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RELAY COUNTER

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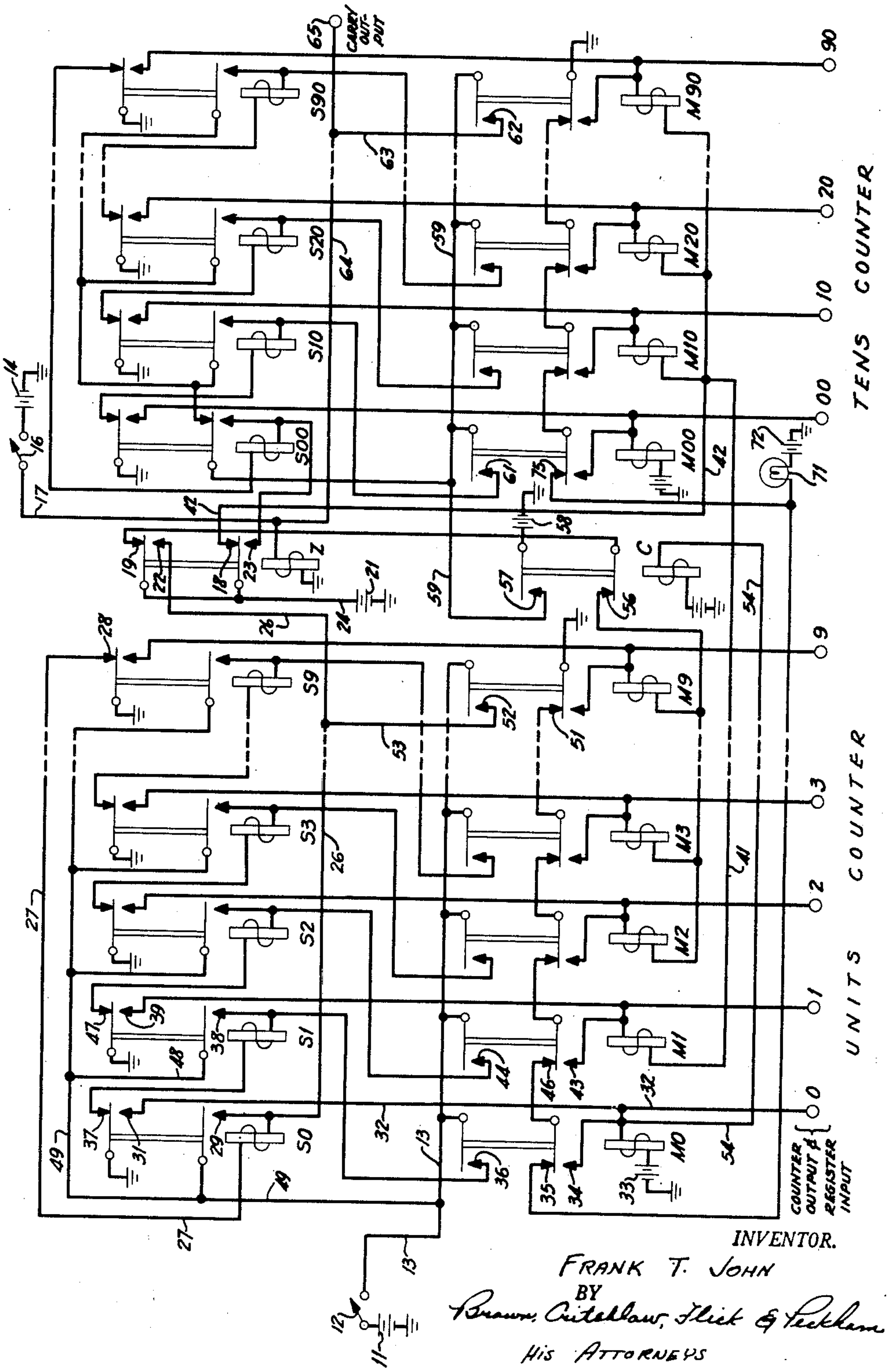

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RELAY COUNTER

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11 Claims. (Cl. 235—92)

It is among the objects of this invention to provide a counter that will count electrically any predetermined number of current pulses of random length occurring at random intervals in an impulse receiving circuit, that will store the count electrically and indicate the total count stored at any given moment, and that will indicate any loss of the stored count because of electrical or mechanical failure.

