Oct. 22, 1957 D. H. LEE 2,810,903

CODE TYPER

Filed May 9, 1955 4 Sheets-Sheet 1

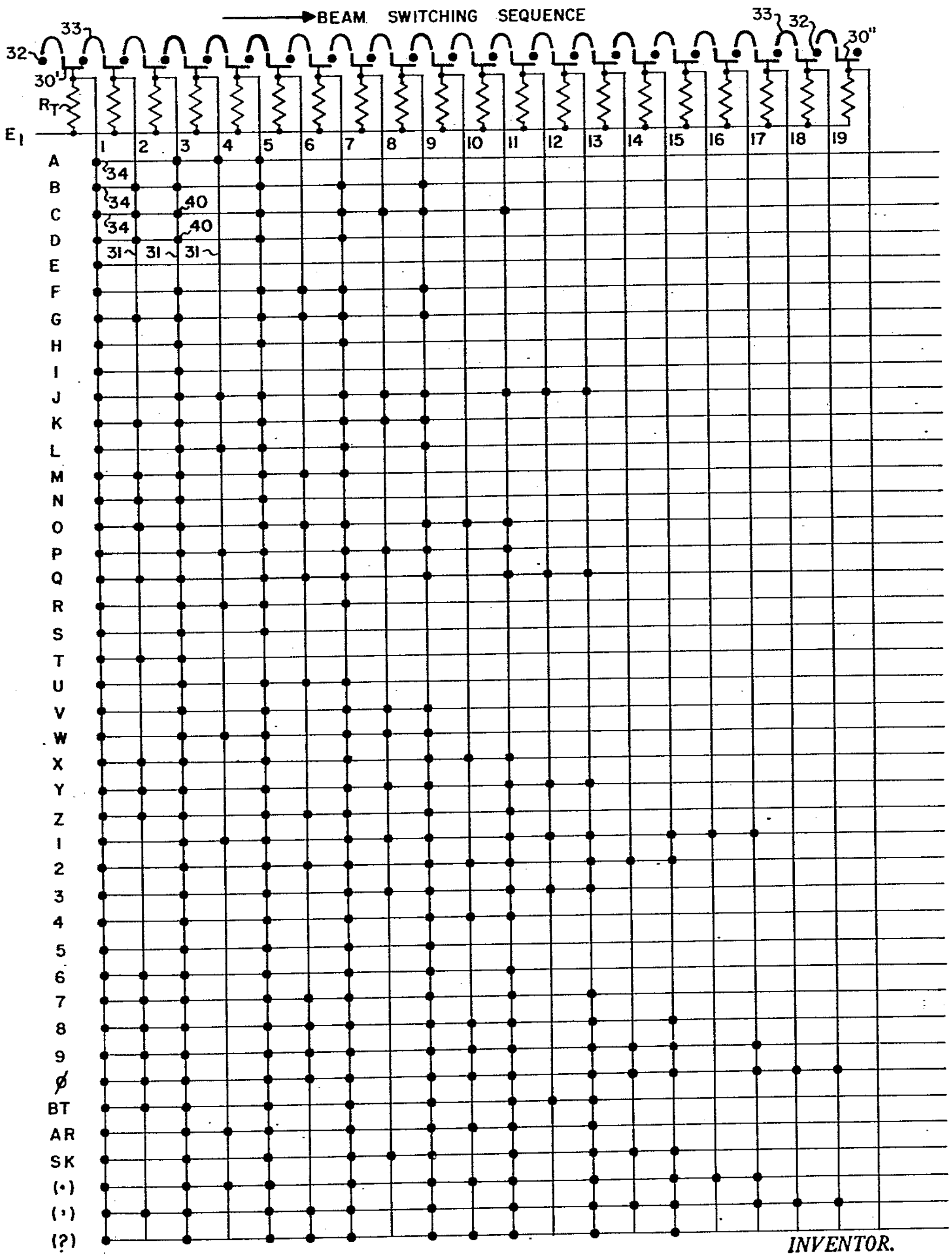

Fig. 1a

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