integration; and

Figure 4 is a curve of the integrated wave of Figure 3.

Referring now to the drawings, there is shown in Figure 1 an electron gun type tube which comprises the usual envelope 10 having therein the gun type cathode 11 and accelerating anode 12, the accelerating anode being maintained at a positive potential as respects the cathode 11 by means of the battery 13 in the usual manner. The potential supplied by battery 13 should be

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100 volts or more there being no upper limit. Upon this voltage as well as upon the spacing of the plates 14 relative to plates 15 depends the time of transit of electrons from plates 14 to plates 15.

Disposed within the tube are two sets of deflecting plates 14 and 15, the plates being arranged parallel to each other and being spaced apart longitudinally of the tube such an amount that the transit time for an electron from the plates 14 to plates 15 is equal to one-half of the period of the frequency modulated input signal at one extreme of the frequency band.

Interposed between the plates 14 and 15 is a collector plate or anode 16, both this collector plate and one of each pair of deflector plates 14 and 15 being grounded in the usual manner, the signal input being applied to the other one of each of the pairs of deflecting plates 14 and 15 as is indicated in the drawing. At the far end of the tube 10 are located three collecting plates 17, 18 and 19, these plates being generally rectangular and of a width substantially equivalent to the width of the rectangular slot 20 in the collector plate 16. The outer plates 17 and 19 are connected directly to ground while the center plate 18 is connected to ground through a series resistor 21. The output from the plate 18 is taken by means of the conductor 22 to the audio stages of the receiver, being integrated by means of the integrating condenser 23 which is connected to conductor 22 and to ground.

It will be clear from the above that the voltage applied to the accelerating anode 12 may be adjusted so that the transit time of an electron from plates 14 to plates 15 will be exactly the time of a half period of the signal wave at one extreme of frequency deviation. Any signal applied to plates 14 will cause a spurt of electrons to pass through the window 20 in the plate 16 at each null point in the wave. At other times, the signal voltage applied to plates 14 will deflect the electron beam so that it will strike the collector 16 and be conducted to ground.

Further, if at the time when an electron which has been permitted to pass through window 20 reaches the plates 15 a half cycle of the signal wave has passed, then at this instant the signal wave will be at another null point and there will be no deflection of the electron beam which will then strike the collector plate 16.

At the opposite end of the frequency range a spurt of electrons which passes through the window 20 will arrive at the deflecting plates 15 at a time when the signal input applied to these

plates is at some value other than zero and consequently there will be a deflection of the electron beam so that either plate 17 or 19 will receive all, or substantially all, of the electrons. In connection with the foregoing attention is again called to the fact that the electron beam is of substantially the width of the collector plate 18.

It will be seen from the above that there is a maximum voltage on plate 18 at one extreme of the frequency range and a minimum voltage thereon at the other extreme of the frequency range and, of course, between these two extremes there is a condition of mean application of voltage or reception of electrons by the plate 18.

Although the above has described the conditions when the transit time between the plates 14 and 15 has been adjusted to be equal to a half period of the signal wave at one extreme of the frequency deviation it will be clear that the same results may be obtained by adjusting the transit time to be equal to any small number of half cycles of the signal wave at the extreme of frequency deviation.

Referring now to Figure 2 there is shown therein a curve of voltage plotted against time for a typical input signal which is applied at the point indicated in the drawing, this input signal being, of course, at the intermediate frequency having been reduced thereto in any well known manner as, for example, by use of a heterodyne circuit. This curve indicates a wave which starts at the center frequency of the frequency modulated signal, decreases to the lowest frequency, then increases to the highest frequency of the range of deviation, thereafter again reduces to the lowest frequency, increases to the highest frequency, reduces to the lowest frequency, and finally terminates at the center frequency.

At the center frequency the voltage derived from the collector plate 18 will have a definite value resulting from the deflection of the electron beam to such an extent that substantially half of it strikes the collector plates 17 or 19 and the voltage derived therefrom is passed directly to ground without effect, the voltage applied to the plate 18 being effective to produce a voltage impulse which is indicated in Figure 3 at 25. As the incoming signal frequency decreases the electron beam is deflected less and less until finally substantially all the beam during each spurt (resulting from the null point of the cycle concurring with the passage of the electrons between the plates of the pair 14) strikes the plate 18, thus resulting in a voltage impulse indicated at 26 in Figure 3. As the frequency again passes through the center frequency an impulse such as that indicated at 27 occurs. Of course, between pulses 25 and 26 and 26 and 27 there are additional pulses the value of which is in proportion to the instantaneous frequency.

