

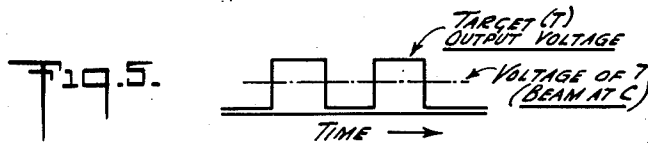
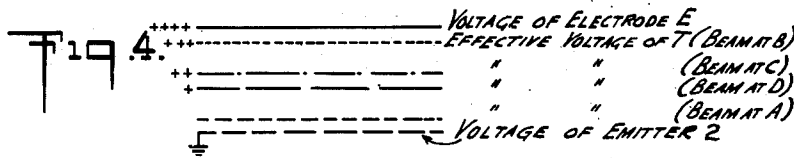
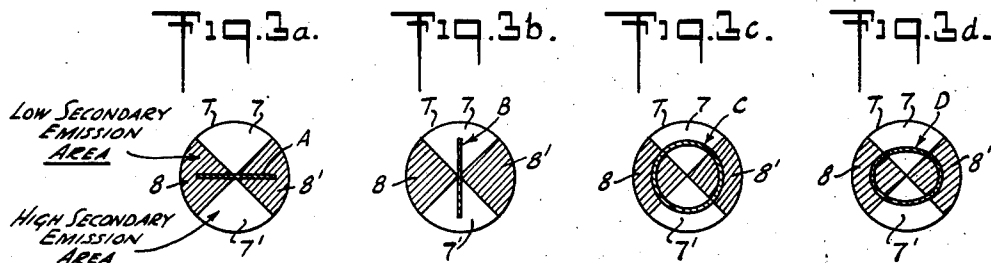
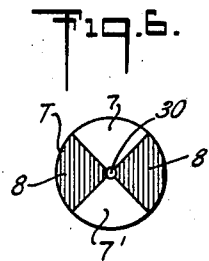
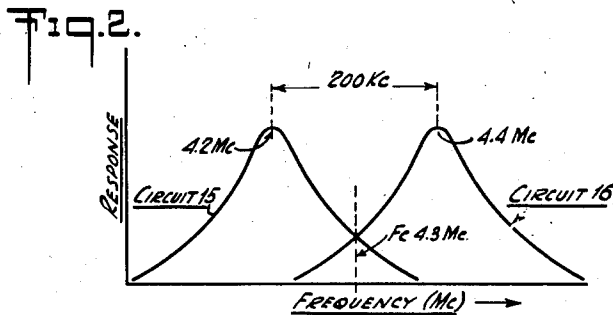
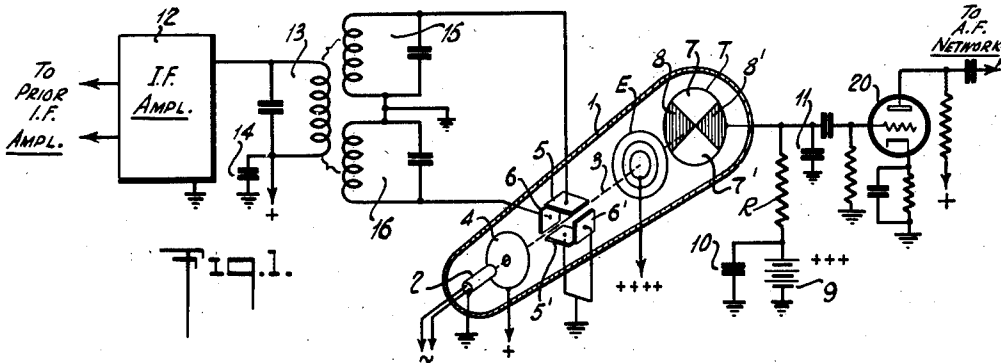
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2,470,731

ANGLE MODULATED CARRIER WAVE DETECTOR

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ANGLE MODULATED CARRIER WAVE
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My present invention relates generally to detectors of angle modulated carrier waves, and more particularly to a novel circuit for detecting frequency or phase modulated carrier waves independently of amplitude variations.