Still further objects of this invention are to provide a counter of the type referred to, which requires a minimum current drain on the power supply, which operates at a speed not limited by the circuit configuration but only by the characteristics of the electrical devices employed therein, and which is adapted to be used as a register and for inserting any predetermined figure in the counter before the start of the counting operation.

In accordance with this invention, the counter comprises at least one set of relays, each set including a series of impulse relays and an equal number of holding relays both types of relays arranged to operate successively in cyclic sequence. When any impulse relay is energized by a pulse of current in the impulse receiving circuit, its corresponding holding relay is also energized by a holding circuit, locking itself into that circuit and, at the same time, unlocking and disconnecting from that circuit the immediately preceding holding relay and making a potential connection between the next succeeding impulse relay and the impulse receiving circuit, so that the latter relay will be energized by the next pulse to be counted. In this way, successive pulses of current in the impulse receiving circuit energize the successive impulse relays in cyclic sequence. When more than one set of relays is used, provision is made for generating a new current impulse at the end of each cycle in each set and for transferring that impulse to the next set, so that the system can be adapted to count units, tens, hundreds, etc.

The accompanying drawing is a circuit diagram of a counter embodying this invention; this counter has a capacity for counting up to ninety-nine in the decimal system, which is sufficient to illustrate the operation of the device.

The circuit shows a set of units counting relays on the left and a set of tens counting relays on the right. Each set includes ten set-up or impulse relays, designated by the letter S followed by the numbers 0 to 9 in the units counting set and by the numbers 00 to 90 in the tens counting set. Each set of relays also includes a series of memory or holding relays, designated by the prefix M followed by the same number as that used to designate the corresponding impulse relay. It will be noted that there is one holding relay for each impulse relay in each set. To simplify the drawing, some of the intermediate relays in each set have been omitted, as indicated by the broken line circuit connections; but, since these intermediate relays are interconnected in the same manner as the other relays shown, their omission is not material to an understanding of this disclosure.

In the middle of the drawing, there is shown a zero

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reset relay Z and a carry relay C, the functions of which will be explained below.

All of the relays shown in the drawing include an energizing coil and two switches, each switch having an armature and a normally open or closed contact, the armatures of any one relay being mechanically linked together in the usual manner. All of the relays shown in the drawing are represented in their released positions, which are assumed when no current is flowing through their coils.

At the extreme left of the drawing, there is shown a source of current in the form of a battery **11**, one terminal of which is grounded and the other terminal connected through a pulsing switch **12** to a conductor **13**. For the purposes of this disclosure, the successive manual closings of the pulsing switch **12** represent the operations to be counted, but it will be understood that this switch, or any other equivalent device for generating current pulses, can be made responsive to the occurrence of any other operations that it may be desired to count. Upon each closing of the pulsing switch, a pulse of current will be delivered to the impulse receiving circuit, which includes the conductor **13** and the various impulse relays in the units counting set that are successively connected in that circuit as hereinafter described.

Before the system is ready to count pulses in the impulse receiving circuit, it is necessary to energize momentarily the zero reset relay Z for the purpose of clearing any count already stored in the device and for initially energizing the zero holding relays M0 and M00. A battery **14** (located at the top center of the drawing), having one of its terminals grounded and the other connected to a manual switch **16**, supplies the current for energizing the zero reset relay Z through a conductor **17** when switch **16** is closed. When relay Z is energized, its normally closed contacts **18** and **19** are opened. The opening of contact **19** disconnects the holding relays M2 to M9, inclusive, in the units counting set from a holding circuit, which has a source of current represented by a battery **21** (located near the zero reset relay). If any of those holding relays should happen to be energized, storing the count of a previous operation of the device, they are now released. Similarly, the opening of contact **18** disconnects from the holding circuit the holding relays M10 to M90 in the tens counting set, and also holding relay M1 in the units counting set. However, the opening of the foregoing contacts **18** and **19** does not affect the configuration of holding relays M0 and M00, which, if they are not already energized, will now be energized through the closing of normally open contacts **22** and **23**, respectively, of relay Z. Relay M0 is so energized in the following manner: current flows from the battery **21** through a conductor **24**, now closed contact **22**, and a conductor **26** to the coil of impulse relay S0 in the units counting set; the other side of that coil is connected to ground through a conductor **27** and the normally closed contact **28** of relay S9; relay S0 is accordingly energized and the armatures of its two switches move down, closing their normally open contacts **29** and **31**; with the closing of contact **31**, current flows from ground through a conductor **32** to the coil of holding relay M0, which is also connected to the ungrounded terminal of a battery **33**.

