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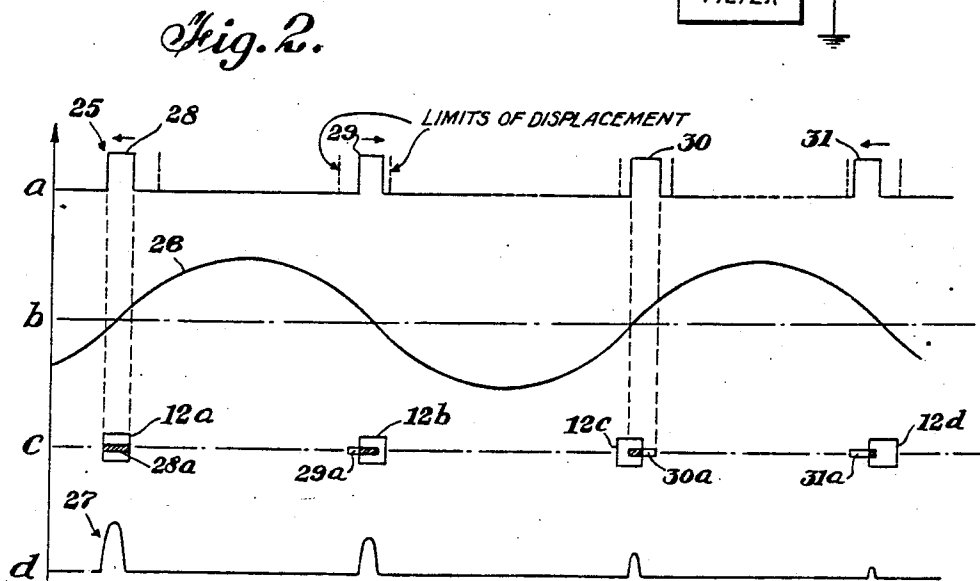
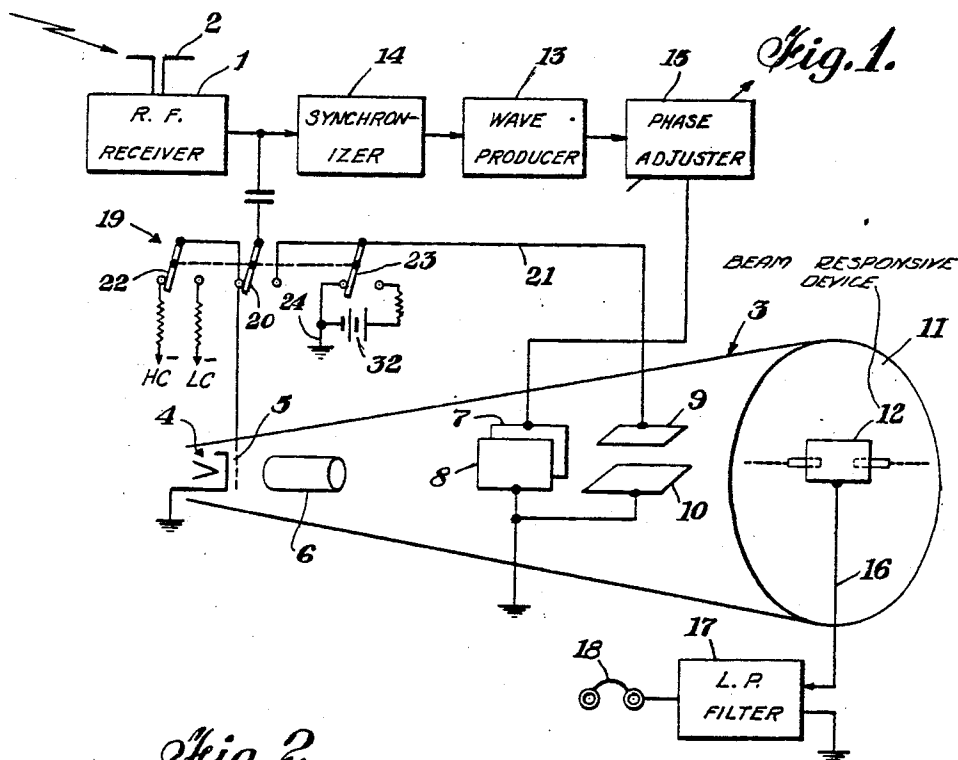
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CATHODE RAY TUBE PULSE DEMODULATOR SYSTEM

Filed Nov. 13, 1944

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

Fig. 3.

