

April 18, 1944.

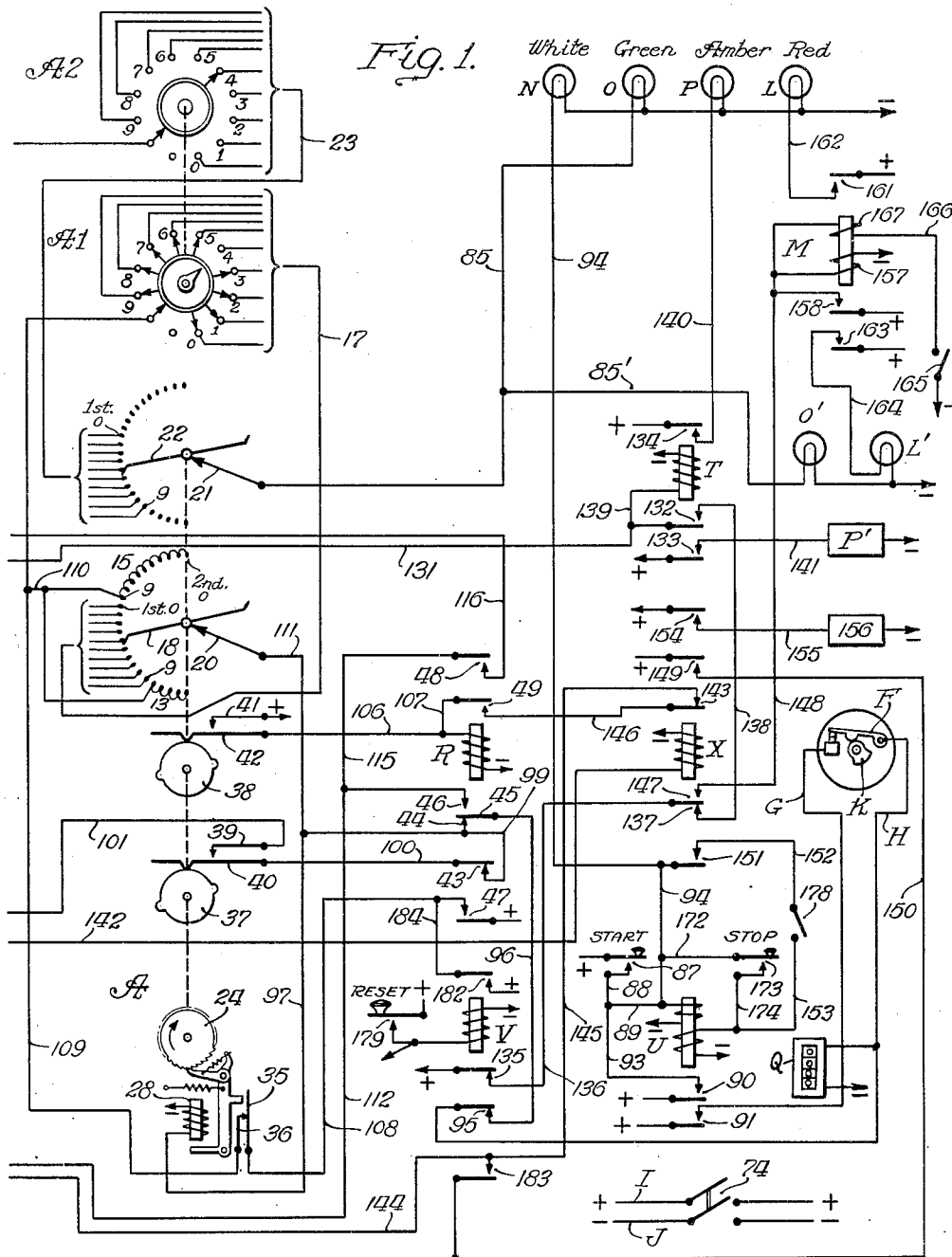
F. A. POOLE

2,346,869

PREDETERMINED COUNTER CONTROL

Filed Oct. 17, 1941

5 Sheets-Sheet 1



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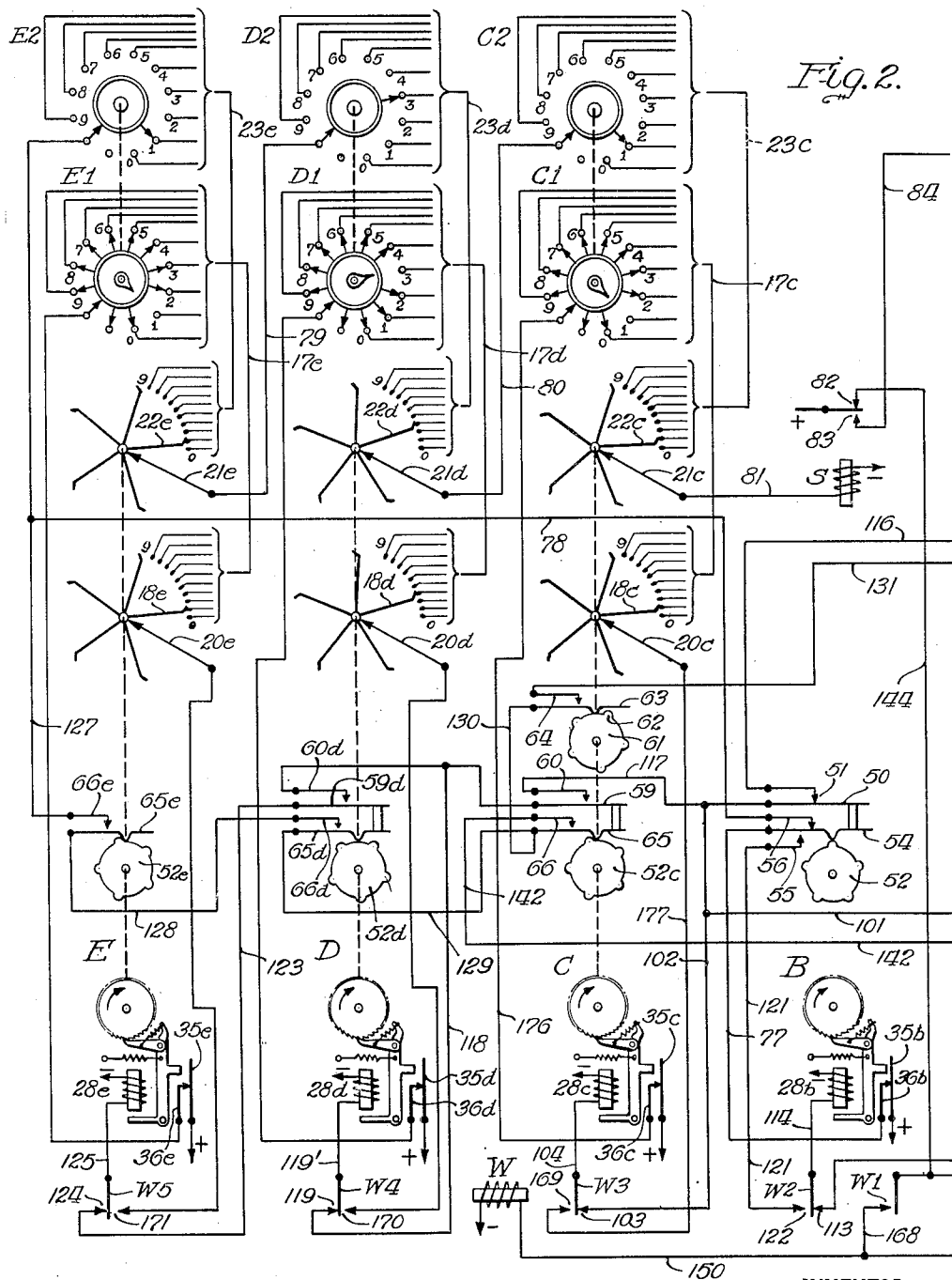
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5 Sheets-Sheet 2