As relay M0 is energized, the armatures of its two switches move down to close their normally open contacts **34** and **36**. With the closing of contact **34**, the coil of relay M0 secures an additional connection to ground through the normally closed contacts of the lower switches of the succeeding holding relays M1 to M9. That additional connection locks relay M0 in the holding circuit after relay S0 is released by the release of relay Z on the opening of switch **16**. In similar fashion, the closing of contact **23** of the zero reset relay Z will energize impulse relay S00 and holding relay M00 in the tens counting set, and the latter relay will be locked in the holding circuit in the same manner as relay M0.

When the system has been reset to zero, as above described, by closing and opening switch 16, it is ready to count the pulse imputs produced in the impulse receiving circuit by successive closings of pulsing switch 12. With the first pulse input, current flows from battery 11 through conductor 13 and the now closed contact 36 of holding relay M0 to the coil of impulse relay S1, which is also connected to ground through normally closed contact 37 of relay S0. Relay S1 is now energized, and its normally open contacts 38 and 39 are closed. The closing of contact 39 connects one side of the coil of relay M1 to ground, the other side of that coil being connected through conductors 41 and 42 and now closed contact 18 of zero reset relay Z to the ungrounded terminal of battery 21. Relay M1 is accordingly energized when relay S1 is energized.

With the energizing of relay M1, the armatures of its two switches move down to close normally open contacts 43 and 44 and to open normally closed contact 46. The closing of contact 43 locks relay M1 in the holding circuit; and the closing of contact 44 connects one side of the coil of relay S2 with the impulse receiving circuit. The other side of that coil, however, is not connected in that circuit, and relay S2 is not energized, so long as relay S1 remains energized and its normally closed contact 47 remains open (as it does until the end of the first pulse input). The opening of the contact 46, when relay M1 is energized, disconnects holding relay M0 from the holding circuit. As that relay is released, it opens contact 36, through which relay S1 initially received current from the impulse receiving circuit. As soon as it was energized, however, relay S1 connected itself in that circuit through an alternate conductor path represented by its closed contact 38 and by conductors 48 and 49. This alternate connection of relay S1 to the impulse receiving circuit is a locking connection that keeps relay S1 energized so long as a pulse of current is flowing in the impulse receiving circuit. The purpose of this locking connection is to keep contact 47 open for the duration of the first pulse input so that relay S2 cannot also be energized by that pulse.

When pulsing switch 12 is opened, the first pulse input ends. Relay S1 is then released, but relay M1 remains energized, because of the holding circuit connection through its closed contact 43. Its normally open contact 44 is also closed, as is contact 47 of relay S1, thereby connecting impulse relay S2 to the impulse receiving circuit. Relay S2 will accordingly be energized when the second pulse input is generated by the second closing of pulsing switch 12.

From the foregoing description and from the circuit diagram, it will be clear that as each successive impulse relay S1, S2, S3, etc. in the units set, is energized by successive pulses in the impulse receiving circuit, a corresponding holding relay M1, M2, M3, etc. will also be energized and lock itself into the holding circuit, at the same time disconnecting the preceding holding relay from the circuit and partially connecting the next subsequent impulse relay in the impulse receiving circuit, that partial connection being completed only when the preceding impulse relay is released at the end of the pulse input. In other words, each successive pulse input in the impulse receiving circuit operates successive impulse relays in numbered sequence in the units set of relays, and the accumulated units count is stored in a corresponding memory or holding relay, which is locked in a separate holding circuit until the next pulse inpuet actuates the next impulse relay and the new count is stored in the next holding relay.

At the end of the first nine pulses in the impulse receiving circuit, relay M9 will alone be energized (storing the units count of nine) in the units set of relays; and its contacts 51 and 52 will be closed. When the tenth pulse imput occurs, current will flow through conductor 13, closed contact 52, and conductors 53 and 26 to energize relay S0 in the same way as it was previously energized by current flowing in conductor 26 when the zero reset relay Z was operated by the closing of switch 16. Holding relay M0 will then be energized and the first cycle in the units counter will have been completed. At the same time, the current flowing in conductor 32 that energizes relay M0 will also flow through a conductor 54 to energize the carry relay C, opening its normally closed contact 56 and closing its normally open contact 57. The opening of contact 56 disconnects relay M9 from the holding circuit. With the closing of contact 57, a new current pulse flows from a battery 58 through a conductor 59 and closed contact 61 of holding relay M00 (which was energized by the zero reset relay Z at the beginning of the operation described herein) to energize relay S10 in the tens counting set of relays. Similarly, on each subsequent tenth pulse in the impulse receiving circuit controlled by pulsing switch 12, a new pulse of current will be generated by the carry relay C and delivered to the second set of relays through conductor 59, and those relays will be energized in the same way and in the same cyclic sequence as those in the units set.

