July 29, 1958 F. P. TURVEY, JR 2,845,617

PULSE-COUNT CODER

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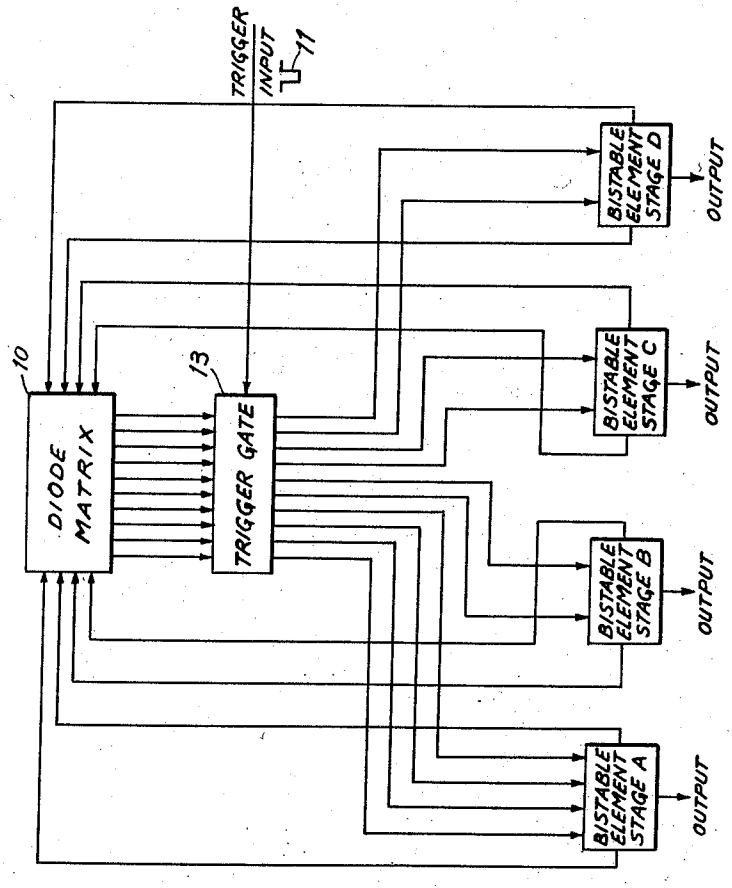
Fig. 3

NUMBER OF INPUT PULSES	DIGITAL POSITIONS A	B	C	D
0				
1		X	X	
2	X	X	X	
3	X		X	
4			X	
5			X	X
6	X		X	X
7	X	X	X	X
8		X	X	
9		X		X