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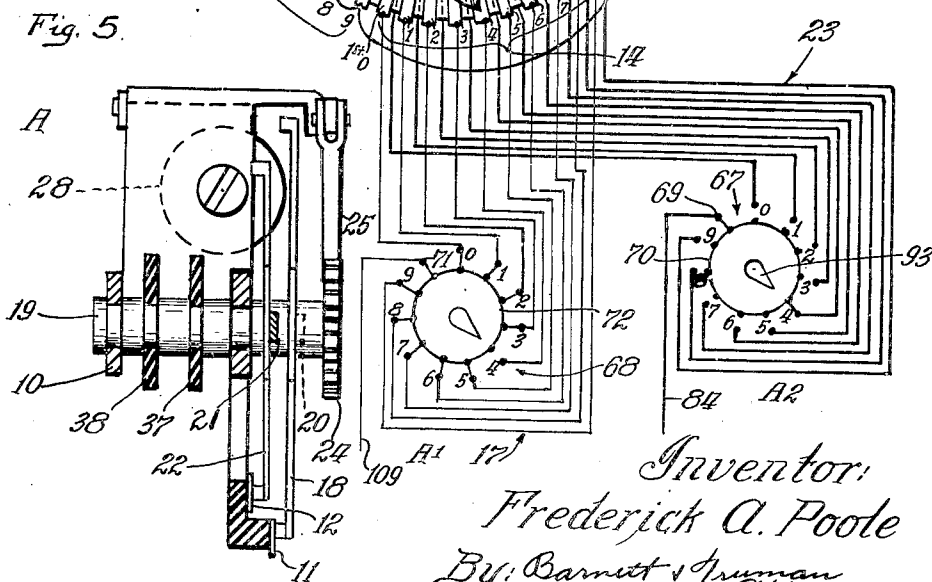
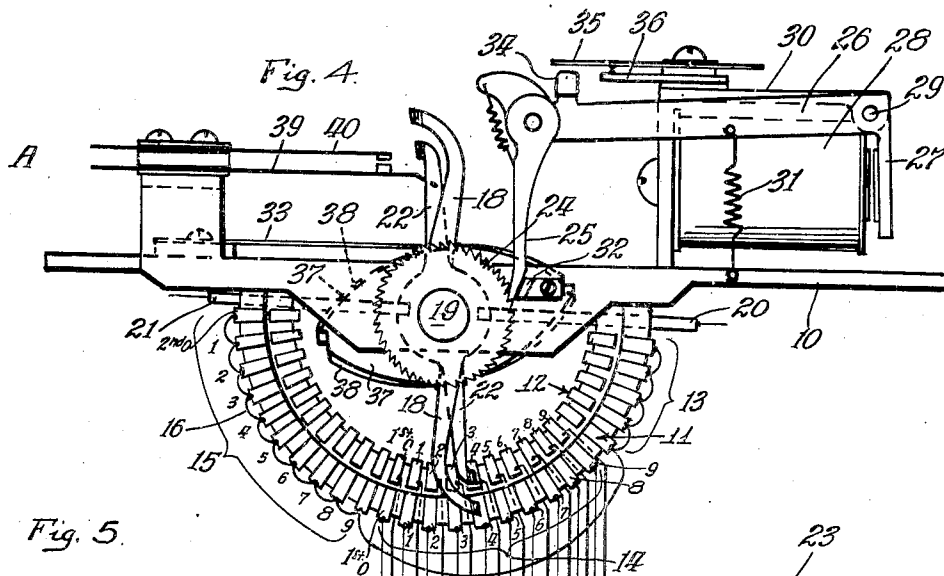
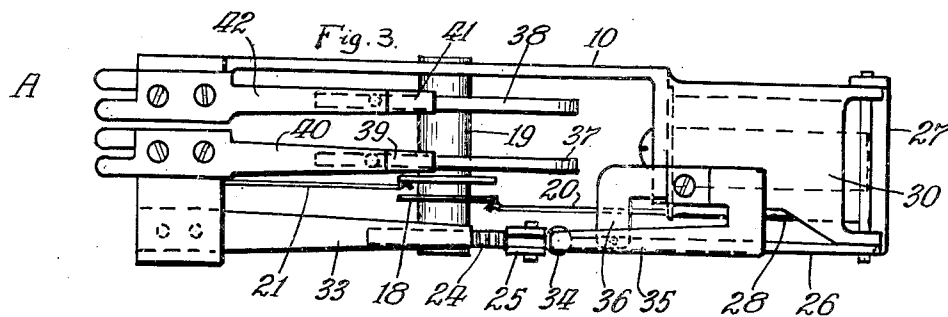
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PREDETERMINED COUNTER CONTROL

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5 Sheets-Sheet 3



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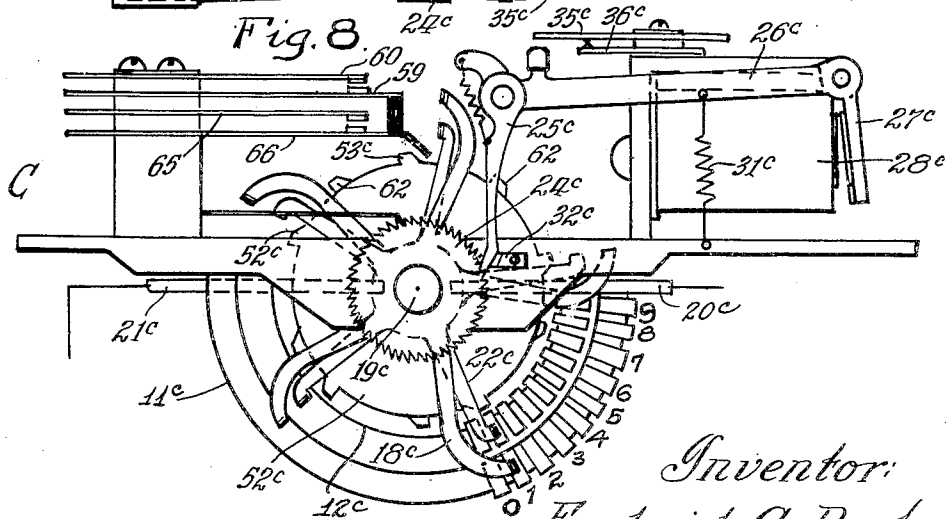
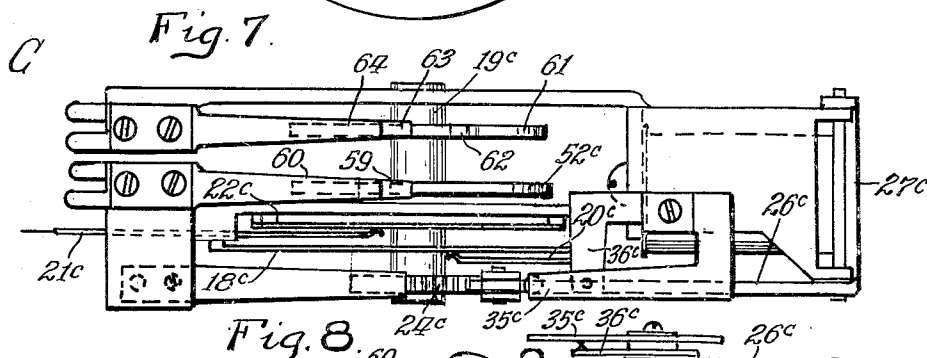
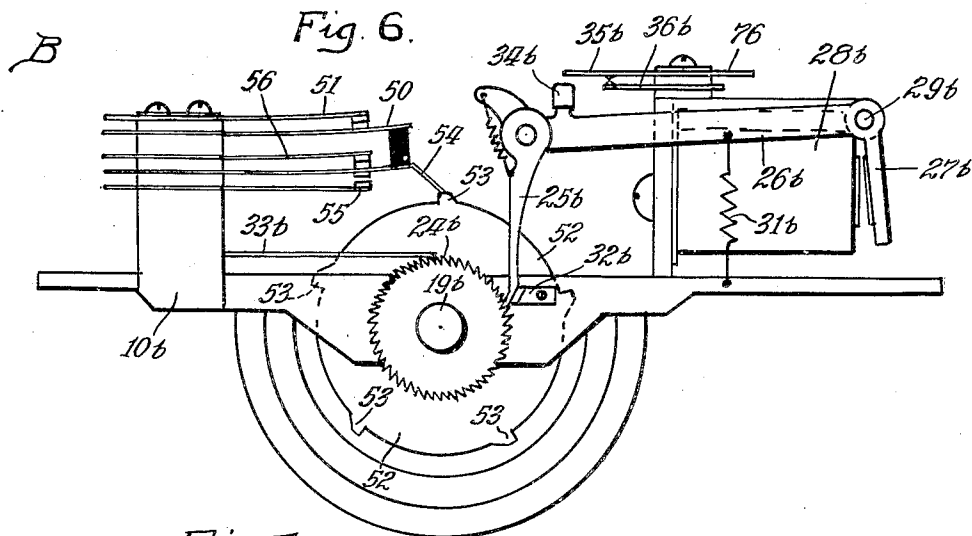
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PREDETERMINED COUNTER CONTROL

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5 Sheets-Sheet 4



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2,346,869

PREDETERMINED COUNTER CONTROL

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Fig. 9.

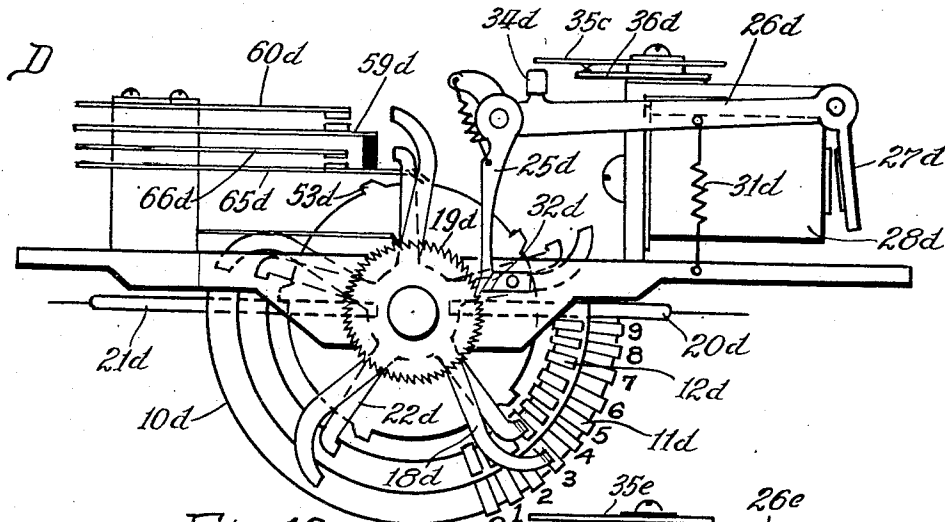
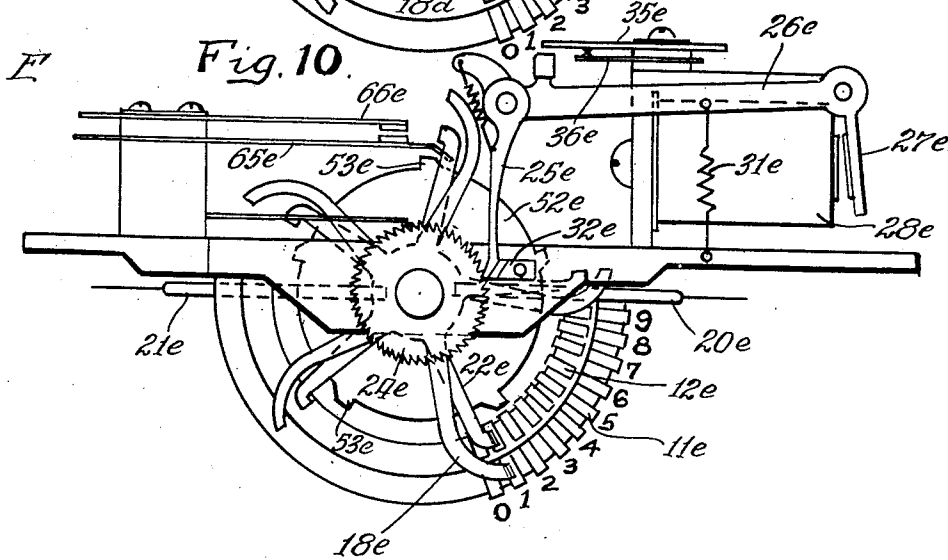


Fig. 10



UNITED STATES PATENT OFFICE

2,346,869

PREDETERMINED COUNTER CONTROL

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28 Claims. (Cl. 177—311)

This invention relates to a control apparatus adapted, upon the completion of its responses to a series of separate actuating forces, to close a signal and/or control circuit for a shop machine or other mechanism whose performance is being controlled.

