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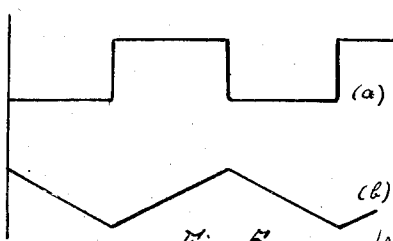
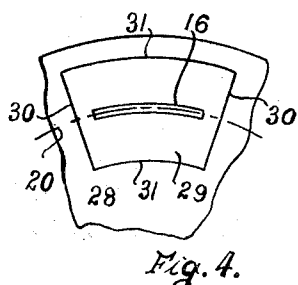
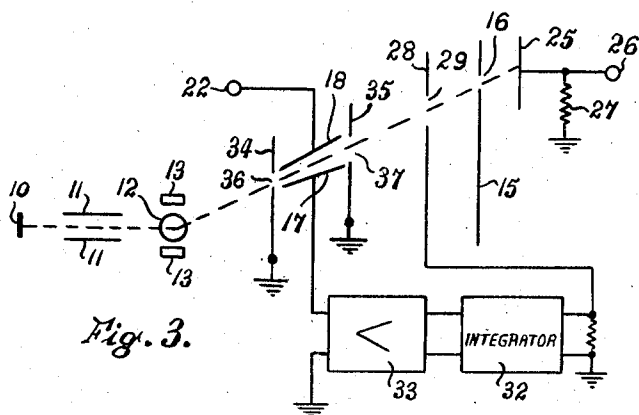
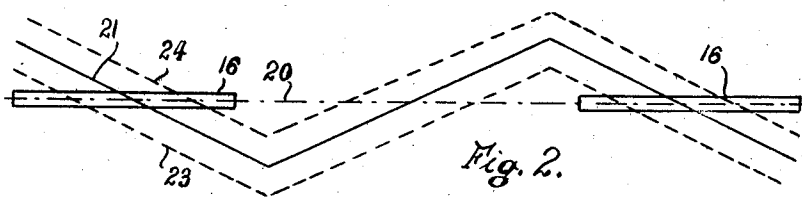
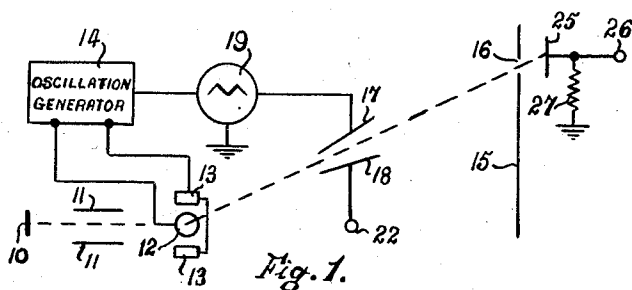
L. I. FARREN ET AL

