Jan. 16, 1962 J. J. SAYKAY 3,017,459

CODING APPARATUS

Filed July 14, 1958 6 Sheets-Sheet 1

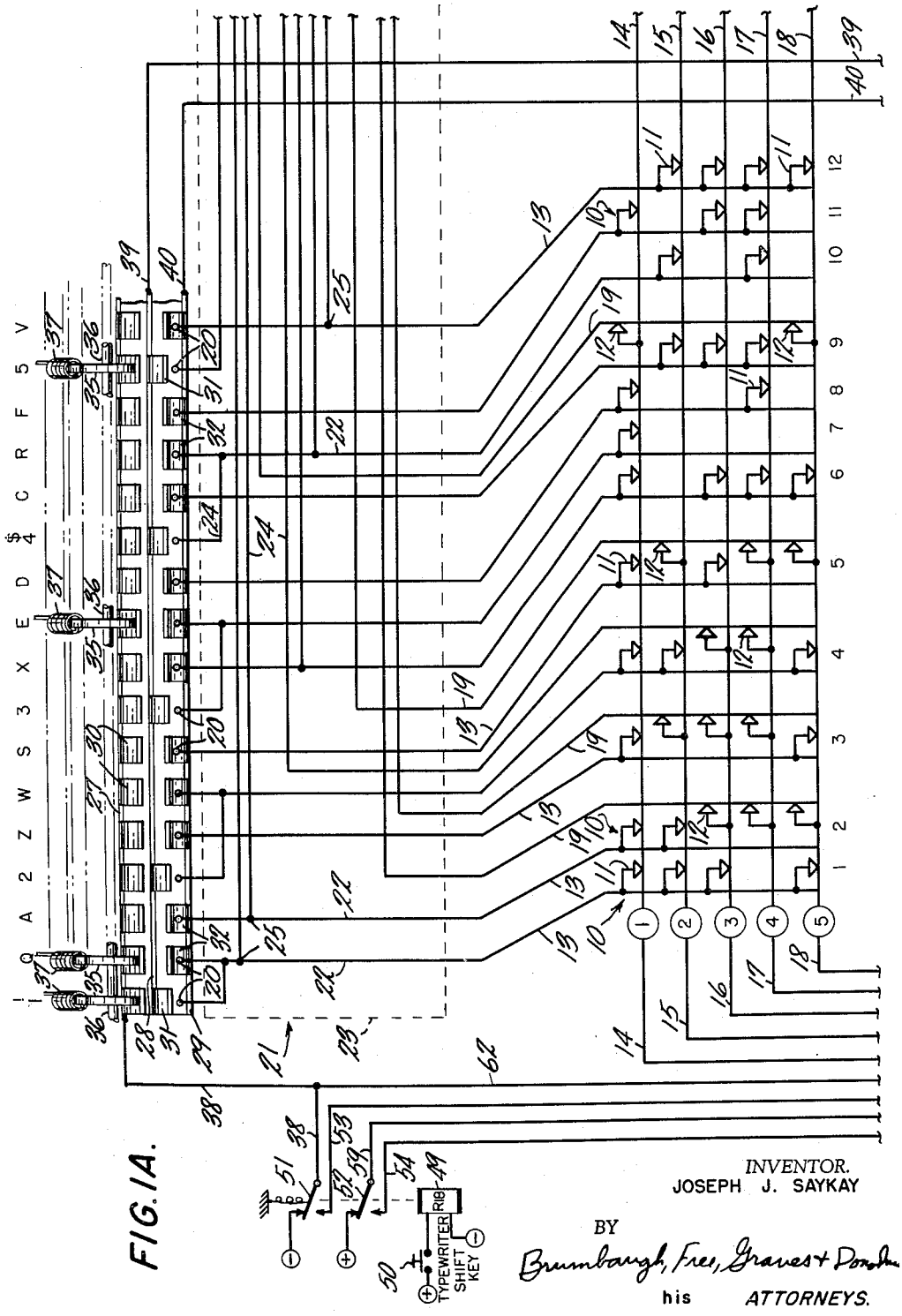


FIG. 1A.

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Jan. 16, 1962 J. J. SAYKAY 3,017,459

CODING APPARATUS

Filed July 14, 1958 6 Sheets-Sheet 2

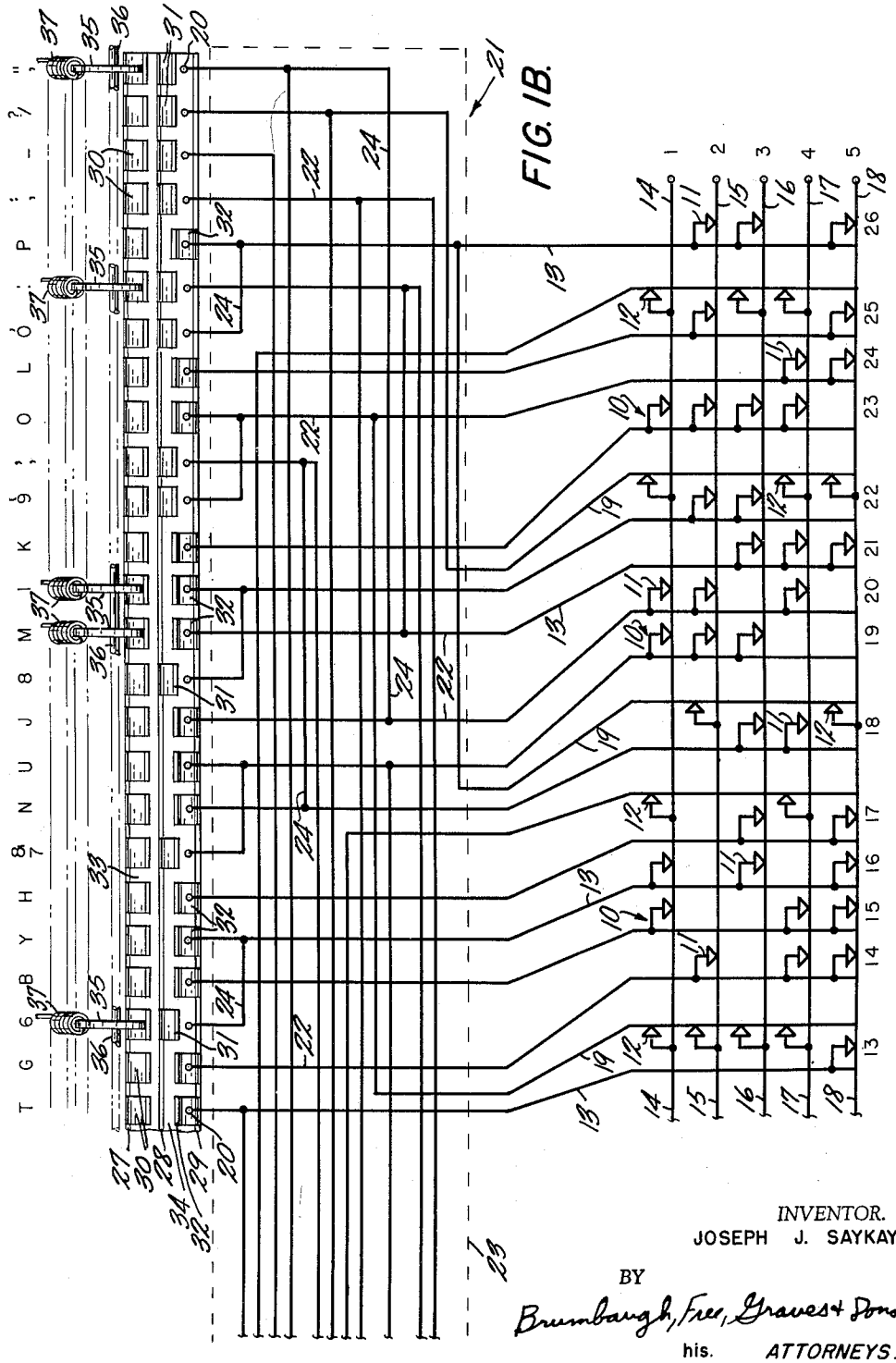


FIG. 1B.