Fig. 1



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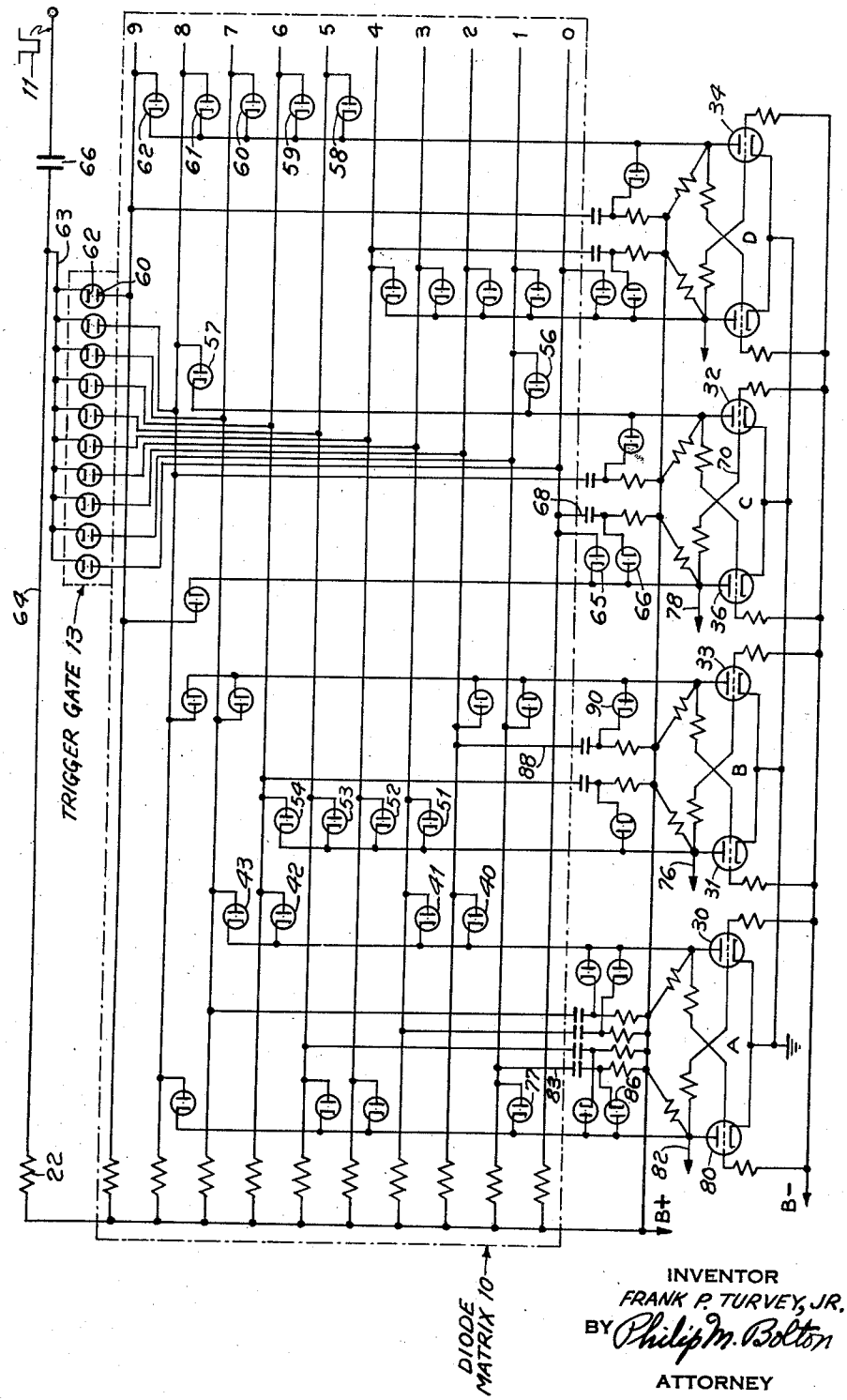

Fig. 2

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United States Patent Office 2,845,617 Patented July 29, 1958

2,845,617

PULSE-COUNT CODER

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Application May 17, 1956, Serial No. 585,494

9 Claims. (Cl. 340—347)

The invention relates to a pulse-count coder which in response to incoming pulses produces a coded output signal representing the number of input pulses.

Many uses exist in electronic systems, such as computers and control devices, for devices producing a coded output signal corresponding to the number of input signals or pulses. The coded output signal or pulses may be used for various indicating and control functions, in the latter often serving as gating pulses to control the energization or transmission of electrical energy to various utilization devices.

In many instances, the nature of the code is determined by the apparatus to which the output of the counting device is to be applied. It therefore becomes desirable to have a counting device which is capable of producing an output in accordance with an arbitrarily selected code. Moreover, to accommodate any required change in the control function of the output signals from the counting device, it is desirable to be able to change the code in which the count is expressed.

These requirements for arbitrary coding and for flexibility in changing the code are not easily met; and conventional devices have, in general, not proven satisfactory or have been of relatively limited application.

An object of the present invention is the provision of an improved device for producing a coded output signal expressing according to an arbitrary code the number of input pulses.

Another object of the present invention is the provision of a device of the type hereinbefore described in which the particular code in which the count is expressed may readily be changed into another arbitrary code.

Other and further objects of the present invention will become apparent and the foregoing will be better understood with reference to the following description of embodiments thereof, reference being had to the drawings, in which:

Fig. 1 is a block diagram of a device for producing an arbitrarily coded output signal corresponding to the number of sequential input pulses;

Fig. 2 is a schematic diagram of the embodiment represented in block form of Fig. 1 arranged to produce an Excess–3 Gray coded signal output; and

Fig. 3 is a chart of the Excess–3 Gray Code.

Referring more specifically to Fig. 1, there is shown in block form four trigger-responsive bistable stages A, B, C and D which may be, for example, in the form of multivibrators. Each stage controls a diode matrix configuration **10** and is connected thereto through appropriate connecting leads. The trigger input pulses **11** are applied to trigger gate **13**, which pulses, depending upon the unique conditions of the gate, are transmitted to the various ones of the counter stages A, B, C and D. The unique conditions of the trigger gate are controllable directly by the matrix **10** which is, in turn, controlled by the trigger-responsive stages A, B, C and D.

