ABSTRACT OF THE DISCLOSURE

A high speed relay pulse counter is provided. High speed as well as reliability and economy are obtained by providing a counting chain in which only one counting relay operation or only one counting restoration takes place during each pulse interval or each inter-pulse interval. An ideal pulse receiving rate is obtained in this way, since the time duration of the received pulses and the time interval therebetween is a function of one relay operation or one relay restoration. With this invention a separate relay is operated or released during each change-of-state of signalling.

This invention relates in general to pulse counters and in particular to a high-speed all-relay pulse counter. Its principal object is to provide a new and improved pulse counter of the above character which is more economical and reliable than prior-art pulse counters.

Pulse counters are known which comprise a finite series of relays interconnected in a chain and arranged to respond to a received series of impulses. At the end of each series of impulses, one or more counting relay is operated and contacts thereon provide an output indicative of the number of impulses in the received series. The repetition rate of the impulses received is directly related to the operate and release time of each counting relay. In addition, the maximum repetition rate is limited by the number of sequential operations or restoration of the counting relays and associated control relays during each received impulse.

These noted prior-art pulse counters have circuit configurations which utilize at least one counting relay operation and at least one counting relay restoration during either the pulse period or during the inter-pulse period, or during both periods. While these known counters employ various arrangements to reduce the operation and restoration times of the relays to a minimum, nevertheless, some increment of time is used, which time when added to other time intervals, reduces the maximum counting rate obtainable.

According to the present invention, the above-noted counting rate limitations of the prior-art counters are overcome by providing a counting chain in which only one counting relay operation or only one counting relay restoration takes place during the pulse interval or inter-pulse interval. Under such conditions, the time duration of the received pulses and the time interval therebetween is a function of one relay operation or one relay restoration. This results in a counting chain having an ideal pulse receiving rate. Thus, another object of this invention is to provide counting chain circuitry in which a separate relay is operated or released during each change-of-state of signalling.

Another disadvantage of prior-art pulse counters resides in the arrangement wherein two or more counting relays are maintained operated at the end of each received impulse. This requires the output or work contacts on each counting relay to be interconnected with output contacts on another counting relay, thereby resulting in a complex output contact configuration.

According to the present invention, circuitry is provided in which only one counting relay is operated at the end of each received impulse, whereas a decimal read-out only a single output contact is required on each counting relay. Accordingly, it is still another object of this invention to provide a counting chain having a single output contact configuration on each relay.

A feature related to the above object resides in the arrangement wherein the output contacts on each counting relay may be selectively connected for decimal or two-out-of-five read-out, since only a single pair of output contacts is required for each counting relay. Also, a counting chain may be provided for a combined decimal and two-out-of-five read-out. This minimum number of output contacts on a counting chain further increases the counting rate of the chain since it is well-known that a lightly loaded relay can be made to respond more rapidly than a counting relay having a large contact stack-up.

Still a further object is to provide inter-relay wiring within the counting chain which utilizes a minimum of contacts and which does not require critically adjusted or specially wound relay coils. This is in keeping with the above feature wherein the over-all spring stack-up on each counting relay is kept to a minimum.

Another object is to provide a counting chain of relays having the above advantages of high speed, simple output contact configuration and one relay operation or restoration each change-of-state of signalling yet being reduced in number by providing a change-over relay which permits the counting relays to be re-used during a single digit train.

Other objects and features of the invention will become apparent and the invention will be best understood when the specification and claims are read in conjunction with the accompanying drawing comprising a single figure showing a schematic diagram of the inventive counter.

Referring now to the drawing, the counting chain comprises five counting relays P1 to P5, a start relay A and a combined counting and switch-over relay P6. When the counting chain is employed to count a series of impulses in excess of five, the change-over relay P6 is used as a counting relay.

The counting chain is provided with a group of control relays L, H, S and AS for exercising control over various wires connected to the counting chain relays A and P1 to P6. A pulse source INT is shown as a telephone dial contacts for purposes of simplicity in describing the invention. It is to be understood that any suitable pulse source could be used to generate the pulses which are received over wire 17 associated with relay L.

Two sets of output contacts are shown associated with relays P1 and P5. One set, comprising contact assemblies 4 and 5 provide a decimal output and the other set comprising contact assemblies 6 and 7 provide a two-out-of-five output. It is to be understood that only one contact assembly per set for decimal read-out could be provided if the number of counting relays were increased to correspond to the number of impulses to be counted. To illustrate, if only five impulses were to be counted, only contact assembly 4 of relays P1 to P5 would need to be provided. If seven impulses were to be counted, then two additional relays and wiring similar to that provided for relays P1 to P5 could be provided. However, it has been chosen to illustrate the invention as using a change-over relay P6 so that counting relays P1 to P5 could be reused to count impulses in excess of six. Nonetheless, it is clear that an indefinite number of relays could be provided in one chain without a change-over relay.