The principal object of the invention is to provide an apparatus of the above character which repeatedly counts groups of predetermined numbers of electrical impulses out of a continuous series of impulses.

Another object is to provide, during such continuous series of impulses, means for resetting the counters without interfering with the continuous reception of impulses.

A further object is to provide means so operative that, during such continuous series of impulses, the predetermined number of impulses in a succeeding group may be changed while counting the preceding predetermined group without interfering with the count of either group.

The control apparatus of the present invention operates on the principle of a predetermined counter in that it may be set to perform a predetermined number of separate operations and thereafter discontinue such operations. It may be described briefly as follows:

A series of counter switches A, B, C, D, E, etc., are set by means of cooperative manually operated selector switches A¹, C¹, D¹ and E¹, etc., to operate a predetermined number of times in response to energizing electrical impulses. The switch A responds to the units and tens impulses. Switch B responds to all subsequent impulses. The switch C responds once for each ten impulses, the switch D responds once for each hundred impulses and the switch E responds once for each thousand impulses. As many additional switches may be added to the apparatus as may be necessary or desirable for higher order numerals than are shown in the specific form of the device herein illustrated. The electrical impulses are produced by opening and closing a circuit breaker F interposed in the wires G—H for directing current from the main line I—J to the various counter switches. The circuit breaker F is operated by means of a shop machine K or other device whose operations are being counted or otherwise controlled. The opening of the electrical circuit G—H may be of considerable duration or merely momentary, depending upon the speed of operation of the machine K. However, for the purpose of brevity, each closing of the circuit in wires G—H will be hereinafter re-

ferred to as an electrical impulse regardless of the duration of such energization.

The counter-switch A is referred to herein as the "odd units" counter. This term is used merely for the purpose of convenience to designate the counter-switch which responds to the number of electrical impulses corresponding to the digit in the unit position of any selected setting of the apparatus. Theoretically, its operation may take place either at the beginning or at the end of the count of a selected number of impulses, depending primarily, but not necessarily, upon whether the count ascends from zero to a designated setting, or descends from the particular setting to zero.

The "odd units" counter has two important functions. First, it responds to a sufficient number of the electrical impulses being counted, whereby the other portion or the remainder, as the case may be, of the original number, can be accurately counted in groups of ten impulses each. Second, it divides the counters into two parts and makes it practicable to return either portion of the apparatus to its pre-set position while the other portion is counting, for example, while the higher order counter switches are counting, the odds units switch is reset in readiness to start the count of a following series, and while the odd units counter is counting the units of a following series, the higher order counters are reset in readiness to count their respective orders in the said following series.

In practice, it is found desirable to utilize the "odd units" counter not only to count the number of electrical impulses corresponding to the digit in the units position of any selected setting of the apparatus, but to also include in its count, one full group of ten impulses.

The counting of both the units pulses and one group of tens pulses by the odd units counter switch of a following series of impulses gives ample time to complete the resetting operation of the higher order counters before they are required to begin counting.

In the embodiment herein shown, the apparatus is constructed to count down from a pre-set position to zero. The "odd units" counter switch A, therefore, responds to the number of electrical impulses corresponding to the digit in the unit position of the particular setting and then continues to count the next group of ten electrical impulses. At this point in the operation the counter-switch A is automatically cut out of the impulse circuit G—H and is reset to its starting position. All subsequent electrical impulses are

directed to the regular units counter B. The counter B responds to all the impulses after the odd units switch A has completed its count and therefore usually responds to many more impulses than the other counting switches. Switch B has therefore been designed for substantially continuous duty and only operates cam springs once per ten impulses instead of operating wipers over bank contacts which are subject to wear from continuous use. This is considered an important commercial feature of the invention. Considering again this operation in connection with the particular setting of the apparatus as herein illustrated: The apparatus is illustrated as being set to operate 1,314 times. The counter-switch A, therefore, will operate four times, corresponding to the digit in the units position of the particular setting and then continue to respond to the next group of ten impulses, making a total count of fourteen impulses before the count is taken over by the regular units counter B. At each operation corresponding to a zero an electrical impulse is transmitted to one or more counter-switches of higher order.

When the counter-switches B, C, D, E, etc., have completed their required number of operations, a switch is closed to automatically return them to their initially set position. At this time an appropriate signal L is given together with the closing of an electric circuit through one side of a differential relay M. The closing of the circuit through said relay M energizes a suitable signal or operates mechanism to stop the machine K or perform such other operations as may be suitable or desirable in connection with the control operation.

In addition to the giving of a final signal and the operation of a control circuit, the apparatus is preferably provided with a permanent signal N in the form of a white light, which remains energized throughout the entire operation of the apparatus, a green light signal O which is energized only when all counter switches are in their pre-set positions, and a signal P in the form of an amber light. The amber light P is preferably energized a short time before the completion of the full series of counts for which the apparatus is set so that the operator or supervisor may have an opportunity to observe and check the results before the full series of operations are completed.

The apparatus also includes, preferably, an electrical counter Q which is operated by the electrical impulses from the impulse circuit G—H. By means of the counter Q in combination with the various signals O, P and L, the operation of the apparatus can be accurately checked from time to time.

A further object of the invention is to provide a control apparatus constructed and operating as above briefly described and including the various other devices and combinations shown in the accompanying drawings and described more in detail in the specifications which follow.

In the drawings:

Figs. 1 and 2 illustrate the wiring diagram of the control apparatus.

Fig. 3 is a plan view of the counter-switch A.

Fig. 4 is a side view of the counter-switch A together with diagrammatic showings of its counting selector switch A¹ and its associated signal selector switch A².

Fig. 5 is a vertical section through the counter-switch shown in Fig. 4.

Fig. 6 is a side view in elevation of the regular units counter-switch B.

Fig. 7 is a plan view of the tens counter switch C.

Fig. 8 is a side elevation of the tens counter switch, and

Figs. 9 and 10 are similar views in side elevation of the hundreds and thousands counter-switches D and E.

Referring first to Figs. 3, 4 and 5 illustrating the counter-switch A: The switch comprises a frame 10 on which are suitably secured, in semi-circular arrangement, two rows of fixed contact members. Each of said rows consists of twenty-five fixed contacts which are arranged into three groups 13, 14 and 15. The contacts of row 11 are used in connection with a resetting circuit which is closed, as hereinafter described, to return the counter switch to a pre-set position in readiness to begin another series of operations. The contacts of row 12 are used in connection with the circuit for the green light signal O.

Inasmuch as the contacts of group 13 in row 11 do not correspond to any portion of the number for which the apparatus is set, these contacts are not individually identified. The ten contacts composing the group 14 of row 11 are numbered 9 to 1st 0 (first zero). The ten contacts composing the group 15 of row 11 are numbered 9 to 2nd 0 (second zero). All contacts in groups 13 and 15 of row 11 are electrically connected with each other by means of a wire 16. The contacts of group 14 are connected individually with correspondingly numbered contacts (9 to 1st 0) of selector switch A¹. The conductors for effecting these connections are not individually numbered, but are designated collectively by the numeral 17. A wiping contact member 18 composed of a central portion and oppositely extending arms is suitably fixed to a revoluble shaft 19 so that it will engage, successively, each of the fixed contacts in row 11, during each one-half revolution of the wiper. A line wire contact 20 has constant wiping engagement with the central portion of the wiper and is thereby electrically connected, through the arms of the wiper, with the several fixed contacts of said row 11.

The group 14 of fixed contacts in said row 12 are, as before indicated, used in connection with the circuit for the green signal O. The contacts composing groups 13 and 15 of row 12 do not perform any special function in the present circuit for signal O and therefore do not require further detailed description. However, the contacts of group 14 in row 12 correspond to the similar contacts in row 11 and should be regarded as having the same value of 9 to 1st 0. They are electrically connected, successively, to a line wire contact 21 by means of a rotating wiper contact 22 fixed to the shaft 19. They are also individually connected to similarly numbered contacts of the signal selector switch A². The wires for effecting these connections are not individually numbered, but are designated collectively by the reference numeral 23.

The rotating wipers 18 and 22 are operated simultaneously in a step by step movement by imparting intermittent operations to the shaft 19. This movement is obtained by means of a ratchet wheel 24, having fifty teeth, fixed to one end of the shaft 19 for engagement with a pawl 25. The said pawl is pivotally supported at one end of an arm 26. The said arm is formed in-

tegral or otherwise suitably fixed to a pivoted armature 27 of an electro-magnet 28. The armature 27 and arm 26 are pivotally supported at 29 to a portion 30 of the frame 10. It will be observed, therefore, that the energization of the electro-magnet 28 attracts the armature 27 and therefore raises the outer end of the arm 26. This movement of the arm elevates the pawl 25 the height of one ratchet tooth. When the electro-magnet is de-energized the pawl 25 is moved downwardly by means of a spring 31. A stop member 32 is secured to the frame in a position to engage the lower end of pawl 25 at the limit of its downward movement so as to limit the movement of the ratchet wheel to the amplitude of one tooth thereof. Reverse movement of the ratchet wheel 24 is prevented by means of a spring detent 33 mounted on the frame 10 and engaging the teeth of the ratchet wheel.