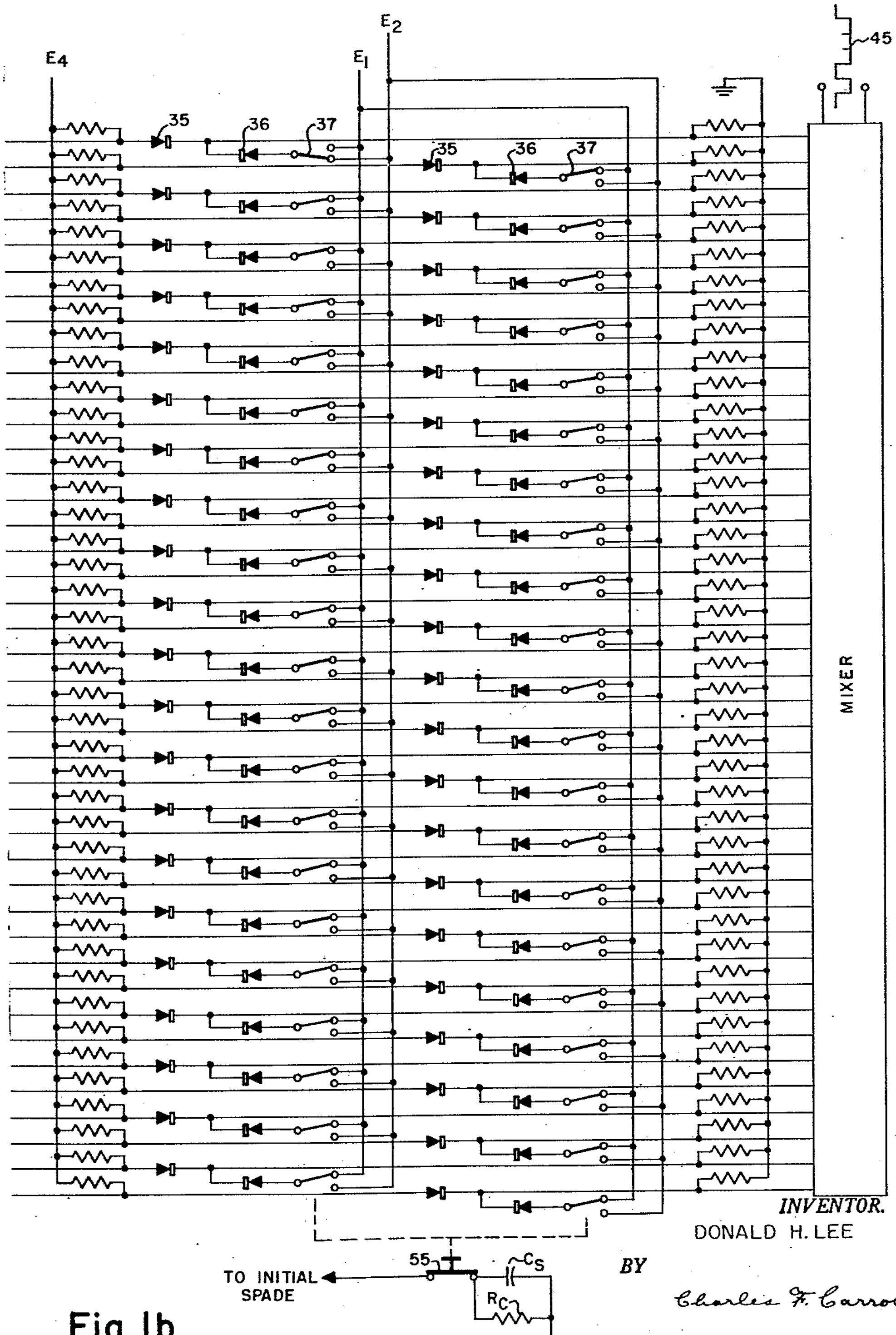

Fig. 1b

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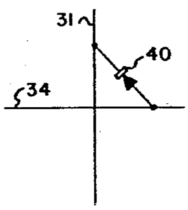