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CODING APPARATUS

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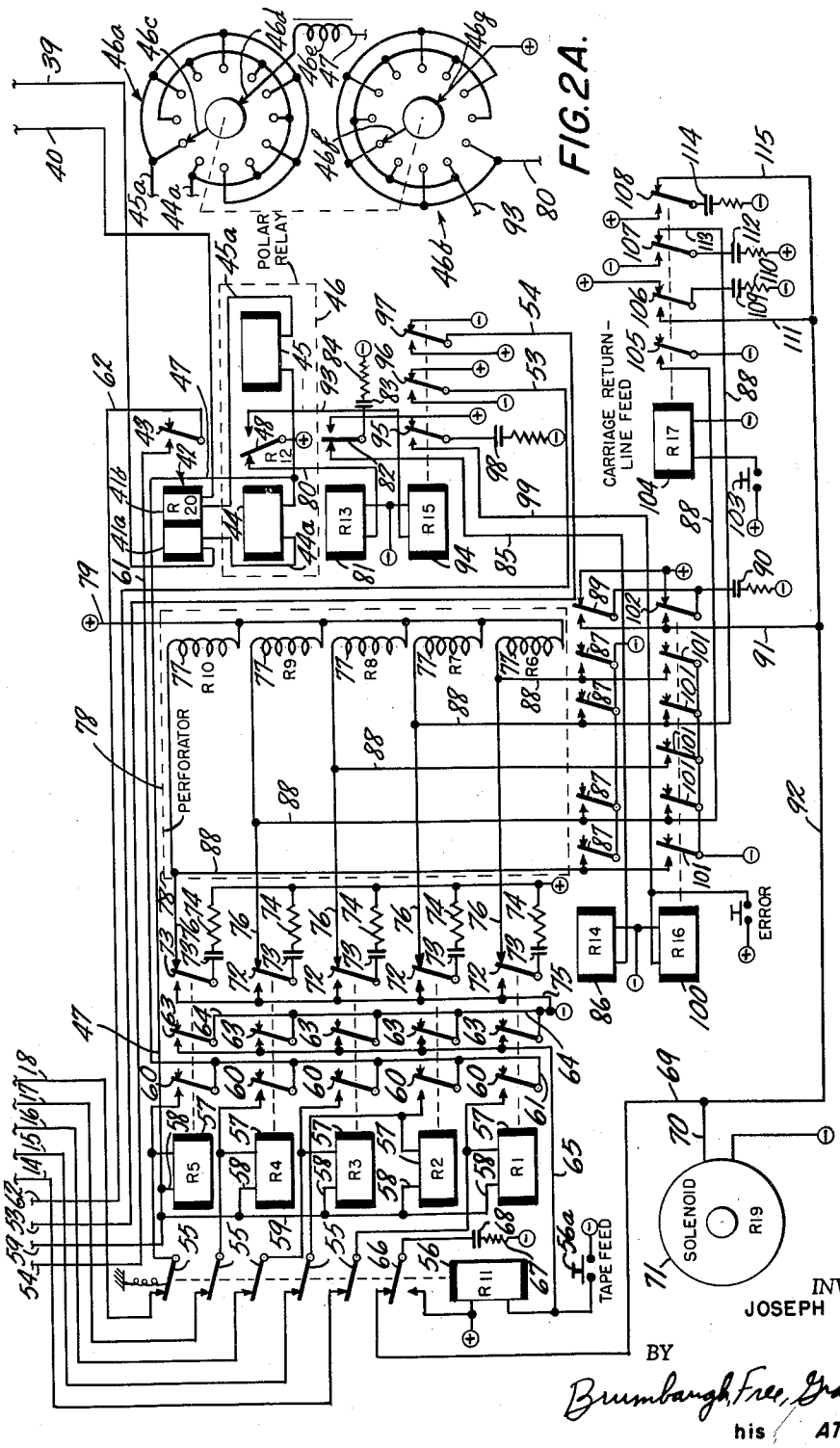


FIG. 2A.

FIG. 2.

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FIG. 4.

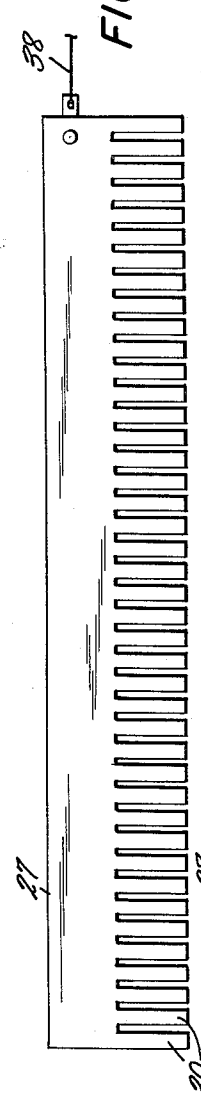


FIG. 5.

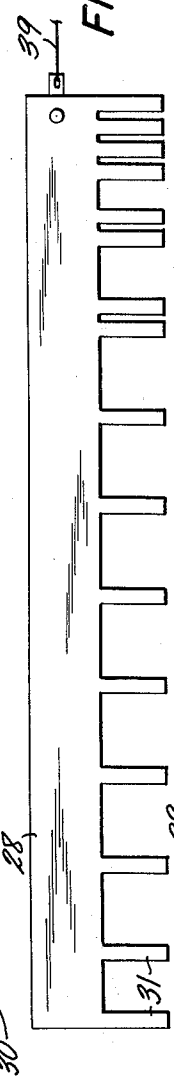


FIG. 6.

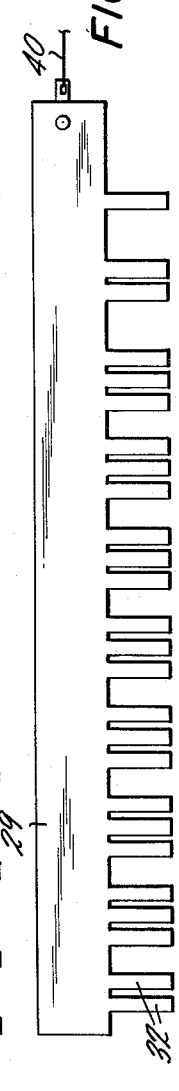


FIG. 3.

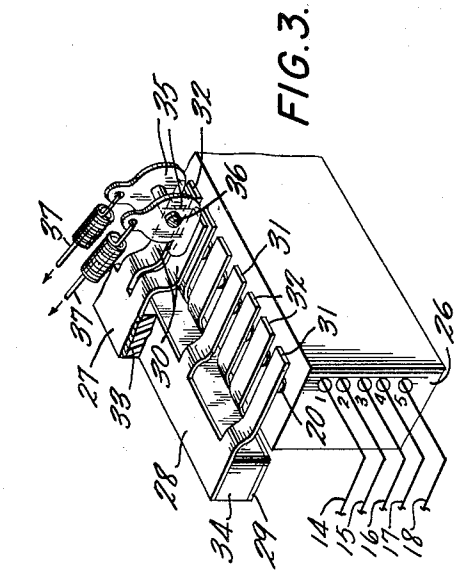
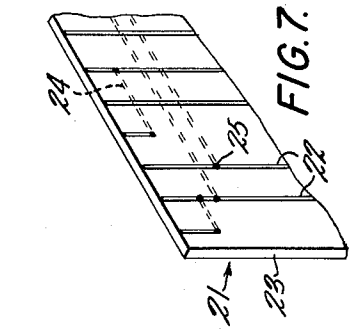


FIG. 7.



