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COUNTERS

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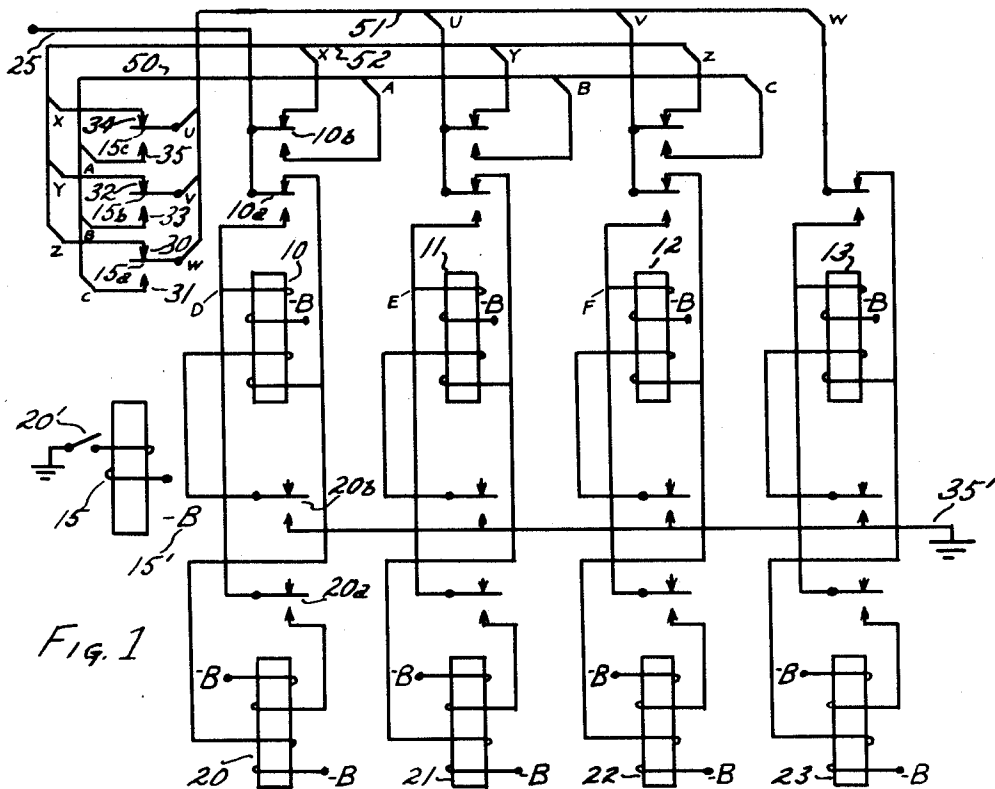


Fig. 1

Fig. 2

GND. PULSE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
RELAY 10																
" 20																
" 11																
" 21																
" 12																
" 22																
" 13																
" 23																

Fig. 3

GND. PULSE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
RELAY 10																
" 20																
" 11																
" 21																
" 12																
" 22																
" 13																
" 23																

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COUNTERS

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The invention described in the foregoing specification and claims may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention is in counting apparatus and specifically is a novel binary relay ring circuit suitable for adding and subtracting functions.

The principal object of the invention is to provide a simple relay circuit of the nature mentioned, embodying but two relays per stage, and producing an accurate total of pulses applied thereto, the speed of operation depending only upon the characteristics of the relays used.

Other objects will be apparent from the reading of the following specification and claims.

An air line drawing, it will be understood, is a simplified showing of an electrical circuit wherein exist a plurality of circuit parts, especially conductors, essentially alike in structure and function, and differing perhaps only in the stages they connect or otherwise affect. In the interest of simplifying the showing, it is possible to terminate the conductors at artificial boundary lines, omitting the major portion of each conductor, and indicating by letters or numerals the manners in which the several leads should be connected. Another expedient is to show one of a group of leads, again utilizing reference numerals or letters to show exactly how connections should be made.