Fig. 2

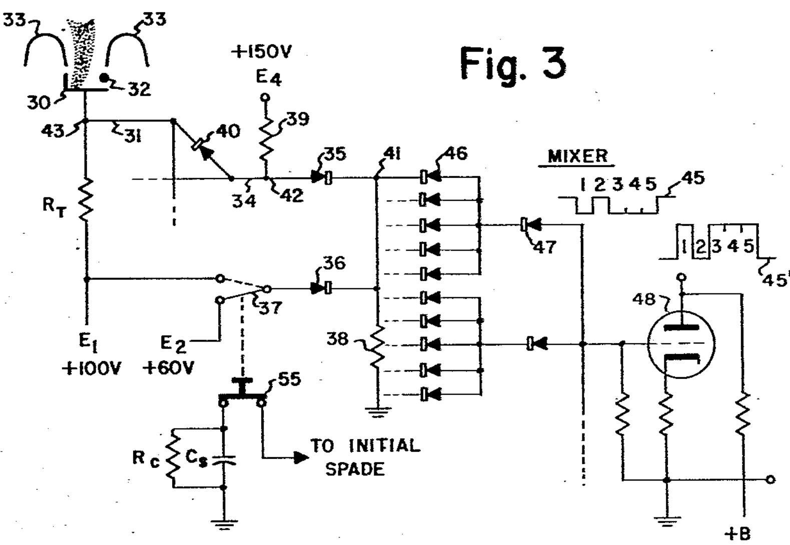

Fig. 3

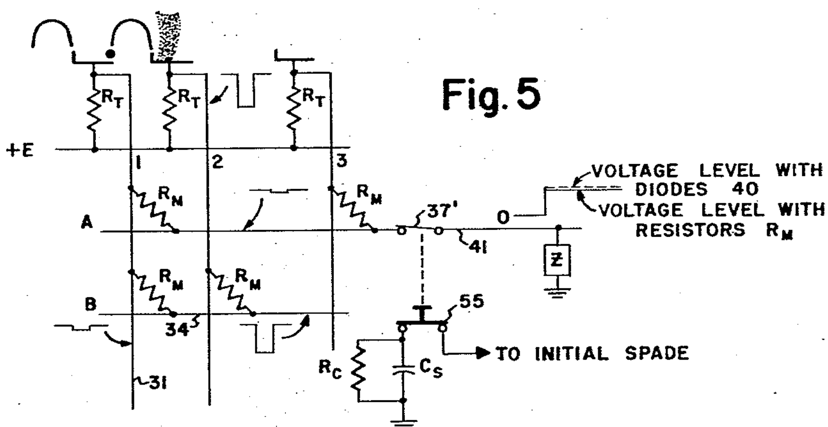

Fig. 5

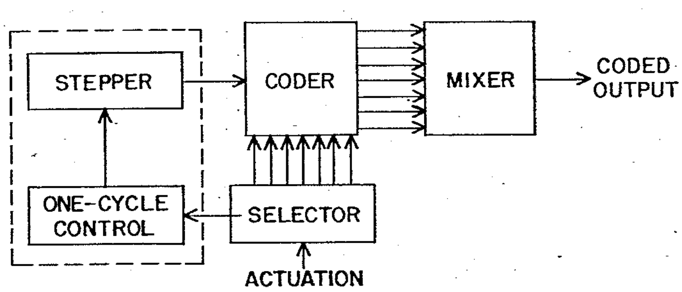

Fig. 6

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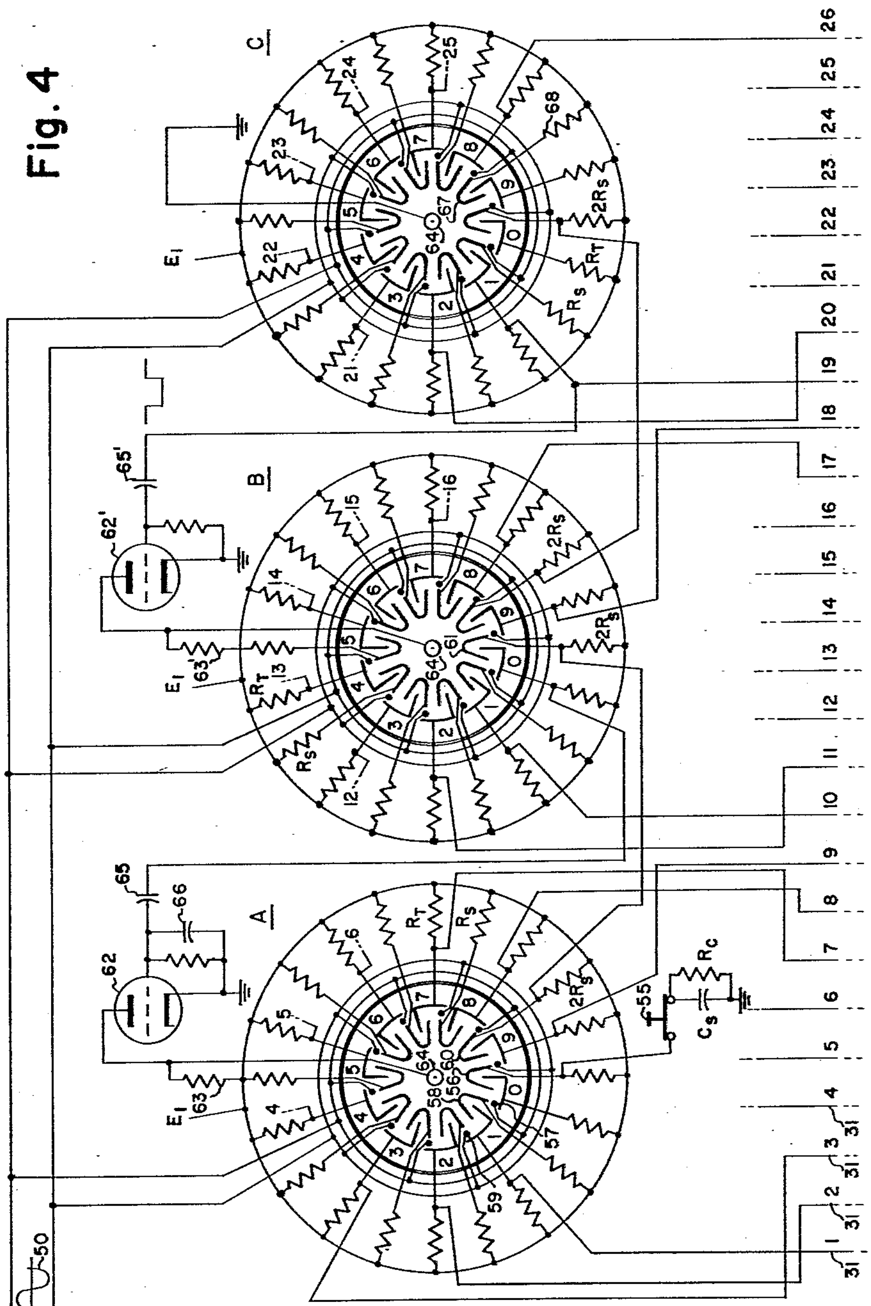
Fig. 4