As the frequency rises above the center frequency until it reaches its extreme at the other end of the deviation range the impulses become progressively less in amplitude and as is shown at 29 finally reach a minimum. This minimum is the result of an electron spurt being deflected the maximum amount due to the fact that the electron spurt passing through the window 20 arrives at plates 15 the maximum amount out of synchronism with the signal applied to plates 15, or, in other words, at a time when the signal voltage applied to plates 15 is at the maximum value which is possible.

Thus, the signal being deflected the maximum amount substantially the entire electron spurt or

impulse is applied to the plates 17 or 19 rather than to plate 18 and the voltage derived therefrom is passed to ground rather than being applied across the resistor 21. As a result, a wave such as that shown in Figure 3 is produced which wave, as can be readily seen, has an envelope which is an audio frequency signal. This signal is integrated by known means as by means of the integrating condenser 23 of Figure 1 and results in the wave of Figure 4.

It should be noted that whether the deflection is to plate 17 or plate 19 depends solely upon whether the null point at the beginning of a negative half cycle is considered or the null point at the beginning of a positive half cycle.

This will perhaps be clearer if values are assumed for the various frequencies involved as well as for the transit time of the electrons from plates 14 to plates 15.

Thus if F_0 be the center frequency of the incoming signal, F_d the frequency at maximum negative deviation, and F'_d the frequency at maximum positive deviation, and if it is assumed that the deviation range is 150 kc., then

$$F_0 = F_d + 75 \text{ kc.}$$

and

$$F'_d = F_0 + 75 \text{ kc.} = F_d + 150 \text{ kc.}$$

Also the accelerating voltage on the anode 12 has such a value that an electron which passes plates 14 at a null point of the cycle at frequency F_d ($\omega=0$) reaches deflecting plates 15 at the next null point and, therefore, at a time which is $\frac{1}{2}F_d$ seconds later ($\omega=180^\circ$).

At the center frequency F_0 the time between two successive null points in the wave will be $\frac{1}{2}F_0$ seconds or $\frac{1}{2}(F_d + 75 \text{ kc.})$ seconds which is clearly a lesser time interval than $\frac{1}{2}F_d$ seconds. Thus the voltage on plates 15 will be of some value other than zero and will be negative when the null point of the wave permitting the passage of the electron spurt was one preceding a positive half cycle and positive when the null point was one preceding a negative half cycle.

At the maximum positive deviation F'_d , the time interval between two successive null points of the signal wave will be $\frac{1}{2}F'_d$ seconds or $\frac{1}{2}(F_d + 150 \text{ kc.})$ seconds which is clearly less than $\frac{1}{2}F_d$ and also clearly less than $\frac{1}{2}(F_d + 75 \text{ kc.})$ seconds.

Therefore, the voltage applied to plates 15 will, as in the case of the center frequency F_0 be positive or negative according to whether the voltage giving rise to the spurt considered preceded a negative or positive half cycle of the wave. Also the voltage will be proportional to the time interval and will thus be greater for the center frequency than for the maximum negative deviation and also greater for the maximum positive deviation F'_d than for the center frequency F_0 .

Of course, if the maximum positive frequency deviation be chosen to yield zero deflection of the electron spurts, then the conditions above outlined, will be reversed and the voltage applied to plates 15 will be positive at the time when the electron spurt deflected results from a null point preceding a positive half cycle and negative when the electron spurt results from a null point preceding a negative half cycle.

In any event, the application of a negative voltage to plates 15 will deflect the electron spurts toward collector plate 17 and application of a positive voltage will deflect electron spurts toward

plate 19.

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While I have described a preferred embodiment of my invention it is obvious that other embodiments and constructions may be adopted without departing from the spirit thereof and, consequently, I desire to be limited, not by the foregoing description, but solely by the scope of the appended claims.