The several stages may be connected to the single representative line in a distinctive manner, as by 45° lines (see A, B, and C of Figure 1), while making connections of conventional type in standard fashion (see D, E, and F), although this practice is not uniform. In Figure 1, then it follows that A—A should be considered to be a separate conductor from B—B, although a single line 50 is shown. One description of the air line convention may be found in Bell Telephone Standard Drafting Practices, Issue 6, April 8, 1937, and another in Electrical Drafting Applied to Circuits and Wiring, Van Zieson, see page 14 (in this case, the term "air line" is not employed).

In the drawings,

Figure 1 is a schematic air line diagram of a counting circuit according to my invention, four stages being shown.

Figure 2 displays in chart form the operation, that is, the timing, of the several relays of the ring.

Referring now to the drawings, and particularly Figure 1, there can be seen four ring relays proper 10, 11, 12, and 13, and four ancillary or transfer relays 20, 21, 22, and 23, associated respectively therewith. There also may be seen a further relay 15 with associated movable contacts *a*, *b* and *c*, and an add-subtract switch 20' the function of which will become more apparent hereinafter.

According to Figure 1, the input for the device should take the form of "ground" pulses although, obviously, with minor circuit modifications which will be apparent to those skilled in the art, other types of pulses can be employed. The input pulses are fed to the ring circuit over a lead 25.

It is believed to be unnecessary to describe the circuitry in detail apart from describing the operation of the apparatus. Let it be assumed, therefore, that switch

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20' is closed, that winding 15 is energized by source 15', and that contacts 15*a*, 15*b*, and 15*c* are thereby altered (from their conditions shown) and are pulled down against contacts 31, 33, and 35, respectively, of the several pairs of contacts 30-31, 32-33, and 34-35; the circuit thereupon is in its initial condition, prepared for adding.

The first pulse entering over lead 25 is conducted to the unoperated contacts 10*a* and 10*b* of relay 10, and a circuit is completed through contact 10*a* to the lower winding of relay 20 to battery -B, and the relay is operated. Immediately upon operation of relay 20, its associated movable contacts 20*a* and 20*b* close against their lowermost cooperating fixed contacts.

Thereupon, ground is applied over lead 35', movable contact 20*b* (cooperating with its lower fixed contact), and the lower winding of relay 10, but this relay does not immediately operate because of the input pulse (at ground potential) at the other end of the winding, by way of movable contact 10*a* (unoperated). As soon, however, as the input pulse terminates, relay 10 operates, so that at the end of the first input pulse relays 10 and 20 are both in operated condition.

The second input pulse enters the circuit through operated contacts 10*a* and 10*b* of relay 10. Its first-mentioned path extends through the upper winding of relay 10, and this serves to hold this relay operated. By an extension of that operating circuit, it also reaches the upper winding of relay 20 by way of movable contact 20*a* and its lower cooperating fixed contact. It will be seen that the two windings on relay 20 are mutually opposed, and, therefore, the net effect of the second input pulse is to hold relay 10 operated while opening relay 20.

The same pulse, occurring on contact 10*b* follows a circuit which includes contact 10*b* and its lower fixed contact, line 50, fixed contact 35 and cooperating movable contact 15*c*, and line 51, to the input of relay 11, whence it follows a course altogether analogous to the first input pulse in the first stage of the ring. The result is, of course, that the relay 21 operates responsive to the pulse, and relay 11, responsive to the termination thereof. At the beginning of the second pulse, therefore, and throughout its duration, relays 10 and 21 are operated, and at the expiration thereof, relays 11 and 21 only are in operated condition.

The sequence continues through 15 pulses. Upon receipt of the sixteenth pulse, all of the transfer relays 20 through 23 are released, and relays 10 through 13 are in operated condition.

To subtract with the circuit of my invention, switch 20' is opened (as shown in the drawing), relay 15 is thus deenergized, and its movable contacts 15*a*, 15*b*, and 15*c* assume their unoperated (upper) conditions.