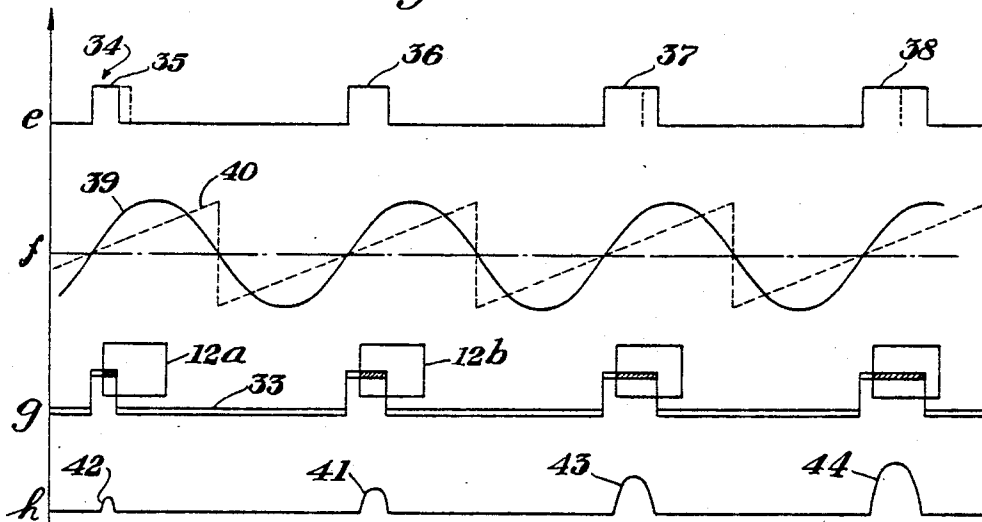
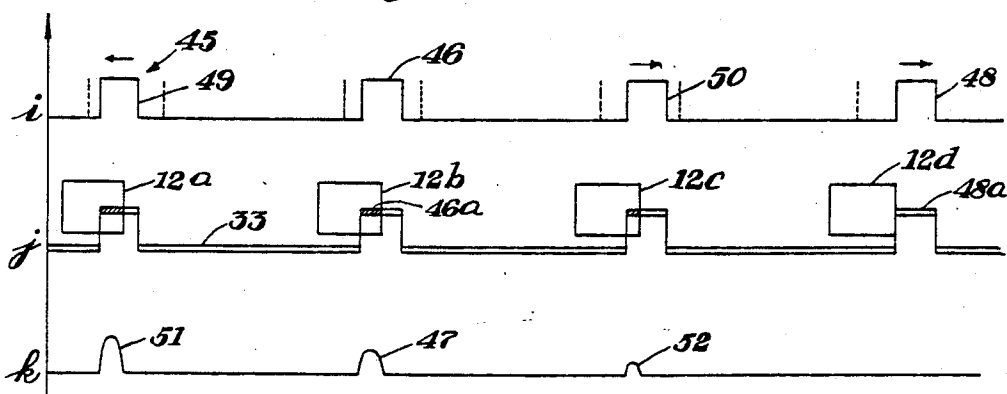


Fig. 4.

