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RELAY COUNTING CIRCUIT

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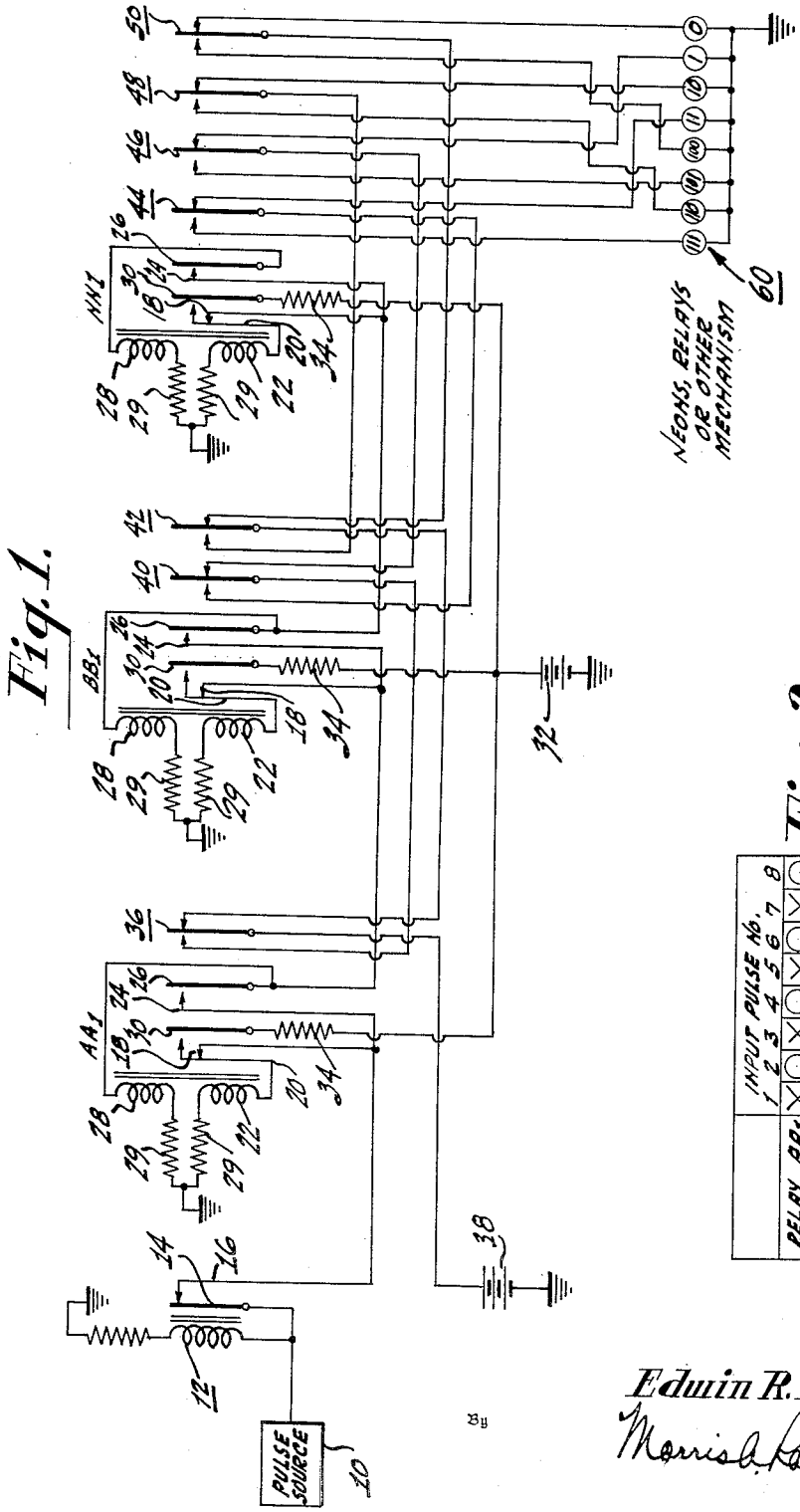


Fig. 1.

	INPUT PULSE No. 1	2	3	4	5	6	7	8
RELAY AA1	X	O	X	O	X	O	X	O
RELAY BB1	O	X	O	X	O	X	O	X
RELAY NN1	O	X	O	O	X	X	X	X

O = UNOPERATED POSITION
X = OPERATED POSITION

Fig. 2.

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RELAY COUNTING CIRCUIT

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The present invention relates to electrically operated calculating equipment, and more specifically to improved apparatus for converting numbers expressed in a first radix to numbers expressed in a second radix.

The primary object of my present invention is to provide improved apparatus to receive information in the decimal system, or radix ten, and translate this information into the binary system, or radix two.

Another object of my present invention is to provide an improved counting system which may be easily expanded or continued in any desired number of digits in the manner shown and described herein.