2,578,527

ELECTRIC PULSE SIGNALING SYSTEM

Filed Feb. 3, 1949

2 SHEETS—SHEET 1



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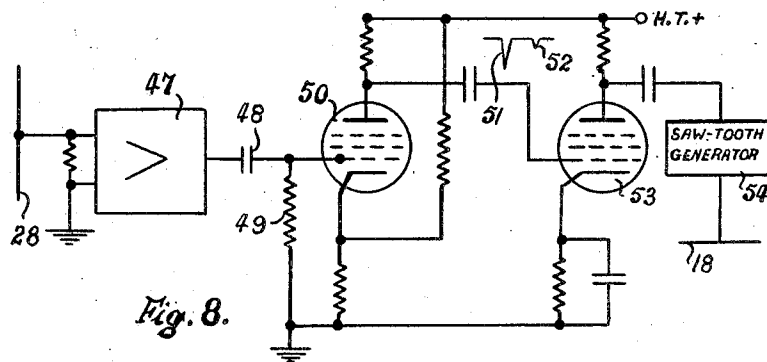
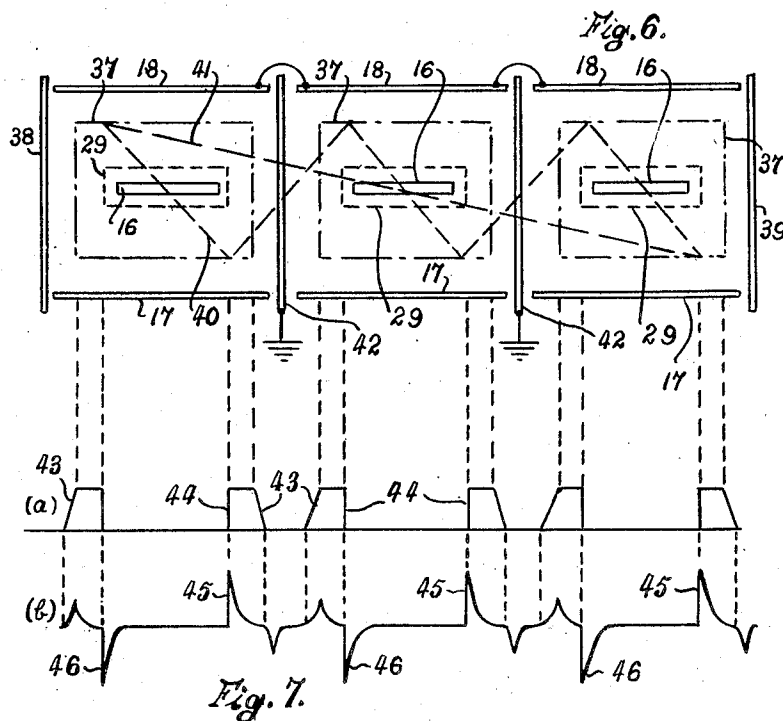
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ELECTRIC PULSE SIGNALING SYSTEM

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2 SHEETS—SHEET 2



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ELECTRIC PULSE SIGNALING SYSTEM

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The present invention relates to electric pulse signalling systems and is concerned with means for producing time-modulation of pulses.

In a pulse signalling system using time-modulation, a train of regularly recurrent pulses of short duration has the instant of occurrence of the individual pulses varied in accordance with a modulating signal to be transmitted. The invention is mainly, although not exclusively, concerned with multi-channel systems. In multi-channel systems, each channel is represented by a train of pulses, the pulses of all trains having the same recurrence frequency and being interleaved with one another in time. The pulses of each channel are allotted a suitable fraction of each recurrence period such that the times allotted to each channel do not overlap the times allotted to other channels.

One known method of effecting the time-modulation in a multi-channel pulse system makes use of a cathode ray tube containing a plate having arranged around a circle a number of slots equal to the number of channels to be dealt with by the tube. These slots are disposed at an angle, for example 45°, both to tangents to the said circle and to radii of this circle. The beam is caused to sweep over the plate in a circular path which, in the absence of modulation, passes through the centers of the slots. A number of deflecting electrodes equal to the number of slots is provided for deflecting the beam radially inwards and outwards as it comes into the region of each slot, and thus the instant of time at which the beam passes over any one slot is made dependent upon the modulation voltage which at that instant is applied to the corresponding deflecting electrode. A collecting electrode is provided for collecting electrons which pass through each slot. These collecting electrodes may be separate for each channel, but usually a single collecting electrode is employed for all the channels and in this way modulated pulses of all the channels appear on the collecting electrode in the interleaved relation required for transmission. Voltage pulses may be obtained across a resistor arranged in series with the collecting electrode. The pulses obtained from the collecting electrode will be negative and if positive pulses are desired they may be obtained from the apertured plate.

Instead of an apertured plate and a collecting electrode there may be used a number of conducting strips of the same shape as the slots in the apertured plate. In this case negative pulses are obtained from the strips.