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2,810,903

Patented Oct. 22, 1957

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2,810,903

CODE TYPER

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Application May 9, 1955, Serial No. 506,872

3 Claims. (Cl. 340—348)

This invention is concerned with improvements in code communication and in particular with typers for producing code signals representative of each letter or other character of a message.

Code communication presents several advantages over voice communication. Equipment for generating the energy which is utilized to carry the information can be much simpler, in that no modulator beyond an "on-off" control is required. Further, this carrier energy has its maximum change, in varying from "off" to "on" condition, so the changes which convey information have their maximum signal-to-noise ratio in code communication.

When a human operator produces the successions of dots and dashes of code communications, there is a vulnerability to error from human fatigue and distraction. Additionally, each operator unconsciously adds his own physical characteristics to his keying so that skilled intercept operators can identify various operators through their personal differences in keying. Such personal operator characteristics are as vital as transmitter behavior, in identifying senders by their signal's "fingerprints." It, therefore, becomes highly desirable to be able to send the dots and dashes of International code or any other similar pulse code in an automatic or machine manner.

An object of this invention is to provide a machine having a typewriter type keyboard, which is operated as a typewriter is operated, and produces electrical output sequences of dots and dashes, or other pulse sequences representative of the characters being typed. These output pulses can be used to key a radio transmitter or any other suitable sender.

A further object of this invention is to provide a code machine wherein the speed of the code pulse sequences is regulated in the machine and is not affected by operator characteristics.

An additional object of this invention is to provide a code machine which produces a wide variety of code pulse/space sequences, useful for purposes other than communication such as remote control, interrogation, identification, and "unlocking" secure channels of a communication link.

In accordance with the features of one embodiment of this invention, the targets of several magnetron beam switching tubes are connected to the conductors of one coordinate (the columns) of a matrix. The magnetron beam switching tubes are as shown and described in Electronic Design of January 1954, in an article titled, "A New Beam Switching Tube."

A magnetron beam switching tube has an elongated axial cathode and circular concentric arrays of other electrodes surrounding this cathode. On a first or smallest radius from the cathode is an array of evenly spaced spade electrodes. These spade electrodes are of approximately U-shaped cross-section with their convex surface facing the cathode. These spades serve to form a beam within the tube and to hold the beam on other electrodes. In line with one side of each spade and on a slightly larger radius is an array of switching electrodes. These switching electrodes are elongated rods and are aligned parallel to the axial cathode. They serve to disturb the stable beam-holding function of an associated spade and to cause the beam to switch over to the next position in which it can be stably held. On the next larger radius is an array of L-shaped target electrodes. One arm of each L is arcuate and positioned on the circumference and in line with one of the spaces between spades. The radial arm of each L extends inwardly toward a spade and may actually project slightly into the concave space or cavity of that spade. One of the switching electrodes is positioned between the spade on the other side of the space and the end of the arcuate arm of the L-shaped target. Each space between spades, with its target electrode, provides a beam receiving position or compartment. The spade adjacent to the radial arm of the L-shaped target holds a beam on that target when the electrodes are connected to appropriate circuitry. The switching grid and spade on the other side of the space and target serve to move the beam toward them and into the next compartment to strike the next target. An axial magnetic field is required, permeating this tube. For the beam's movement in a clockwise direction, the flux lines must flow toward the observer. The axial magnetic field usually is provided by a cylindrical permanent magnet surrounding the above-described tube structure, but could be an electromagnet or a combination of both types of flux sources.