The operation of the counting chain in responding to a series of pulses will now be described. For purposes of description, it is assumed that the pulse generator INT is
selectively operated to generate any desired number of pulses in a series. Also it is assumed that key K comparable to hookswitch contacts is selectively operable to seize the counting chain for use by grounding input wire 11. All control relays and counting chain relays are in an unoperated position as shown.

The pulses used to drive the counting chain are considered to be interruptions of ground potential. Thus, the start or leading edge of a pulse will be the disappearance of ground from input wire 11 and the end or trailing edge of each pulse will be each reappearance of ground potential thereon.

Assuming the hookswitch K is operated to seize the counting chain and the digit “3” is dialed, the operation of the counting chain is as follows:

The appearance of ground on wire 11 from dial INT closes an operate circuit for relay L. Relay L operates and closes an operate circuit for relay H.

Relay H operates and extends ground through its make contacts 2 and through break contacts 2 of relay S to wire 501. The ground on wire 501 energizes the lower winding of relay A through break contacts 6 of relay P5.

Relay A operates and at its make contacts 1, prepares a locking circuit from wire 401 for itself and also prepares an operate circuit for relay P1.

At the start of the first pulse, ground disappears from wire 11 and relay L is restored, removing ground from the winding of relay H and wire 501, and placing ground on wire 401 through break contacts 1 of relay H. Relay H remains operated for a time interval in excess of the inter-pulse interval of a series of impulses.

The noted ground on wire 401 locks relay A operated and closes an operate circuit for both counting relay P1 and control relay S. Since relay A is now locked operated, the removal of ground from wire 501 is of no consequence at this time.

Relay S operates and at its contacts 2 prepares a circuit for grounding wire 601 and at its contacts 1 energizes relay AS.

Relay P1 operates from ground on wire 401 through contacts 2 of relay A and locks operated to this ground through its own contacts 1. While not shown, the connection from the winding of each relay P1 to P6 to their associated contacts 1 could include a voltage dropping element to reduce the current used for holding these relays locked operated. At the same time, contacts 3 of relay P1 prepares a second locking circuit for itself to wire 601.

Relay AS operates and at its contacts prepares a second path for grounding wire 601.

At the end of the first pulse, when ground re-appears on wire 11, relay L re-operates and re-applies ground to relay H which remains operated. At this time, ground from contacts on relay L passes through make contacts 2 of relay H to wire 601 which is connected to the lower winding of relay P1 through break contacts 3 of relays P2 to P6, and through make contacts 3 of relay P1, locking relay P1 operated. Also, ground is removed from wire 401, opening the operate and first holding circuit of relay P1; opening the locking circuit of relay A; and opening the operating circuit of relay S. Relay A releases, relay P1 remains operated through its lower winding and relay S remains operated by virtue of its slow-release characteristics. When relay A releases, its break contacts 1 prepare an operate circuit for relay P2 on the start of the next interpulse.

It can be seen that each change-of-state of the signal appearing on wire 11 results in a different yet single relay operation occurring in the counting chain. For example, on seizure, relay A operated; on the start of the first pulse, relay P1 operated; and at the end of the first pulse, relay P1 restored. Therefore, the shortest pulse that can be received is limited by the speed of operation of a single relay P1 and the shortest inter-pulse interval that is permissible is limited by the release time of a single relay, relay
At any time that the relay L is held operated for an interval of time in excess of the hold-over time of relay S, all operated counting relays are restored and relay A is operated if not already in an operated position. This release of all counting relays indicates the end of a series of impulses.

It will be noted that operation of relay P5 from ground on wire 401 as a result of the beginning of the eleventh pulse will energize the alarm wire AL through contacts 1 of relay P6. The rectifier DR will preclude the holding ground of relay P5 from energizing the alarm wire during the receipt of the sixth pulse when relay P6 is first operated.

In summary, as regards relays A and P1 to P5, the counting chain illustrated in the drawing operates a new counting relay on the start of each pulse, releases the last operated relay at the end of each pulse and has only one counting relay operated at any one time. It is to be understood that the same principle could be employed in extending the counting chain to any desired number of counting relays. Also, the principle of employing a change-over relay to permit re-use of the counting relays could also be extended to apply to a counting chain for counting any desired number of impulses. Still further the principle of employing a change-over relay as a counting relay could be applied to chains arranged to count any desired number of pulses.