It is well-known that in the absence of special precautions the conventional frequency modulation (FM) detector not only has an output dependent on frequency deviation, but also on intensity variation of the signal. Even in the case of a balanced FM detector circuit, which has zero output at carrier frequency, cross-modulation effects are obtained if the carrier intensity changes during production of output energy in response to frequency deviation, i. e., simultaneously with reception of frequency modulated signals. In the past an amplitude limiter stage has been used prior to the FM detector to minimize such carrier intensity changes. Limiters are, in general, clipper tubes which require a minimum signal to operate, and this minimum signal determines the sensitivity of the detector and of the receiver.

One of the disadvantages of a limiter is that it has a comparatively large portion of its normally high gain diverted into amplifying carrier harmonics during actual limiting. In my Patent No. 2,408,702, granted October 1, 1946, I have shown circuits for receiving angle modulated carrier waves without the use of a special limiter stage prior to the detector. In that application a tube of the so-called electron beam type is provided with a target element having sections thereof capable of emitting secondary electrons. In addition, the beam tube included a special means for controlling the electron beam of the tube so as to minimize the effects of intensity variations of the received signal energy on the output current of the beam tube.

In his U. S. Patent No. 2,344,679 granted March 21, 1944, M. G. Crosby has disclosed and claimed a detector for angle modulated carrier waves comprising a beam type tube whose operation is independent of amplitude variation of the applied angle modulated carrier waves. In the Crosby system a plurality of output or anode quadrants are utilized to collect electrons from a beam subjected to deflection by two signal voltages whose phase differences are to be detected.

It may be stated that it is an important object of my present invention to utilize a detector of the general type disclosed by Crosby, but, in addition, utilizing as the actual output electrode of the beam tube a target element embodying features generally disclosed in my aforesaid application.

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In my aforesaid application a pair of deflection plates functioned to provide control voltages for sweeping an electron beam over a non-uniform secondary electron emission area of the output electrode of the beam tube. Another important object of my present invention is to simplify the detector of my aforesaid application by utilizing as the output electrode thereof a circular target having secondary emission sectors or quadrants of alternately different emissivity.

Another object of my invention is to provide an improved phase detector employing a beam tube having a deflecting and target system that is inherently non-responsive to amplitude changes, and the target being so constructed that a relatively high impedance may be satisfactorily employed as the output element whereby a high modulation voltage output level is provided.

A more specific object of my invention is to provide a beam tube for use in detecting angle modulated carrier waves; the output electrode of the beam tube being divided into four sectors, two of the sectors being diametrically opposed and being coated with a material of low secondary emissivity, and the remaining two opposed sectors being coated with a material of relatively high secondary emissivity.

Further objects of my invention are to improve generally beam tube circuits for the detection of FM or PM carrier waves, and more particularly to provide such circuits in an efficient and economical manner.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

In the drawing:

Fig. 1 shows an FM detector system embodying the invention, the beam tube envelope being broken away to show the tube interior;

Fig. 2 illustrates ideal resonance curves of the discriminator section of the FM detector;

Figs. 3a, 3b, 3c and 3d show respectively different appearances of the electron traces, patterns or figures formed on the output or target electrode;

Fig. 4 graphically depicts the effective voltage levels of the output electrode T for the respectively different patterns of Figs. 3a to 3d;

Fig. 5 graphically shows the wave form of the

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output electrode (target) voltage in response to the pattern C shown in Fig. 3c; and

Fig. 6 shows a modification of the target T used in my invention.

Referring now to the accompanying drawing, wherein like reference characters in the different figures designate similar circuit elements, the tube 1 will first be described before explaining the nature of the electrical circuits of the phasing (or discriminator) network which furnish the control voltages for the deflection electrodes. The tube 1 may generally be of the well-known cathode ray oscilloscope type. The tube envelope may be made of glass or metal, and is suitably evacuated. A suitable source of electrons, indicated by numeral 2, is connected to ground. The electron emitter 2 may be a cathode or "gun" of the indirectly-heated type, and is adapted to project or emit a stream of electrons in the form of a beam 3. The beam 3 is schematically represented by a dotted line.