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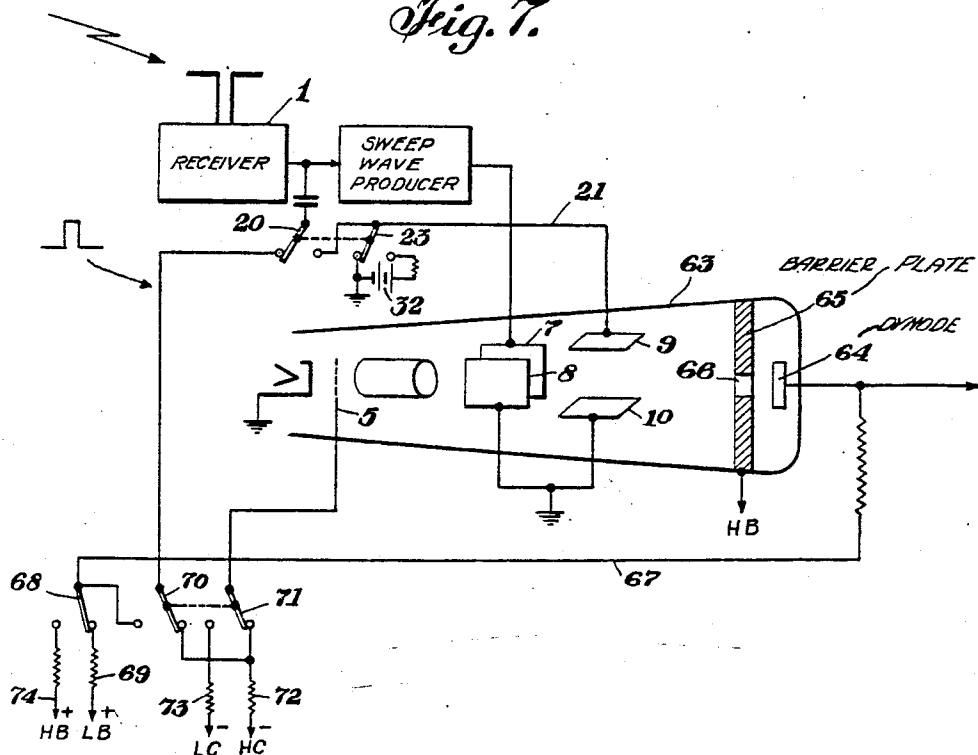
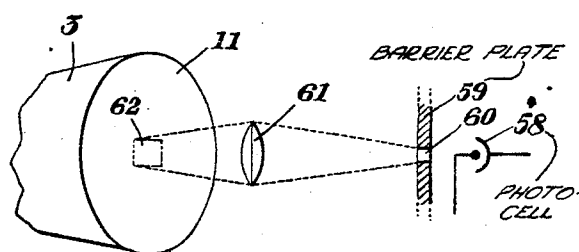
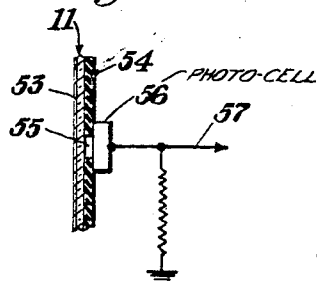
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3 Sheets-Sheet 3



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CATHODE-RAY TUBE PULSE DEMODULATOR SYSTEM

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15 Claims. (Cl. 250-27)

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This invention relates to radio receivers and more particularly to a demodulator for time modulated pulses.

One of the objects of the invention is to provide an improved method and means for translating time modulation of pulses into amplitude modulated energy.

Another object of the invention is to provide a method and means for controlling a beam of energy such as a beam of electrons or an electromagnetic beam relative to a beam sensitive device for translation of various forms of time modulation of pulses into amplitude modulated energy.

One of the features of the invention is the employment of a cathode ray tube or other electron beam producing apparatus together with means for controlling the beam and/or the sensitivity of a beam responsive device for translation of the time modulation of the pulses into amplitude modulated energy. The electron beam is caused to sweep through a normal cycle in synchronism with the average timing of the pulses, as when the pulses are free of modulating energy. The beam in its movement is caused to either traverse a beam sensitive device or to move along a path adjacent thereto. The time modulated pulse energy may be used to control coaction between the beam and the responsive device in any one of several ways. This coaction between the beam and the responsive device causes a flow of energy in a circuit associated with the device, the amplitude of such energy being proportional to the time modulation of the pulses.

One method of controlling the coaction between the beam and the responsive device is to key the beam on and off according to the leading and trailing edges of the pulses. When this method is applied, the beam is normally caused to traverse the responsive device during a given part of its cyclic movement, whereby the keying on and off of the beam in relation to such part, controls the coaction referred to.