Turning now to Fig. 2 wherein a detailed schematic

drawing of the invention is illustrated, the operation of a specific embodiment of the invention will be described in conjunction with a particular chosen code, namely, the Excess–3 Gray Code of which a chart is shown in Fig. 3. Four bistable trigger circuits of the multivibrator type are illustrated, namely, stages A, B, C and D; and the output signal from each of the trigger-circuit outputs represents a different digital position in the output pulse code selected. For example, if only stage C produces an output signal, then the count or number of input pulses would be "4," as noted from the Excess–3 Gray Code Chart in Fig. 3. On the other hand, if only stages B and D were to produce an output signal, then again with reference to Fig. 3, the number of pulses that would be counted would be "9."

As will be shown, the code chosen is determined by the diode arrangement in the diode matrix **10**. Fig. 2 shows the matrix diode arrangement necessary to produce the Excess–3 Gray Code illustrated in chart form in Fig. 3. There are ten diode matrix lines numbered from 0 to 9 in consecutive order. Each line is connected to a positive source of potential B+ through a coupling resistor **22**. The trigger gating circuit **13** is comprised of a group of diodes, the anode of each diode being connected to a separate one of the matrix lines and the cathodes of the diodes being tied together to form a common connection **63** to line **64** to which the input pulses **11** are applied.

With reference to Fig. 3, the chart shows that for a count of "0" the bistable stages A, C and D produce no output signals whereas bistable stage B does develop an output signal. Under these conditions, the right triodes **30**, **32** and **34** of stages A, C and D, respectively, are conductive whereas the left triode **36** of stage B is conductive. The operation of bistable multivibrators is such that normally one of a pair of cross-connected electron tubes is conducting, the other nonconducting. To reverse this condition, a triggering pulse is applied to the stage so that one of the tubes, the conducting one, is biased to cutoff. The conduction of triodes **30**, **32** and **34** of stages A, C and D, respectively, biases the matrix diodes on matrix lines 1 through 9, inclusive, but not the zero (0) matrix line. The conducting triode **30** of stage A has associated therewith a series of matrix diodes **40**, **41**, **42** and **43**, each diode being associated with matrix lines 2, 3, 6 and 7, respectively. The cathodes of the diodes **40**, **41**, **42** and **43** are connected together and tied to thte anode **45** of triode **30** whereas their respective anodes are separately tied to the associated matrix line. Whenever a matrix diode is conducting, the matrix line normally associated with such diode has a potential whose value is less than that of the B+ supply voltage by an amount equal to the voltage drop across the dropping resistor **22**. Consequently, the matrix lines 2, 3, 6 and 7 are at a reduced potential when triode **30** of stage A is conducting. With respect to stage B, triode **31** is conducting when the count is "0" placing diodes **51**, **52**, **53** and **54** in a conductive state which, in turn, causes a reduction in voltage of the matrix lines 3, 4, 5 and 6 associated with each of the said diodes. Likewise with respect to stage C, triode **32** is also conducting at the "0" count placing diodes **56** and **57** in a conductive or unblocked condition which puts matrix lines 1 and 8 at reduced voltages with respect to the supply voltage. Finally, triode **34** of stage D, being also conductive at the "0" count, renders matrix diodes **58**, **59**, **60**, **61** and **62** conductive thereby effectively placing matrix lines 5, 6, 7, 8 and 9 at reduced potentials. It may be noted that in certain instances there are overlapping matrix diodes, e. g., more than one matrix diode associated with a matrix line; but this does not affect the count operation. One illustration of this

is that matrix line 5 has diodes 53 and 58 both conductively associated therewith. From the foregoing, it is seen that for a count of "0" the matrix lines from 1 to 9 have reduced potentials whereas matrix line zero (0) retains its original potential equal to that of the B+ supply voltage.

A trigger-gate arrangement 13 is associated with the matrix-line arrangement in such a manner that the matrix controls the transmission of triggering pulses 11 through the trigger gate 13 to the bistable multivibrator stages. The trigger gate 13 comprises a series of diodes each having its anode 60 connected separately to a single matrix line. The cathodes 62 of these diodes are connected to a common point 63 which, in turn, is connected to the input line 64 to which the triggering impulses 11 are applied via a coupling capacitor 66. Line 64 is also connected to the potential supply source 20 to coupling resistor 22. When the count is "0," as heretofore explained, matrix lines 1 through 9, inclusive, are at a reduced potential; and the diodes of the trigger gate 13 connected to lines 1 through 9 are thereby blocked because their anodes are at a reduced potential with respect to their cathodes. Thus, a negative input trigger pulse along line 64 cannot pass through any of the diodes associated with matrix lines 1 through 9. However, the diode in trigger gate 13 which is connected to the zero (0) matrix line is not blocked, and the incoming negative pulse passes this diode and thence through decoupling diode 66 via conductive lead 68 to bistable stage C. The negative trigger pulse by means of the cross-coupling arrangement in stage C is coupled to the grid electrode 70 of triode 32 and causes the said triode 32 to become nonconductive while the triode 36 of stage C starts to conduct. Now two stages, namely, stages B and C, have their left triodes 31 and 36 conducting thereby producing signals at their outputs 76 and 78, respectively. The chart of Fig. 3 shows that for output signals from stages B and C the code represents a count of "1" input pulse.