It will be understood by those skilled in the art of cathode ray tube construction that suitable focusing electrodes may be positioned along the path of beam 3 to maintain the normal beam formation along a line terminating at the center of the disc-like target or output electrode T. The numeral 4 designates such a focusing electrode. The electrode 4 is a disc provided with a central aperture through which the beam 3 passes. The electrode 4 is positively biased relative to the grounded electron emitter 2, and, hence, the electrode 4 functions as a beam-forming electrode. Of course, additional beam-forming electrodes could be interposed between electrode 4 and the deflection electrodes. Further, the invention is not restricted to the specific configuration of electrode 4.

The beam 3 normally passes between, and along the central axis of, two pairs of equidistantly spaced deflection plates 5-5' and 6-6'. The spacing between the plates of the respective pairs is equal, and the planes of plates in different pairs are normal to each other. The deflection plates form a deflecting or control area over beam 3 which normally passes along a median line relative to the four plates. Although the deflection plates are shown at the same point along the electron beam, it is to be understood that one pair of plates (say 5-5') may be positioned closer to the electron emitter 2 than the other pair as is often done in cathode ray oscilloscopes.

The electrode E is a high voltage, electron-collector electrode. It is shown as consisting of a plurality of concentric metallic rings all conductively connected to each other and to a source of positive potential. The potential of electrode E is highly positive relative to the potential of electrode 4. Four plus signs (++++) are employed to indicate that collector E is highly positive; this is a purely illustrative representation. The electron beam 3 normally passes through the center of the smallest ring, but the beam is capable of passing through the inter-ring spaces in response to appropriate deflection of the beam.

The target or output electrode T is metallic, and is shown as having a circular configuration. The target is spaced from the end of the tube, although it may be provided as a coating on the inner face of the end of the tube. The target is divided into four effective quadrants or sectors. The sectors are of equal area, and comprise two pairs of diametrically-opposed, secondary electron emission surfaces of different characteris-

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tics. Thus, sectors 7 and 7' are of like secondary electron emissivity, and are capable of emitting a copious flow of secondary electrons upon bombardment by the beam of primary electrons 3. The second pair of sectors 8 and 8' of like emissivity are capable of emitting a relative weak flow of secondary electrons in response to bombardment by primary electrons of beam 3. By way of specific example, sectors 8 and 8' may be coated with carbon to provide surfaces of low secondary emission ratio. The sectors 7 and 7' may be coated with caesium oxide to provide surfaces of high secondary emission.

The diameter of target T may be substantially greater than that of collector E so that all the primary electrons passing through the collector inter-ring spaces will impinge on the target. It is to be clearly understood that the invention is not limited to the specific configurations of electrodes E and T. Further, the specific materials described above for the high and low secondary emission surfaces need not be employed, but may be replaced by any other suitable materials capable of functioning as required.

When the beam 3 is deflected in such a way that the electrons thereof land on the low secondary emission surfaces 8 and 8' of target T, only a relatively small number of secondary electrons leave the target. On the other hand when the beam is deflected so that its electrons hit the high secondary emission areas 7 and 7', a large number of secondary electrons leave the target. The target is normally maintained at a positive potential which is substantially less than the voltage of collector E. The direct current source 9 is shown as having its negative terminal grounded, while the positive terminal +++ is connected to target T through a resistor R of high impedance value. The condenser 10 bypasses the direct current source 9 to ground. It may have a value of 0.5 to 10 microfarads, and may be omitted if desired. Normally, and with no alternating voltage applied to deflection plates 5, 5' and 6, 6', the electron beam 3 lands at the center of the disc T, i. e., at the intersection point of the sector division lines.