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CODING APPARATUS

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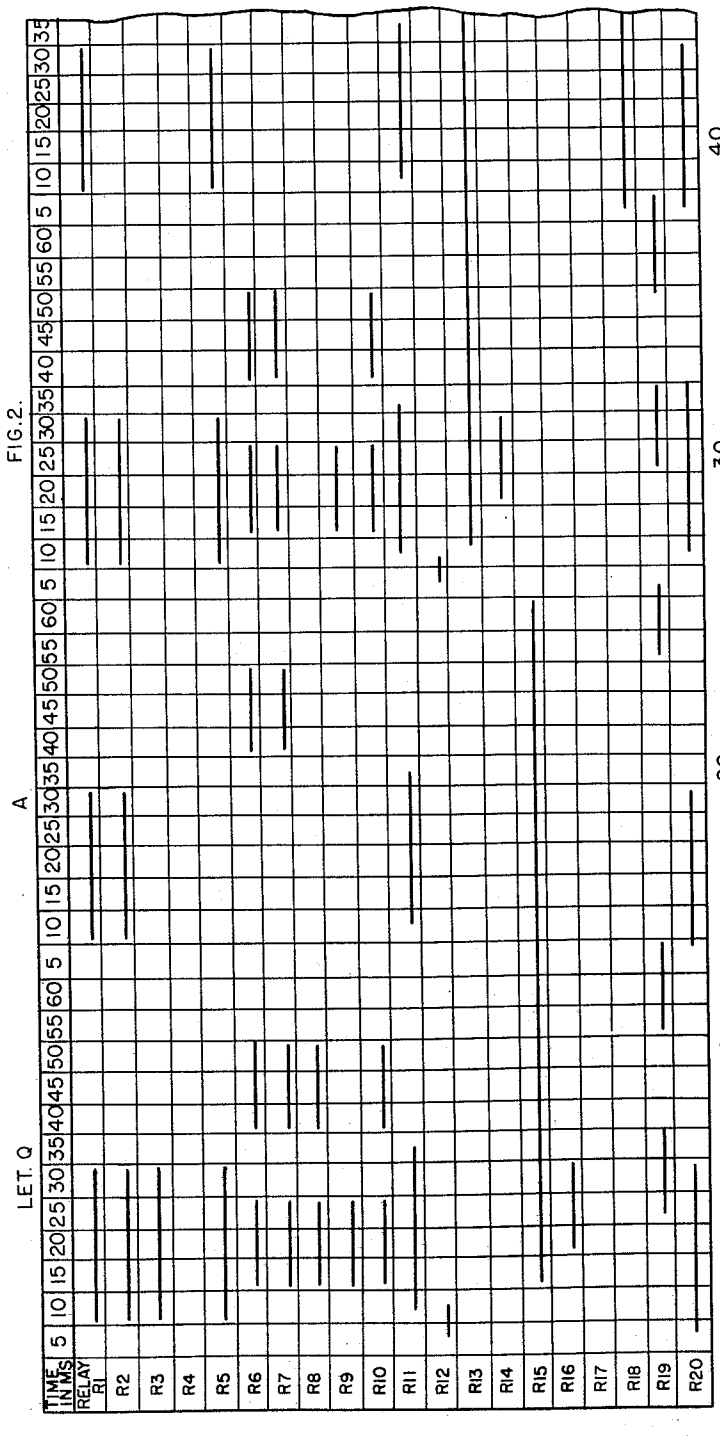


FIG. 2.

FIG. 9A.

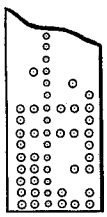


FIG. 8.

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Jan. 16, 1962 J. J. SAYKAY 3,017,459

CODING APPARATUS

Filed July 14, 1958 6 Sheets-Sheet 6

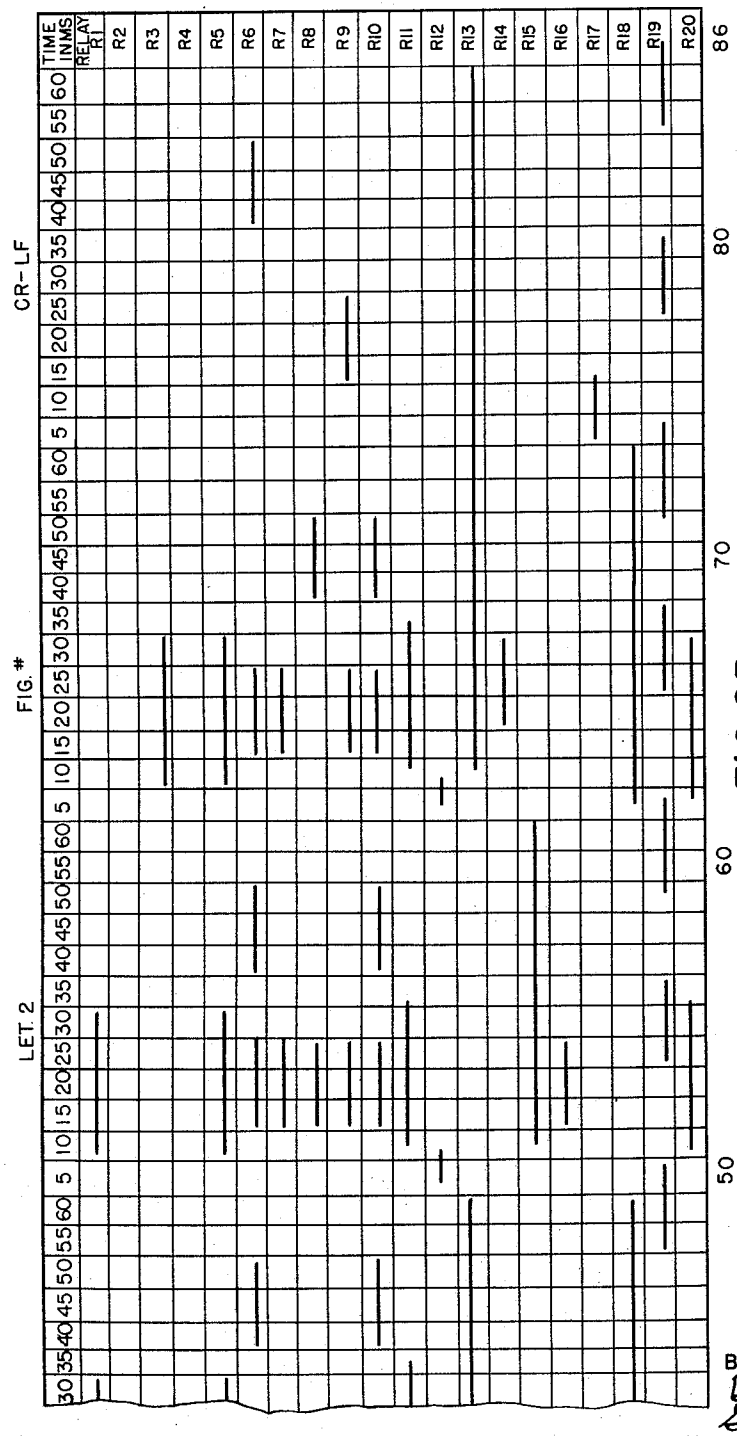


FIG. 9B.