What is claimed is:

1. In a receiver for frequency modulated signals, in combination, an electron gun tube comprising a gun type cathode, an accelerating anode and a plurality of deflecting plates, means for applying a potential between said cathode and said anode, said deflecting plates being arranged in pairs, one pair being spaced from the other longitudinally of the tube, said spacing and said anode potential being of an order of magnitude such that the transit time of an electron from one pair of plates to the other will be equal to the period of a small number of half cycles of a received frequency modulated signal at one of the limits of the deviation band of said signal, and means for applying received frequency modulated signals to said two pairs of deflecting plates simultaneously.

2. In a receiver for frequency modulated signals, in combination, an electron gun tube comprising a gun type cathode, an accelerating anode, means for applying a potential between said cathode and said anode, a plurality of deflecting plates, said deflecting plates being arranged in pairs one pair being spaced from the other longitudinally of the tube, said spacing and the said anode potential being of an order of magnitude such that the transit time of an electron from one pair of plates to the other will be equal to the period of a small number of half cycles of a received frequency modulated signal at one of the limits of the deviation band of said signal, a collector plate arranged substantially transversely of the tube between said pairs of deflecting plates, said collector plate having a window therein in alignment with the central plane between the pairs of deflecting plates, said collector plate being at a sufficient potential relative to said cathode to attract electrons falling thereon, and a plurality of collecting plates arranged transversely of the tube at the end thereof remote from said cathode, said collector plates being at a sufficient potential relative to said cathode to attract electrons falling thereon, the center one of said collecting plates being of substantially the same width as the said window in said first mentioned collector plate, means for applying a received frequency modulated signal to said deflecting plates simultaneously, and means comprising a resistor connected in the circuit of said second mentioned collector plates for developing voltage impulses having amplitudes proportional to the instantaneous frequency of the received signal.

3. In a receiver for frequency modulated signals, in combination, an electron gun tube comprising a gun type cathode, an accelerating anode, a plurality of deflecting plates, means for applying a potential between said cathode and said anode, said deflecting plates being arranged in pairs one pair being spaced from the other longitudinally of the tube, said spacing being of an order of magnitude such that the transit time of an electron from one pair of plates to the other will be equal to the period of a small number of half cycles of the received frequency modulated signal at one of the limits of the deviation band of said signal, a collector plate arranged trans-

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versely of the tube between said pairs of deflecting plates, said collector plate having a window therein in alignment with the central plane between the pairs of deflecting plates, said collector plate having a sufficient potential applied thereto to conduct away electrons falling thereon, and a plurality of collecting plates arranged transversely of the tube at the end thereof remote from said cathode, the center one of said collecting plates being of substantially the same width as the said window in said first mentioned collector plate, means for applying a received frequency modulated signal to said deflecting plates simultaneously, and means comprising application of a potential to said plates to conduct away electrons falling thereon and a resistor connected to said central one of said second mentioned collector plates for developing voltage impulses having amplitudes proportional to the instantaneous frequency of the received signal.

4. In a receiver for frequency modulated signals, in combination, an electron gun tube comprising a gun type cathode, an accelerating anode, means for applying a potential between said cathode and said anode, a plurality of deflecting plates, said deflecting plates being arranged in pairs one pair being spaced from the other longitudinally of the tube, said spacing being of an order of magnitude such that the transit time of an electron from one pair of plates to the other under the potential conditions existing at the accelerator anode will be equal to the period of a half cycle of the received frequency modulated signal at one of the limits of the deviation band of said signal, a collector plate arranged substantially transversely of the tube between said pairs of deflecting plates, said collector plate having a rectangular window therein in alignment with the central plane between the pairs of deflecting plates, and having sufficient potential applied thereto to attract electrons falling thereon, and a plurality of collecting plates arranged at the end of the tube remote from said cathode, the center one of said collecting plates being of substantially the same width as the said window in said first mentioned collector plate, means for applying a potential to said plates to conduct away electrons falling thereon, means for applying a received frequency modulated signal to said deflecting plates simultaneously, and means comprising a resistor connected to said central one of said second mentioned collector plates and to said potential supplying means therefor for developing voltage impulses having amplitudes proportional to the instantaneous frequency of the received signal.