In subtract condition, the first input pulse serves to operate all relays in the following fashion:

The pulse is received on swingers 10*a* and 10*b* (relay 10 being in unoperated condition). One circuit is completed as before to operate relay 20. Another circuit, including swinger 10*b*, its upper fixed contact, line 52, contacts 34, 15*c* and line 51 serves to energize relays 21, 22, and 23 in essentially like fashion. For the duration of the pulse, therefore, relays 20 through 23 are energized. All of these last mentioned relays, when energized, alter their associated contacts, just as in the adding operation, and, as a result, relays 10 through 13 will operate upon the expiration of the first input pulse, while relays 20 through 23 remain operated.

A second pulse will enter the circuit as before. With movable contacts 10*a* and 10*b* closed upon their lower cooperating fixed contacts, however, this pulse, after holding relay 10 operated, also extends to the upper winding of relay 20. Since, as earlier explained, the two windings

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of the last mentioned relay are in opposition, the net effect is to deenergize relay 20.

At the expiration of the second pulse, relay 10 is deenergized.

Without specifically defining the several successive circuits (since it is believed these will be obvious), it may be said that the third input pulse will reactivate relay 20 but at the same time will buck down relay 21 and, upon the expiration of this pulse, will deenergize relay 11.

The fourth input pulse deenergizes relay 20 and, upon expiration, relay 10. The fifth pulse will reenergize relays 20 and 21 while deenergizing relay 22, and, as the pulse expires, relays 10 and 11 will be energized while 12 will be opened. Initiation of the sixth pulse affects only relay 20, opening the same, and upon termination, reopens the circuit for relay 10.

The sequence of operations should be clear from the foregoing and, in any case, can easily be followed from the chart of Figure 3. It is believed to be sufficient here to say that the fifteenth input pulse deenergizes relay 21 and energizes relay 20, and, at the close thereof relay 10 is reactivated. On the arrival of the sixteenth pulse, relay 20 is deenergized, leaving only relay 10 operated, and, on the expiration thereof, all relays will be found to be in normal (unoperated) condition.

The foregoing is in specific terms, and modifications will suggest themselves. For the true scope of the invention, therefore, reference should be had to the appended claims.

I claim:

1. In a counting circuit, a source of current, a succession of relays each having two operating windings, a similar succession of other relays electrically interconnected with said first mentioned relays in pairs, each relay of said second succession also having two operating windings, the interconnecting circuitry including an input lead for pulses and a normally closed circuit including one of the operating windings of said other relay of said first pair, said other relay upon operation closing a circuit including said source of current and a winding of the first relay of said first succession thereof to apply

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thereto a current in opposition to the input pulse whereby the last-mentioned operating circuit is effective upon termination of the input pulse to operate said first relay of said first succession.

2. The invention of claim 1 further characterized by additional circuit means interconnecting said first relay of said first succession and the second relay thereof including a circuit closed on operation of said first relay for transferring a succeeding pulse from said input lead to said second relay, the circuit therefor including an operating winding normally in open circuit condition and a closed operating circuit for the other relay associated with said second relay, said last-mentioned other relay upon operation closing the open circuit of the energizing circuit for said second relay, the input pulse serving also to maintain the operated condition of said first relay of said first succession while restoring to unoperated condition said first other relay.

3. In a subtraction circuit, a plurality of n stages each stage including a base relay and another relay, each base relay having two similar operating windings and each other relay having two opposed operating windings, an input for pulses, a source of potential substantially like the potential of the input pulses, and interconnecting circuitry including means for paralleling said stages so that an initial pulse is directed simultaneously from said input to all said stages, each parallel circuit including an operating winding for one of said other relays and including a terminal of a winding of the corresponding base relay, the other terminal of said winding being connected to said source of potential, the line between said two terminals being normally open-circuited, and means responsive to the closing of said other relays for closing the said open-circuit conditions.

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