When the left triode 36 of stage C conducts, the right triode 32 becomes nonconducting. Therefore, no current can flow through diodes 56 and 57 of the matrix. Consequently, the potential of matrix line 1 will rise to that of the B+ source. The potential of matrix line 8 will not rise, however, since matrix diode 61 connected to line 8 is still conducting through conducting triode 34.

With matrix line 1 at its higher potential, the next negative input trigger pulse on line 64 will pass through that diode of trigger gate 13 which is connected to matrix line 1 since that diode is unblocked. This negative input trigger pulse reaching matrix line 1 passes via connection 83 and decoupling diode 86 to stage A and through the cross-connection to the grid to triode 30 blocking said triode 30 and causing triode 80 to conduct. An output signal is thereby produced at output terminal 82. Under these conditions, triodes 80, 31 and 36 are conducting providing outputs at 76, 78 and 82 which in the Excess-3 Gray Code Chart represent the count of "2."

The counting continues in this manner with each input pulse being fed through the open trigger gate and decoupling diode to trigger the appropriate multivibrator stage, the proper trigger-gate diode being open for conduction by the potentials of the matrix lines as determined by the conduction of the matrix diodes, the conduction of the matrix diodes, in turn, being controlled by condition of the multivibrator stages.

It will be apparent that the matrix diodes may be rearranged to provide different codes for expressing the input-pulse count. Greater flexibility in changing the code is provided by the fact that the connections from the trigger-gate diodes to the different triodes of the multivibrator stages may also be changed.

It will be obvious that many changes may be made in the arrangement disclosed without departing from the teachings of the present invention. Amongst these obvious changes is the replacement of the electron discharge diodes and triodes by the equivalent solid-state rectifiers and transistors. In place of the classical multivibrator stages, other stages having a plurality of stable operational levels may also be employed. Changes in the arrangement of the matrix and the use of other forms of similar organizations are also envisaged by the present invention.

Accordingly, while I have describe above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

I claim:

1. A pulse-count coder for producing a code output representative of the number of input pulses from a pulse source comprising a plurality of code-producing stages each having a plurality of stable operational levels, a diode matrix consisting of a plurality of matrix conductors and groups of matrix diodes coupled to said conductors, means coupling said matrix diodes to said stages to produce potentials on said conductors determined by the particular operational level at which the associated stage is operating, and means including a plurality of gate circuits coupled to and controlled by the potentials of said matrix conductors for applying said input pulses to different points of said stages in accordance with a predetermined code.

2. A pulse-count coder for producing a code output representative of the number of input pulses from a pulse source comprising a plurality of trigger circuits each having a plurality of stable operational levels, means including a plurality of gate circuits for applying input pulses from said source to different points of said plurality of trigger circuits to trip said trigger circuits from one to the other of said operational levels, a diode matrix coupled to said gate circuits to control the conductivity of each of said gate circuits, and means for coupling the diodes of said matrix to different points of said trigger circuits to change the conductivity of said matrix diodes in accordance with changes in the operational levels of said trigger circuits.

3. A pulse-count coder for producing a code output representative of the number of input pulses from a pulse source comprising a plurality of trigger circuits each having a plurality of stable operational levels, means including a plurality of gate circuits for applying input pulses from said source to different points of said plurality of trigger circuits to trip said trigger circuits from one to the other of said operational levels, a diode matrix including matrix lines and groups of matrix diodes coupled to said lines, means for coupling the diodes of said matrix to different points in said trigger circuits to change the potential of said matrix lines in accordance with changes in the operational levels of said trigger circuits, and means coupling said matrix lines to said gate circuits to control the conductivity of said gate circuits in accordance with the potential of said matrix lines whereby the input pulses are applied to trip the trigger circuits in accordance with a predetermined code.