A buffer 34 of insulating material is carried on the arm 26 so that it will engage and separate the spring contact 35 from its associated contact 36 and thereby make and break the previously mentioned re-setting circuit each time the arm 26 is raised.

The numerals 37 and 38 designate cam elements made of insulation and secured to the rotating shaft 19, in predetermined angular relation to each other and to the rotating wipers 18 and 22. Both cams are of identical shape and are so formed as to close their respective switch contacts 39-40 and 41-42 only momentarily. The cam 37, however, is positioned one step or impulse in advance of the cam 38 and is so positioned relative to the rotating wiper 18 that the movement of the wiper (under the influence of spring 31) onto the No. 1 contact of group 15 is simultaneous with the movement of the cam into a position to close contacts 39-40. The cam 38 is set to close contacts 41-42 when an arm of the said wiper 18 engages the second zero fixed contact in row 11.

In regard to the function of contacts 39-40 it will be sufficient to say, without tracing the circuits at this time, that the fourteenth impulse for the present setting of the apparatus, will energize the electro-magnet 28 of counter switch A and will also pass through the switch contacts 39-40 to energize a similar electromagnet 28^c of counter switch C. This impulse, when operative, has a double action in that it energized the actuating magnets 28 and 28^c, respectively, of the counter switches A and C. In this respect it can be regarded as a delayed transfer, to the tens counter switch C, of the impulse corresponding to the first zero in the operation of the counter switch A.

Immediately following the double action of the last mentioned impulse, both counter switches A and C are advanced one step by the action of similar springs 31-31^c. This one step advance of the counter switch A positions its wiper 18 on the second zero contact of row 11, advances the position of the cam 37 so as to permit the spring contacts 39-40 to open, and also advances the position of cam 38 so as to close the cam operated switch contacts 41-42.

The closing of the contacts 41-42 establishes an energizing circuit for relay R (Fig. 1). The energization of this relay opens its normally closed switch 43 and opens a normally closed circuit through the lower contact 44 of a double switch 45. The energization of said relay also closes switches 47, 48 and 49 together with the

circuit through the upper contact 46 of the double switch 45.

The closing of said relay switch 47 establishes a resetting circuit through the electro-magnet 28 of the odd units counter switch A, whereby the said odd units counter is returned to its present starting position, wherein it will be in readiness for response to another series of electrical impulses as soon as the present series is completed by all counter switches of higher order. The closing of said relay switch 48 establishes connection for a circuit through the electro-magnet 28^c of the tens counter switch C. The last mentioned circuit is made possible by virtue of the fact that the switch arm 50 of the regular units counter B is always closed against its contact 51 prior to the transmission of an impulse corresponding to any zero of the count. The closing of relay switch arm 45 against its contact 46 establishes connections for a circuit through the electro-magnet 28^b of the regular units counter B.

From the above it will be seen that the electrical impulse corresponding to the second zero, to wit, the fifteenth impulse of the present setting of the apparatus, is transmitted through certain of the switches of relay R to the actuating electro-magnets of the two counter switches B and C. The said impulse is transmitted to the regular units counter B, because the counter B responds to all impulses after the odds unit counter is cut out of the impulse circuit. The said impulse is transmitted to the tens counter C because it represents a zero insofar as the tens counter C is concerned. The impulse is also transmitted, as will be presently seen, to the hundreds switch D, because it represents a count down from 1314 to 1300.

The above transmission of the 2nd zero impulse to the actuating electro-magnet 28^d of the hundreds counter D was made possible by the previous actuation of the tens counter switch C, whereby the switch arm 59 was moved against its contact 60. This phase of the operation is an important feature of the present invention. In all cases, before the transfer of an impulse to a counter switch of higher order, the previous operation of the adjacent counter of lower order conditions the connections whereby the next impulse energizes the actuating magnets of two or more counter switches of successively increasing order.

Counter switch B

The counter switch B (Fig. 6), as before stated, takes up the count of all impulses after the odd units counter switch A has been disconnected from the impulse circuit. The counter switch B includes a frame, an actuating electro-magnet, ratchet means, actuating spring and a cam shaft which are constructed and operate in the same manner as the corresponding elements of switch A. These elements are therefore identified in switch B by corresponding reference numerals provided with an exponent "b." Inasmuch as the counter-switch B responds to all electrical impulses in said impulse circuit after the odd units counter A has been disconnected from such circuit, it does not require the fixed and the rotating contact members shown in the previous switch and such members are therefore omitted from the present switch B. The omission of said rotating and fixed contacts is made possible in the present counter-switch since it is unnecessary to set the switch B at any particular starting point, it being adapted to always reset to zero.

Switch B is further distinguished from counter switch A by the provision of switch cam 52. The cam is fixed to the shaft 19^b and is formed on its periphery with five lugs 53. The said lugs are spaced apart a distance equal to ten intermittent step operations of the switch device. It will be observed, therefore, that for each ten electrical impulses through the magnet 23^b a cam lug 53 will pass beneath the spring arm 54 to open the electrical contact between said arm 54 and arm 55 and simultaneously close electrical contacts between the arm 54 and arm 53 and also close the previously mentioned contacts 50—51. Each upward movement of the electrically operated arm 26^b presses a buffer 34^b against spring arm 35^b to open the contact between the arm 35^b and arm 36^b of a circuit making and breaking device interposed in the resetting circuit for counter-switch B.

Tens counter switch C

The tens counter switch C is illustrated in Figs. 7 and 8 of the drawings. In general construction it is somewhat the same as switch A in that its frame, electromagnet, ratchet means, actuating spring and cam shaft are identical. These identical elements are therefore designated for switch C by the same reference numerals provided with an exponent "c."

The switch C, being intended to start its operation from a selective pre-set position, it is provided with two rows of fixed contacts designated 11^c and 12^c, respectively. These rows of contacts have ten contacts each. They are numbered 9 to 0 are electrically connected to corresponding contacts of associated selector switches C¹ and C² (Fig. 2). The electrical connections may be made substantially as indicated (Fig. 3) by similar groups of wires 17^c and 23^c (Fig. 2).

A rotating wiper contact 13^c, comprising a central portion and five radially extending arms, is fixed to the shaft 19^c so that the ends of the arms will wipe each of the contacts 9 to 0 in row 11^c, successively, during the rotation of the wiper and thereby effect momentary electric connection between the said contacts 9 to 0 with a line wire contact 20^c, which has engagement with the central portion of the wiper. A line wire contact 21^c engages the central portion of a similar wiper contact 22^c which wipes across the similar contacts in row 12^c.

The fixed contacts in row 12^c are used, like the similar contacts of switch A, in a circuit controlling the relay S which in turn controls the circuit for the green light signal O. Therefore, one arm of the wiper 22^c is positioned on the contact No. 1 to correspond to the digit appearing in the tens position of the particular setting (13-14) of the apparatus. A cam 52^c of the same configuration as shown in the switch B (Fig. 6) and provided with five lugs 53^c is fixed to the shaft 19^c. The cam member is so positioned that one cam lug 53^c thereof will engage the switch arm 65 when the wiper and cam are moved one step forward. In other words, any time the wipers 13^c and 22^c move onto the zero contacts a cam lug 53^c will force the switch arms 65 and 59 against their cooperating contacts 6 and 60, whereby arm 59 conditions the connections, as previously described in connection with the 2nd 0 operation, to direct to the hundreds counter D, the said 2nd 0 impulse. This impulse, as previously noted, corresponds to the second zero of the count down from the setting of 1314 to 1300 and is therefore directed to the hundreds

counter D and to all other counters of higher order. The transmission of said 2nd 0 count to the hundreds counter D is determined by the particular setting (1314) of the apparatus. It might be directed through the cam switch of any number of the higher order counters according to the requirements of the selected setting of the apparatus.

Warning signal cam switch

In order to close an energizing circuit through the relay T and thereby in turn control the warning signal P in advance of the final signal, a cam 61 is fixed on the shaft 19^c of counter switch C. The lugs 62 of cam 61 are positioned to close switch contacts 63 and 64 (Figs. 2 and 7) in advance of the closing of switch contacts 59—60 by the cam lugs 53^c. The amount of the advance spacing of lugs 62 relative to lugs 53^c depend upon the length of the warning signal desired. In the present embodiment the lugs 62 are spaced four steps in the operation of the tens counter C or approximately forty impulses in advance of the operation of the final signal. The said lugs 62 will, of course, close the switch contacts 63—64 many times during the operation of counter switch C, but these closings will not be effective unless the cam switch contacts of the higher order counters D and E are closed.

Counter switches D and E

Referring now to the hundreds counter-switch D illustrated in Fig. 9 and also the thousands counter-switch illustrated in Fig. 10 of the drawings: Both of these counter-switches D and E are identical with each other and with the tens counter-switch C except in those respects hereinafter mentioned. Those parts of the said switches D and E which correspond in structure to the parts illustrated in Fig. 3 are given like reference characters with the addition of exponents "d" and "e," respectively and therefore need not be again described. The switch members D and E are provided in each case with a single cam member designated 52^d, 52^e provided with five cam lugs thereon. The cam lugs 53^d of the counter switch D, operate to close the electric contacts between arms 59^d—60^d and also the contacts between arms 65^d—66^d. The similar cam lugs 53^e of the counter-switch E (Fig. 10) operate to close the electric contact arms 65^e—66^e when it reaches its zero position in the series for which the apparatus is set to operate. The above switches 52^d, 52^e when closed also condition the final signal circuit so that the final signal will be energized when all previously described cam operated switches are closed in series with the switch contacts 65—66 of the tens counter switch C.