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These known arrangements suffer from a number of disadvantages. One of these is that it is clearly desirable that there should be some predetermined relation between the value of the modulating voltage and the time-modulation produced thereby, for instance, a linear relation. Since this relation is dependent upon the contour of the edges of the slots (or of the strips), and since the desired relation will not generally be obtained with a rectangular slot or strip, the determination of the required contour is a complicated matter. This is aggravated by the fact that in general the relation between modulating voltage and deflections produced thereby is not linear and the deflection is often not even exactly radial. Secondly, it is found that inaccuracies inevitably arise in the cutting of the slots, or in the manufacture and mounting of the strips, which, of course, results in corresponding inaccuracies in the above-mentioned relation. The inaccuracies may include a variation in slot or strip width, which in turn results in the introduction of some width-modulation superimposed upon the time-modulation.

Another disadvantage is that as the beam is moved radially inwards and outwards by the modulating voltages, the field through which the beam passes becomes non-uniform and this gives rise to a change in the focusing of the beam. The result of this may be further distortion of the time-modulation.

The present invention has for its object to provide apparatus for time-modulating pulses in which one or more of the above-mentioned disadvantages are substantially reduced.

According to the present invention apparatus for modulating pulses in time comprises a cathode ray tube, means for deflecting the cathode ray beam along a path to cause the beam to pass recurrently over or close to an elongated slot or strip, means, operating irrespective of the presence or absence of modulating signals, for deflecting the beam transversely with respect to said path to cross the slot or strip in a direction transverse with respect to its length and means for applying a modulating signal to deflect the beam in such a manner as to vary the point along the length of the slot or strip at which the beam crosses it, the nature of the deflecting means and the disposition of the slots or strips being such that the instant at which the beam crosses the slot or strip varies in dependence upon the modulating voltage. The slot or strip is preferably arranged with its major axis along or parallel to the said path.

The invention further provides apparatus for modulating pulses in time, comprising a cathode ray tube, means for deflecting the cathode ray beam to cause it to execute a recurrent scanning movement along a zigzag track crossing successively over a plurality of elongated slots or strips disposed at acute angles to the said track in the regions of crossing, and means for applying modulating signals corresponding to a plurality of different signalling channels to vary the positions of the said regions along the slot or strips of the respective channels. The slots or strips may be of arcuate shape and may be disposed concentrically and the modulating signals may be applied in such a manner as to vary the radius of the median line of the zigzag path in accordance with a different one of the modulating signals for each of the slots or strips.

The invention will be described by way of example with reference to the accompanying diagrammatic drawings in which

Fig. 1 is a schematic circuit diagram of one embodiment of the invention,

Fig. 2 is a developed view of apertures or conducting strips for use in the embodiment of Fig. 1, showing the tracks of the electron beam thereover,

Fig. 3 is a diagram similar to that of Fig. 1 showing a modified arrangement according to the invention,

Fig. 4 is a fragmentary face view of certain parts of the cathode ray tube shown in Fig. 3,

Fig. 5 illustrates diagrams of waveforms at certain points in Fig. 3,

Fig. 6 is a front view of parts of a cathode ray tube embodying another modified form of our invention,

Fig. 7 contains diagrams illustrating the operation of Fig. 6, and

Fig. 8 is a circuit diagram of a further part of the embodiment of Fig. 6.

Referring to Fig. 1, a cathode ray tube comprises a cathode 10, focusing electrodes diagrammatically represented at 11 for concentrating electrons from the cathode in a fine beam and deflecting coils 12 and 13 whereby the beam can be deflected by means of oscillations from a generator 14 in a circular path over a flat plate 15 having therein a number of equally-spaced arcuate slots 16 (of which only one is shown in this figure) of small width in a radial direction. The circular path of the beam, in the absence of modulation, passes through the center-line of the arcuate slots 16. At a suitable region along the beam are provided deflecting means 17, 18 for imparting a radial deflection to the beam. There is provided a generator 19 of symmetrical saw-tooth oscillations whose frequency is locked, by suitable coupling to the generator 14, to the frequency of the oscillation determining the movement of the beam in a circular path. The frequency of the oscillation of saw-tooth form is arranged to be n times the frequency with which the beam executes one rotation in its circular path, where n is equal to the number of slots provided around the path. These oscillations of saw-tooth form are applied to the deflecting means 17 to urge the ray in a radial direction. The result is that there is superimposed upon the circular track of the cathode ray a zigzag component whereby the cathode ray beam is caused to traverse each slot in a direction inclined at a suitable angle to the tangent to the slot. Thus as shown in the developed view of Fig. 2, the circular path 20 passes through the center line of