I have shown the cathode ray tube 1 connected in an FM receiver to function as an FM detector. The FM receiver is assumed to be a superheterodyne receiver employed in the 42 to 50 megacycle (mc.) band, the present FM broadcast band. In that band each carrier frequency is varied at the transmitter in accordance with modulation signals. The extent of frequency variation is a function of modulation signal amplitude, while the rate of variation is dependent upon the modulation frequencies per se. The permissible frequency variation or swing, in accordance with present broadcast transmitting standards, is a maximum of 75 kilocycles (kc.) to each side of the carrier frequency. My invention is not restricted to the FM range of 42-50 mc., nor to FM reception, nor to the specific overall frequency swing of 150 kc. The term "angle modulated carrier wave" used in this application includes phase modulated (PM) carrier waves, FM carrier waves, or hybrid modulations of PM and FM possessing characteristics of each. At the receiver it is desirable to prevent so far as possible the appearance of amplitude modulation (AM) on the received carrier wave so as to preserve the correspondence between the original frequency modulation of the transmitted wave and the modulation output of the detector. In the aforesaid Crosby patent it has been shown that the beam

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tube inherently prevents amplitude modulation (AM) in the received wave from affecting the detector output current.

The numeral 12 in Fig. 1 designates an amplifier preceding the usual discriminator network feeding tube 1. Amplifier 12 may be a non-limiting amplifier of intermediate frequency (I. F.) signals whose input electrodes are coupled to a prior I. F. amplifier, or to a converter. Of course, amplifier 12 may be made to serve as a limiter, if desired. The networks which precede I. F. amplifier 12 are of suitable and well-known construction. They may comprise a signal collector and one or more selective high frequency amplifiers followed, if the receiver is of the super-heterodyne type, by a converter which functions to produce the I. F. signal energy. The I. F. value may be chosen from a range of 2 to 15 mc., as for example 4.3 mc. My invention is not limited, however, to any specific I. F. value.

The amplifier 12 amplifies the I. F. signal energy at the 4.3 mc. value. In the plate circuit of amplifier 12 there is arranged a resonant circuit 13 tuned to the selected 4.3 mc. value. The low potential side of circuit 13 is connected to the B+ terminal of a suitable direct current energizing source, while condenser 14 bypasses I. F. currents to ground. The primary circuit 13 is magnetically coupled to a pair of separate secondary circuits 15 and 16. The secondary circuits are preferably free of coupling therebetween. The junction of the secondary circuits 15 and 16 is established at ground potential for I. F. currents. The circuits 15 and 16 are tuned to respectively opposite sides of the I. F. value, and the frequency spacings between the resonant frequency of each secondary circuit and the primary resonant frequency (4.3 mc.) are preferably equal.

In Fig. 2 I have graphically represented idealized resonance curves of secondary circuits 15 and 16. Circuit 15 has a peak frequency of 4.2 mc., while circuit 16 has a peak frequency of 4.4 mc. Hence, the peak spacing is 200 kc., which is substantially in excess of the overall maximum frequency swing of 150 kc. The curves of Fig. 2 cross over at 4.3 mc., the center frequency (F_c) of applied I. F. signal waves. The circuits 13, 15 and 16 provide a form of frequency discriminator of well-known characteristics. My invention is not limited to this specific form of discriminator, since the discriminator shown by S. W. Seeley in his U. S. Patent No. 2,121,103, granted June 21, 1938, may be used to supply the deflection voltages for tube 1. Reference is made to the aforesaid Crosby patent for a disclosure of other forms of frequency, or phase, discriminators that may be employed to energize deflection plates 5, 5' and 6, 6'.

The functioning of the discriminator of the present application is well-known. Instantaneous deviations of frequency from the center or reference frequency F_c (the I. F. value) cause corresponding increases or decreases of signal voltage across the respective secondary circuits 15 and 16. For example, should the frequency of the signal energy instantaneously deviate to 4.2 mc., there will be maximum radio frequency voltage built up across the circuit 15 while minimum voltage exists at circuit 16. Conversely, an instantaneous shift of signal frequency to 4.4 mc. results in maximum radio frequency voltage being developed across circuit 16, with minimum voltage across circuit 15. At the value F_c the voltages across circuits 15 and 16 are equal. Hence, by connecting plate 5 to the high potential

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side of circuit 15 and opposite plate 5' to ground, any radio frequency voltage across circuit 15 will be applied between plates 5 and 5'. Similarly, the plate 6 is connected to the ungrounded side of circuit 16, while plate 6' is grounded. Hence, voltage across circuit 16 is applied between plates 6 and 6'.