Another method of control is to deflect the beam according to the pulse energy. According to this method the beam movement is adjusted so that the beam path is normally adjacent the responsive device, and when the beam is deflected, it is caused to coincide with the responsive device for a time interval proportional to the degree of time modulation of the pulses.

A third method of control is to apply the pulse energy to an element of the beam responsive device whereby the beam responsive device is made

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responsive to the beam only when pulse energy is applied to such element. In this method of control the beam intensity is maintained constant, and its path of movement is caused to coincide periodically with the responsive device.

The above and other objects and features of the invention will become more apparent upon reading the following detailed description with reference to the accompanying drawings in which:

Fig. 1 is a schematic block and wiring diagram of a receiver according to the principles of this invention;

Figs. 2, 3 and 4 are graphical illustrations useful in explaining the invention;

Figs. 5 and 6 are fragmentary illustrations of variations of the energy collector means shown in Fig. 1; and

Fig. 7 is a schematic block and wiring diagram of a further variation of the invention.

Referring to Fig. 1, there is shown a radio frequency receiver 1 with an antenna 2 for receiving pulsed radio frequency energy, the radio frequency carrier being removed by the usual detector means thereof. The pulse energy thus detected may be modulated according to any one of several principles of time modulation. For example, the successive pulses may be time displaced toward and away from each other according to the push-pull type of time modulation or the pulses may be modulated in width, either symmetrically or by displacements only of one edge thereof, or the successive pulses may be time displaced relative to their unmodulated time positions. These are the more common types of time modulation but it will be clear as the description proceeds that practically any type of time modulation of pulse energy may be demodulated, that is, translated into amplitude modulated energy, according to the principles of our invention.

The demodulator part of the system shown in Fig. 1, comprises a cathode ray tube 3 having the usual electron gun equipment 4 for producing a beam of electrons which is controlled by grid 5 and shaped by the usual focusing means 6. The beam is projected between two pairs of deflection plates, 7, 8 and 9, 10. The deflecting voltage applied to the plates 7, 8 control the normal sweep of the beam on the screen 11 with respect to a beam responsive device or collector 12 which may be disposed on one face or the other of the screen 11, depending upon the characteristics of the screen and the collector. The deflecting voltage applied to plates 7, 8 is produced

by a wave producer 13. The producer 13 may be synchronized with the detected pulses through known synchronizing means 14. Should the wave energy desired be sinusoidal, producer 13 might include a tunable shock excitable capacitance-inductance circuit, or if the wave desired is of a saw-tooth character, the producer might include a known relaxation oscillator adapted to be controlled by the detected pulses. In either case, the wave generated should have recurring substantially inclined portions and have a period comparable in at least a harmonic relation to the average timing of the pulses. For controlling the phase relation of the wave, a phase adjuster 15 is included so that the sweep cycle of the beam with respect to the collector 12 and the average pulse timing will produce the desired current condition in the output circuit 16 of the collector 12. The current flow produced in the circuit 16 may be applied to a low pass filter 17 and thence to a utilization circuit such as phones 18.

The circuit of Fig. 1, is arranged to provide a selection with respect to the control of the cathode ray beam by the detected pulses from receiver 1. This selection is controlled by a switch arrangement 19 whereby a movable contact 20 controls the application of the input pulses to either the grid 5 or over circuit 21 to deflection plates 9, 10. As shown, the contact 20 is positioned to apply the pulses to the grid 5 whereby the beam is keyed on and off according to the occurrence of the leading and trailing edges of each pulse. The grid 5, for this position of the movable contacts of switch 19, is provided with a high negative bias by being connected over contact 22 to the negative side of a source of potential HC whose positive side is connected to the cathode via ground, whereby the grid is normally biased to cut off in the absence of pulse energy. The bias voltage of the grid is controlled by contact 22. Movable contact 23 provides a ground for the plate 9 when the switch is in the position illustrated in Fig. 1. When the contacts of switch 19 are moved to the position opposite that shown, the contact 23 is moved free of ground connection 24, the contact 22 is moved to a low source of biasing potential LC whose positive side is connected to ground, and contact 20 is moved to close connection with line 21 to plate 9. The low bias LC provided for the grid 5 in this position of switch 19 insures a flow of electrons to form a beam of constant intensity. Other biasing circuits for the circuit of Fig. 1 will be apparent to those versed in the art and accordingly the details thereof are omitted.