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United States Patent Office 3,017,459 Patented Jan. 16, 1962

3,017,459

CODING APPARATUS

Joseph J. Saykay, Seacliff, N.Y., assignor to Fairchild Camera and Instrument Corporation, Syosset, N.Y., a corporation of Delaware

Filed July 14, 1958, Ser. No. 748,341
14 Claims. (Cl. 178—17)

This invention relates to coding apparatus, and has particular reference to such apparatus useful with key operated writing mechanisms to store written information in coded form on a desired storage medium.

Key operated mechanisms, such as typewriters, adding machines and like apparatus, generally provide printed information. In many instances, it is desirable to convert this information into coded symbols on a particular storage medium, for example, punched tape. Substantial savings in time may be effected if such coded information is transferred to tape simultaneously with printing by the key operated machine. For example, so-called common language machines operating on a five-unit or Baudot code are widely used. If printed information can be placed on punch tape in accordance with that code, it may then be transmitted immediately or at a later time over telegraph lines or the like, and be read at the receiving end by conventional "Teletype" printers.

Common language machines utilize the five-unit code which makes available only thirty-two different code combinations. Accordingly, two shift conditions ordinarily designated "figures" and "letters" are required to increase the possible code combinations to sixty-four. For that reason, each key of a telegraph printer keyboard carries two characters, one representing the lower case characters or "letters" and the other representing the upper case characters or "figures." In order to receive the lower case characters correctly, they must be preceded by the "letters" code symbol and in like manner the upper case characters must be preceded by the "figures" code symbol. While the two code symbols are purely functional in that the "letters" or "figures" symbols or code combinations are not printed, they still must be punched into the tape in order to operate the reading printer correctly.

Greater use of storage mediums such as perforated tape and magnetic tape is contemplated, and has actually been initiated in fields other than communications to provide information storage for data processing, computers and like devices. Therefore, it is desirable in many instances to use key mechanisms other than telegraph printers, and to modify typewriters, adding machines, computers and the like to condition them for use in storing information on punched tape and other mediums.

However, when such modified standard office equipment is used to prepare tape punched with the five-unit code, difficulties are encountered because such machines include keyboards consisting of a row or rows of keys in which characters are carried in the lower and upper case, as in the standard typewriter. Such a type-writer keyboard contains four rows of keys in which the first row represents the digits 2 to 0 in the lower case and punctuation marks in the upper case. Thus, the operator is not required to depress the typewriter shift key when writing the digits 2 to 0. However, if five-unit code tape is being prepared, unless such digits are preceded by the "figures" code symbol, the tape will not be properly perforated and will actuate the printing mechanism incorrectly.

In this circumstances, it has been necessary to allocate two of the typewriter keys to provide the "figures" and "letters" code symbols on the perforated tape. Obviously, the use of these additional keys will, especially with an inexperienced operator, make for inefficiency in the entire typing operation.

Suggestions have been made that the foregoing problems be overcome by employing a six-unit code which has enough combinations to represent every key in the typewriter by a distinctly different code symbol. While information punched in a six-unit code can be transmitted over telegraph lines with the same facility as that in five-unit code, it is, of course, less economical in the use of line time. Thus, for every ten words in the six-unit code transmitted, eleven and one-half words may be transmitted in the five-unit code over the same period of time and at the same cost.

In my copending application Serial No. 504,065, filed April 26, 1955, apparatus to punch tape with five-unit code symbols for use with key operated mechanisms such as typewriters has been described. A diode matrix used in such apparatus was divided into three sub-assemblies representing "letters" "figures" in the lower case and "figures" in the upper case. Such a composite matrix results in assembly complexities, a large number of separate output terminals and unnecessary size, an important consideration because such matrix must be affixed directly to the key operated mechanism involved.

Furthermore, the automatic insertion of the "figures" and "letters" symbols in copending application Serial No. 504,065 required the performance of two distinct operations within the time interval extending from the depression of one printing key to the depression of the next key. When two punchings ("letters" code and particular letter, for example) within the described single interval were required, correct operation of the perforator depended upon the correct timing of selector relays involved. Because of the nature of the five-unit code, load requirements were not uniform and the same relay could become involved in several different timing cycles depending on the number of other relays in the particular group. As a result certain relays were not releasing quickly enough and some repetition followed the shift signal. Although that error could be remedied by the proper choice of relays, it does require careful adjustment in assembly and operation.

My copending application Serial No. 657,886, filed May 8, 1957, of which this application is a continuation-in-part, relates to coding apparatus utilizing a bipolar diode matrix and circuits to provide two cycles of operation the first of which is initiated by depressing a key and the second by releasing to key in a key operated mechanism. The present invention relates generally to the same type of coding apparatus in which the diode matrix has been modified to generate code signals with fewer diodes, and in which the "letters" and "figures" code signals are generated through the use of means external to the improved diode matrix.

Accordingly, it is an object of the invention to provide an improved bipolar diode matrix simplified in construction and producing a plurality of coded output signals.

It is a further object of the invention to provide a bipolar diode matrix in combination with external switching elements to produce signals representative of the particular code signals generated by the diode matrix.

It is a further object of the invention to provide coding apparatus incorporating the improved bipolar diode matrix.

These and further objects of the invention are accomplished by the use of a diode matrix incorporating diode stacks formed by diodes polarized in one direction and at least some of the stacks incorporating diodes polarized in the other direction. One set of conductors joins a number of diodes to the matrix input terminals while an-

other set connects oppositely polarized diodes to the input terminals.

In one embodiment of the improved bipolar diode matrix for use with the five-unit code, there are a total of twenty-six diode stacks in twenty-six binary code groups, or positions, each of which may represent two code symbols, thereby providing a total of fifty-two possible combinations or code symbols. This will be evident when it is understood that every code symbol in a binary code consists of a number of positive or marking pulses and a number of negative or spacing pulses. The marking pulses, expressing one code symbol, can be generated by diodes polarized in one direction, and oppositely polarized diodes positioned in some or all of the spacing positions can be used to generate signals representative or another code symbol. It is apparent, therefore, that only half as many code stacks and binary groups or positions are required to represent a desired number of code symbols, using the foregoing arrangement.

In other words, to distinguish between two code symbols, the diodes in one stack are oppositely polarized for each code symbol. Thus, if five diodes are inserted in a stack, and the first and second diodes are connected to a single input lead, application of a suitable potential to the lead will provide signals on two output conductors only. If the remaining three diodes are polarized oppositely to the first two diodes and joined to another input lead, which is energized by a potential of opposite polarity, output conductors three, four and five will carry signals representative of another code symbol. In this example, the second code symbol is the complement of the first. The second code symbol may also use only one or two out of the three remaining positions and not be a true complement. In any event, it is apparent that two different code signals may be provided from a single stack or position by the use of energizing potentials of different polarities.

In the particular embodiment of the invention described hereinafter (a twenty-six position diode matrix) coded signals indicative of twenty-six letters may be generated by impressing a potential of one polarity on the appropriate input leads and coded signals representative of any selected number of figures up to twenty-six may be represented by impressing a potential of the opposite polarity on the other input leads. The reversal of polarity to provide coded output signals from the diode matrix also produces signals representative of "figures" and "letters" code symbols.

One use of the inventive bipolar diode matrix involves the transfer of information printed by typewriters to another storage medium such as punched tape simultaneously with such printing. To accomplish that result, a number of selector relays, five in the case of the five-unit code, are selectively energized by signals from a diode matrix associated with the key operated mechanism. Those relays determine, through further circuits, the information transfer devices that must be actuated to punch appropriate code symbols into the tape or suitably impress such symbols on any storage medium. Signals from switching elements associated with the diode matrix also control further circuits so that when switching from "letters" to "figures" or from "figures" to "letters," signals representative of the appropriate code symbol are generated and also supplied to the information transfer means to punch the tape appropriately.