Accordingly, the amplitude variations in the voltages across circuits 15 and 16 are respectively applied to deflection plates 5, 5' and 6, 6'. The variations in deflection voltage control the electron beam 3, and cause the beam to sweep or trace figures or patterns over the inner face of target T. It will now be seen that the discriminator network derives from the angle modulated carrier waves (specifically FM carrier waves) a pair of radio frequency voltages whose relative amplitudes are a function of the direction and degree of angular deviation of the waves relative to a reference phase or frequency value, and that the pair of voltages are employed to control the path of an electron beam normally positioned to impinge the target T at the center thereof.

In Figs. 3a, 3b, 3c and 3d I have shown, in a purely illustrative and idealized manner, the various electron patterns or traces formed on the target T by the beam 3. When the frequency of the I. F. signals at circuit 13 deviates to a frequency of 4.4 mc., the resonant frequency of circuit 16, the voltage between plates 6 and 6' will be a maximum, and the voltage between plates 5 and 5' will be substantially zero. This results in the horizontal trace A of Figure 3a, since the electron beam 3 will be deflected between the horizontal plates 6 and 6', and the vertical plates 5 and 5' will exercise no effect on the beam. Assume, now, that the frequency instantaneously deviates to the peak frequency of circuit 15; the vertical plates 5 and 5' will then produce the vertical trace B of Fig. 3b. The circular trace C of Fig. 3c will result in response to the applied signal energy having a frequency of F_c . Since the deflection voltages are necessarily equal at this center frequency, and since they are in phase quadrature as well, the electron beam will be caused to trace the circular path C over the target sectors. An elliptical trace results when the deflection voltages are unequal and the instantaneous frequency of applied signal energy is at a value between one limiting frequency (4.2 or 4.4 mc.) and F_c . In Fig. 3d the horizontal axis of the ellipse is greater than the vertical axis thereby signifying that the horizontal plates 6 and 6' have a greater voltage difference than vertical plates 5 and 5'.

The electron beam patterns or traces on the target T are readily translated into variations of voltage across output resistive impedance R. The latter has a relatively high impedance. Hence, it develops a relatively high voltage drop thereacross due to current flow in the target circuit. In general, then, a relatively high gain is secured at the output terminals of detector tube 1 as compared with prior art detectors. The voltage variations across output resistance R, integrated by shunt condenser 11, correspond to the modulation of the received carrier waves and may be amplified by the modulation amplifier 20. The latter, in the case of audio frequency modulation, is preferably coupled by resistance-capacity coupling to the output resistor R. The amplified audio frequency voltage may be utilized in any well-known and suitable manner.

Considering now, the manner in which the electron beam deflections are translated into tar-

get current variations, assume first that the circular trace C is being produced in response to the FM wave at circuit 13 having an instantaneous frequency F_0 . The electron beam traverses all of the target sectors uniformly and at a uniform rate. Hence, secondary electrons are caused to be emitted from the sectors 7, 8, 7' and 8' in that alternate order. Accordingly, the target output current and, consequently, the output voltage, will follow the idealized square wave form shown in Fig. 5. That the target output voltage follows the wave form of Fig. 5 is seen from the following considerations.

During the time that beam 3 sweeps across the high secondary emission sector 7 there will be a relatively large flow of secondary electrons from sector 7 to the highly positive collector electrode E. Hence, the target T will become relatively more positive since the electrode E diverts electron current from it and thereby lessens the voltage drop across resistor R. This is, also, true when the beam sweeps over sector 7'. During the sweep periods over 7 and 7', then, the target will be highly positive, approaching the potential of collector E. These periods of target voltage are represented by the successive square peaks of the wave form of Fig. 5. The intermediate valleys of the wave form correspond to the periods when beam 3 sweeps over sectors 8 and 8'.