For the purpose of explaining the operation of the system of Fig. 1, when time modulated pulses are applied to grid 5, the graphs of Fig. 2 are provided. Graph *a* illustrates a train of pulses 25 which is time modulated according to the push-pull principle. It will be noted also that the pulses 25 have a given offset bias, that is to say, the pulses, in the absence of modulation, will assume a paired off spaced relationship. Graph *b* illustrates a sinusoidal wave 26 such as may be produced at wave producer 13 in accordance with the average timing of the detected pulses. Graph *c* represents the coincident timing of the collector 12 at 12a, 12b, etc., with respect to a given portion of the cyclical movement of the wave 26 and also the pulse occurrence timing as represented by the keying on and off of the beam at 28a, 29a, 30a and 31a. Graph *d* represents at 27 the pulse energy flowing in the output circuit 16

in response to the keying on and off of the beam with respect to the collector 12.

Referring particularly to Fig. 2, pulse 28 is shown to be in one extreme position or 100% of time displacement, pulse 29 is shown displaced to the right about 50%, pulse 30 is shown to be centered at zero modulation and pulse 31 is shown displaced about 50% to the left. The displacement of pulse 28 is shown to key the beam on for complete coincidence with the collector 12. The coincidence of the keyed-on beam with the collector at 12b is shown to have only about 3/4 coincidence with the collector, while the centered pulse 30 is shown to provide a 50% coincidence and the pulse 31 to provide about 25% coincidence with the collector 12. The current flow in circuit 16 being proportional to the number of electrons impinging upon collector 12 during each keyed-on part of the beam cycle, produces an output pulse, as indicated by pulses 27 for the time positions of pulses 25.

Assume now that the switch 19 is shifted to the right so as to provide a low bias LC on grid 5, to apply pulses from receiver 1 to deflection plates 9, 10 and to remove the ground connection 24 from line 21. In this condition it will be assumed that the contact 23 now applies a constant voltage from battery 32 to the plate 9 in addition to the energy of the pulses from receiver 1. This, as indicated in graph *e* of Fig. 3, causes the beam to sweep adjacent the collector 12, as indicated at 33.

For the purpose of illustrating a further form of time modulation, the pulse train 34 of graph *e* is shown to be modulated in width. For example, the successive pulses 35, 36, 37 and 38 are progressively greater in width. The wave producer 13 may provide either a sinusoidal or saw-tooth wave substantially as indicated at 39 and 40 in graph *f* for application to the deflection plates 9 and 10. The pulse 36 represents the pulse width in the absence of a modulating signal. When this pulse energy is applied to the deflection plates 9 and 10, the beam, which now is keyed on constantly at a given intensity is deflected for interception with the collector as indicated at 42b. The output energy of the collector circuit 16 is indicated at 41, graph *h*, which is of amplitude proportional to the electrons collected by the deflection produced in response to pulse 36. Pulse 35 is shown to be of a smaller width and may therefore be regarded as representing a modulating signal of negative potential. The deflection of the beam in response to this pulse produces a coincidence with the collector 12a for a duration corresponding to the pulse width, the output pulse thereof being represented at 42. Likewise the greater widths of pulses 37 and 38 produce upon deflection of the beam pulses of greater amplitude as indicated at 43 and 44.

Graph *i* of Fig. 4 shows a further principle of time modulation wherein the pulses are time displaced relative to their normal timing according to the instantaneous value of the modulating signal. These pulses are applied to the deflecting plates 9 and 10 similarly as described in connection with the pulse train 34 of Fig. 3. Graph *j* represents the deflection of the beam during its trace 33 with respect to the collector 12, thus indicating the degrees of coincidence of the deflected portions therewith. Pulse 45 is shown to be in an unmodulated position and according to graph *j* produces a 50% coincidence between the beam and the collector 12b, as indicated at 46a, thereby producing an average flow of cur-

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rent as indicated at 47. The pulse 48, however, is shown to be in one extreme position of modulation and in such position, the deflection at 48a is shown to be displaced to one side of the collector 12d. Thus, the circuit 16 does not conduct current for the pulses in this extreme position. Pulses 49 and 50 are shown to be displaced a given distance in opposite directions from the centered position of pulse 46, and they produce according to the resulting degree of coincidence of the beam and collector 12 output pulses 51 and 52, respectively.