Selector switches

The several selector switches are arranged in pairs A¹—A², C¹—C², D¹—D², E¹—E², etc., there being one pair for each counter switch A, C, D, E, etc. The switches of each pair are preferably, though not necessarily, embodied in a unitary device so that they may be operated in unison. Each pair of switches, as herein illustrated in Fig. 4, comprises an upper group 67 of fixed contacts and a lower group 68. The upper group includes ten contacts numbered 9 to 0 and a line wire contact 69. The contact 69 has wiping engagement with a revoluble member 70. This member may be set selectively to establish electrical connection between said contact 69 and any one of the contacts 9 to 0, respectively, of group 67. In the illus-

trations in Figs. 1 and 4, the said contacts 9 to 0 are shown electrically connected by the group 23 of wires to correspondingly numbered fixed contacts in row 12 of counter switch A. However, the electrical connection from contact 69 is completed through only one of such wires, depending upon the particular setting of the selector switch. In the illustration in said Figs. 1 and 4 the electric connection is through the contact No. 4 of the selector to the No. 4 contact of group 15 in row 12 of counter switch A, so as to correspond with the particular setting of the apparatus. In the selector switches C², D² and E², the similar electric connections for the control circuit of the green signal relay S are effected through contacts Nos. 1, 3 and 1, respectively, so as to correspond with the setting of the several switches.

The said lower group of contacts 68 includes ten contacts numbered 9 to 0 and a line wire contact 71 connected with line 109. The 9 to 0 contacts are connected by the group of wires 17 to correspondingly numbered contacts in group 14, row 11 of counter switch A. A revoluble member 72 effects electrical connection between the said contact 71 and any nine of the selector switch contacts numbered 9 to 0, depending upon the particular setting of the switch. Inasmuch as the upper revoluble member 70 and the lower revoluble member 72 of the pair of switches are suitably connected so as to operate in unison, the blank or open connection of the lower member 72 is disposed directly beneath the pointer 33 of the switch A².

From the above description it will be seen that when the selector switch pointer 33 is positioned at any one of the numbered contacts 9 to 0 in group 67, the selector control circuit for the green signal relay S is closed at that contact and that the like contact in the lower group 68, for the resetting circuit of the counter switch, is open. Consequently in the present setting of the apparatus for 1,314 operations, the re-setting circuit of the odd units counter-switch A is opened at the contact No. 4 of the lower group 68 of selector switch contacts. Likewise the re-setting circuit of counter-switches C, D and E, respectively, are opened through the selector switches at the fixed contacts indicated by the pointers on the several dials, to-wit: numerals 1, 3 and 1, respectively.

When the resetting circuit is in control of said counter-switches, the switches will operate in a forward direction until one of their wiper arms comes to rest on the fixed contact in the re-setting circuit (contact No. 4 in group 14 of present illustration for switch A) which is connected to the corresponding open contacts in the selector-switch. The corresponding counter-switch will then remain in that position until it receives an electrical impulse from the pulsating circuits G—H.

The green light signal O operates only when all counter switches are in their pre-set positions, the circuit including one contact in the inner row 12 of fixed contacts of each selector switch. The electric current, therefore, passes from said contact 69 of the selector switch to the closed contact (No. 4 in Fig. 4) and the connection leading to the corresponding fixed contact of the row 12 of the counter-switch to the rotating wiper 22 thereof and thence to the fixed line contact 21.

Operation and circuits

Referring now to the diagram shown in Figs. 1 and 2: The operation of the device as a whole may be described as follows: Assuming that all

of the counter-switches A, B, C, D, E, etc., are set to their starting positions, the closing of the main circuit switch 74 connects the positive line wire I and the negative line J with the service line or other suitable source of direct electric current. It should be understood that in the description of the wiring, all wires marked + or - (plus or minus) connect directly with the positive or negative lines I—J, as the case may be. These various wires have been given the plus and minus symbols but have not been shown extended to and connecting with the said positive and negative lines I and J since to do so would unduly multiply the wires in the diagram.

Circuit—Green signal O

The first circuit to be established, in response to the setting of the counter switches, is a circuit through the green light signal relay S. This circuit leads from the positive line I through, normally closed cam switch arms 35b—36b of counter B, wire 77 through closed cam switch contacts 54 and 56 of counter switch B, wire 78, through the closed contacts of signal selector switch E² and wiper contact 22e and line contact 21e to wire 79; thence through the closed contacts of signal selector switch D² and wiper contact 22d to line contact 21d of counter switch D to wire 80; thence through the closed contacts of signal selector switch C² to the rotating wiper 22c and line contact 21c of counter switch C to wire 81 and the coil of relay S to the negative line J.

The energization of relay S opens its normally closed switch 82 and closes its switch 83. The closing of switch 83 establishes a circuit from the positive line through switch 83, wire 84, through the closed contacts of signal selector A² to the rotating wiper 22 and line contact 21 of counter switch A, thence through wire 85 and green signal O to the negative line J. An additional green signal light O' may be connected in the above circuit by means of wire 85.

The continuity of the above signal circuit is conditioned upon the accurate setting of all counter switches. Consequently when the green signal O is operating it is certain that all counter switches are in their starting positions.

As soon as the apparatus starts its counting operation, that is to say as soon as the first counter to operate, for example the odd units counter A, responds to the first electric impulse, the green signal circuit is broken by the movement of the signal wiper, for example wiper 22 of counter switch A off its closed contact No. 4 in said row 12 of signal contacts. However, the green signal is not extinguished until the starting circuit is energized.

Starting circuit

The second circuit is established by operating the starter key 87 for the purpose of energizing a starting relay U. It comprises positive line I, starter push button or key 87 and wires 88 and 89, through the upper coil of the differential relay U to the negative line J. The energization of relay U closes circuits through switches 90 and 91. The circuit through switch 90 includes wires 93 and 89. It constitutes a holding circuit for the said upper coil of the starting relay U.

Circuit for signal N

Simultaneously with the closing of the starting circuit through the said relay U, a circuit leading from wire 88 is established through wire 94 and light N to the negative line J. This circuit

is maintained and consequently the white light signal is illuminated throughout the entire operation of the apparatus.

Pulsating circuit

The circuit closed through switch 91 of relay U is a pulsating circuit. It includes the wires G—H and the circuit breaker F. When the circuit breaker F is operated by the shop machine K or other device being controlled, the electric current passes from the lead G through the circuit breaker to the pulsating side H thereof. The wire H for the electric impulse leads to a normally closed switch 95 of a re-set control relay V. From here the impulse follows wire 96 to contacts 45—46 of relay R, thence through wire 97 and electro-magnet 28 to the negative line wire J. It will be seen, therefore, that the electro-magnet 28 of the counter-switch A will be energized with an electric impulse each time the circuit breaker F is closed until the said counter-switch A is cut out of the impulse circuits G—H.

The first electrical impulse transmitted through the electro-magnet 28 raises the arm 26 and the ratchet pawl 25 to engage the lower edge of the pawl with the next successive tooth of the ratchet wheel 24. When the said electro-magnet is de-energized by the breaking of the said pulsating circuit at F the spring 31 operates to move the pawl downwardly into engagement with a ratchet tooth and impart movement to the ratchet wheel 24. This movement of the ratchet wheel moves the rotating wipers 18 and 22 off their fixed contacts 4 and onto the adjacent contacts designated 3 in each row 11 and 12 of fixed contacts shown in Fig. 4. The movement of the wiper 18, while the impulse circuit is in control, does not establish an additional circuit since the said contacts engaged by the wiper 18 function only in connection with the re-setting circuit hereinafter described. The movement of wiper 22 off its contact No. 4 breaks the green signal circuit at the wiper 22 and therefore extinguishes the green light signal. However, the green signal relay S remains energized so that the green signal O will be again established by the return of the odd units counter A to its pre-set position when the series of impulses being counted do not require the operation of the regular units counter B.

First zero transfer

The pulsating energization of electro-magnet 28 moves the wiper contact 18 of counter-switch A in a step-by-step movement from the fixed contact 4 in group 14 to the 1st 0 (first zero). For the time being the count to the first zero is not transferred to higher order counters. The counter-switch A merely functions to count through the next group No. 15 of fixed contacts from contact No. 9 to contact No. 1. Simultaneously with the movement of wiper 18 onto contact No. 1 of said group 15 of contacts, the cam 37 (Fig. 4) closes the switch contacts 39—40 momentarily so that the next impulse (the fourteenth transmitted and corresponding to the first zero) is directed to the tens counter C. The circuit above established leads from the normally closed contact 44 of relay R, through connector 99, normally closed switch 43 of relay R, wire 100 to cam switch arms 39—40 of counter-switch A, wires 101, 102, normally closed switch contact 103 of a re-setting relay W, and wire 104 to counter switch magnet 28^c of counter switch C, thence to negative line wire J.

Re-setting of odd units counter A

The last mentioned (the fourteenth) impulse, it will be observed, energizes the relays of both counter switches A and C. Immediately following this impulse, the springs 31 and 31^c and their associated ratchet means (Figs. 4 and 8) function to move the wipers 18 and 18^c of counters A and C one step forward. This movement positions wiper 18 of counter A on the 2nd 0 contact and positions wiper 18^c on the zero contact of counter switch C. The movement of wiper 22^c from the No. 1 contact to the zero contact breaks the circuit of relay S, which now deenergizes.

