Jan. 21, 1941. G. E. PRAY 2,229,125

ELECTRONIC HIGH SPEED KEYER

Filed July 6, 1937

FIG. 1

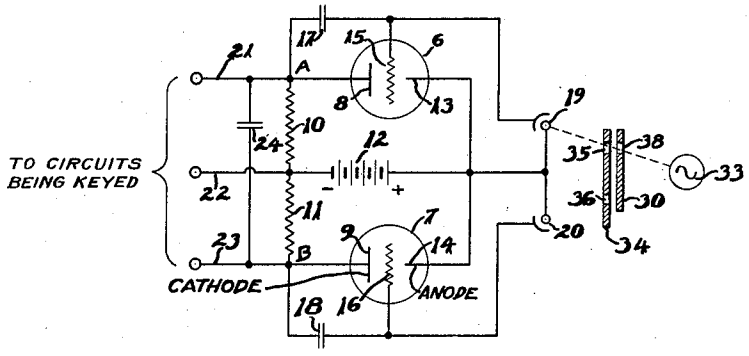


FIG. 2

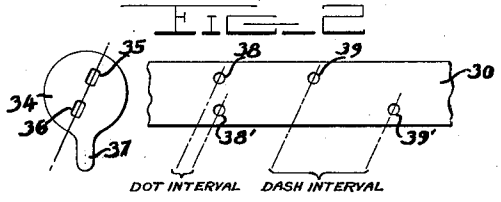


FIG. 3

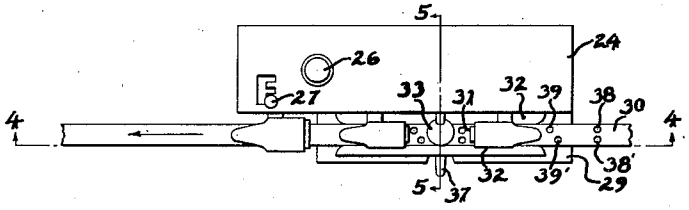


FIG. 4

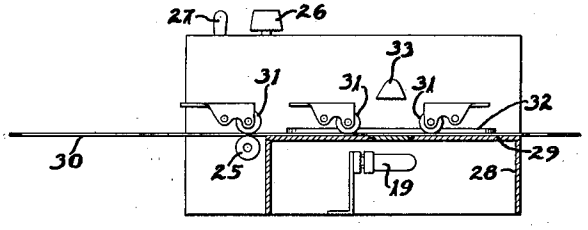
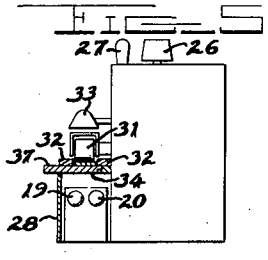


FIG. 5



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Patented Jan. 21, 1941 2,229,125

UNITED STATES PATENT OFFICE

2,229,125

ELECTRONIC HIGH SPEED KEYER

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Application July 6, 1937, Serial No. 152,222

17 Claims. (Cl. 178—17)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

This invention relates to a novel means for keying a radio or other transmitter at speeds up to and exceeding 10,000 words per minute. Among the several objects of this invention are:

To provide means for the high speed actuation of a relay;

To provide means for very rapidly reversing potentials across an impedance;

To provide a relay responsive to signalling perforations in a tape, the speed of operation of said relay being not limited by mechanical inertia;

To provide electronic high speed means for keying a transmitting circuit.

The keying mechanisms at present in use are too well-known to those skilled in this art to require detailed discussion, and it is equally well-known that the speed of such devices is very definitely limited by the mechanical inertia of contact fingers and relays used to translate the messages from punched tape into electrical impulses of the "mark" and "space" type. This invention eliminates all mechanical contactors and relays in the keying circuit and the speed is therefore unlimited by any such elements. The "mark" and "space" type of keying depends upon reversing the direction of potential difference across the control elements of the keyed stage of the transmitter, the duration of the potential difference in one direction being varied in accordance with the dots and dashes of the signal code and the length of the intervals during which the potential is reversed is that of the space between the dots and dashes.