Since the sectors 8 and 8' are low secondary electron emission areas, they will emit relatively few secondary electrons to collector E in response to the primary electrons of beam 3. This means that more negatively charged primary electrons will be arriving at target T than secondary negative electrons are lost by the target. Hence, there will be a relatively large flow of current to the target through resistor R and the target voltage tends to approach the potential of emitter 2 for the periods when beam 3 sweeps over sectors 8 and 8'. It will now be seen that whereas the target current decreases sharply during periods when the beam sweeps sectors 7 and 7' with resultant sharp increase in target voltage, the target current increases sharply during the sweeping of sectors 8 and 8' with resultant sharp decrease in target voltage. The average voltage of target T for the entire circular trace C is depicted as a dot and dash horizontal line in Fig. 5.

The variation of target output voltage may be explained on still another basis. During those periods when beam 3 sweeps low emission sectors 8 and 8', it may be said that there exists a closed series circuit which is traced from the grounded emitter 2, through the resistive path of the beam 3 to sector 8 (or 8') of target T, through resistor R and current source 9 back to ground. The resistance of the beam path is very small, whereby high impedance R is in series with the source 9 and causes target T to approach the potential of emitter 2, which is at ground potential. Attention is directed to Fig. 4 which depicts in a purely illustrative fashion, and does not represent absolute potentials but comparative potentials, that the average potential level of target T is close to ground potential of emitter 2 when beam 3 sweeps sectors 8, 8'. This is the "A" position of Fig. 3a.

When the beam sweeps sectors 7, 7' (position "B" in Fig. 3b) the effective or average voltage of target T is close to the voltage of electrode E. This is shown in Fig. 4. In this case the resistor R of the aforementioned closed series circuit is shunted by a circuit comprising the current source and energizing electrode E in series with the re-

sistive impedance of the secondary electron path from sector 7 (or 7') to collector E. The potential of target T is now lifted above ground potential, and is close to the potential of collector E.

Fig. 4 shows the average or effective potentials of target T resulting from the corresponding traces A, B, C and D of Figs. 3a, 3b, 3c and 3d respectively. The average potential of T is depicted in Fig. 4 as a dot-dash ++ line marked "Beam at C." The elliptical trace D of Fig. 3d whose corresponding target potential level is represented by the + line of long dashes in Fig. 4, involves relatively longer sweeps of sectors 8 and 8' than of sectors 7 and 7'. Hence, the average or effective potential of target T will be more positive than for the "A" trace, but less positive than for the "C" trace.

It has been found that when the electron beam sweeps over the target T it produces a narrow pulse when it passes the center of the target. Even when it sweeps over the target horizontally as in Fig. 3a or vertically as in Fig. 3b it produces a narrow pulse in a positive or negative sense respectively. The reason for the creation of these pulses is believed to be that the electron beam, due to its finite diameter, impinges on both sectors 7, 7' and 8, 8' at the central, cross-over point. Condenser 11 acts to by-pass these high frequency pulses, greatly above the range of audibility, which would otherwise appear across resistor R.

It is moreover preferred to choose the values of resistor R and condenser 11 so that they will have a time constant of 100 microseconds, according to present standards of deemphasis. If, for example, R is 1 megohm, then C_{11} may be 100 micro-microfarads; if R is equal to 5 megohms then C_{11} may be about 20 micro-microfarads, etc.

It will be readily seen that the deflection of the primary electron beam, in response to variations in relative amplitude of the applied alternating voltages arising from variations in frequency of the received signal, will cause corresponding electron traces or patterns on the alternate sectors of the target T. The length of the arc sweeping one sector area or the other of the target will charge the latter to a potential dependent on whether the pattern is mainly on sectors 7, 7' or on sectors 8, 8'. Accordingly, variations in potential of target T are representative of the modulation which was originally applied to the carrier wave at the transmitter.