In a preferred embodiment of the invention, depressing a key initiates one cycle of operation in which code symbols such as "figures" or "letters" information is punched into the tape, for example. Upon release of the key, a second cycle is initiated in which the character represented by the key is punched into the tape.

Actuation of another key, such as a typewriter shift key, to condition the printing machine for operation of a dual function key, results in a change in polarity of the potential applied to the diode matrix. Accordingly, diodes polarized oppositely to those normally used are then effective to supply different coded signals to the selector relays.

These and further objects and advantages of the invention will be more readily understood when the following description is read in connection with the accompanying drawings, in which:

FIGURES 1A and 1B show portions of a schematic circuit diagram incorporating an improved bipolar matrix and other apparatus in accordance with the principles of the present invention;

FIGURE 2 is the remainder of the schematic circuit diagram of FIGURES 1A and 1B incorporating the improved diode matrix and illustrating control elements cooperating with the matrix;

FIGURE 2A shows a stepping switch arrangement that may be substituted for a polar relay in FIGURE 2;

FIGURE 3 is a view in perspective of one end of the diode matrix of FIGURE 1 together with switching elements cooperating to provide code signals representative of "figures" and "letters";

FIGURES 4, 5 and 6 are plan views of switch contact strips illustrated in FIGURE 3;

FIGURE 7 is a fragmentary view in perspective of one end of a printed circuit that may be incorporated in the circuits of FIGURES 1A and 1B;

FIGURE 8 illustrates a piece of tape perforated by the apparatus of FIGURES 1A, 1B and 2; and

FIGURES 9A and 9B comprise a timing chart helpful in understanding the operation of disclosed embodiment of the invention in perforating the tape of FIGURE 8.

Referring to an illustrative embodiment of the invention in greater detail with particular reference to the drawings, apparatus adapted to be employed with a standard keyboard typewriter is shown. It will be understood, however, that the invention is not limited to typewriters but may utilized with adding machines, computers, and like mechanisms. Moreover, the inventive apparatus may also be used in code inverters.

The improved bipolar matrix of FIGURES 1A and 1B comprises twenty-six diode or code stacks **10** in a like number of code positions formed by a selected number of unidirectional conducting elements or diodes **11** polarized in one direction and similar diodes **12** polarized in the opposite direction. Negative potentials on input conductors **13** are coupled selectively by the diodes **11** to five output conductors **14** to **18**, inclusive, fastened to diagrammatically represented output terminals **1** to **5**, since the five-unit or Baudot code is being used in the example given. Positive potentials on other input conductors **19** are coupled selectively by the diodes **12** to the same output conductors **14** to **18**.

Input terminals **20** of the diode matrix are connected to one or more of the input conductors **13** and **19** by conductors formed in a printed circuit **21**, shown in detail in FIGURE 7. Vertical conductors **22**, leading from the input terminals **20**, may be formed by copper strips deposited on one side of a phenolic plate **23**. Similarly formed horizontal conductors **24** on the other side of the plate **23** are selectively connected to the strips **22** by connector pins **25**.

In practice, the diode stacks **10**, input conductors **13** and **19**, output conductors **14** to **18**, and the printed circuit **21**, are assembled in a suitable container **26** (FIGURE 3) on which are visible the input terminals **20** and output terminals **1** to **5**.

Referring to FIGURES 1A, 1B and 3 to 6, associated with the diode matrix are switching elements including three conductive strips or combs **27**, **28** and **29** formed with lateral spring contact fingers **30**, **31** and **32**, respectively. The contact fingers **32** are associated with a first group of input terminals **20**, in this case the terminals representative of "letters," and the contact fingers **31** with a second group representative of "figures." The strips or combs are secured to opposite sides of insulating strips **33** and **34** with one contact finger **30** above each

terminal 20 and selected ones of the fingers 31 and 32 positioned between each resilient finger 30 and corresponding "figure" or "letter" terminals 20, respectively.

To apply potential to the diode matrix, bell crank cams 35, rotatably mounted on an insulated fixed shaft 36 are joined by suitable operating springs 37 to any desired element on a typewriter with which the diode matrix is associated, the springs being urged in the direction of the arrow when a corresponding typewriter key is depressed. Initial movement of the bell crank 35 displaces its associated spring finger 30 into engagement with one of the fingers 31 and 32, and further movement of the crank cams both fingers against the terminal 20.

A conductor 38, connected in a manner described hereinafter, energizes the strip 27 and fingers 30 so that depression of a particular typewriter key (not shown) carrying one of the characters indicated in FIGURES 1A and 1B causes an associated one of the bell cranks 35 to cam one of the fingers 30 against one of the fingers 31 or 32 initially, thereby energizing one of the strips 28 or 29 and supplying a signal on one of output conductors 39 or 40, respectively connected thereto (FIGURES 4 to 6).

Signals on the lines 39 and 40 are respectively coupled through windings 41*a* and 41*b* (FIGURE 2) of a two-winding relay 42, controlling an armature 43, to magnets 44 and 45 of a polar relay 46, the return being through a conductor 47. The magnets 44 and 45 in the relay 46 actuate an armature 48 between a pair of contacts connected in a manner described hereinafter.

To control the output signals from the diode matrix in accordance with the condition (shifted or unshifted) of the associated typewriter, a relay 49 operates in accordance with depression of a typewriter shift key 50 to change the polarity of the potential on the conductor 38 which, in turn, reverses the polarity of the voltage applied to the diode matrix terminals 20 through the spring fingers 30.

More specifically, normally negative and positive potentials are supplied to the back contacts of armatures 51 and 52, respectively, of the relay 49. Displacement of the armatures 51 and 52, the former engaging its front contact which leads to a conductor 53 normally carrying a positive potential, and the latter being energized by a negative potential on a conductor 54, results in a reversal of polarities on the conductors 38 and 59. The diode matrix thereby is suppled through the spring fingers 30, 31 and 32 with negative or positive potentials, according to the position of the typewriter shift key 50.

The output conductors 14 to 18 normally couple signals from the diode matrix through armatures 55 of a relay 56 (FIGURE 2) to selector relays 57 to actuate them in accordance with the code combination associated with the particular character on a selected typewriter key. One side of each of the relays 57 is normally supplied with a positive potential through conductors 58 and 59 which lead to the armature 52 of the relay 49 (FIGURE 1).

Each of the relays 57 is provided with a hold circuit armature 60 coupled through a conductor 61, the armature 43 of the relay 42, when actuated, and another conductor 62 to the line 38. Accordingly, upon energization of any one of the relays 57, the armature 60 engages its front contact which leads to one side of the energized relay. The resulting hold circuit for that particular relay remains intact as long as the relay 42 is excited, this interval being determined by the depression time of any one of the typewriter keys.

A second armature 63, maintained at a negative potential by a line 64, is also actuated by each of the relays 57 to energize, through a conductor 65, the relay 56 whose other side is returned to a positive potential. It will be apparent that when the relay 56 picks up, the diode matrix will be disconnected from the selector relays 57 by the armatures 55. As pointed out in the above-referred to copending applications, such disconnection eliminates the adverse effects of current leakage through the diodes and prevents unwanted operation of any of the selector relays 57.

A further armature 66, when actuated by the relay 56, completes a charging circuit through a resistor 67 to a capacitor 68, the resistor 67 being joined to a negative potential and the relay forward contact being energized by a positive potential. Accordingly, upon deenergization of the relay 56, the armature 66 engages its back contact and the capacitor 68 discharges through conductors 69 and 70 to operate a punch solenoid 71 of conventional design, returned to a negative potential.

Each relay 57 controls a third armature 72 connected through a capacitor 73 and a resistor 74 to a source of positive potential. When actuated against their forward contacts, each capacitor 73 is charged from a negative potential through a conductor 75. Accordingly, the capacitor 73 discharges, when the relay 57 releases, through a conductor 76 to a magnet coil 77 in a perforator 78, one coil 77 being provided for each of the selector relays 57. The other side of each coil 77 is returned to a positive potential through a conductor 79.