5. In a receiver for frequency modulated signals, in combination, an electron gun tube comprising a gun type cathode, an accelerating anode, means for applying a potential between said cathode and said anode, a plurality of deflecting plates, said deflecting plates being arranged in pairs one pair being spaced from the other longitudinally of the tube, said spacing and said anode potential being of an order of magnitude such that the transit time of an electron from one pair of plates to the other will be equal to the period of a small number of half cycles of the received frequency modulated signal at one of the limits of the deviation band of said signal, a collector plate arranged substantially transversely of the tube between said pairs of deflecting plates, said collector plate having a window therein in alignment with the central plane between the pairs of deflecting plates and

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having sufficient potential applied thereto to conduct away electrons falling thereon, and a plurality of collecting plates arranged transversely of the tube at the end thereof remote from said cathode, said last mentioned collecting plates having a sufficient potential applied thereto to conduct away electrons falling thereon, the center one of said collecting plates being of substantially the same width as the said window in said first mentioned collector plate, means for applying a received frequency modulated signal to said deflecting plates simultaneously, means comprising a resistor connected to said second mentioned collector plates for developing voltage impulses having an amplitude proportional to the instantaneous frequency of the received signal, and means for integrating said voltage impulses to yield an audio frequency signal.

6. In a receiver for frequency modulated signals, in combination, an electron gun tube comprising a gun type cathode, an accelerating anode, means for applying a potential between said anode and said cathode, a plurality of deflecting plates, said deflecting plates being arranged in pairs one pair being spaced from the other longitudinally of the tube, said spacing and said anode potential being of an order of magnitude such that the transit time of an electron from one pair of said plates to the other will be equal to the period of a small number of half cycles of the received frequency modulated signal at one of the limits of the deviation band of said signal, a collector plate arranged substantially transversely of the tube between said pairs of deflecting plates, said collector plate having a window therein in alignment with the central plane between the pairs of deflecting plates, and having sufficient potential applied thereto to conduct away electrons falling thereon, and a plurality of collecting plates arranged substantially transversely of the tube at the end thereof remote from said cathode, said last mentioned collecting plates having a sufficient potential applied thereto to conduct away electrons falling thereon, the center one of said collecting plates being of substantially the same width as the said window in said first mentioned collector plate, means for applying a received frequency modulated signal to said deflecting plates simultaneously, means comprising a resistor connected to said central one of said second mentioned collector plates for developing voltage impulses having an amplitude proportional to the instantaneous frequency of the received signal, and means for integrating said voltage impulses to yield an audio frequency signal.

7. In a receiver for frequency modulated signals, in combination, an electron gun tube comprising a gun type cathode, an accelerating anode, means for applying a potential between said anode and said cathode, a plurality of deflecting plates, said deflecting plates being arranged in pairs one pair being spaced from the other longitudinally of the tube, said spacing and said anode potential being of orders of magnitude such that the transit time of an electron from one plate to the other will be equal to the period of a small number of half cycles of the received frequency modulated signal at one of the limits of the deviation band of said signal, a collector plate arranged substantially transversely of the tube between said pairs of deflecting plates, said collector plate having a rectangular window therein in alignment with the central plane between the pairs of deflecting plates, and having

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sufficient potential applied thereto to conduct away electrons falling thereon, and a plurality of collecting plates arranged substantially transversely of the tube at the end thereof remote from said cathode, said last mentioned collecting plates having sufficient potential applied thereto to conduct away electrons falling thereon, the center one of said collecting plates being of substantially the same width as the said window in said first mentioned collector plate, means for applying a received frequency modulated signal to said deflecting plates simultaneously, means comprising a resistor connected to said central one of said second mentioned collector plates for developing voltage impulses having an amplitude proportional to the instantaneous frequency of the received signal, and means for integrating said voltage impulses to yield an audio frequency signal.