In the drawing:

Fig. 1 illustrates schematically the electronic relay and the perforated tape and aperture plate associated therewith to control the energization of the relay;

Fig. 2 is a plan view of a portion of a tape and the aperture plate over which the tape runs, the tape being cut away from the plate to permit showing the details thereof;

Fig. 3 is a top plan view of the keying assembly;

Fig. 4 is a side elevational view thereof with the housing for the photoelectric cells shown in section, on line 4—4, Fig. 3;

Fig. 5 is an end elevation of the same with the photoelectric cell housing shown in transverse section on line 5—5, Fig. 3.

Referring now to Fig. 1, the relay circuit comprises two electron discharge tubes 6 and 7, which may be of the grid glow, gas filled, or grid control rectifier type. The cathodes 8 and 9 of these tubes are connected to opposite ends of impedance members 10 and 11 that are in common connected at their other terminals to the negative terminal of battery 12, whereof the positive terminal is connected to the anodes 13 and 14. The grids 15 and 16 are isolated from the respective cathodes by condensers 17 and 18 and are connected to the respective anodes through intermediacy of photoelectric cells 19 and 20. Output leads 21, 22 and 23 are respectively connected to the terminal of impedance 10 to which cathode 8 is connected, to the common point of impedances 10 and 11, and to the terminal of impedance 11 to which cathode 9 is connected, a capacitance 24 being connected across leads 21 and 23 to control the time constant thereof.

Referring now to Figs. 3 to 5, the housing 24 encloses a suitable motor, together with variable speed mechanism of any well-known type (not shown), to drive the tape puller wheel 25, the speed of the motor being controlled by a rheostat operated by knob 26 and the variable speed mechanism being adjustable by a lever 27. Attached to the housing 24 is a light proof enclosure 28 wherein are disposed the two photoelectric cells 19 and 20. The upper wall 29 of enclosure 28 serves as a track over which the perforated tape 30 is drawn, the tape being held in continuous contact with the track and with wheel 25 by spring pressed rollers 31 and being constrained to move over the desired portion of the track by guide strips 32. The source of light 33 is disposed above the photocells 19 and 20 with the aperture plate 34 rotatably mounted in an opening in the upper wall 29 in such manner that the apertures 35 and 36 in the aperture plate will respectively permit the passage of light to the photocells 19 and 20. As may be seen in Figs. 4 and 5, the edge of the aperture plate is rabbetted to cooperate with the rabbetted edge of the opening in wall 29 whereby the aperture plate may be manually rotated by means of tab 37, the guide strips 32 serving to retain the aperture plate in its operative position. The tape 30 is provided with pairs of perforations 38, 38' and 39, 39', the said perforations being disposed in two longitudinal rows with one member of each pair in each of these rows, the transverse spacing between the members of each pair being such that the perforations in one row permit light to pass through aperture 35 while those in the other row permit light to pass through aperture 36. The longitudinal spacing of the perforations in each pair corresponds to the duration of a dot or a dash and the longitudinal

distance between the rearmost member of one pair of perforations and the foremost member of the next succeeding pair of perforations gives the spacing interval between the succeeding signal elements.

As is depicted in Fig. 2, the line passing through the center of aperture plate 34 and through the apertures 35 and 36 is disposed at an angle other than a right angle to the edge of the tape 30 whereby the perforation 38, for example, will coincide with aperture 35 an instant earlier than coincidence of perforation 38' with aperture 36; the angle at which the said line lies with respect to the edge of tape 30 may be varied by rotating plate 34 and thereby the duration of the interval between the coincidence of the two members of a pair of perforations with their respectively cooperating apertures in the plate 34 may be changed.