When ninety-nine pulses have been counted, relay M9 in the units counting set and relay M90 in the tens counting set will both be energized. The next pulse input produced by pulsing switch 12 will operate the carry relay C, thereby resetting the units counting set to zero as already described. Relay C will also deliver a tenth new pulse to conductor 59 in the tens counting set. Since relay M90 in that set is energized and its normally open contact 62 is now closed, this new pulse will be routed through conductors 63 and 64 to the zero reset relay Z. The energizing of that relay will reset the relays in the tens counting set to their zero positions, as previously described. The entire system will accordingly be reset and made ready to count a new cycle of operations on each tenth pulse generated by carry relay C.

For counting to numbers higher than ninety-nine, the last described pulse in conductor 64, which is the tenth pulse generated by the carry relay C and occurs on every one-hundredth closing of switch 12, can be routed through a terminal 65 to a third set of hundreds counting relays similar to those in the second set. And it will be clear to those skilled in the art that still further sets of relays may be cascaded to increase the counting capacity of the system to any desired figure.

The lower armature of each holding relay in both sets is shown in the drawing in the normally raised position that is assumed when the coils of the respective relays are deenergized. However, when the system is in operation, one holding relay in each set will always be energized, except when mechanical or electrical failure, or in some cases the receipt of an improper pulse input, may create a condition in which all of those relays are in their released positions. Should that condition occur, provision is made for warning the operator by a signalling device, such as an error light 71, in a circuit that is closed only when all of the holding relays in either set are deenergized. Such a circuit is shown in the drawing, where the light 71 is connected to a source of current 72 in series with the lower armatures of the holding relays in each set when those armatures are in their raised positions. It is a feature of this invention that this error-indicating function is carried out without the use of any relay armatures or contacts in addition to those required to carry out the normal counting operations of the system, except contacts 35 and 75 of relays M0 and M00, respectively.

As previously stated, the total count at any given time is stored in one of the memory or holding relays in each set. To indicate that count, ten output terminals are provided (extending across the bottom of the drawing) for each set of relays, numbered 0, 1, 2, etc., for the unit sets and 00, 10, 20, etc., for the tens sets. Each output terminal is connected to a conductor in the holding circuit of the correspondingly numbered holding relay and the conductor is connected to ground when that relay is energized, first through the upper switch of the corresponding impulse relay and then through the locked lower switch of the holding relay. It will be obvious that each output terminal can be connected to an external circuit, including an appropriate indicating device, which will indicate the stored count at any given moment in each set of relays.

It is an advantage of this invention that the counter circuit herein described is particularly suited to being used as a storage register. For this operation, the zero reset relay Z is not closed, as it is before the start of the normal counting operation, and all of the relays in each set are initially in this released position. The proper count is entered in each set of relays by an input pulse from an external circuit delivered to one of the output terminals referred to above. For example, if it is desired to register a count of three in the counter, that operation may be carried out by a single input pulse from an external ground source to the terminal **3**. That pulse will energize the holding relay M3, which will then lock itself in the holding circuit; and the counter will then count additional pulses produced by pulsing switch **12**. Of course, the same count of three could be stored in the system by operating the zero reset relay, as previously described, and following that operation by three successive closings of the pulsing switch **12**.

It is a further advantage of this invention that there is a minimum amount of current drain on the power supply during the operation of the counter. Before receiving the starting impulse from the zero reset relay Z, no current at all is required by the system, despite the fact that the operations to be counted, represented by successive closings of the pulsing switch **12**, may be going on. Until one of the holding relays is first energized and locked in the holding circuit, pulsing switch **12** can be repeatedly closed without affecting any relay in the system or causing any current to flow in the impulse receiving circuit. During the operation of the device, the storage of the accumulated count at any time exacts a maximum current drain from the holding circuit equal to the requirements of only one relay in each set of relays. Likewise, the maximum current drain on the impulse receiving circuit is limited to that required for operating one impulse relay in the units set.