8. In a receiver for frequency modulated signals, a detector comprising an electron gun type tube, said tube having two pairs of deflecting plates spaced longitudinally of the tube such an amount that at one of the limits of deviation of the signal to be received an electron will travel from one pair of plates to the other during the interval between one zero voltage interval in the cycle and the next, means for applying input signals to the two pairs of deflecting plates simultaneously, means comprising a collector plate interposed between the two pairs of deflecting plates for attracting electrons deflected by said first pair of plates and permitting a group of electrons to pass to the second pair of plates for each passage of the signal wave through zero, said applied signals causing said group of electrons to pass through the second pair of deflecting plates without being deflected when said signal is at the selected limit of deviation, and said group of electrons to be deflected to an extent proportional to the variation of the received signal from the selected limit of deviation when the signal is at other than the selected limit of deviation, a collector plate located at the end of the tube remote from the cathode, and circuit means connected to said collector plate for developing a series of impulses of voltage each proportional to the electrons received by said plate.

9. In a receiver for frequency modulated signals a detector comprising an electron gun type tube, said tube having two pairs of deflecting plates spaced longitudinally of the tube such an amount that at one of the limits of deviation of the signal to be received an electron will travel from one pair of plates to the other during the interval between one zero voltage interval in the cycle and the next, means for applying input signals to the two pairs of deflecting plates simultaneously, means comprising a collector plate interposed between the two pairs of deflecting plates for attracting and conducting away electrons deflected by said first pair of plates and permitting a group of electrons to pass to the second pair of plates for each passage of the signal wave through zero and for causing said group of electrons to pass through the second pair of deflecting plates without being deflected when said signal is at the selected limit of deviation, and said group of electrons to be deflected to an extent proportional to the variation of the received signal from the selected limit of deviation when the signal is at other than the selected limit of deviation, a plurality of collector plates located at the end of the tube remote from the cathode, and circuit means

connected to said collector plates for developing a series of voltage impulses each proportional to the number of electrons received by one of said plates.

10. In a receiver for frequency modulated signals, a detector comprising an electron gun type tube, said tube having two pairs of deflecting plates spaced longitudinally of the tube such an amount that at one of the limits of deviation of the signal to be received an electron will travel from one pair of plates to the other during the interval between one zero voltage interval in the cycle and the next, means for applying input signals to the two pairs of deflecting plates simultaneously, means comprising a collector plate interposed between the two pairs of deflecting plates and extending substantially transversely of the tube for attracting and conducting away electrons falling thereon and permitting a group of electrons to pass to the second pair of plates for each passage of the signal wave through zero, said applied signals causing said group of electrons to pass through the second pair of deflecting plates without being deflected when said signal is at the selected limit of deviation, and said group of electrons to be deflected to an extent proportional to the variation of the received signal from the selected limit of deviation when the signal is at other than the selected limit of deviation, a collector plate located at the end of the tube remote from the cathode, circuit means connected to said collector plate for developing a series of impulses of voltage each proportional to the electrons received by said plate, and additional collector plates located adjacent said last mentioned collector plate, said additional plates being connected to ground and serving to dissipate the energy of electrons which are deflected and strike said additional plates.

11. In a detector for frequency modulated signals, in combination, an electron gun type tube comprising means for producing a beam of electrons, a pair of deflecting plates arranged in said tube in position to deflect the beam of electrons projected along the axis of said tube, a collector plate arranged transversely of said tube on the side of said plates remote from the said electron beam source, said plate being provided with a

potential sufficient to collect electrons falling thereupon and said plate having a window centrally disposed therein opposite the central plane between said deflecting plates, through which window electrons deflected by said first pair of plates pass, a second pair of deflecting plates arranged in said tube in position to deflect electrons passing through said window in said collecting plane, said second pair of plates being spaced from said first pair of plates a distance such that under the conditions of beam velocity produced by said source, the transit time of an electron from said first to said second pair of plates is equal to the period of a small number of half cycles of received frequency modulated signals at one of the limits of deviation of the frequency band of said signals, means to apply said received frequency modulated signals to said pairs of plates simultaneously whereby the groups of electrons passing undeflected by said first pair of plates at each null point of the received signals and passing through said window in said collector plate is acted upon by said second pair of deflector plates being deflected when the group arrives at said second plate at other than a succeeding null point of the signal cycle and being undeflected as it arrives at said second pair of plates at a null point, said electron groups being deflected in proportion to the deviation of the signal frequency from the chosen limit of deviation of the band, and means for collecting the groups of electrons and producing output voltages in proportion to the size of the groups collected and the deflection produced by said second pair of deflecting plates.

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