With a positive potential applied to the spade electrodes and target electrodes, the crossed magnetic/electrical fields of a magnetron are provided. These fields are adjusted to place the tube well into the cut-off region of its magnetron characteristics, so no beam is formed and no current flows to any target electrode. If the potential of one of the spades is lowered to near the cathode's potential, the symmetrical electrical field is changed and electrons will flow to the compartment adjacent to this spade, forming a beam. Some electrons strike this spade and flow through a resistance which connects each spade to the positive potential. The resulting IR voltage drop enables that spade to hold the beam stably in that compartment, striking the target thereof. If now the switching electrode in the compartment receiving the beam is lowered in potential, the beam moves toward that electrode and some electrons will strike the spade closest to this switching grid. As with the other spades, this spade also has a resistor connecting it to a positive potential. The beam current through this resistor lowers the spade's potential until the beam sweeps over it and locks in the next compartment, being held there by this lowered potential of this second spade. In a similar manner, switching signals on successive switching grids will advance the beam from one compartment and target to the next. It is these targets which connect to the conductors of one coordinate (the columns) of a matrix.

The conductors of the other coordinate (the rows) of the matrix are connected to keying circuits and then to an output mixer. Within the matrix, connections between rows and columns are provided in particular sequences for each keying circuit. Sequential stepping of the beam in the magnetron beam switching tubes will produce a series of output signals from a selected keying circuit which series is representative of that keying circuit's connections to the matrix and of the code pulses of the letter or character for that particular row across the matrix. Non-linear elements such as crystal diodes provide a very efficient means for connections between rows and columns, but resistors also can be used to provide an acceptable matrix.

The invention now will be described in greater detail, in connection with the accompanying drawings, in which:

Fig. 1*a* is a schematic diagram of part of one embodiment of this invention;

Fig. 1*b* is a schematic diagram of the remainder of the embodiment of Fig. 1*a*;

Fig. 2 is a representation of a diode-connected intersection in the diode matrix;

Fig. 3 is a schematic diagram of a particular position within the circuitry of the invention;

Fig. 4 is a schematic diagram of beam switching tubes connected for sequential switching;

Fig. 5 is a schematic diagram of another embodiment of the circuitry shown in Fig. 3; and

Fig. 6 is a functional diagram of the overall combination of this invention.

Referring to Figs. 1*a* and 1*b*, targets **30** of a series of beam switching tubes are connected to different columns along one coordinate of a matrix here designated the Y coordinate. Each target **30** is connected to a separate conductor **31** in each column as shown. Switching grids **32** and spade electrodes **33** of the beam switching tubes function to form, hold, and move the beams of their respective tubes as is described in a copending application of S. P. Fan et al., Serial No. 370,086, filed July 24, 1953, entitled "Multi-Position Beam Tube," now U. S. Patent 2,721,955 issued October 25, 1955. The details of beam forming, holding, switching, and extinguishing pertinent to beam switching as utilized in this invention are described hereinafter in connection with Fig. 4. The beam forming step in the switching sequence between tubes can be as shown and described in copending application of Hilary Moss, Serial No. 487,548, filed February 11, 1955, entitled "Multiple Output Switching System," as described in connection with Fig. 4.

In an examination of Figs. 1*a* and 1*b* consider that the beam will dwell a short but accurately controlled period of time on each of generally designated targets **30** in sequence and will be extinguished when it reaches the last position of the last tube. The arrays of target, switching grid, and spade electrode which are used only for switching between tubes and for forming or extinguishing a beam are not shown in Fig. 1*a*. When the beam fails on a particular one of targets **30**, that target will drop in potential due to the beam current flowing through the corresponding target resistor RT. This negative signal will be applied along the respective column **31** connected to that target which is receiving beam current. As the beam switches to successive targets, successive column conductors **31** receive a negative pulse as above described. Thus, negative pulses are applied to the conductor **31** for positions 1, 2, 3, etc., across the matrix, in a sequence of accurately defined pulse periods.

Conductors **34** connect along the rows of the other coordinate of the matrix, here designated the X coordinate. Each row conductor **34** is connected to a first diode **35** of a negative coincidence circuit. Another diode **36** of each concidence circuit is connected to a contactor or key **37** which is actuated when the response characteristic of a particular row of the matrix is desired. Thus, a separate coincidence circuit and key are provided for each row A, B, C, . . . (.), (,), etc., down the matrix. Each key **37** drives a second contactor **55** which is simultaneously actuated to connect the first spade **33** of the first tube to a capacitor CS to momentarily lower this spade to ground potential. This causes the beam to form at the first position at the beginning of a cycle.