4. A pulse-count coder for producing a code output representative of the number of input pulses from a pulse source comprising a plurality of code-producing stages each having a plurality of stable operational levels, a diode matrix coupled to said stages and producing voltages determined by the particular operational level at which the associated stage is operating, and means including a plurality of gate circuits controlled by the voltages from said matrix for applying said input pulses to different points of said stages in accordance with a predetermined code.

5. A coded counter system substantially as described comprising a plurality of bistable multivibrator stages each having a pair of selectively conducting triodes responsive

to input triggering pulses and an output, a diode matrix array comprising a plurality of code-selective groups of non-conductive matrix diodes, said groups being selectively coupled to one of said trigger-responsive triodes and adapted to become conductive in response to said conducting triode, a gating circuit adapted to receive pulses from a pulse source and having a plurality of diodes disposed to have a common cathode input and individual anode outputs, a plurality of matrix lines disposed in said matrix array to selectively engage the said matrix diodes and the output anodes of said gating circuit, the said matrix lines being adapted to receive pulses from said gate in response to the said selective conductive changes in the said matrix diodes, and means for coupling the said matrix-line pulses to the said bistable multivibrator stages in accordance with the said preselective code.

6. A coded counter system substantially as described comprising a plurality of bistable multivibrator stages each having a pair of selectively conducting electron discharge devices responsive to input signals and an output, a diode matrix array comprising a plurality of code-selective groups of blocked matrix diodes, said groups being selectively coupled to one of said responsive electron discharge devices and adapted to become unblocked in response to the said conducting electron discharge device, a gating circuit adapted to receive pulses from a pulse source comprising a plurality of diodes disposed to have a common cathode input and individual anode outputs, a plurality of signal lines disposed in said matrix array to selectively engage the said matrix diodes and the output anodes of said gating circuit, the said signal lines being adapted to receive pulses from said gate in response to the said unblocking of said code selective groups of matrix diodes, and means for coupling said signal-line pulses to the said bistable multivibrator stages in accordance with the said preselected code.

7. A signal translation system for producing a predetermined coded output signal responsive to sequential input signals comprising a plurality of bistable multivibrator stages each having a pair of on-off triodes responsive to input triggering signals and an output, a diode matrix array comprising a plurality of groups of matrix diodes, each of said groups being selectively coupled to one of said on-off triodes and adapted to become blocked when said triode is on and unblocked when said triode is off, a gating circuit adapted to receive pulses from a pulse source comprising a plurality of diodes disposed to have a common cathode input and individual anode outputs, a plurality of signal lines disposed in said matrix array to selectively engage the said matrix diodes in accordance with said selected code and the output anodes of said gating circuit, the said signal lines being adapted to receive pulses from the said gate when the engaged matrix diode is blocked and no pulse when the said matrix diode is unblocked, and means for coupling the said signal-line pulses to the said bistable multivibrator stages to produce a signal from them in accordance with the said selective code.

8. A signal translation system for producing a predetermined coded output signal responsive to input signals comprising a plurality of bistable multivibrator stages each having a pair of selectively conducting electron discharge tubes responsive to input triggering pulses and an output, a control matrix array comprising a plurality of code-selective groups of nonoperative electron discharge devices, said groups being selectively coupled to one of said trigger-responsive electron discharge tubes and adapted to become operative in response to said conducting discharge tubes, a gating circuit adapted to receive pulses from a pulse source comprising a plurality of electron discharge devices having an anode and a cathode disposed to have a common cathode input and individual anode outputs, a plurality of signal lines disposed in said control matrix array to selectively engage the said matrix electron discharge devices and the output anodes of said gating circuit, the said signal lines being adapted to receive pulses from said gate in response to the operative changes in the said matrix electron discharge devices, and means for coupling said signal-line pulses to the said bistable multivibrator stages to produce a signal from the said output thereof in accordance with the said preselective code.

9. A coded counter system comprising a group of bistable controllable flip-flop circuits, each circuit having a pair of triodes with on-off characteristics, a plurality of bias-controlled bus lines, a series of control diodes interposed between said triodes and bus lines and responsive to the on-off characteristics of said triodes, the said responsive control diode controlling the bias of said bus lines, a gate circuit including a plurality of diodes each having its anode separately connected to said bus lines and its cathode commonly connected, the said gate circuit being adapted to receive electrical signals from a signal source at its cathode and transmit said signals to a controlled bus line, and means for coupling said bus-line signal to a controllable flip-flop circuit.

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