Ignoring for the present the zero position of counter switch C, it will be seen that simultaneously with movement of wiper 18 of the odd units counter onto the second zero, its cam 38 operates to close the switch-contacts 41—42. These contacts close an energizing circuit from positive line I through wire 106 to the magnet coil of relay R and thence to the negative side of the main line J. The energization of the relay R opens its switch 43 and the pulse circuit for counter A through the lower contact 46 of switch 45. The said energization of relay R also closes the normally open switches 47, 48, 49 and the contact 46 of switch 45. The circuit established through switch 49 and wire 107 constitutes a holding circuit for the relay. The circuit established through switch 47 is the resetting circuit for counter switch A. It leads from the positive line I through the switch 47 of relay R, wire 108, closed switch arms 35—36 of counter switch A, wires 109 and 110 to the connected groups 13 and 15 of contacts in row 11 of switch A to the wiper 18 thereof. This circuit also extends from wire 109 through the closed contacts of selector switch A¹ to said wiper 18, and thence through line contact 20 and wires 111 and 97 to the electro-magnet 28 and thence to the negative line J. The circuit just described, being opened at the spring contact arms 35—36 each time the ratchet arm 26 is raised, is in the nature of a buzzer circuit whereby the rapid series of energizations of the magnet 28 operate to rapidly move the wiper arms 18 and 22 of the counter-switch A to the pre-set position on fixed contact No. 4. At this position all operation of counter-switch A is discontinued because of the opening in the re-setting circuit at contact No. 4 of the selector switch A¹.

Second zero transfer

The said closing of the pulse transfer relay R, as before indicated, closes its switch contacts 45—46 and thereby directs the next impulse (the fifteenth and corresponding to the second zero) to counter switches B, C and D. This transfer of the impulse is effected through the following circuit: From wire 96 and switch contacts 45—46 of relay R through wire 112, normally closed switch 113 of the re-setting relay W, thence through wire 114, and electro-magnet 28^b of counter switch B to the negative line J. The said second zero impulse is directed to the electro-magnet 28^c of the tens counter C by virtue of the fact that the cam switch arms 50—51 of the regular units counter switch B are closed when the counter switch is at rest. All subsequent transfers of zero impulses to higher order counters are effected because said cam switch arms 50—51 are closed immediately prior to the transmission of all subsequent zero impulses.

The circuit for the tens counter C insofar as the first zero is concerned has been previously described. The impulse circuit to said tens counter C, in connection with the second and all subsequent zero impulses, leads from the impulse wire 96 through switch contacts 45—46 of relay R, thence through conductor 115, switch 48 of relay R and wire 116 through said cam switch contacts 50—51 of the regular units counter B, thence through wire 102, closed switch contact 103 of the resetting relay W, wire 104, and electro-magnet 28^c to the negative side of the main line J.

Inasmuch as the counter switch C was previously energized by the transfer of the first zero, and the switch was itself moved to its zero position, its cam switch contacts 59—60 are now closed. Consequently, the said second zero impulse is directed to the hundreds counter switch D through the following leads. From the cam switch arm 50 the impulse follows through wire 117 through the closed cam switch arms 59—60 of counter switch C, thence through wire 118, closed contact 119 of resetting relay W, wire 119', and electro-magnet 28^d to the negative line J.

As soon as the second zero impulse is completed the springs 31^b, 31^c and 31^d function to advance their respective counter switches B, C and D one step forward, thereby moving the wiper 18^d of counter switch D onto its fixed contact No. 2; moving a wiper arm 18^c of counter C onto the No. 9 contact and also opening the cam switch contacts 59—60 of counter switch C and opening the cam switch arms 50—51, and 54—56 of counter switch B. The said movement of counter switch B also closes cam switch arms 54—55. However, the circuit controlled by said cam switch arms 54—55 and wire 121 is open at contact 122 of said resetting relay W.

Operation of counter switch B and subsequent zero transfers

The counter-switch B continues its response to the electrical impulses transmitted by the circuit breaker F. Immediately following the ninth impulse of each series of ten, the cam switch arms 50—51 are again closed so that the tenth or zero count of each group of ten impulses will be directed through the switch arms 50—51 to the counter-switch C. This cycle of operation continues until the impulses transferred to the electro-magnet 28^c of counter-switch C are sufficient to again move one arm of its wiper 18^c onto its zero contact, whereupon its cam switches 59—60 are again closed to direct the next impulse (corresponding to the final impulse of another series of one hundred impulses) to both the tens counter C and the hundreds counter D.

When the hundreds counter-switch D has received sufficient impulses to move one of its wiper arms 18^d onto its zero contact (three impulses for the indicated setting of the apparatus) the cam switch arms 65^d—66^d of counter-switch D close so that the next impulse received by electro-magnet 28^d of counter-switch D will be transmitted also to the thousands counter-switch E as follows: Through cam switch arms 59^d—60^d, wire 123, contact 124 of re-set relay W, wire 125, and electro-magnet 28^e of counter-switch E to the negative line J.

The energization and deenergization of electromagnet 28^e is effective to move an arm 18^e of counter-switch E to its zero position. In this position of counter-switch E a lug 53^e of cam 52^e

closes the switch arms 65^e and 66^e, thereby preparing the final signal circuit for energizing relay X. The final signal circuit is not completed at this time because the impulse which energizes the electromagnet 28^e (the 315th impulse) also energizes the electromagnet 28^d of the hundreds counter-switch D (also 28^c and 28^b) and the counter-switch D is moved in position 9 at the same time that counter-switch E is moved to zero position. The movement of counter-switch D to position 9 opens the final signal circuit at switch arms 65^d and 66^d.

The counter-switches B, C and D continue to respond to impulses in the manner described. The 415th impulse moves the hundreds counter-switch D to position 8, the 515th impulse moves it to position 7, and so on, until finally, in response to the 1215th impulse, the counter-switch D is moved to zero position, thereby closing another point in the final signal circuit at switch arms 65^d and 66^d. This circuit is opened at counter-switch C, however, which moves from zero position to position 9 at the same time that counter-switch D moves to zero position.

The counter-switches B and C continue to respond to impulses. The 1225th impulse moves the counter-switch C to position 8, the 1235th impulse moves it to position 7, and so on, and the 1305th impulse moves the switch to zero position, whereupon the cam 52^c closes the switch arms 65 and 66 and closes another point in the final signal circuit. The circuit is simultaneously opened at counter-switch B, however, which moves from zero position to position 9 in response to the 1305th impulse.

The counter-switch B now responds to the remaining impulses to be counted. The switch moves to position 8 in response to the 1306th impulse, to position 7 in response to the 1307th impulse, and so on, reaching its zero position in response to the 1314th impulse. When switch B moves to zero or normal position, the cam 52 closes the switch 54—56 and completes the final signal circuit. The explanation of this circuit will be deferred until after the warning signal circuit has been explained.

Warning signal circuit

During the count of the last one hundred electrical impulses the counter-switch C continues its operation of receiving impulses from the regular units counter B, as just described. When it has received six of such impulses so that one of its wiper arms 18^c comes to rest on the fixed contact 4 of said counter-switch, a cam lug 62 of the cam 51 closes the switch arms 63—64 of counter-switch C. This operation prepares a circuit for the warning signal relay T, which is completed at the counter-switch B the next time this switch reaches its zero or normal position. This circuit leads from the positive line I through re-setting switch contacts 35^b—36^b of counter-switch B, wire 77, cam switch-arms 54 and 56 of counter B, wire 78, wire 127, closed cam switch arms 65^c—66^c of counter-switch E, wire 128, closed cam switch arms 65^d—66^d of counter-switch D, wires 129 and 130, through cam actuated switch arms 63—64 of counter C, thence through wire 131 and coil of relay T to the negative line J. Relay T, upon energizing, closes a holding circuit through switch 132, a circuit through the amber light signal P and a circuit for an additional warning signal member P'. The said relay holding circuit leads from the positive line I to a normally closed contact 135 of

relay V, wire 136 through a normally closed contact 137 of a final signal relay X, wire 138, closed switch 132 of relay T, thence through wire 139 and coil of relay T to the negative line J. The closing of the switch 134 of the warning signal relay T establishes a circuit through the said amber light signal as follows: Positive lead to said switch 134, wire 140 through amber light P (Fig. 1) to the negative line J. The switch 133 establishes a circuit through a second warning signal P' which may be arranged at a remote location, for example at the machine being controlled. This circuit is from positive lead to switch 133 of said warning signal relay, wire 141 to the remote signal P', thence to the negative line J. The signals P and P' are operated until the relay T is unlocked by the energization of relay X responsive to the completion of the final signal circuit.

Final signal circuit

The final signal circuit over which relay X is energized is closed by the movement of the counter-switch B to zero position, as previously mentioned, and may be traced from the positive line I by way of re-set switch arms 35^b—36^b of counter-switch B, wire 77, cam-operated switch arms 54—55 of counter-switch B, wires 76 and 127 to closed switch arms 65^c—66^c of counter-switch E, wire 128, closed switch arms 65^d—66^d of counter-switch D, wire 129, closed switch arms 65—66 of counter-switch C, wire 142, and through the coil of the final signal relay X to the negative line J.

The energization of final signal relay X opens the two normally closed circuits through its switch contact 137 and the normally closed switch 143. The opening of said contacts 137 of said relay X breaks the circuit through the warning signal relay T. This opens all circuits controlled by said relay T and, therefore de-energizes the amber light signal P and the remote signal P'. The opening of said switch 143 opens a line of a holding circuit for the pulse transfer relay R, which holding circuit leads from the positive line I through the normally closed switch contact 82 of relay S, wires 144 and 145 to said switch 143 of the final signal relay X, thence through wire 146, switch 49 of the pulse transfer relay R, and coil of relay R to negative line J. Relay R accordingly deenergizes. In addition to breaking the two circuits above mentioned, the final signal relay X closes four actuating circuits as follows: One circuit includes the wire 136, closed contact 147 and wire 148. It directs the electric current through the lower coil 157 of differential relay M for closing and holding certain final signal and control circuits hereinafter described. A second circuit includes the switch 149 and wire 150. This circuit energizes the re-set relay W, Fig. 2, which in turn establishes re-setting circuits through each of the counter-switches B, C, D and E to return their respective wiper contacts to their respective starting positions. A third circuit closed by the final signal relay X comprises switch 151 and wires 152—153 for energizing the lower coil of the start and stop relay U, thereby causing said relay to deenergize, opening the several circuits closed by such relay and also extinguishing the white signal light N. A fourth circuit closed by said final signal relay X includes the switch 154 and wire 155 for momentarily energizing a signal, preferably, though not necessarily, an audible signal 156, in the vicinity of the machine K.