Perforation 38 permits light from source 33 to pass through aperture 35, falling on photo-cell 19. Cell 19 becomes conductive and permits current to flow from battery 12 through resistor 10, capacitor 17, and cell 19, charging capacitor 17 so that grid 15 is at a positive potential with respect to cathode 8. The rate of rise of potential on grid 15 is governed by the capacitance of 17, the resistance of cell 19, and resistance 10. When the potential on grid 15 reaches the igniting voltage for the tube 6, the gas within the tube becomes ionized and allows the passage of current from battery 12, through resistor 10, cathode 8, and anode 13. The current through resistor 10 produces a potential drop across resistor 10, resulting in point A being at a positive potential with respect to the negative side of battery 12. This potential drop across resistor 10 charges capacitor 24 through resistor 11, resulting in point A being at a positive potential with respect to point B. A "marking" voltage is then available between terminals 21 and 23. Now when the tape 30 is moved to cut off the light through aperture 35 to photo-cell 19, the photo-cell becomes non-conductive, cutting off the charging current to grid 15. Capacitor 17 will now discharge through the ionized gas between grid 15 and cathode 8, returning grid 15 to approximately the potential of the cathode 8. Anode current will continue to flow however, until the anode-cathode circuit is interrupted. This interruption occurs when tube 7 breaks down, as follows: Tape 30 is moved until perforation 38' allows light from source 33 to pass through aperture 36 and fall on photo-cell 20. Cell 20 becomes conductive and causes tube 7 to ignite in a manner similar to that just explained for tube 6. The anode-cathode current in tube 7, passing through resistor 11, is equal and opposite to the current in resistor 10, tending to discharge capacitor 24. As is well known in the art, the time of charge or discharge of a capacitor is controlled by the resistance in the charge or discharge circuit. Since capacitor 24 must discharge through both resistors 10 and 11, this discharge may be delayed sufficiently to produce another desired condition. Thus the charge across capacitor 24 momentarily adds to the potential across resistor 10 produced by the current from tube 6, and applies a potential across resistor 10 which is twice the initial value, thus placing cathode 8 at a high positive potential relative to anode 13. This is equivalent to a reversal of potential across tube 6, and definitely cuts off the flow of current through said tube. Capacitor 24 then discharges through resistors 10 and 11, and becomes charged in the reverse polarity by the potential across resistor 11 due to current from tube 7. This results in point B being at a positive potential relative to point A, and provides a "spacing" voltage between terminals 21 and 23. As the tape 30 is further drawn across the apertures 35 and 36, when either of tubes 6 or 7 is made conductive, the other tube becomes non-conductive by the above process.

If it is desired to utilize only a "make" and "break" type of keying, in which a potential is applied during the "make" period and no potential during the "break" period, such a keying signal may be obtained across terminals 21 and 22, or 22 and 23.

According to the provisions of the patent statutes I have set forth the principle and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically illustrated and described. For instance, instead of two separate photocells, 19 and 20, I may use a single cell having in it two sets of photoelectric elements, and the term "pair of photocells" is intended to cover such construction.

The invention herein described and claimed may be used and/or manufactured by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

1. In combination, a track, a plate mounted therein flush with the upper surface thereof to be angularly adjustable in its own plane, said plate having two apertures spaced apart on a line lying at an acute angle to the side of the track, a source of light disposed to project light through said apertures, a pair of photocells respectively disposed to receive light each from one of said apertures, a perforated tape movable over said track, the perforations therein being in two rows spaced to be respectively registrable with said aperture to permit light to pass therethrough, the said perforations being in pairs with one member of each pair in each row, means to move said tape over the track, and an electronic relay controlled by said photocells, said relay including output impedance means across which the potential difference is in one direction when one of said cells is energized and in the opposite direction when the other cell is energized.

2. In combination, a track, a plate mounted therein flush with the upper surface thereof to be angularly adjustable in its own plane, said plate having two apertures spaced apart on a line lying at an acute angle to the side of the track, a source of light disposed to project light through said apertures, a perforated tape movable over said track, the perforations therein being in two rows spaced to be respectively registrable with said apertures to permit light to pass therethrough, the said perforations being in pairs with one member of each pair in each row, means to move the tape over the track, impedance means, a source of potential operatively connected to said impedance means, and means controlled by the passage of light through said apertures and said perforations to govern the direction of application of potential difference to said impedance means by said source.