The perforating mechanism including the magnet coils 77 and punch 71 have not been described in detail since any conventional apparatus well known in the art may be used to perform their functions. It suffices to say that when the punch 71 operates, it perforates the tape and steps it forward, the perforations being in accordance with the perforator magnet coils 77 that are or have been energized. Moreover, operation of the punch solenoid 71 resets the perforator 78.

Since the five-unit or Baudot code affords only thirty-two different signal combinations, it is necessary to use the same code combinations twice and to identify them as "figures" or "letters" combinations by an appropriate code symbol on the punched tape, or other storage medium such as magnetic tape, preceding the coded information. In the past, a pair of additional keys on a typewriter converted to this use were required so that the operator could place the "figures" or "letters" code information on the tape and this, of course, considerably slowed the typing operation. In the present instance the polar relay 46, which actuates the armature 48 between a pair of contacts, provides, together with additional apparatus described hereinafter, automatic punching of the "figures" and "letters" code on the perforated tape.

More particularly, the "figures" conductor 39 when energized excites the magnet 44 to displace the armature 48 against a contact joined to a conductor 80 leading to a relay 81 which is returned to a negative potential. When energized, the relay 81 actuates an armature 82 against its front contact. A previously charged capacitor 83 discharges through a resistor 84, a conductor 85 and a further relay 86, returned to a negative potential, to operate the relay 86 momentarily. Such operation displaces four negatively biased armatures 87 against front contacts leading through conductors 88 to four of the perforator coils 77. A further armature 89 discharges a charged capacitor 90, when actuated, through conductors 91, 92 and 70 to operate the punch solenoid 71. Accordingly, the "figures" code symbol is punched into the tape.

When the "letters" conductor 40 is energized, the magnet 45 actuates the polar relay armature 48 against its other contact to energize a conductor 93 and operate a relay 94 which picks up three armatures 95, 96 and 97. A charged capacitor 98, connected to the armature 95, is discharged through a conductor 99 and a relay 100 to operate five negatively biased armatures 101 momentarily. This energizes the conductors 88 leading to all five of the perforator magnet coils 77, thereby conditioning the punching mechanism to punch the "letters" code symbol on the tape. A further armature 102, joined to the charged capacitor 90, energizes, when actuated, the punch

solenoid 71 through the conductors 91, 92 and 70 to punch the "letters" symbol into the tape.

A stepping switch arrangement, such as shown in FIGURE 2A, may replace the polar relay 46. The switch incorporates two sets of contacts 46*a* and 46*b*. The first set 46*a* includes alternate contacts connected to the conductors 44*a* and 45*a*, respectively, and the second set 46*b* incorporates alternate contacts joined to the conductors 80 and 93, respectively. A rotating arm 46*c* is connected by a sliding contact 46*d* to one side of a stepping magnet 46*e*, its other side being energized by the conductor 47. The arm 46*c* is ganged with a similar arm 46*f* in the contact set 46*b*. A sliding contact 46*g*, connected to a positive potential, energizes the arm 46*f*, whereby stepping of the arm 46*f* alternately energizes the conductors 80 and 93.

With the arms 46*c* and 46*f* positioned as shown in FIGURE 2A, energization of the "figures" control conductor 39 and the conductor 44*a* will not affect the stepping switch. Energization of the "letters" control conductor 40 and the conductor 45*a* will, however, cause the switch to advance one step, thereby energizing the conductor 93 and deenergizing the conductor 80.

Returning to the relay 94, the armatures 96 and 97 when operated reverse the polarity of the conductors 53 and 54, leading to the front contacts of the relay 49 (FIGURE 1), for a purpose apparent from the hereinafter discussion of the operation of the present system.

A tape feed key switch 56*a* also may be depressed to energize the relay 56 thereby charging the capacitor 68. Release of the armature 66 energizes the punch solenoid 71 to step the tape without perforating since none of the coils 77 have been energized. If it is desirable to provide for rapid automatic tape feed, a vibrating relay may be incorporated to energize and deenergize the relay 56 repeatedly while the switch 56*a* is depressed.

A carriage return-line feed key switch 103 when depressed closes a circuit to a relay 104 which picks up armatures 105 to 108. The negatively bised armature 105 energizes one of the perforating coils 77 through one of the conductors 88. At the same time, actuation of the armature 106 discharges a capacitor 109, previously charged through a resistor 110, through conductors 111, 92 and 70 to operate the solenoid 71 and punch the carriage return code symbol on the tape. Upon release of the key 103, the armature 107, which in its actuated position provides a charging circuit for a capacitor 112, engages its back contact and energizes one of the perforating magnet coils 77 through conductors 113 and 88. Simultaneously, the armature 108, which functions to charge a capacitor 114 when actuated, returns to its back contact and through conductors 115, 92 and 70 energizes momentarily the solenoid 71 to punch the line feed code symbol.

Several typical operating cycles of the above-described illustrative embodiment of the invention will now be described with particular reference to the perforated tape of FIGURE 8 and the timing chart of FIGURES 9A and 9B. In the interests of clarity, each of the relays is identified by a letter and number such as R1, R2, R3, etc., as well as by a reference numeral.

Assuming first the depression of the typewriter key "Q," the bell crank 35 cams the spring fingers 30 and 32 together and against the terminal 20 to energize the strip 29 and the terminal 20 of the stack 10. The resulting signals from the diode matrix actuate the selector relays 57 (R1, R2, R3 and R5), such signals being supplied by the diodes 11 and the signal output conductors 14, 15, 16 and 18, respectively. In addition, the "letters" line 40 is energized by the strip 28 and causes the relay 42 (R20) to pick up its armature 43 and close a hold circuit for the selected relays 57.

The magnet 44 in the polar relay 46 (R12) also responds to signals on the line 40 to shift its armature 48 to the "letters" position if a "figures" key had been operated previously. The relay 94 (R15) then picks up its armature 95 to energize the relay 100 (16) momentarily so that the armatures 101 are shifted to energize the relay coils 77 (R6 to R10) in the perforator 78. At the same time, the armature 89 initiates operation of the punch solenoid 71 (R19) to punch the "letters" code symbol on the tape, as shown in FIGURE 8.

The timing chart of FIGURE 9A illustrates clearly the foregoing sequence, the fast-acting polar relay R12 closing its contact shortly before the relays R1, R2, R3 and R5 pick up their armatures. As soon as one of the armatures 63 engages its front contact, the relay 56 (R11) is energized to disconnect the selector relays 57 from the diode matrix and initiate charging of the capacitor 68. Moreover, the hold relay (R20) maintains the relays 57 operated for as long as the key "Q" is depressed.

Upon release of the typewriter key "Q," the relay 42 drops out to open the hold circuits for the relays 57. As a result, those relays are deenergized and their armatures 72 engage back contacts and energize the perforator selector magnets 77 (R6, R7, R8 and R10). In addition, the armature 63 open the energizing circuit for the relay 56 to permit the armature 66 to swing against its back contact. That action discharges the capacitor 68 through the solenoid 71 to punch the "Q" code combination on the tape, as will be evident from the tape of FIGURE 8 and the timing chart of FIGURES 9A and 9B.

It will be apparent from the above that depressing the key "Q" results in one series of operations and releasing the key another. In other words, two separate operating cycles of the relays in the inventive apparatus occur the first during depression and the second during release of a typewriter key, and this contributes greatly to the efficiency and reliability of the system.