The system disclosed herein is inherently non-responsive to amplitude changes. Amplitude changes of the carrier will change only the amplitude of the beam sweep, but not the arc or angle. Hence, the target potential at any instant will be substantially independent of carrier amplitude changes, and, therefore, no special amplitude limiter need be used ahead of the discriminator network. The use of pairs of opposed sectors for target T permits sensitive detection to take place. The frequency deviation is thereby translated into a high voltage gain at the detector. If desired, however, only one sector 7 and one sector 8 may be employed.

My present detector circuit is characterized by an improved "adjacent channel selectivity." That is, the response to signals outside the operating channel is negligible. The beam tube will not substantially change its target potential, according to any modulation, save within the frequencies of 4.2 to 4.4 mc. Outside of these frequencies, regardless of the presence or absence of a signal, the target potential will be constant,

except for the high frequency pulses heretofore mentioned as arising when the electron beam passes the center of the target and as being removed by condenser 11. This follows from the fact that it does not matter how wide the beam is swept, so long as it is swept only over high, or only over low, secondary electron emission areas. In other words, a signal outside the frequency band (200 kc.) delimited by the peaks of Fig. 2 will if above 4.4 mc. cause the trace pattern to be always on sectors 8-8', and if below 4.2 kc. cause the trace pattern to be always on sectors 7, 7'. Of course, these conditions would be reversed if we reversed the tuning points of circuits 15 and 16. Even if a signal outside the frequency range of 4.2 to 4.4 mc. were within the admission band of the circuit, it would produce equal pulses as the electron beam crossed the center of the target regardless of its amplitude or frequency. So long as the pulse width does not change, no audio frequency output will be obtained. Hence, the adjacent channel selectivity is of a relatively high order of magnitude in my circuit.

In the form of my invention thus far specifically described, when no signal is available thermal agitation and other random sources may give rise to voltages which cause the electron beam to make short excursions in any direction from the center of the target thereby producing a noise output. In the modification shown in Fig. 6, I provide a small circular opening 30 at the center of the target T. This opening will be of suitable diameter and will be at least slightly larger in diameter than the electron beam. Accordingly, when no signal is present or when the electron beam is moved only slightly in response to noise potentials, the beam does not impinge on the target, and no alternating current voltage output arises across resistor R. Of course, provision of opening 30 affects the high frequency pulses produced by the excursion of the electron beam across the center of the target. However, such high frequency pulses will still be removed by the condenser 11.

While I have indicated and described a system for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of my invention.

What I claim is:

1. A method of translating angular modulation of a carrier wave into modulation voltages, which includes producing a beam of primary electrons, collecting the primary electrons, deriving a voltage in response to said collected electrons, concurrently producing a stream of secondary electrons in response to the collection of said primary electrons, collecting the secondary electrons thereby to affect the magnitude of said derived voltage, producing from said modulated carrier wave at least two carrier voltages whose relative magnitudes are a function of the angular modulation of said carrier wave, deflecting said primary electron beam in one direction in accordance with the relative magnitude of one of said two voltages and at right angles to said one direction in accordance with the relative magnitude of the other one of said two voltages thereby to produce a variation in the intensity of said stream of secondary electrons whereby said derived voltage is varied in accordance with said angular modulation.

2. A detector of angle modulated carrier waves comprising a frequency discriminator network for deriving from said waves a first and a second high frequency voltage whose relative magnitudes vary in accordance with instantaneous frequency deviations of said waves relative to the center frequency thereof, a cathode ray tube including an emitter of a primary electron stream, a target arranged to be traversed by said electron stream and having at least two areas of substantially different secondary electron emission ratio, an electrode for collecting secondary electrons liberated from said target, deflectors coupled to said frequency discriminator network and constructed so as to deflect said electron stream in one direction in accordance with said first voltage and at right angles to said one direction in accordance with said second voltage, and an output circuit including an impedance element effectively connected between said target and said collector electrode for developing an output voltage representative of the modulation of said waves.