3. In combination, a tape provided with pairs of perforations in two longitudinal rows with one

member of each pair in each row, the members of said pairs being longitudinally spaced to correspond to dot and dash signals, a track over which said tape is movable, a plate mounted flush in said track, said plate having two apertures respectively registrable with the perforations in one row and being angularly adjustable to vary the interval between the time of registry of a perforation with one aperture and the time of registry of the other perforation of the pair with its respective aperture, means to project light through said apertures, an electronic relay, and means controlled by light through said apertures when said perforations are in registry therewith to govern the actuation of said relay.

4. In combination, an electronic relay including a pair of grid controlled ionization conduction devices, means to control the actuation of said relay including two photocells each connected to initiate conduction in a respective one of said devices and a source of light to energize said cells, and means to control the energization of said cells including a tape disposed to be moved between said source and said cells normally to intercept the light from source but provided with two rows of perforations so arranged that light through the perforations in each of said rows respectively energizes one of said cells.

5. In combination, an electronic relay including a pair of grid controlled ionization conduction devices, an output impedance, means to control the actuation of said relay including two photocells each connected to initiate conduction in a respective one of said devices and a source of light to energize said cells, and means to control the energization of said calls including a tape disposed to be moved between said source and said cells normally to intercept the light from source but provided with two rows of perforations so arranged that light through the perforations in each of said rows respectively energizes one of said cells, the energization of one of said cells causing a potential difference across said impedance in one direction and the energization of the other cell causing an oppositely directed potential difference across said impedance.

6. A device for "mark and space" keying of a circuit, comprising an electronic relay including a pair of grid controlled ionization conduction devices, an output impedance, output leads operatively connected across said impedance, means connected across said impedance to fix the time constant of the output of said relay, means to actuate selectively one or the other of the devices in said relay to set up potential differences across said impedance in opposite directions and a travelling member having portions arranged in accordance with a desired sequence of "mark" and "space" conditions of keying operatively associated with the last mentioned means to control the same in accordance with said portions.

7. A device for "mark and space" keying of a circuit, comprising an electronic relay including a pair of grid controlled ionization conduction devices, an output impedance, output leads operatively connected across said impedance, means to actuate selectively one or the other of the devices in said relay to set up potential differences across said impedance in opposite directions, and a travelling member having portions arranged in accordance with a desired sequence of "mark" and "space" conditions of keying operatively associated with the last mentioned means to control the same in accordance with said portions.

8. A device for "mark and space" keying of a circuit, comprising an electronic relay including a pair of grid controlled ionization conduction devices and output impedance, output leads operatively connected across said impedance, means to actuate selectively one or the other of the devices in said relay to set up potential differences across said impedance in opposite directions, and a travelling member having portions arranged in accordance with a desired sequence of "mark" and "space" conditions of keying operatively associated with the last mentioned means to control the same in accordance with said portions, and adjustable means to vary the duration of the "mark" and "space" intervals.

9. In combination, an electronic relay including a pair of grid controlled ionization conduction devices, an output impedance, means to control the actuation of said relay including a pair of photocells and a source of light, and a travelling member between said source and said cells, said member having portions arranged in accordance with a desired sequence of energization of said cells whereby to cause said cells to be energized in accordance with said sequence and set up corresponding potential differences across said impedance.

10. High speed keying means, comprising an impedance, leads to the circuit to be keyed operatively connected across said impedance, a pair of grid controlled ionization conduction devices for selectively setting up potential differences in opposite directions across said impedance, and means to control said devices including a pair of photocells each respectively connected to ignite one of said devices, a source of light to energize said cells, and a tape disposed to be moved between said source and said cells normally to intercept the light from said source but provided with two rows of perforations so arranged that light through the perforations in each of said rows respectively energizes one of said cells.