The point P, as hereinbefore noted could be selectively connected to either wire 101 or 201 and the output contact configuration associated with the unconnected one of the wire 101 or 201 could be eliminated from the disclosed counting chain. In this manner, a counting chain providing decimal output only, a two-out-of-five output only, or a combination thereof can readily be provided. In this respect, the terminals associated with the counting relay output contacts could be terminated on a terminal board and jumpering provided to convert the counting chain from one type of readout to the other without altering the relay internal wiring.

While I have described my invention in conjunction with specific apparatus and circuitry, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

1. An impulse counting circuit for counting the number of impulses in a series of received impulses, a chain of counting relays, means for operating and restoring said relays in response to said received series of impulses with only one counting relay being operated at the beginning and only one being released at the end of any received impulse, the operation of any relay being determinative of the shortest impulse capable of being counted by said circuit and the release time of any relay being determinative of the shortest inter-impulse interval of any series of impulses capable of being counted by said circuit.

2. An impulse counting circuit as set forth in claim 1 wherein means are provided on said counting relays for selectively indicating in decimal form, in coded form and in both decimal form and coded form, the number of received impulses.

3. An impulse counting circuit as set forth in claim 1 wherein the number of counting relays operated at any one time does not exceed two and wherein only one counting relay is operated at the end of any received impulse.

4. An impulse counting circuit as set forth in claim 1 wherein the operate time intervals of said relays is equal to the release time intervals of said relays.

5. An impulse counting circuit for counting the number of impulses in a series of received impulses, comprising a chain of counting relays, means for operating said relays in succession in response to received impulses with a separate relay operating during each impulse duration, means for successively restoring said relays in the order of their operation with a separate relay restoring during the interval following each received impulse after the second received impulse, whereby only one counting relay is in operated condition at the end of any received series of impulses.

6. An impulse counting circuit for counting the number of impulses in a series of received impulses, comprising a chain of counting relays each having an operate winding and a hold winding, means for closing an energizing circuit to the operate winding of said relays in succession in response to the start of each impulse, means for energizing the hold winding of each last operated relay in response to the end of each received impulse and for opening the last-closed energizing circuit, and means on each last-operated relay for maintaining the said operate winding thereof energized throughout the duration of the last received impulse.

7. An impulse counting circuit as set forth in claim 6 wherein the said means for closing an energizing circuit to the operate winding of any counting relay succeeding the first includes contact means on an immediately preceding counting relay.

8. An impulse counting circuit as set forth in claim 6 wherein the said means for opening the last-closed energizing circuit for the operate winding of any relay succeeding the first includes means for restoring the immediately preceding counting relay.

9. In an impulse counting circuit for counting the number of impulses in a series of received impulses, a chain of relays including a plurality of counting relays and a control relay, means for operating said control relay to prepare said counting relays for operation, means responsive to the start of each received impulse for operating a different one of said relays and means responsive to the end of each received impulse for restoring a different one of said operated relays whereby the number of operated relays of said chain does not exceed two and only one relay of said chain is operated at the end of said series of impulses.

10. An impulse counting circuit as set forth in claim 9 means responsive to the end of the impulse operating the last relay of said chain for re-operating said control relay and for maintaining said last relay operated, means responsive to the start of each impulse in excess of the number of counting relays for re-operating a different one of said restored relays, and means responsive to the end of each of the last-said impulses for restoring a different one of said re-operated relays.

11. An impulse counting circuit for counting the number of impulses in a series of received impulses, a chain of counting relays, means for operating the first relay of said chain responsive to the start of the first received impulse and for operating the second relay of said chain responsive to the start of the second received impulse, means for restoring said first relay responsive to the end of said second received impulse, and means for thereafter operating a different relay on the start of each succeeding received impulse and restoring the previously operated relay at the end of each received impulse, whereby the number of chain relays operated at any one time does not exceed two and wherein only one relay is operated at the end of any received impulse.

12. An impulse counting circuit for counting the number of impulses in a series of received impulses, a chain of counting relays fewer in number than the number of received impulses in a series, means for operating said relays in succession in response to a number of received impulses equal in number to said relays with a separate relay operating during each impulse interval of said incoming impulses, means for successively restoring said relays preceding the last in the order of their operation with a separate relay restoring during the interval following each received impulse after the second received
impulse, means for re-operating said relays in succession in response to received impulses greater in number than the number of relays with a separate relay operating during each impulse interval, and means for restoring said re-operated relays preceding the last re-operated relay whereby the last relay of the said chain and one additional chain relay are operated at the end of any received impulse greater in number than the number of chain relays.