3. A detector of angle modulated carrier waves comprising a frequency discriminator network for deriving from said waves a first and a second high frequency voltage whose relative magnitudes vary in accordance with instantaneous frequency deviations of said waves relative to the center frequency thereof, a cathode ray tube including an emitter of a primary electron stream, a target arranged to be traversed by said electron stream and having four sector-shaped areas, alternate areas of said target being of substantially different secondary electron emission ratio, an electrode for collecting secondary electrons liberated from said target, a pair of deflectors coupled to said frequency discriminator network and constructed so as to deflect said electron stream in one direction in accordance with said first voltage and at right angles to said one direction in accordance with said second voltage, and an output circuit including an impedance element effectively connected between said target and said collector electrode for developing an output voltage representative of the modulation of said waves.

4. A detector of angle modulated carrier waves comprising a frequency discriminator network for deriving from said waves a first and a second high frequency voltage whose relative magnitudes vary in accordance with instantaneous frequency deviations of said waves relative to the center frequency thereof, a cathode ray tube including an emitter of a primary electron stream, a target positioned to be traversed by said electron stream and having at least two sector-shaped areas of substantially different secondary electron emission ratio, an electrode for collecting secondary electrons liberated from said target, a pair of deflector elements connected to said frequency discriminator network, one of said pair of deflector elements being positioned so as to deflect said electron stream in one direction in accordance with said first voltage, the other of said pair of deflector elements being positioned so as to deflect said electron stream at right angles to said one direction in accordance with said second voltage, and an output circuit including an impedance element effectively connected between said target and said collector electrode for developing an output voltage representative of the modulation of said waves.

5. A detector of angle modulated carrier waves comprising a frequency discriminator network for deriving from said waves a first and a second

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high frequency voltage whose relative magnitudes vary in accordance with instantaneous frequency deviations of said waves relative to the center frequency thereof, a cathode ray tube including an emitter of a primary electron stream, a target arranged to be traversed by said electron stream and having at least two areas of substantially different secondary electron emission ratio, a perforated electrode between said emitter and said target for collecting secondary electrons liberated from said target, a pair of deflectors coupled to said frequency discriminator network and constructed so as to deflect said electron stream in one direction in accordance with said first voltage and at right angles to said one direction in accordance with said second voltage, and an output circuit including an impedance element effectively connected between said target and said collector electrode for developing an output voltage representative of the modulation of said waves.

6. A detector of angle modulated carrier waves comprising a frequency discriminator network for deriving from said waves a first and a second high frequency voltage whose relative magnitudes vary in accordance with instantaneous frequency deviations of said waves relative to the center frequency thereof, a cathode ray tube including an emitter of a primary electron stream, a target arranged to be traversed by said electron stream and having at least two sector-shaped areas of substantially different secondary electron emission ratio, an electrode for collecting secondary electrons liberated from said target electrode, a pair of deflector elements connected to said frequency discriminator network and constructed so as to deflect said electron stream in one direction in accordance with said first voltage and at right angles to said one direction in accordance with said second voltage, an output impedance element effectively connected between said target and said collector electrode, and an integration circuit

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coupled to said output impedance element for developing an output voltage representative of the modulation of said waves.

7. A detector of angle modulated carrier waves comprising a frequency discriminator network for deriving from said waves a first and a second high frequency voltage whose relative magnitudes vary in accordance with instantaneous frequency deviations of said waves relative to the center frequency thereof, a cathode ray tube including an emitter of a primary electron stream, a target arranged to be traversed by said electron stream and having at least two areas of substantially different secondary electron emission ratio, said target having a central aperture of a diameter larger than that of said electron stream, an electrode for collecting secondary electrons liberated from said target, deflectors coupled to said frequency discriminator network and constructed so as to deflect said electron stream in one direction in accordance with said first voltage and at right angles to said one direction in accordance with said second voltage, and an output circuit including an impedance element effectively connected between said target and said collector electrode for developing an output voltage representative of the modulation of said waves.

GEORGE C. SZIKLAI.

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