the arcuate slots 16 and the effect of the saw-tooth oscillations applied to electrode 17 is to cause the beam to follow the zigzag track 21 shown in full lines. The phasing of the saw-tooth oscillation is arranged to be such that in the absence of modulation the beam passes through the centers of the arcuate slots. Modulating voltages are applied at a terminal 22 to the electrode 18 to produce further displacement of the beam in a radial direction and thus have the effect of altering the mean radius of the zigzag path of the beam in accordance with the modulating voltage. For this purpose, a separate modulating electrode 18, or its equivalent, is provided in association with each slot, and modulating voltages of different channels are applied to different ones of the modulating electrodes. The modulating voltages thus cause the beam to follow such tracks as are indicated in broken lines at 23 and 24 in Fig. 2. The effect of the modulating voltages is thus to vary the instant at which the beam traverses each slot 16 and thus to generate in a collecting electrode 25, Fig. 1, which collects electrons passing through the slot, pulses of electron current which are modulated in time in accordance with the modulating voltages. Pulse voltages may be derived at a terminal 26 from across a resistor 27 connected in series with the collecting electrode. These voltages, derived from the collecting electrode or a plurality of such electrodes, will be negative in sense and if positive voltages are required they may be obtained from the slotted plate 15.

The slots 16 in Fig. 2 are suitably disposed for a multi-channel system where the two slots shown are associated with two say odd-numbered channels. A separate cathode ray tube arrangement is then provided for the even channels.

It will be evident that the slots may be replaced by conducting strips of the same shape. Thus in Fig. 2, 16 may be regarded as strips of conducting material. Pulses of negative sign are then generated in the strips which in a multi-channel system may be connected together. The collecting electrode 25 is not then required.

If desired, a saw-toothed oscillation combined with the modulating signal may be applied to the same deflecting means associated with each aperture, the saw-toothed oscillations being all of the same wave-form and phase. Preferably, however, the electrode 17 is constructed as a single frusto-conical electrode, to which the saw-toothed oscillation is applied, and a plurality of separate deflecting electrodes 18 are provided, one associated with each slot 16. The separate deflecting electrodes 18 may be located outside the frusto-conical electrode or they may cooperate with the beam at a different region along its length from the frusto-conical electrode. Instead of producing the zigzag motion of the beam in the manner described by the use of a saw-tooth oscillation derived from a generator, there may be used a saw-tooth oscillation derived by negative feedback. For this purpose, as shown in Figs. 3 and 4, there may be disposed between the slotted plate 15 and the cathode 10 a further plate 28 (referred to as an apertured plate to distinguish from the slotted plate) having apertures 29 bounded by two radii 30 and two circular arcs 31 whose center lies on the axis of the tube which also passes through the centre of the circular arcs bounding the arcuate slots 16. One such aperture 29 is associated with each slot 16 in the slotted plate 15 and its angular extent is arranged to be

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slightly greater than that of the arcuate slot with which it co-operates. As the beam rotates in its circular path 20, it reaches the leading edge of one of the apertures 29, whereupon electrons cease to be collected by the apertured plate 28 and instead fall upon the slotted plate 15. Electrons are not again collected by the apertured plate 28 until they reach the trailing edge of the aperture 29. There is thus generated in the apertured plate a voltage of approximately rectangular wave-form as shown at (a) in Fig. 5. This voltage is passed to an integrating circuit 32 which serves to derive therefrom a symmetrical saw-tooth oscillation as shown at (b) in Fig. 5 which, after suitable amplification in an amplifier 33, is applied to a deflecting electrode 17 to provide the required zigzag motion of the beam.