In Fig. 5 a collector arrangement is shown wherein the screen 11 includes a fluorescent coating 53. The outer main portion of the screen is coated with an opaque substance as indicated at 54, leaving a small opening at 55 over which a selenium type of photocell 56 is positioned. A type of a cell other than selenium may of course be used. This selenium cell is responsive to the light produced by the beam on the fluorescent substance 53 so that when the beam is keyed on or deflected for coincidence with the fluorescent screen area of aperture 55, the cell responds to produce a flow of current in output circuit 57, the amplitude of which corresponds to the degree of coincidence of the beam with respect to the aperture area. When the selenium cell is used it may be desirable to add amplifiers to circuit 16 to boost the amplitude of the output pulses.

In Fig. 6 a variation of the photoelectric cell is shown utilizing the ordinary gas or photocell as indicated at 58. Disposed in spaced relation in front of the fluorescent coated screen 11 is a barrier plate 59 having an aperture 60 in alignment with the cell 58 and a lens 61, whereby an area 62 of the fluorescent screen is focused upon the cell 58. The cell 53 thus responds to the coincidence of the beam with the area 62 to produce pulse energy as hereinbefore described in connection with Figs. 2, 3 and 4.

In Fig. 7 a cathode ray tube 63 is shown similar in construction to the tube 3 of Fig. 1, except that the collector arrangement is of the secondary emission type. The collector, or rather, beam sensitive equipment of this tube, includes a dynode 64 which is located in spaced relation to a barrier plate 65. The barrier plate has an aperture 66 in alignment with the dynode 64 whereby the beam when in coincidence with the aperture 66 impinges upon the dynode 64, thereby causing secondary emission of electrodes from dynode 64 to the barrier plate 65. In order to provide this condition the barrier plate 65 is maintained at a high potential HB while the dynode 64 is maintained at a lower potential LB as indicated by connection 67, movable contact 68 and bias source 69. In the positions shown in Fig. 7 for contact 20, 68, 70 and 71, the pulse energy from receiver 1 is applied together with cut-off bias HC from source 72 to the grid 5 the positive side of said source being connected to the cathode via ground. The bias HC maintains the grid at cut-off so that only the pulse energy applied thereto keys the beam on and off similarly as hereinbefore described in connection with Fig. 1. The operation of the tube 63 is substantially the same as described in connection with tube 3 of Fig. 1 except that the secondary emission feature of this tube provides a much greater signal amplitude output than is obtainable, for example, by collector 12 of Fig. 1 or the selenium cell of Fig. 5. The dynode arrangement has a further advantage in that a fluorescent screen is not used thereby avoiding halation defects that occur

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in the fluorescent coating and glass of screen 11, and in addition allows the return current to flow through the dynode-anode circuit rather than through the beam, thereby avoiding space-charge effects as well as the high impedance effect of the beam.

Besides, the keyed on and off control of the grid 5, the deflection of the beam may be controlled by the pulses over connection 21 to plates 9, 10 by switching contacts 20 and 23 to the right similarly as described in connection with the circuit of Fig. 1. When this change is made it will also be desirable to shift the contacts 70 and 71 to the left so as to provide a cut-off bias from source 73 to grid 5. In this condition the operation is substantially the same as hereinbefore described in connection with Figs. 3 and 4, with the exception that the output current is here produced by secondary emission between elements 64 and 65.