These and other objects are achieved in accordance with my present invention by using a plurality of relays connected in tandem to a source of sequential pulses. The relays are of the type that have two opposing windings and are operated by a first pulse and remain operated until a second pulse is applied, when the relay is released. The relays are interconnected so that each relay receives pulses from the source through preceding ones in said series when the preceding ones are all operated. By using the combinations provided by the coinciding closure of contacts associated with each of the relays, a pulse input equal in number to a desired decimal number will operate the relays to provide the proper radix two equivalent number. The radix two number is indicated by an indicator, such as one utilizing lights.

The novel features of the invention, as well as the invention itself, both as to its organization and method of operation, will best be understood from the following description when read in connection with the accompanying drawings in which:

Figure 1 is a schematic circuit diagram of an embodiment of my invention, and

Figure 2 is a chart showing the operating sequence of the relays used in the embodiment of my invention shown in Figure 1.

The radix of any numbering system is a number which is the base of that system. Thus, ten is the radix of the decimal system and two is the radix of the binary system. To convert a number from radix 10 to radix 2, the radix 10 number is expressed as multiples of two and then a ten is substituted for each two that appears in the radix ten number expressed in multiples of two. For example, 16 is expressed as 2^4; and in the binary system, its equivalent is $10^4=10000$. As another example, 19 is expressed as 2^4 plus 2^1 plus 2^0, which corresponds to 10^4 plus 10^1 plus $10^0=10011$. More complete discussion of the binary and similar systems of computation may be found in "Elementary Number Theory" by Uspenski and Heaslett, "Mathamatical Excursions" by H. A. Merrill and "A Mathamatician Explains" by M. I. Logston.

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Referring, now, to Figure 1, a source of an arithmetical train of electrical pulses 10 is connected to a timing relay 12 which is so arranged as to permit only a portion of an applied pulse to enter the line to a plurality of counting relays AA_1, BB_1 . . . NN_1 through its contacts 14, 16 when it operates to break the circuit to the line. The purpose of the timing relay 12 is to assure that only uniform pulses are applied to the counting relays. However, if the input pulses all have a similar timed duration, the timing relay 12 may be omitted and the input pulses may be applied directly to the line to the counting relays and they will operate properly.

The counting relays AA_1, BB_1 . . . NN_1 are of the double coil, neutral relay type. Each relay has a pair of normally closed contacts 18, 20 which are connected between the pulse input to the relay and one of two coil windings 22, and a pair of normally open contacts 24, 26 which are connected between the pulse input to the relay and to the other coil winding 28. The latter coil winding 28 is connected to oppose the former coil winding 22. Each coil winding has a current limiting resistor 29 in series with it. A first pulse applied to any one of the counting relays is applied to the coil winding 22 through normally closed contacts 18, 20, thereby operating the relay and opening the normally closed contacts 18, 20. A hold in contact 30 which is connected to an operating bias source 32 through a current limiting resistor 34 engages the contact 20 thus connecting the bias source to the coil winding 22 and holding the relay operated. The normally open contacts 24, 26 are also closed by operation of the relay. A second pulse supplied to any one of the counting relays which is operated is applied through the now closed, but normally open, contacts 24, 26 to the opposing coil winding 28. This releases the relay and restores the former conditions.

Counting relay AA_1 has its contacts 18 and 24, the respective ones of the normally closed and normally open contacts not connected to the coil windings 22, 28, connected to the pulse source 10 through the timing relay contacts 14, 16. Contact 26 of relay AA_1 is connected to contacts 18, 24 of relay BB_1. Contact 26 of re-

lay BB_1 is connected to contacts 18, 24 of relay NN_1. It may therefore be seen that the counting relays of the counting chain are all interconnected in tandem in such fashion that they are all connected to the pulse source 10 through preceding relays in the series interconnection only when all preceding relays are operated.

A first pulse applied to the first relay AA_1 in the series from the timing relay 12 operates the first relay AA_1. A set of auxiliary contacts 36 associated with relay AA_1 and connected to a functional power supply 38 is also operated, causing an "0" or standby light of an indicator 60 to be extinguished and a "1" light to be operated. The circuit to the "1" light may be traced from the functional input power supply 38 through the auxiliary contacts 36 associated with the first counting relay AA_1, the auxiliary contacts 40 associated with the second counting relay BB_1, and the auxiliary contacts 46 associated with the third counting relay NN_1 through the "1" light to ground.

A second pulse from the timing relay 12 is applied, simultaneously through the AA_1 now closed but normally open contacts 24, 26 to the opposing winding 28 of the first relay AA_1 thus releasing the relay AA_1 and through the BB_1 normally closed contacts 18, 20 to the winding 22 of relay BB_1, thus operating the second counting relay BB_1. In view of the circuit now made by the auxiliary contacts 36, 42, 48 as a result of only the second relay BB_1 being operated, the "10" light is lit and the "1" light is extinguished.

A third pulse applied from the timing relay 12 now causes only the first counting relay AA_1 to be operated. Relay BB_1 remains operated. The auxiliary contacts 36, 40, 44, as a result of the first and second counting relays AA_1, BB_1 now being operated, illuminate the "11" light and extinguish the "10" light.