It is not essential that the slots should be arranged with their longitudinal center lines around a circular arc; they may be disposed with these center lines at some angle to the tangent to the circle constituting the median line of the zigzag. The slots must of course be so disposed that they are inclined at acute angles to the zigzag path at the regions of crossing as otherwise there will no time modulation when the median line of this zigzag is displaced inwards and outwards. However, the arrangement of the slots in such a manner that their outer and inner boundaries lie on common circles is greatly to be preferred. The design and construction of the apparatus is then greatly facilitated. Any desired modification in the relationship between modulating voltage and the time-modulating produced thereby can be achieved by modification of the wave-form of the saw-tooth oscillation. It is not essential that the zigzag path followed by the cathode ray beam should be in the form of a symmetrical saw-tooth. It may have a non-symmetrical saw-tooth wave-form or even a non-rectilinear wave-form, such for instance as a sinusoidal wave-form. The symmetrical saw-tooth wave-form is, however, preferred. The use, as shown in Fig. 4, of slots having boundaries lying on either side of the beam circle, and coaxial therewith, has the further advantage that the point at which the beam crosses the slot is in each case at the same distance from the axis and consequently defocusing of the beam is avoided.

If desired, the zigzag movement may be such that the beam passes twice (in two opposite directions) over each slot, thus producing double pulse modulation.

It has been found desirable to introduce radial screens to screen adjacent modulating electrodes 18 from one another and also screens such as are shown at 34 and 35 in Fig. 3 having apertures 36 and 37 respectively for the passage of the beam. These screens or masks 34, 35 have been found to introduce difficulties owing to the fact that they intercept the electron beam and thus interfere with the generation of the waveform shown at (a) in Fig. 5. Another difficulty encountered has been noise generated at the electrode 28 and accentuated by the feedback.

One way in which these difficulties may be overcome will be described with reference to Figs. 6 and 8. Fig. 6 shows an arrangement of three slots 16 arranged for operation with rectilinear instead of circular motion of the cathode ray beam. A saw-tooth oscillation applied between electrodes 38 and 39 serves to deflect

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the beam relatively slowly from left to right and relatively rapidly from right to left. A symmetrical saw-tooth oscillation of three times the frequency of that previously referred to is applied to electrodes 18 which are electrically connected together and thus behave as a single electrode. The result of these deflecting oscillations is to cause the beam to follow relatively slowly the broken line path 40 from left to right and relatively rapidly the path 41 from right to left.

The relative shapes of slots 16 and apertures 29 and 37 are indicated in Fig. 6. Screens 42 are disposed between adjacent modulating electrodes 17. In Fig. 7(a) there is shown the electron current in the apertured plate 28 plotted as ordinate against time as abscissa. This current is in the form of pulses beginning as the beam enters the apertures 37 in the screen 35 (not shown in Fig. 6) and ending as the beam enters the apertures 29. Since the screen 35 is closer to the source of the beam than the apertured plate 28, it has a larger cross-section in the region of the screen 35 than in the region of the apertured plate. The result is that the edges of the apertures 37 give rise to pulse edges 43 which are considerably less steep than the edges 44 produced by the apertures 29. Differentiation of the wave-form at (a) in Fig. 7 produces a waveform somewhat as shown at (b) in Fig. 7. Either the positive peaks 45 or the negative peaks 46 can be used to control the generation of the saw-tooth voltage for application to the electrodes 18, the smaller positive or negative peaks respectively being readily eliminated by an amplitude limiter or the saw-tooth generator may be made unresponsive to the smaller amplitude.

One circuit for using the positive peaks 45 is shown in Fig. 8. Voltage from the apertured plate 28 is amplified at 47 and applied through a differentiating circuit 48, 49 of suitably short time constant to a valve 50 having its cathode positively biased to anode current cut-off. The positive pulses 45 appearing on the control grid of 50 produce negative pulses 51 at the anode of the valve and the smaller positive pulses on the grid produce smaller negative pulses 52 at the anode. The negative pulses 46 on the control grid produce substantially no change of anode voltage. The sense of these pulses is reversed by a valve 53 and the positive pulses from the anode of 53 are applied to a saw-tooth generator 54, which may be a Miller transitron, to control the generation of saw-tooth oscillations for application to the deflecting electrode 18. The generator 54 is made unresponsive to the amplitude pulses and is preferably made to be free running at a frequency somewhat lower than that of the controller pulses so that on failure of a controlling pulse the generator continues in operation, although momentarily not locked.