In addition to these two beam control operations, the coactive relationship between the beam and the dynode may be controlled by varying the sensitivity of the dynode in accordance with the pulse energy. This is accomplished by placing in Fig. 7 all of the contacts 20, 23, 68, 70 and 71 to the left. In this condition, the pulses from receiver 1 are applied through contacts 20 and 70 and over connection 67 to the dynode 64. In addition, the dynode 64 is provided with a cut-off bias from source 74 through contact 69. Thus, the dynode in the absence of pulses will not respond to the electron beam, but when biased according to the energy of the time modulated pulses will respond according to the degree of coactive coincidence of the beam therewith, thereby producing a corresponding pulse amplitude output. (In this case it may be necessary to reverse the polarity of the pulses from the preceding in order to cause the dynode potential to drop during the arrival of each pulse.)

While we have disclosed the principles of our invention in connection with specific apparatus, it will be clearly understood that such apparatus is given by way of illustration only and not in restriction of the scope of the invention as set forth in the objects and the appended claims.

We claim:

1. A demodulator for time modulated pulses comprising means for producing a beam of energy, means for causing said beam to sweep through a cyclic movement in synchronism with the timing of said pulses in the absence of modulation, whereby coincidence of said pulses and a given part of said beam movement is varied in proportion to the amount of time modulation of said pulses, and means for causing a flow of electrical energy proportional in amplitude to the degree of coincidence of said pulses and said given part of the cyclic movement of said beam.

2. A demodulator according to claim 1, wherein the means for causing flow of energy includes means for keying the beam on and off according to the leading and trailing edges of each pulse.

3. A demodulator according to claim 1, wherein the means for causing flow of energy includes means for deflecting the beam from its normal movement with respect to said given part of its cyclic movement according to the energy of said pulses.

4. A demodulator according to claim 1, wherein the means for causing flow of energy includes means responsive to energy of said beam and means for controlling the responsiveness of said

responsive means according to the energy of said pulses.

5. A demodulator according to claim 1, wherein the means for causing the beam to have a cyclic sweep movement includes means for producing a voltage in response to the time modulated pulses which is of substantially constant cyclic pattern, and means for deflecting said beam according to said voltage.

6. A demodulator for time modulated pulses comprising means for producing a beam of energy, a beam sensitive device, means for causing said beam to sweep through a cyclic movement, the path of which bears a given relationship with respect to the location of said device, means for causing said beam to coincide with said device in response to at least certain of said pulses, and a circuit associated with said device for conducting a flow of current in response to coincidence of said beam and said device.

7. A demodulator according to claim 6, wherein said beam is an electronic beam, and said device includes an electron responsive element.

8. A demodulator according to claim 6, wherein said device includes means for producing light upon coincidence with said beam and means responsive to intensity of said light to produce flow of current.

9. A demodulator according to claim 6, wherein said device includes a fluorescent screen responsive to said beam for producing light, a light responsive cell associated with said screen and means for defining the active area of said screen with respect to said cell.

10. A demodulator according to claim 6, wherein said device includes a barrier disposed in the path of said beam, said barrier having an aperture therein, a dynode disposed in alignment with said aperture for interception of said beam when said beam is projected through said aperture.

11. A demodulator for time modulated pulses comprising means for producing a cathode ray beam, means for producing a sweep voltage for controlling the cyclic movement of said beam to

cause said beam to follow a given path, means for synchronizing said sweep voltage with the timing of said pulses in the absence of modulation, a beam responsive device for producing a current when said beam coincides with said device, and means to cause said beam to coincide with said device in accordance with the time characteristics of at least certain of said pulses.

12. A demodulator according to claim 11, wherein said device includes a barrier member having an aperture for passage of said beam, and a dynode element disposed in alignment with said aperture for interception of the beam passing therethrough.

13. A demodulator according to claim 11, wherein the means for controlling said beam in accordance with said pulses includes means for keying the beam on and off according to the leading and trailing edges of each pulse.

14. A demodulator according to claim 11, wherein the means for controlling said beam in accordance with said pulses includes means for deflecting the beam from its normal path of movement in response to the energy of said pulses, the deflection of said beam controlling the degree of coincidence of the beam with respect to said device.

15. A demodulator according to claim 11, wherein the means for effecting coactive relation between the beam and said device includes means for controlling the sensitivity of said device to said beam in accordance with the energy of said pulses.

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