It is a still further advantage of the invention, as will be apparent to those skilled in the art, that the speed with which the counter operates is limited only by the type of relays used in the circuit and not by the circuit itself. Moreover, the pulses being connected can be of random length separated by random intervals, because only one impulse relay on any set is energized during the continuance of any pulse input, and because the count at any given time is stored during the interval between pulses in a holding relay that is locked in a separate holding circuit until the next pulse input is received.

It will be noted that the coil of holding relay M1 is connected to battery **21** through conductors **41**, and **42** and normally closed contact **18** of zero reset relay Z, while the subsequent holding relays M2 to M9 in the units set are connected to the same source of current through normally closed contact **56** of carry relay C. The reason for providing a different connection for relay M1 is that holding relay M0 and carry relay C remain energized, and contact **56** of the latter relay remains open, until relay M0 is unlocked from its holding circuit by the energizing of relay M1. Therefore, relay M1 will not operate unless it is connected to its holding circuit by a conductor path that is independent of the configurations of relay M0 and carry relay C.

While the counter circuit herein described is adapted to count in the decimal system, it will be understood that this invention is equally adapted to count in any other system of numeration by using an appropriate number of impulse and holding relays in each set of relays, and by cascading the necessary number of sets.

It will be apparent to those skilled in the art that the functions of the carry relay C in unlocking holding relay M9 at the end of each cycle in the units counter and at the same time generating a new current pulse and transmitting it to the tens counter may be performed with equal effectiveness by holding relay M0, because carry relay C and holding relay M0 are both energized and locked in the holding circuit at the same time and are both released at the same time. Accordingly, if the two switches of relay C are added to those of relay M0, the opening and closing of contacts **56** and **57**, functions previously carried out by carry relay C, will be performed at the same times and for the same purposes by relay M0.

Similarly, the functions of zero resetting relay Z in releasing holding relay M90 and in energizing impulse relay S00 on each hundredth pulse input to the impulse receiving circuit (i. e., on each tenth pulse generated by the units counter set) can be equally well carried out by holding relay M00, provided conductor **64** is connected to the coil of impulse relay S00 and the lower switch of relay Z is transferred to holding relay M00. Relay S00 will then be energized on the tenth pulse received by the tens counter set and will in turn energize relay M00; and the added switch of the latter relay will then open contact **18**, to disconnect battery **21** from the holding relay M90. However, zero resetting relay Z would still be used, when it is desired to clear the counter after any intermediate count had been completed, i. e., a count of less than one hundred, as for example, at the beginning of a new counting operation.

As used in the appended claims, a cylic series of relays refers to a plurality of relays arranged to operate successively in endless or cyclic sequence, i. e., after all of the relays in the series have been energized successively the first relay is again energized and the cycle is repeated.

According to the provision of the patent statutes, I have explained the principle of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. A counter for counting electrical impulses in an impulse receiving circuit, comprising a cyclic series of impulse relays, a cyclic series of corresponding holding relays equal in number to the number of impulse relays, a holding circuit, means controlled by each impulse relay and operable when that relay is energized for initially connecting the corresponding holding relay in the holding circuit, means controlled by each holding relay and operable when that relay is initially energized for locking that relay in the holding circuit and for unlocking and disconnecting the next preceding holding relay from that circuit, and means controlled by each impulse relay and its corresponding holding relay and operable when the former is deenergized and the latter is energized for connecting the next succeeding impulse relay in the impulse receiving circuit, whereby after one of the holding relays is initially energized successive current impulses in the impulse receiving circuit will energize successive impulse relays in cyclic sequence and the completed count at any time in each cycle will be indicated by the energized state of the holding relay corresponding to the impulse relay that was last energized.

2. A counter according to claim 1 that also includes means for initially energizing one of the holding relays

corresponding to a predetermined count before the counting operation is started.

3. A counter according to claim 1 that also includes a resetting means for unlocking and disconnecting from the holding circuit all but one of the holding relays and for connecting that one holding relay corresponding to a zero count in the holding circuit, whereby the next subsequent impulse relay corresponding to a unit count of one will receive the next pulse input in the impulse receiving circuit to begin a new counting cycle.