Final signal holding circuits

Referring again to the final signal holding relay M which is energized by the first of the said circuits closed by the energization of the relay X: The energization of the coil 157 of relay M closes a holding circuit from positive line I through switch 158, and through coil 157 of relay M to the negative line J. Another circuit includes the switch 161 and wire 162, through the red light signal L and to the negative line J. A third circuit closed by relay M includes positive lead through the switch 163 and wire 164 through a maintained signal L', preferably a red light in the vicinity of the machine K. The signals L and L' continue to function until a switch or other circuit closing device 165 is closed in the negative lead 166 from the coil 167 at the other end of relay M. At this time both coils 157 and 167 of relay M are brought into momentary balance. Consequently, relay M is deenergized and the switch arms controlled thereby are returned to their circuit opening positions.

Resetting circuits

Referring now to the re-setting circuits of the counter-switches B, C, D and E: The re-setting relay W is energized, as before stated, by a momentary circuit closed through switch 149 of the final signal relay X and through wire 150. This momentary energization of the re-setting relay W closes a holding circuit which leads from positive lead and switch contact 82 of green light signal relay S, wire 144, switch W¹ and wire 163 through coil of re-set relay W and to the negative line J. In addition to closing the said switch W¹ the re-set relay W also actuates its four additional switches W², W³, W⁴ and W⁵ to close the normally open contacts 122, 169, 170 and 171, respectively.

Resetting counter switch B

The closing of contact 122 of switch W² does not, in the present instance, result in any re-setting function of counter-switch B, because the counter-switch normally stops at 0 and therefore requires no re-setting. However, it is possible, by pressing the stop button to close a stop circuit through switch contact 90, wires 93, 89 and 172 to stop button 173 and wire 174 to energize the lower coil of the differential start and stop relay U, and thereby deenergize said relay to interrupt the operations of the apparatus when the counter-switch B is not at its 0 position. In such event the cam switch contacts 54—55, of counter-switch B, will be closed. Consequently the re-setting circuit for said counter-switch B will be established from positive lead I by way of the make and break contacts 35^b—36^b of the re-set circuit switch, cam switch arms 54—55, wire 121 and contact 122 of switch W², wire 114, and through the electro-magnet 28^b of counter-switch B to the negative line J. The making and breaking of this circuit at the contacts 35^b—36^b produce rapid intermittent energization of said electro-magnet 28^b and therefore rapidly advances the counter-switch B to its zero position and thereby opens the re-setting circuit at the cam switch contacts 54—55.

Resetting counter switch C

Referring now to the re-setting circuit of counter-switch C: The closing of contact 169 of switch W³ closes the re-setting circuit for this counter-switch as follows: Positive wire I, the re-

setting circuit making and breaking contacts 35°—36° of the counter-switch C, wire 176 through the closed contacts of selector switch C¹ and counter-switch C to the wiper contact 18° of said counter-switch, thence through fixed contact 20° of said counter-switch and wire 177 to closed contact 169 of relay switch W³, wire 104, and through electro-magnet 28° to negative line J. The resetting of counter switch C continues until one of its wiper arms 18° comes to rest on the open contact No. 1.

Resetting counter switches D and E

The closing of contact 170 of resetting switch W⁴ establishes a re-set circuit, similar to the one described for counter-switch C, through counter-switch D to move its wiper arm onto the fixed contact (No. 3) which is opened through the fixed contact No. 3 of the selector switch D¹. The wires and making and breaking contacts of this circuit are given the same reference characters as the circuit for counter-switch C, but with the addition of the exponent "d." A like resetting circuit for counter-switch E is effected by closing the contact 171 of switch W⁵. This circuit is designated by the same reference characters as the corresponding re-setting circuits for counter-switch C, but with the exponent "e." The opening and closing of this circuit operates its wiper contact 18° in a forward direction until it comes to rest on the fixed contact (No. 1), the connection to which is open due to the particular setting of the selector switch E¹.

Upon the completion of the re-setting operation of the counter-switches C, D and E, the previously described circuit for relay S is again completed and this relay energizes. At switch 82 relay S breaks the holding circuit of the reset relay W, which accordingly deenergizes. Also, and since the counter-switch A has already been reset, relay S closes the previously described circuit for the green signal lights O and O' at switch 83.

Continuous counting operation

As hereinabove described, one possible circuit closed by the final signal relay X may establish a circuit including wires 152 and 153 through the lower coil of the start and stop relay U to release the switch arms of this relay and thereby stop all further response to the impulses from impulse circuit G—H, for example, by breaking the connection between the circuit G—H and the positive line I. Such stoppage results when switch 179 is closed. However, when it is desired that the apparatus begin immediately to count or respond to another full series of impulses from the said line G—H, the switch 178 is opened in the lead wire 153. When the switch 178 is opened before the energization of the final signal relay X, the start-stop relay U remains energized. Consequently, the electric impulses from line G—H are again directed to the electro-magnet 28 of the counter-switch A, which switch A begins the count of a new series as previously described.

Changing number of count

In some situations it may be desirable to increase or diminish the number of impulses for which the apparatus is set to count for each full series. If the apparatus is so constructed that the odd units counter begins its operation near the end of a series—in other words, if the apparatus is so modified or connected that it resets to zero and will count up from zero to a predetermined number, the said number may be increased or

diminished for any current series during the count of that series. However, in the specific construction herein shown, the counting operations begin at a pre-set number and count to zero. Consequently the position of the selector switches may be altered during the operation, but this change will not be effective for the current series of impulses being counted. Such altered setting of the apparatus, however, will be effective for the next series after the apparatus is reset, or returned to the newly designated starting position.

Reset control relay V

In the specific form of apparatus herein illustrated, as above indicated, the pre-setting of the selector switches determines the starting point of a series of counts rather than the finish of such series. Therefore, it is necessary for accuracy, when beginning operations, to set the selector switches to the desired positions and then reset the apparatus to the newly set positions before starting the counting operation. The above results may be accomplished in the present apparatus by pressing a re-set push button 179 to energize the re-set control relay V.

The energization of relay V closes its switches 182—183 and opens the switches 95 and 135. The closing of switch 182 of said relay establishes connection from the positive line I through lead 184 to the make and break contacts 35—36 of the previously described resetting circuit of the counter switch A.

The closing of the switch 183 of relay V connects the positive lead 144 with wire 150 and therefore energizes resetting relay W, whereupon the several relay switches W¹, W², W³, W⁴ and W⁵ are actuated to close the previously mentioned resetting circuits through counter switches B, C, D and E.

Additional start, stop and re-set push buttons may be connected in series with the buttons 87, 173 and 179 to permit the apparatus to be controlled from a plurality of locations.

I claim:

1. A control apparatus responsive to a series of make and break impulses in a direct current electric circuit comprising an odd units counter switch, a regular units counter switch, a plurality of additional counter switches of higher order, operating means for said switches including electromagnetically energized means, means providing electric circuits for energizing the electro-magnets of said switches, a circuit making and breaking device interposed in said energizing circuit to provide electric impulses, means connecting said impulse circuit with the electro-magnet of the odd units counter, means including a selector switch for determining the number of energizing impulses to be received by said odd units counter, circuit closing means effective at the termination of the counting operations of said odd units counter to transfer all subsequent impulses to said regular units counter, and means actuated by the movement of the regular units counter for directing certain of said subsequent impulses to a counter of higher order.

2. A control apparatus responsive to a series of make and break impulses in a direct current electric circuit comprising an odd units counter switch, a regular units counter switch, a plurality of additional counter switches of higher order, electro-magnetically operated means and spring means made effective thereby for operating said switches, means providing an electric circuit for energizing the electro-magnets of said switches,

a circuit making and breaking device interposed in said energizing circuit to provide electric impulses, a relay for connecting said impulse circuit with the electro-magnet of the odd units counter, means including a selector switch for determining the number of energizing impulses to be received by said odd unite counter, circuit means closed by the final counting movement of said odd units counter to energize said relay and thereby transfer all subsequent impulses to said regular units counter, and means for transferring certain of said subsequent impulses to a counter of higher order, and selectively positioned means for determining the number of impulses to be received by each of said higher order counter switches.

3. An apparatus for counting a predetermined series of electric impulses including a counter member operable to count the number of impulses corresponding to the lowest order digit of the series plus ten, and a second counter member thereafter operable to complete the count of the series and comprising a step by step switch operable one step for each impulse and including means actuated whereby each tenth impulse is also received by a counter member of higher order; means for also transmitting to said higher order counter member an impulse for said additional ten count of the first mentioned counter member, the said additional ten count constituting a time period during which the higher order counters are re-set to their starting positions, and means for re-setting said higher order counters to their starting positions during said time period.

4. In a counting device, a plurality of electromagnetically operated step-by-step counter switches of different numerical order, each said switch having ten positions corresponding to the ten digits, means for setting said switches to positions corresponding to digits of a number to be counted, and means responsive to a series of electrical impulses containing a number of impulses equal to said number to be counted for successively restoring said counter switches to zero position, the restoring of each counter switches of higher numerical order being controlled by counter switches of lower numerical order.

5. A counting device as claimed in claim 4, including a circuit completed through said switches responsive to the restoration thereof.