We claim:

1. Apparatus for modulating pulses in time comprising a cathode ray tube, means to generate a cathode ray beam, a plurality of elongated regions, means for deflecting the cathode ray beam in a zig-zag track crossing each of said regions at an acute angle to the longitudinal center line of such regions, means for applying modulating signals to deflect said track transversely with respect to the median line thereof to vary the position along the center line of each said region at which the said track

crosses it and means to derive time-modulated pulses in response to traversals of edges of said region by said beam.

2. Apparatus according to claim 1, wherein said regions are slots in a conducting member.

3. Apparatus according to claim 1, wherein said regions are conducting strips.

4. Apparatus for modulating pulses in time comprising a cathode ray tube, means to generate a cathode ray beam, an elongated region, means for deflecting the cathode ray beam recurrently in a direction along the longitudinal axis of said region, means for deflecting the beam in a direction transverse with respect to said axis to cause the beam to cross said region at an acute angle, means for applying modulating signals to vary in accordance with such signals the point along said axis at which said crossing occurs, and means to derive time-modulated pulses in response to traversals of edges of said region by said beam.

5. Apparatus for modulating pulses in time comprising a cathode ray tube, means to generate a cathode ray beam, an elongated region, means for deflecting the cathode ray beam recurrently in a direction along the longitudinal axis of said region, an apertured electrode located with its aperture in the path of said beam to said region to have voltage pulses generated therein from traversals of an edge of said aperture, means for generating saw-tooth oscillations under the control of said voltage pulses, and means to apply said saw-tooth oscillations to deflect said beam transversely with respect to said axis.

6. Apparatus for modulating pulses in time comprising a cathode ray tube, means to generate a cathode ray beam, an elongated region, means for deflecting the cathode ray beam recurrently in a direction along the longitudinal axis of said region, an apertured electrode located with its aperture in the path of said beam to said region to have voltage pulses generated therein of approximately rectangular waveform from traversals of an edge of said aperture, means to integrate said voltage pulses to generate saw-tooth oscillations and means to apply said saw-tooth oscillations to deflect said beam transversely with respect to said axis.

7. Apparatus for modulating pulses in time comprising a cathode ray tube, means to generate a cathode ray beam, an elongated region, means for deflecting the cathode ray beam recurrently in a direction along the longitudinal axis of said region, an apertured electrode located with its aperture in the path of said beam to said region to have voltage pulses generated therein from traversals of edges of said aperture,

means selectively responsive to those of said voltage pulses derived from a selected edge of said aperture to generate saw-tooth oscillations and means to apply said saw-tooth oscillations to deflect said beam transversely with respect to said axis.

8. Apparatus for modulating pulses in time comprising a cathode ray tube, means to generate a cathode ray beam, a plurality of elongated regions, means for deflecting the cathode ray beam recurrently in a direction along the center line of said regions, transverse deflecting means for deflecting the beam in a direction transverse with respect to said center line to cross said regions and modulating deflecting means to deflect the beam in a direction transverse with respect to said center line, said transverse deflecting means comprising an apertured electrode disposed with an aperture in the path of the beam to each of said regions to have voltage pulses generated therein, from traversals of edges of said apertures, means to generate saw-tooth oscillations under the control of said voltage pulses and means to apply said saw-tooth oscillations to deflect the beam transversely with respect to said axis.

9. Apparatus according to claim 8 comprising screening means disposed to screen from one another over a large part of their length the zones traversed by the beam between each of said modulating deflecting means and each of said regions.

10. Apparatus according to claim 8 comprising an apertured screen having an aperture disposed in the path of the beam to each of said regions, said screen being disposed transversely with respect to said path and between said modulating deflecting means and said apertured electrode.

11. Apparatus according to claim 8 comprising an apertured screen having an aperture disposed in the path of the beam to each of said regions, said screen being disposed transversely with respect to said path and between said modulating deflecting means and the cathode of said tube.

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