If the letter "A" must next be printed by the typewriter and punched on the tape, depression of the appropriate key results in the actuation of the bell crank 35 and the energization of the selector relays 57 (R1, R2). In this instance, however, the polar relay armature 48 remains in its "letters" position and the "letters" code symbol is not punched on the tape. Upon release of the typewriter key "A" the relay 42 (R20) drops out causing the appropriate code symbol to be punched in the tape by the solenoid 71 (R19).

In operating the typewriter, the shift key 50 will be depressed to print capital letters. Assuming that this operation occurs when the letter "A" is to be printed, the relay 94 (R15) remains energized through the polar relay armature 48 so that the armatures 96 and 97 supply negative and positive potentials, respectively, through the conductors 53 and 54 to the front contacts engaged by the armatures 51 and 52 of the relay 49 (R18). Accordingly, energization of the relay 49 by the shift key 50 fails to change the polarity on the lines 38 or 59 while capital letters are being printed.

If the figure "2" is to be printed, actuation of the appropriate bell crank 35 results in the excitation of suitable relays 57 (R1, R2, and R5). Moreover, due to energization of the corresponding resilient finger 31 and the strip 28, a signal is coupled through the "figures" line 39 to energize the relay 42 (R20) and the magnet 44 of the polar relay 46 (R12).

The polar relay armature 48 snaps against its "figures" contact to pick up the relay 81 (R13) and actuate the armature 82 against its forward contact, thereby discharging the capacitor 83 through the relay 86 (R14). Accordingly, the armatures 87 engage their front contacts to energize the perforator relay magnets 77 (R6, R7, R9, and R10). At the same time, the armature 89 engages its front contact and the capacitor 90 discharges through the punch solenoid 71 (R19) to punch the "figures" code on the tape. Upon release of the typewriter key "2," the relay 42 drops out and the figure "2" is punched in the tape in the manner described above in connection with the letter "Q."

Assuming that a quotation mark is to be printed, the typewriter shift key **50** is depressed and the resulting energization of the relay **49** (R18) actuates the armatures **51** and **52** against their front contacts which lead through the conductors **53** and **54** and the armatures **96** and **97** to positive and negative potentials, respectively. Accordingly, the potentials on the lines **38** and **59** are reversed. Subsequent depression of the quotation mark key operates the corresponding bell crank 35 to urge the spring fingers **30** and **31** together and against the terminal **20**, and a positive potential is applied through the strip **27**, the fingers **30** and **31**, the terminal **20** and the corresponding conductor **19** to the diodes **12** in the corresponding stack **10**.

It will be apparent from FIGURES 1A and 1B that the diodes **12**, polarized oppositely to the diodes **11**, will be effective to energize the lines **14** and **18** and the selector relays **57** (R1 and R5), which are returned to the line **59**, now of negative polarity. The "figures" line **39** is also energized when the finger **30** engages the finger **31** and completes a circuit from the positive line **38** through the strip **27**, the fingers **30** and **31**, the strip **28**, the line **39**, the winding **41***a*, the magnet **44** of the polar relay **46**, and the line **47** to the now negative line **59**. Since the polar relay armature **48** remains in the "figures" position, the "figures" symbol will not be punched on the tape. The quotation mark symbol will, however, be punched in the usual manner upon release of the typewriter key, which opens the circuit to the relay **42** and causes a perforating operation.

The remaining operations to punch the tape illustrated in FIGURE 8 will be apparent from the time charts of FIGURES 8*a* and 8*b*. However, it might be well to examine the carriage return-line feed operation which is initiated by depressing the switch key **103**. The relay **104** (R17) picks up its armature **105**, which energizes the perforator magnet relay **77** (R9), and its armature **106**, which operates the punch solenoid **71** (R19). Accordingly, the carriage return symbol is punched in the tape. The armatures **107** and **108** are also picked up at this time to charge the capacitors **109** and **112**. Upon release of the key **103**, the armatures **107** and **108** are returned to their back contacts to energize the perforator magnet **77** (R7) and the solenoid **71** (R19) to punch the appropriate line feed code symbol in the tape.

Considering next the functioning of the apparatus, if the figure "4" is to be printed, actuation of the appropriate bell crank **35** results in the excitation of the relays **57** (R2 and R4). Moreover, due to the energization of the appropriate resilient finger **31** in the strip **38**, a signal is coupled through the figures line **39** to energize the relay **42** (R20) and the magnet **44** of the polar relay **46** (R12).

The polar relay armature **48** snaps against its "figures" contact to pick up the relay **81** (R13) and actuate the armature **82** against its forward contact, thereby discharging the capacitor **83** through the relay **86** (R14). Accordingly, the armatures **87** engage their front contacts to energize the perforator relay magnets **77** (R6, R7, R9, and R10). At the same time, the armature **89** engages its front contact and the capacitor **90** discharges through the punch solenoid **71** (R19) to punch the "figures" code on the tape. Upon release of the typewriter key "4," the relay **42** drops out and the figure "4" is punched in the tape in the manner described above in connection with the letter "Q."

When cross connections are made by one of the conductors **24** so that depressing typewriter keys to print the letter "R" or the figure "4" energizes, through one of the conductors **13**, the same code stack **10**, there will be no difficulty. On the other hand, if the shift key **50** is operated to print the dollar sign ($), which is located on the same key as the number "4," the letter "R" conductor **22** must be connected by another one of the conductors **24** to a code stack which, in reverse, generates the code combination representative of the letter "D," which also represents the dollar sign ($).

Referring to FIGURES 1A and 1B, in the code stack **10** at position 17 the diodes **12** are positioned to energize the conductors **14** and **17** when positive potential is supplied to the diode matrix. Normally, the code symbol for the letter "H" is generated by the diodes **11** in position 17 when negative potential is applied to the diode matrix. With the foregoing arrangement, operation of the key representative of the letter "H" will not cause false printing of the letter "R."

In the illustrative embodiment of the invention described herein, one group of input terminals associated with keys representative of single characters are joined by conductive means includring conductors **13**, **22** and **24** to the diodes **11** in the stacks **10**, while a second group of input terminals associated with keys representative of two characters are joined by conductive means including conductors **19**, **22** and **24** to the diodes **12** in the stacks **10**. It is necessary, as is apparent from FIGURES 1A and 1B, to provide ten separate positive paths to the diodes **12** at code positions 2, 3, 4, 5, 9, 13, 17, 18, 22 and 25.

It will be evident from the foregoing that by using complementary combinations of the diodes **11** and **12** in selected code stacks, a great number of diodes may be eliminated by use of the improved bipolar matrix. For example, the code symbol for the letter "A" in the five-unit code is 1 and 2 having a complement of 3, 4 and 5 which, in that code, represents a period (.).

Referring to FIGURES 1A and 1B, the typewriter key representing a period (.) when depressed closes a circuit to one of the conductors **19** leading to the diodes **12** in the code stack **10** in position 2, also representative of the letter "A." Simultaneously the "figures" conductor **39** will be energized through the corresponding contact finger **31** and strip **28** to shift the polar relay **46**, if necessary, and change the polarity on the line **38** to energize the lines **16**, **17** and **18** and the selector relays **57** (R3, R4 and R5) through the oppositely polarized diodes **12**. Punching of the tape then is accomplished as above.

From the above, it will be apparent that the present apparatus may be employed to convert standard key operated mechanisms such as typewriters to machines capable of perforating tape with a five-unit code. By virtue of the automatic punching of the "letters" and "figures" code symbols, the two additional keys necessary in prior devices of this type to perform those functions may be eliminated to increase the efficiency of the typing operations. Moreover, the improved diode matrix minimizes the number of necessary diodes.

It will be understood that the above-described embodiments of the invention are illustrative only and modifications thereof will occur to those skilled in the art. Therefore, the invention is not to be limited to the specific apparatus disclosed herein but is to be defined by the appended claims.