A fourth pulse applied from the timing relay 12 is simultaneously applied through their now closed but normally open contacts 24, 26 to the opposing coils 28 of the first and second counting relays AA_1, BB_1, thus causing them to be released, and through the NN_1 normally closed contacts 18, 20 to the coil 22 of the third counting relay NN_1, causing the latter relay to be operated. The auxiliary contacts 36, 42, 50 as a result of only the third counting relay NN_1 being operated illuminate the "100" light and the "11" light is extinguished.

A fifth pulse applied by the timing relay 12 operates the first counting relay AA_1 again. Counting relay NN_1 remains operated. The auxiliary contacts 36, 40, 46 cause the "101" light to be illuminated as a result of the first and third counting relays being operated and the "100" light is extinguished.

A sixth pulse applied by the timing relay 12 operates the second counting relay BB_1 and releases the first counting relay AA_1. Counting relay NN_1 remains operated. The auxiliary contacts 36, 42, 48 cause the "110" light to illuminate, in view of the second and third relays BB_1, NN_1 being operated and the "101" light is extinguished.

A seventh pulse applied by the timing relay 12 operates the first counting relay AA_1. Counting relays BB_1 and NN_1 remain operated. The auxiliary contacts illuminate the "111" light as a result of all the counting relays being operated and the "110" light is extinguished.

An eighth pulse from the timing relay releases all the relays, the "0" light is illuminated again

indicating that the system is reset for a new counting cycle.

Figure 2 shows the operating sequence of the counting relays. That the relays operate in binary fashion in response to the decimal sequence of input pulses may be readily seen from this chart.

Although only three relays are used in the embodiment of my invention for a total decimal count of seven this should not be taken as a limitation of my invention. As high a count as is desired may be obtained merely by connecting the required number of relays in tandem in the manner shown in Figure 1. The number of relays required in a counting chain for a desired count may be obtained from the following formula:

$$C=(2^n)-1$$

where C is the desired count, and n is the number of relays required in the counting chain.

In place of the lights to indicate the binary number equivalent of the number of input pulses, relays or any other mechanism may be inserted to be operative in response to a desired binary count.

From the foregoing description, it will be readily apparent that I have provided a system for converting any decimal number of pulses which are supplied in sequence into its corresponding binary number with provision for operating other mechanisms accordingly. Although I have shown and described but a single embodiment of my present invention, it should be apparent that many changes may be made in the particular embodiment herein disclosed, and that many other embodiments are possible all within the spirit and scope of my invention. Therefore, I desire that the foregoing description shall be taken as illustrative and not as limiting.

I claim as my invention:

1. A relay counter comprising a plurality of relays, each of said relays having a pair of opposing coil windings, first and second normally closed contacts, said first contact being connected in series with one of said pair of opposing windings, a third contact positioned to engage said first contact when said relay is operated, means to apply a bias to said third contact to maintain said relay operated when said first and and third contacts are closed and the other of said pair of opposed windings is not energized, and first and second normally open contacts, said first normally open contact being connected to the other of said pair of opposing coil windings, means to impress pulses simultaneously upon said second normally closed contact and said second normally open contact of a first one of said plurality of relays, each one of the remainder of said plurality of relays having its second normally closed contact and its second normally open contact connected to the first normally open contact of the preceding one of said plurality of relays.

2. A relay binary counter comprising a plurality of tandem connected relays, and means to apply pulses to be counted to a first one of said relays; each of said relays having a pair of opposing windings whereby application of a pulse to one of said pair of opposing windings operates said relay and application of a pulse to the other of said pair of windings releases said relay, each of said relays also having first contact means to apply a first pulse applied to said relay to said one of said windings to operate said

relay, means to maintain said relay operated when operated, and second contact means responsive to said relay being operated to apply a second pulse applied to said relay to a succeeding one of said tandem connected relays and to said other of said pair of windings to release said relay.

3. A relay counter comprising a plurality of relays connected in tandem; each of said relays having a pair of opposing windings, means to operate said relay including a pair of normally closed contacts in circuit with one of said opposing windings, means for holding said relay operated through said opposing winding responsive to the operation of said relay, means to release said relay including a pair of normally open contacts in circuit with the other of said opposing windings; means to apply pulses to be counted sequentially to the means to operate and means to release of a first one of said tandem connected relays; and means coupling the means to operate of each of the remaining relays to the normally open contacts of the means to release of a preceding relay whereby said relays operate in binary fashion responsive to a succession of pulses applied to said first one of said tandem connected relays.

4. A relay counter comprising a plurality of relays connected in tandem, each of said relays having a pair of opposing windings, a pair of

normally closed contacts, a relay holding circuit, a pair of normally open contacts, means to apply a first pulse to one of said opposing windings through said normally closed contacts to operate said relay and to engage said holding circuit, means to apply a second pulse to the other of said opposing windings through the normally open contacts when closed to release said relay, and means coupling said means to apply a first pulse and a second pulse of each relay to the normally open contacts of a preceding relay.

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