11. An electronic relay, comprising a pair of electron discharge tubes having characteristics of the grid glow type and each including a cathode, a grid and an anode, a source of current having its positive terminal connected to both of said anodes, resistance means centrally connected to the negative terminal of said source and having each terminal respectively connected to one of said cathodes, two photo-electric cells operatively connected to the said positive terminal and each respectively connected to one of said grids, a capacitance connecting each grid to the cathode cooperating therewith, and an additional capacitance connected across the terminals of said resistance means to be charged by passage of anode cathode current through one of said tubes and to be discharged when the other of said tubes passes current whereby to apply to the cathode of the said one tube such positive potential as to extinguish the said one tube.

12. An electronic relay, comprising a pair of ionization conduction tubes each having a cathode, a grid and an anode, a source of current having its positive terminal connected to both said anodes, normally non-conducting means connecting said positive terminal respectively to each said grid, impedance means symmetrically connected to the negative terminal of said source and to said cathodes, a capacitance connecting each said grid to the cooperating cathode whereby each said capacitance is charged when the respectively associated said normally non-conducting means is rendered conducting and the

tube is ignited, and said capacitance is discharged through the ionized path in said tube when said normally non-conducting means again becomes non-conducting, and a capacitance connected across said impedance to be charged when one of said tubes passes current and to be discharged and thereby impress an extinguishing potential on the cathode of said one tube when the other said tube passes current.

13. In combination, a track, a plate mounted therein flush with the upper surface thereof to be angularly adjustable in its own plane, said plate having two apertures spaced apart on a line lying at an acute angle to the side of the track, a source of light disposed to project light through said apertures, a pair of photo-cells respectively disposed to receive light each from one of said apertures, a perforated tape moveable over said track, the perforations therein being in two rows spaced to be respectively registrable with said aperture to permit light to pass therethrough, the said perforations being in pairs with one member of each pair in each row, and means to move said tape over the track.

14. In combination, a tape provided with pairs of perforations in two longitudinal rows with one member of each pair in each row, the members of said pairs being longitudinally spaced to correspond to dot and dash signals, a track over which said tape is moveable, and plate mounted flush in said track, said plate having two apertures respectively registrable with the perforations in one row and being angularly adjustable to vary the interval between the time of registry of a perforation with one aperture and the time of registry of the other perforation of the pair with its respective aperture.

15. Apparatus as described, comprising two grid ignited ionization conduction devices each having a grid, an anode and a cathode, a respective capacitance connected between the grid and cathode of each said device, a charging circuit for each said capacitance comprising a resistance and a photocell, a source of current common to the two said charging circuits, said resistances having a common connection to the negative side of said source, means connecting the anodes of both devices to the positive side of said source, a capacitance connected across both said resistances and means to energize one of said photocells in accordance with the "mark" of a signal and the other of said photocells in accordance with the "space" of a signal.

16. Apparatus as described, comprising a relay including a first and a second grid ignited ionization conduction device, each having a grid, a cathode and an anode, impedance means connected to give rise to potential differences in opposite senses, respectively, due to current passing through one or the other of said devices, a capacitance connected to be charged by potential differences developed in said impedance, a respective capacitance connected between the grid and cathode of each said device, means including a photocell connected respectively to each said capacitance between the grid and the cathode of said device to charge said grid-cathode connected capacitances when the respective photocell becomes conducting, and means to control the conducting condition of one of said photocells in accordance with the "mark" of a signal and the other said photocell in accordance with the "space" of a signal.

17. Apparatus as described, comprising two grid ignited ionization conduction devices, an input circuit including a respective photocell to ignite each said device, a source of unidirectional potential common to both said devices, impedance means including reactance and resistance connected at a respective side to an output electrode of each said device, means connecting a common intermediate point of said impedance means to both said devices to complete an output circuit for each said device, whereby when one of said devices is ignited by the photocell connected to such device a potential difference in one sense is developed across said impedance means by the current through said one device, and upon ignition of the other said device by the photocell connected to the other said device there is developed across said impedance means a potential difference in the opposite sense which extinguishes the said one device, means to excite said photocells alternately, and output means connected across said impedance means.

GEORGE EMERSON PRAY.