4. A counter for counting electrical impulses in an impulse receiving circuit, comprising a cyclic series of impulse relays, a cyclic series of corresponding holding relays equal in number to the number of impulse relays, each relay having an energizing coil controlling at least one switch that occupies an energized position when the coil is energized and a released position when the coil is deenergized, a holding circuit, the coil of each impulse relay being connected in the impulse receiving circuit in series with a switch in its released position of the next preceding impulse relay and a switch in its energized position of the holding relay corresponding to the next preceding impulse relay, the coil of each holding relay being initially connected in the holding circuit through a switch in its energized position of the corresponding impulse relay and remaining connected therein in holding circuit relation in series with its own switch in its energized position and a switch in its released position of the next succeeding holding relay, whereby successive impulses in the impulse receiving circuit will energize successive impulse relays in cyclic sequence and the completed count in any given cycle at any time will be indicated by the energized state of one of the holding relays.

5. A counter according to claim 4, in which the coil of each impulse relay when connected in the inmpulse receiving circuit and initially energized by a current pulse therein remains connected in that circuit and energized thereby for the duration of said pulse through its own switch in its energized position in series with a switch in its released position of the next preceding impulse relay.

6. A counter according to claim 4 that also includes an electrical circuit that is closed only when the switches of all of the holding relays are in their released positions and electrically operated warning means connected in said circuit, whereby if none of the holding relays is energized at any time during the counting operation, resulting in the loss of the completed count in a given cycle, the warning means will be energized to indicate that fact.

7. A counter according to claim 4, in which the coil of each holding relay with the exception of the first and last holding relays of the series is additionally connected in series with switch means controlled by the last holding relay of the series and is energized by the holding circuit only when the last holding relay of the series is deenergized.

8. A counter for counting electrical impulses in an impulse receiving circuit, comprising a series of impulse relays arranged to operate successively in cyclic sequence upon the occurrence of each current pulse in the impulse receiving circuit, a series of corresponding holding relays equal in number to the number of impulse relays and arranged to operate successively in cyclic sequence, a holding circuit, switch means controlled by each impulse relay when that relay is energized by a pulse of current in the impulse receiving circuit for locking that relay in the impulse receiving circuit for the duration of that pulse and for initially connecting the corresponding holding relay with the holding circuit to energize that holding relay and for disconnecting the next subsequent impulse relay from the impulse receiving circuit for the duration of that pulse, and switch means controlled by each holding relay when that relay is energized for locking that relay in the holding circuit and for unlocking and disconnecting the next preceding holding relay from that circuit and for connecting the next subsequent impulse relay to relieve the next subsequent current pulse in the impulse receiving circuit.

9. A counter according to claim 8, which includes a resetting relay and switch means controlled by that relay for unlocking and disconnecting from the holding circuit all but one of the holding relays and for connecting that one holding relay with the holding circuit, whereby the next subsequent impulse relay will receive the next pulse input in the impulse receiving circuit to begin a new counting cycle.

10. A counter for counting electrical impulses in an impulse receiving circuit, comprising a first series of impulse relays and corresponding holding relays arranged to operate successively in cyclic sequence, a holding circuit, switch means controlled by each impulse relay when that relay is energized by a pulse of current in the impulse receiving circuit for locking that relay in its energized position for the duration of that pulse and for connecting the corresponding holding relay with the holding circuit to energize that holding relay and for disconnecting the next subsequent impulse relay from the impulse receiving circuit for the duration of that pulse, switch means controlled by each holding relay when that relay is energized for locking that relay in the holding circuit and for unlocking and disconnecting the next preceding holding relay from that circuit and for connecting the next subsequent impulse relay to receive the next subsequent current pulse in the impulse receiving circuit, cycle impulse generating means controlled by one of the relays of the first series for generating a secondary current pulse when a cycle has been completed in the first series of relays, a second series of impulse and holding relays similar to the first series, switch means controlled by each impulse relay of the second series when that relay is energized by a secondary current pulse for initially connecting the corresponding holding relay of that series with the holding circuit and for disconnecting the next subsequent impulse relay of that series from the secondary pulse generating means for the duration of said secondary pulse switch means controlled by each holding relay of the second series when that relay is energized for locking that relay in the holding circuit and for unlocking and disconnecting the next preceding holding relay of that series from that circuit and for connecting the next subsequent impulse relay of that series to receive the next subsequent current pulse from the impulse generating means of the first series, whereby the number of impulse relays energized in the second series will be a function of the number of cycles completed in the first series.

11. A counter according to claim 10, which includes a relay and switch means controlled by that relay for unlocking and disconnecting from the holding circuit all but one of the holding relays in each series and for connecting that one holding relay in each series with the holding circuit, whereby a new counting cycle will begin in each series.

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