Conductors **31** and **34** intersect in a pattern which forms the basis for the diode matrix, with diodes **40** connected therebetween as shown in Fig. 2. Each of such interconnections is designated by a dot **40** at the intersecting conductors in Fig. 1*a*. Dots are used to simplify the presentation of the drawing of the entire matrix. From an examination of the dots **40** in Fig. 1*a*, it will be seen that column conductors **31** of positions A, B, C, etc., have selective connections to row conductors **34** of positions 1, 2, 3, etc., which are characteristic of each particular row.

To examine the operation of the diode matrix, coincidence circuit and key actuated contacts when a particular key **37** is depressed, reference is made to the equivalent circuit of Fig. 3. Before it is depressed, key **37** is in the dashed position, connecting diode **36** to voltage E_1, about +100 volts. Contactor **55** at that time is open. Voltage E_4, about +150 volts, is applied through resistor **39** to point **42**. Through matrix conductors **34** and **31** and matrix diode **40** at an intersection of these conductors, target **30** at point **43** is connected to point **42**. Diode **35** interconnects point **42** and point **41**. Target **30** also connects to voltage E_1 through resistance R_T. Resistor **38** is connected from point **41**, the cathode junction of diodes **35** and **36**, to circuit ground.

When the beam is not falling on target **30**, the voltage difference between E_1 and E_4 drives a current from E_4 through points **42** and **43** to E_1. Current also flows from E_4 through points **42** and **41**, through resistor **38** to ground. These currents develop IR voltage drops across resistors **38**, **39** and R_T such as tend to hold point **41** at about +100 volts. In this situation key **37** connects diode **36** to E_1 (+100) volts and clamps point **41** at E_1, or +100 volts. When the beam strikes target **30**, beam current drawn from E_1 through resistor R_T, and from E_4 through resistor **39** and diode **40**, will drop the potential of points **42** and **43** to about +60 volts. This also tends to draw point **41** down, but the current from E_1 through key **37**, diode **36**, and resistor **38** neutralizes this tendency and clamps point **41** at about +100 volts.

If the key **37** is depressed at a time when a beam is not striking target **30**, key **37** then connects the anode of diode **36** to the lower voltage E_2 of about +60 volts. This lower voltage drives less current through diode **36** and resistor **38**, tending to lower the potential on point **41**. However, with no beam current drawing the potentials of points **42** and **43** down, current from E_4 through diode **35** will hold point **41** at about +100 volts. It is only when the voltage changes from beam current and from a depressed key are applied coincidentally that point **41** will drop to about +60 volts. This drop from +100 volts to +60 volts produces a −40 volt pulse at the mixer diode **46**.

Assume that Fig. 3 is the circuit for row A along conductors **31** and **34**. Diodes **40** will connect targets **30** to conductor **34** at columns 1, 3, 4, and 5. The switching of the beam is controlled so that the "dwell time" of the beam on each target is the duration of a dot or of a space. Accordingly, when key **37** is depressed, contactor **55** initiates a cycle of operation during which a negative pulse sequence **45** is produced. This sequence is composed of a short pulse or dot while the pulse dwells on target **30** for position 1, a space for beam dwell-time on position 2 which is not connected to A in the matrix, and a long pulse or dash while the beam dwells on targets **30** of positions 3, 4 and 5 in succession. It will be seen that the International code for A (. ▁▁) has been generated when key **37** for the A position is depressed. Similar actuation of other keys will cause pulses characteristic of a position to be generated when the key for that position is depressed.

Each key closes contactor **55** when it is depressed. As shown in Fig. 4, contactor **55** connects the initial spade electrode of tube A with a capacitor C_S which has been discharged by resistor R_C between actuations of the keys. This connection momentarily lowers that spade's potential to ground level and causes a beam to form thereon. Switching signal **50** then advances the beam. Resistor R_C is of high ohmic value so that capacitor C_S will charge to normal spade potential if a key is held down. This charging prevents a repetition of a cycle on one depression of a key.

The beam switching sequence will continue until the last position of the last tube is reached. As shown in Fig. 4, the spade resistor **68** for this last position is of an ohmic value too low for stable holding of the beam on the associated target. When this spade resistor is below the stable range for resistor R_S, the small amount of beam current which a spade collects does not produce enough of a voltage drop to hold the beam, so the beam is cut off.

The mixer has groups of about five input circuits feeding through the corresponding diodes **46**, with each group commonly connected to diodes **47**, as shown in Fig. 3. In this manner, loading effects and other interactions between input circuits are avoided. The common output lead is fed to the grid of an amplifier such as triode **48**, producing output pulses **45'**. The portions of pulses **45'** contributed from positions 1 to 5 are identified in the overall pulse sequence.