I claim:

1. In coding apparatus, a diode matrix comprising: a plurality of input terminals; a plurality of output conductors; a plurality of diode stacks each including a plurality of groups of one or more diodes each; means including a code selector for connecting the diodes of each corresponding group of each of said stacks to a different one of said input terminals; and circuits for connecting all of said diodes of each stack to different output conductors.

2. In coding apparatus, a diode matrix comprising: a pair of input terminals of opposite polarities; a plurality of output conductors; a plurality of diode stacks each including two groups of one or more diodes each; means including a code selector for connecting the diodes of one corresponding group of each of said stacks to one of said input terminals with one polarity and for connecting the diodes of the other corresponding group of each of said stacks to the other input terminal with opposite polarity;

and circuits for connecting all of said diodes of each stack to different output conductors.

3. In coding apparatus, a diode matrix comprising: x input terminals; a plurality of output conductors; a plurality of diode stacks each including x groups of one or more diodes each; means including a code selector for connecting the diodes of each corresponding group of each of said stacks to a different one of said input terminals; and circuits for connecting all of said diodes of each stack to different output conductors whereby a total of $x2^y$ possible code combinations may be generated.

4. In coding apparatus, a diode matrix including input terminals in first and second groups, output conductors, a plurality of diode stacks connected in parallel across the output conductors, first conductive means joining each of the diode stacks to one of the first group input terminals, second conductive means joining selected ones of the diode stacks to one of the second group input terminals, an input conductor, switching means operable to connect the input conductor to each of the input terminals, a first control conductor connected by the switching means to the input conductor when the input conductor is connected to one of the first group input terminals, and a second control conductor connected by the switching means to the input conductor when the input conductor is connected to one of the second group input terminals.

5. Apparatus as defined in claim 4, wherein said switching means comprises two conductive members each incorporating a plurality of contact fingers and respectively connected to the first and second control conductors, each of the fingers of one of the conductive members being positioned adjacent to a corresponding one of the first group input terminals, each of the fingers of the other of the conductive members being positioned adjacent to the second group input terminals, a displaceable element connected to the input conductor and associated with each of the input terminals, displacement of the element electrically connecting it to the corresponding contact finger and input terminal, whereby the input conductor is connected to one of the first and second control conductors.

6. In coding apparatus, a diode matrix having a plurality of input terminals, two conductive members each incorporating a plurality of contact fingers, each of said contact fingers being positioned adjacent to a corresponding one of the input terminals, and a displaceable element associated with each of the input terminals, displacement of said element electrically connecting it to the corresponding contact finger and input terminal.

7. In coding apparatus, a diode matrix having a plurality of input terminals, three conductive members respectively incorporating first, second and third contact fingers, one of the first contact fingers being positioned adjacent to each input terminal, the second contact fingers being positioned between the first fingers and some of the input terminals, the third contact fingers being positioned between the first fingers and others of the input terminals, a cam associated with each first contact finger to displace it toward the corresponding input terminal, whereby displacement of each of the first contact fingers by its associated cam electrically connects the first member, one of the second and third members, and one of the input terminals.

8. In coding apparatus, a diode matrix having a plurality of input terminals, two conductive members each incorporating a plurality of contact fingers, each of the fingers being positioned adjacent to a corresponding input terminal, a movable element associated with each of the input terminals and positioned adjacent to a corresponding one of the contact fingers, initial displacement of each of said elements electrically connecting it to the corresponding contact finger, and further displacement of the element electrically connecting the finger and element to the corresponding input terminal.

9. In coding apparatus, a diode matrix having a plurality of input terminals and output terminals, three conductive members each respectively incorporating a plurality of first, second and third resilient contact fingers, each of said first fingers being positioned adjacent to one of the input terminals, said second fingers being positioned adjacent to some of the input terminals, said third fingers being positioned adjacent to the others of the input terminals, a shaft adjacent to the conductive members, movable cams spaced along the shaft associated with each of the first resilient fingers, initial movement of one of the cams connecting the associated first resilient finger electrically to one of the first and second resilient fingers, and further movement of the cam electrically connecting the first finger and the one of the first and second fingers to the associated input terminal.

10. In coding apparatus, a diode matrix including first and second diodes, input terminals in first and second groups, a plurality of output conductors, diode stacks connected in parallel across the output conductors, each of the stacks including at least one diode connected to one of the output conductors, said first and second diodes in any one stack being connected to different output conductors, first conductive means joining the first diodes in each stack to at least one of the first group of input terminals with one polarity, and second conductive means joining the second diodes in each stack to one of the second group of input terminals with the opposite polarity.

11. In coding apparatus, a diode matrix including first and second diodes, input terminals in first and second groups, a plurality of output conductors, diode stacks connected in parallel across the output conductors, each of the stacks including at least one diode connected to one of the output conductors, said first and second diodes in any one stack being connected to different output conductors, first conductive means joining the first diodes in each stack to at least one of the first group of input terminals with one polarity, second conductive means joining the second diodes in each stack to one of the second group of input terminals with the opposite polarity, an input conductor, switching means operable to connect the input conductor to each of the input terminals, a first control conductor connected by the switching means to the input conductor when the input conductor is connected to one of the first group input terminals, and a second control conductor connected by the switching means to the input conductor when the input conductor is connected to one of the second group input terminals.

12. Apparatus as defined in claim 11, wherein said switching means comprises two conductive members each incorporating a plurality of contact fingers and respectively connected to the first and second control conductors, each of the fingers of one of the conductive members being positioned adjacent to a corresponding one of the first group input terminals, each of the fingers of the other of the conductive members being positioned adjacent to the second group input terminals, a displaceable element connected to the input conductor associated with each of the input terminals, displacement of each of the elements electrically connecting it to the corresponding contact finger and input terminal, whereby the input conductor is connected to one of the first and second control conductors.

13. In coding apparatus, a diode matrix including first and second diodes, a plurality of input terminals, a plurality of diode stacks, output conductors connecting said diode stacks in parallel, at least one first diode in selected stacks to generate coded signals on the output conductors when energized by potentials of one polarity, at least one second diode in selected stacks to generate coded signals on the output conductors when energized by potentials of the opposite polarity, said first and second diodes in any one stack being connected to different output conductors, conductive means connecting said first diodes to one of said input terminals with one polarity

and said second diodes to another of said input terminals with opposite polarity, two conductive members each incorporating a plurality of contact fingers, each of said contact fingers being positioned adjacent to a corresponding one of the input terminals, and a movable element adapted to be electrically enerized associated with each of the input terminals, displacement of said movable element electrically connecting it to the corresponding contact finger and the associated input terminal to provide a control signal on one of the two conductive members and energize the diode matrix which provides coded signals on the output conductors as a function of the polarity of the energizing potential on said movable element.

14. In coding apparatus, a diode matrix including first and second diodes, input terminals in first and second groups, a plurality of output conductors, diode stacks each including at least one of the two types of diodes connected to one of the output conductors to generate coded signals on the output conductors when energized by suitable potentials, said first and second diodes being connected to different output conductors in any one of the stacks, first conductive means connecting the first diodes in each stack to at least one first group input terminal, second conductive means connecting the second diodes in each stack to at least one second group input terminal, two conductive members each incorporating a plurality of resilient contact fingers, each of the contact fingers being positioned adjacent to a corresponding input terminal, a movable element adapted to be electrically energized associated with each of the input terminals and positioned adjacent to the corresponding resilient finger, initial displacement of the movable element electrically connecting it to the resilient finger to provide a control signal on one of the two conductive members, and further movement of the cam element electrically connecting it to an associated input terminal to energize the diode matrix which provides coded signals as a function of the polarity of the energizing potential on said movable element.

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