6. In a counting device, a plurality of electromagnetically operated counter switches of different numerical order, each switch having ten positions corresponding to the ten digits, a device to be operated responsive to a predetermined number of electrical impulses, means for setting said switches to positions corresponding to the digits in said number, means responsive to said impulses for successively restoring said switches to zero position, the restoring of the switches of higher numerical order being controlled by switches of lower numerical order and means controlled by the last of said switches to return to zero position for operating said device.

7. In a counting device, a plurality of electromagnetically operated counter switches, each switch having ten positions corresponding to the ten digits, respectively, a plurality of selecting switches associated with said counting switches, respectively, each selecting switch also having ten positions corresponding to the ten digits, respectively, means for adjusting said selecting switches in accordance with the digits of a number, electrical circuit means for operating said counting switches to set the same in digit positions corresponding to the adjusted positions of

their respective selecting switches, indicating means responsive to the correct setting of said counter switches, and means responsive to electrical impulses to be counted for restoring said counter switches to zero position.

8. In a counting device, a plurality of counter switches of different numerical order, each switch having a wiper and a bank of contacts, a plurality of selecting switches associated with said counting switches, respectively, each selecting switch also having a wiper and a bank of contacts, means for adjusting the wipers of said selecting switches to desired contacts in the associated contact banks, means for automatically operating said counter switches to position the wipers thereof on bank contacts corresponding to the contacts engaged by the wipers of said selecting switches, and a circuit including all said wipers and the engaged contacts in series.

9. In an impulse counting device, a plurality of step-by-step counter switches of different numerical order, each switch having ten positions corresponding, respectively, to the ten digits of the decimal system, means for pre-setting said switches, respectively, in accordance with the digits in a number representing the number of impulses to be counted, means responsive to said impulses for successively operating said switches to set each switch in accordance with the zero position thereof, a relay energized responsive to the completion of the setting of said switches in zero position, and means including a second relay controlled by said first relay for resetting said switches in accordance with the digits in the number of impulses to be counted.

10. In an impulse counting device, a plurality of step-by-step counter switches of different numerical order, each switch having two positions corresponding, respectively, to the ten digits of the decimal system, means for pre-setting said switches in accordance with the digits in a number representing the number of impulses to be counted, means responsive to said impulses for successively operating said switches to set each switch in accordance with the zero position thereof, a relay energized through serially related contacts in said switches which are closed in the zero position thereof, a self-locking relay energized by said first relay, a third relay energized by said first relay, and means including said third relay for resetting said switches in accordance with the digits in the number of impulses to be counted.

11. In an impulse counting device, a plurality of step-by-step counter switches of different numerical order, each switch having ten positions corresponding, respectively, to the ten digits of the decimal system, means for pre-setting said switches in accordance with the digits in a number designating the number of impulses to be counted, means responsive to said impulses for successively operating said switches to set each switch in accordance with the zero position thereof, a relay energized responsive to the setting of said switches to zero position, means including said relay for automatically resetting said switches in accordance with the digits in the number of impulses to be counted, and a resetting control relay adapted when energized to stop the response of said switches to said impulses and to energize said first relay.

12. In a counting device for counting a predetermined number of electrical impulses, main and auxiliary units counters, a tens counter, means for operating the auxiliary units counter

responsive to certain of said impulses, means for operating said main units counter responsive to the remainder of said impulses, and means in each counter.

13. In a counting device for counting a predetermined number of electrical impulses, main and auxiliary units counters, a tens counter, means including an impulse circuit for operating said auxiliary units counter responsive to a number of impulses corresponding to the units digit of said number and responsive to a plurality of succeeding impulses, means in said auxiliary units counter for controlling said tens counter, means effective upon the response of said auxiliary units counter to the last of said succeeding impulses for transferring said impulse circuit to said main units counter, whereby the latter counter responds to the remainder of said impulses, and means in said main units counter for controlling said tens counter.

14. In a counter for counting successive series of impulses, each series having a predetermined number of impulses, a plurality of switches adapted to be set in accordance with digits in said number, a plurality of counters, means including said switches for operating said counters to set the same in different positions in accordance with the digits in said number, means responsive to a said series of impulses for restoring said counters, a circuit completed responsive to the restoration of all said counters for marking the end of the series, and means controlled over said circuit for automatically resetting said counters to the same positions as before to enable them to respond to the impulses of the next series.

15. In a counting device for counting impulses, a units counter responsive to impulses to be counted, a tens counter, and means for causing two successive impulses which actuate said units counter to also actuate said tens counter.

16. In a counting device for counting impulses, a units counter responsive to a variable number of impulses not less than ten nor more than nineteen, a tens counter, means for causing the last impulse which operates the units counter to also operate said tens counter, and means for causing the next impulse to operate the tens counter again.

17. In a counting device for counting impulses, a units counter responsive to a variable number of impulses not less than ten nor more than nineteen, a tens counter, means for causing the last impulse which operates the units counter to also operate said tens counter, a second units counter, and means for causing the next impulse to operate said second units counter and said tens counter.

18. In a counting device for counting a predetermined number of impulses, a units counter responsive to a part of the impulses to be counted, a second units counter responsive to the remainder of the impulses to be counted, a tens counter, and means for causing the last impulse which operates the first units counter and the first impulse which operates the second units counter to operate said tens counter.

19. In a counting device for counting a predetermined number of impulses, a units counter having ten different starting positions, means for setting said counter in any one of said positions, a second units counter having only a single starting position, means for directing impulses to be counted to said first units counter, means controlled by said units counter responsive to the receipt of a number of impulses deter-

mined by the starting position to which it was set for directing subsequent impulses to said second units counter, and a tens counter controlled by said units counters.

20. In a predetermined counting device for counting series of electrical impulses, a counter adapted to respond to impulses, a circuit over which impulses are delivered to said counter, a second counter, a transfer relay controlled by said first counter for switching said circuit from the first counter to the second counter, whereby the second counter is enabled to respond to the remaining impulses of a series, means for restoring said first counter to its starting position during the operation of the second counter, and means responsive to the last impulse of the series for deenergizing said transfer relay to switch the said impulse circuit back to the first counter, whereby said first counter is made responsive to impulses of the next series.

21. In a counting device for counting successive series of impulses from an indefinite train of impulses, a counter responsive to certain individual impulses at the beginning of a series, a second counter responsive to the remaining impulses of said series, means for restoring said first counter to its starting position during the operation of the second counter, counters of higher numerical order controlled by said first and second counters, means responsive to the last impulse of the series for restoring said higher order counters to their starting positions, and means also responsive to said last impulse to cause said first counter to start responding to impulses of the next series.

22. In a counting device for counting a predetermined number of impulses a plurality of times, tens and units step-by-step counting switches, means for setting said switches in accordance with the tens and units digits of said number, respectively, means responsive to impulses for advancing said switches to zero position, said means including a second units counter-switch responsive to impulses received subsequent to the restoration of said first units counter-switch, means for resetting said first units counter-switch to prepare it for use in counting said number of impulses the second time, means controlled by said second units counter-switch and said tens counter-switch in zero position for restarting the operation of said first units counter-switch, and means for resetting said tens counter-switch while said first units counter-switch is again advancing to zero position responsive to impulses.

23. In a counting device for counting a predetermined number of impulses, a tens counter, means for setting said counter in accordance with the tens digit of said number, a units counter normally standing in zero position, means responsive to impulses to be counted for operating said units counter, means including a switch closed by the units counter in zero position for causing each impulse received by said units counter in zero position to operate said tens counter, whereby said tens counter is moved to zero position, and a circuit jointly controlled by said counters the next time said units counter reaches zero position.

24. In a counting device for counting a predetermined number of impulses, first and second counting switches of different numerical order, each switch having a bank of ten contacts and wiper means adapted to traverse said contacts always in the same direction, means responsive to impulses to be counted for advancing said first

switch repeatedly to zero, means effective whenever the first switch is in zero position for causing the next impulse to advance both switches, whereby when the second switch arrives at zero the first switch is advanced to the next adjacent position, and a circuit completed by the said first and second switches the next time the said first switch reaches zero.

25. In a counting device for counting a predetermined number of impulses, first and second counting switches, each having motion in one direction only, means for setting said switches in accordance with two digits, respectively, of a number of impulses to be counted, means responsive to impulses to be counted for advancing the first switch repeatedly through its zero position, means effective each time the first switch is in zero position for advancing both switches, whereby when the second switch reaches zero position the first switch will leave zero position, and a circuit extending through both switches in zero position which is completed the next time the first switch reaches its zero position.

26. In a counting device for counting successive series of impulses from an indefinite train of impulses, a signal circuit, counters of different numerical orders responsive to impulses of said train, means controlled by said counters for closing said circuit at the end of each series of impulses, and means for predetermining the number of impulses in each series, including selecting means adjustable while a series of impulses is being counted for changing the length of the

next series without affecting the length of the series being counted.

27. In a counting device for counting successive series of impulses from an indefinite train of impulses, counters of different numerical orders having different starting positions dependent upon the length of said series, means responsive to the impulses of each series for restoring said counters to zero position and for resetting them to their starting positions, a signal circuit completed by said counters each time in zero position, and switching means adjustable during the count of one series of impulses to predetermine new starting positions to which the counters are reset upon the completion of the count, whereby the length of the next series to be counted may be changed.

28. In a predetermined counter, a plurality of step-by-step counter switches of different numerical order, each switch having a plurality of digit positions and a pair of contacts closed in only one of said positions designated as the control position, means for setting said switches, respectively, in accordance with digits in a number representing the number of impulses in a train of impulses to be counted, means responsive to said train of impulses for restoring said switches successively step by step to their control positions, including means whereby the switch of lowest numerical order is restored last, and a circuit extending through said pairs of contacts in series upon the restoration of the last of said switches to be restored.

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