From an examination of Fig. 1, it is seen that at least 19 positions are needed across the matrix for the characters of the International code. Other codes may require more than 19 positions. Such numbers are in excess of the switching positions of a single ten position beam switching tube. A series or cascade arrangement of ten position tubes such as shown in Fig. 4 is to be preferred over a single tube with more output positions. Three magnetron type beam switching tubes, A, B, and C, are connected so that switching signal **50**, applied to odd and even switching grids in respective common connections as shown, will advance a switching beam through the positions of tube A, transfer to tube B, and continue the switching until the last position of tube C is reached, whereupon the beam is extinguished due to the low value of resistor **68**. In some cases resistor **68** can be a direct connection or zero ohms.

The beam of tube A is formed to target 0 by depressing switch **55**, momentarily grounding the spade electrode **56** of the 0 position as capacitor Cs charges. The resulting drop in potential of spade electrode **56** upsets the symmetrical potential gradient within the magnetron configuration of tube A, which symmetrical potential combined with an axial magnetic field has held the tube in stable cut-off condition. Under distorted field conditions a beam forms on the low-potential position. Once the beam forms and strikes target 0 and spade **56**, the voltage drop caused by beam current flowing through resistor R_S lowers the potential of spade **56** and enables it to hold the beam on target 0 after capacitor Cs charges to spade potential or switch **55** returns to its normally open position as shown.

If switching grid **57**, which is adjacent to target 0, receives an adequate negative going signal, the electron beam moves toward grid **57** and a portion of the beam strikes spade **58**. Electron current through the spade electrode resistor R_S in series with spade **58** causes its potential to drop so the beam switches over to target **1**. Since the negative going pulse which is applied to grid **57** is not applied to the next switching grid **59** and in fact grid **59** receives an oppositely polarized, positive pulse at that time, the beam switches only one position. Upon the next half-cycle of switching signal **50**, grid **59** does go negative and the beam advances one more position. The connection of alternate grids in common circuits thus assures a single step for each half-cycle. When the beam strikes a target, the potential of that target drops due to beam current causing an IR type voltage drop in the associated resistor R_T. This produces a large negative pulse which is applied to the corresponding column conductor **31** in the diode matrix. For clarity in Fig. 4, some of the connections of conductors **31** to target electrodes are not completed, such as for positions 4, 5, and 6.

When the beam in tube A is switched to target position 9, spade **60** is lowered in potential due to the beam current it collects flowing through resistor $2R_S$. Spade **61** for position 0 of tube B is connected to spade **60** and is also lowered in potential thereby. This causes a beam to form in tube B, held on target position 0. The negative pulse from target 0 is applied to vacuum tube **62**, driving it to cut-off. When tube **62** cuts off, cathode **64** of tube A cannot provide electrons for beam current, and the beam of tube A is extinguished. Resistor **63** makes this process more abrupt and decisive by running cathode **64** positive as tube **62** cuts off. Coupling capacitor **65** and shunting capacitor **66** are proportioned to delay cut-off in tube A until the desired dwell time of the beam on target position 9 has passed. The switching grids of tube B are connected to the source of switching signals **50** so the next switching signal moves the newly formed beam in tube B to target 1, producing a negative output pulse for position 10 across the matrix. As the switching signals continue, the beam advances in tube B as described for tube A. The transition from tube B to tube C occurs when the beam in tube B reaches target 9, and could be accomplished in the same manner as described for the transition from tube A to tube B. However, an alternate and in some ways more satisfactory extinguishing circuit can be utilized. Thus tube **62'** is shown for extinguishing beam tube B. The negative pulse which biases the quenching tube to cut off is derived from target 1 in the succeeding beam tube C, thereby allowing full dwell time of a beam on target 9 of the preceding beam tube B, without a time delay network. When the beam reaches target position 9 of tube C, the associated spade **67** receives a portion of the beam current. Spade resistor **68** is either low enough in ohmic value or zero ohms so that this current does not depress the voltage enough to enable spade **67** to hold the beam on position 9, and the beam is cut off. It is obvious that this cascading of beam switching tubes could be confined to two tubes or extended to many more than the three which are shown.

Other circuits can be utilized for the sequential stepping of the beam, such as that disclosed in copending application of Donald H. Lee, Serial No. 459,697, filed October 1, 1954, entitled "Counter Circuit," which would permit use of switching pulses of one polarity rather than the described sinusoidal switching signal.

For the particular embodiment where keys **37** represent the letters, numerals, etc., of plain language communications, and the coding is to the International code teletype code, or Morse code, then the keys can be arranged in the form of a typewriter keyboard. Such a keyboard and the associated circuitry for tubes and diodes provides a code typer much more compact and reliable than those heretofore available.

As is shown in Fig. 5, the connections in the matrix can be resistors R_M instead of diodes **40**. While resistor connections are not non-linear and "sneak paths" for current from one row to another can be found, these unwanted circuit paths are so loaded with series/shunt combinations of resistors and other impedances as to keep cross-talk from one row to another at a low level. Consider the instance shown in Fig. 5, when key A is depressed and the beam is on column 2's target. No connection is made at row A to column 2 since this is the space between dot and dash. Resistor R_M connecting row B and column 2 will put a full-amplitude pulse on row B's conductor **34**. This pulse will reach column 1's conductor **31** through resistor R_M at B/1. However, a voltage division will occur between this R_M and R_T, the target load resistor which connects to $+E_T$, since source impedance for E_T is very low as in most power supplies. The result is a strong attenuation in the pulse amplitude on column 1. Now, the pulse reaches row A through resistor R_M at A/1. Again, a voltage division occurs between R_M and the parallel combination of input impedance Z of the mixer and other "R_M+R_T" paths to ground for other target positions. When the entire matrix is examined, additional paths contributing pulse energy to the row being keyed and additional loading or voltage-dividing paths will be found, but the net effect is a slight pulse level for every target position on every key's output. This merely shifts the reference level or average voltage on point **41** slightly.

It is to be noted from an examination of Fig. 5, that it is within the scope of this invention to use keying circuits which do not depend upon coincidence circuits. Keys 37' can connect their respective rows directly to a mixer.

Fig. 6 shows the functional components of a system constructed in accordance with this invention. A stepper provides the timed sequence of accurately defined pulses which are fed into the coder's matrix. The selector also is connected to this matrix, in a manner which selects particular pulse or space sequences for each input actuator of the selector. When an input actuator is energized, the one cycle control runs the stepper through all the positions once and then cuts the stepper off. The selected pulse sequence goes through the mixer to a common output cricuit. Performance of these basic functions of this invention may be done in different manners than in the embodiment of apparatus which is shown and described without necessarily departing from the spirit or scope of the present invention.

What is claimed is:

1. A coding device comprising in combination a plurality of magnetron beam switching tubes each having a cathode, switching grids, beam forming and holding spade electrodes, and target electrodes, spade-coupling beam-forming circuitry and cathode-target-electrode connected quenching tubes interconnecting said beam switching tubes to permit a successive switching sequence among said target electrodes of the several tubes and to produce signal pulses successively at different target electrodes, an input circuit connected to the switching grids of said beam switching tubes and responsive to switching signals to produce said switching sequence, a plurality of contactors for representing coded characters and producing signal potentials, a plurality of diode type coincidence circuits having first input circuits, second input circuits, and output circuits, with said first input circuits connected to said plurality of contactors to receive said signal potentials therefrom, diode circuit means connecting each of said second input circuits to a unique selected pattern of target electrodes of said beam switching tubes to receive signal pulse sequences which are characteristic of the coded characters for each of said contactors to produce coded output pulses from each particular coincidence circuit, a mixer circuit to connect the output circuits of said plurality of coincidence circuits to a single output circuit, including at least a diode connected to each coincident circuit output lead and commonly connected to the input of a pulse amplifier the output of which is connected to said single output circuit.

2. In a coding device; a matrix comprising a plurality of column conductors, a plurality of row conductors and means interconnecting each of said row conductors with a different combination of column conductors according to a code pattern; a separate selector switch for each row conductor; separate keying means for selectively actuating said selector switches to close contacts momentarily, thereby to place a signal momentarily on the row conductor associated with the actuated switch; tube means having a scanning beam and a plurality of target electrodes for receiving successively said beam; means connecting each of said target electrodes to a different column conductor; means responsive to the actuation of any one of said keying means for establishing said scanning beam at an invariable initial position and for thereafter scanning successively, within the period during which sad momentary signal is on said row conductor, each of said target electrodes in a fixed order of succession; an output circuit common to said plurality of row conductors; normally-closed gating means for each row conductor to inhibit the passage of said row signal to said output circuit; and means responsive to the successive impingement of said beam upon those target electrodes which are connected to column conductors which are interconnected with that row upon which a momentary signal exists for opening successively said gating means to pass a coded signal to said output circuit.

3. Apparatus as claimed in claim 2 characterized in that said tube means comprises in combination a plurality of magnetron beam switching tubes each having a cathode and a plurality of switching grids, beam-forming-and-holding spade electrodes and target electrodes, together with spade-coupling beam-forming circuitry and quenching tubes interconnecting the cathode of one beam switching tube with a target electrode of another to permit a successive switching sequence among the target electrodes of the several tubes.

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